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THE MEDIATING ROLE OF AI-ENABLED INTERNAL CONTROL EFFECTIVENESS VIA ARTIFICIAL INTELLIGENCE UTILIZATION AND SUSTAINABLE AUDIT QUALITY IN POWER ENGINEERING PROJECTS

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ABSTRACT

With the growing scale and complexity of large-scale power engineering projects, traditional audit approaches face increasing challenges in supporting continuous governance and risk management. Although artificial intelligence has been widely introduced into auditing practices, the mechanisms through which it contributes to sustainable audit quality remain insufficiently understood. This study examines how artificial intelligence utilization influences sustainable audit quality through the effectiveness of artificial intelligence–enabled internal controls. Using survey data collected from participants involved in large-scale power engineering projects in China, this study applies structural equation modeling to analyze the relationships among artificial intelligence utilization, internal control effectiveness, and sustainable audit quality. The results show that artificial intelligence utilization has a significant positive impact on sustainable audit quality. In addition, artificial intelligence utilization enhances the effectiveness of internal controls, which in turn contributes to improved audit quality. Further analysis confirms that internal control effectiveness partially mediates the relationship between artificial intelligence utilization and sustainable audit quality.These findings indicate that artificial intelligence enhances sustainable audit quality not only through direct technological effects but also by strengthening internal control execution as a governance mechanism. This study contributes to the literature on artificial intelligence–enabled auditing and provides practical insights for improving audit governance in large-scale engineering projects.

KEYWORDS: Artificial Intelligence Utilization, Ai-Enabled Internal Control Effectiveness, Sustainable Audit Quality, Power Engineering Projects.

1. INTRODUCTION

1.1. *Research Background*

In recent years, with the continuous transformation of China's energy structure and the expansion of infrastructure investment, large-scale power engineering projects have played an increasingly important role in ensuring energy security, promoting high-quality economic development, and supporting carbon reduction goals (Zhang et al., 2021; Sovacool et al., 2020). These projects are typically characterized by large investment scales, long construction periods, multiple stakeholders, and high technical and managerial complexity, making effective governance particularly challenging (Flyvbjerg, 2021). Consequently, their governance quality directly affects the efficiency of public resource allocation and the sustainability of project outcomes.

Within the governance framework of large-scale power engineering projects, auditing serves as a critical supervision and control mechanism for regulating managerial behavior and mitigating systemic risks (Hay et al., 2021). However, traditional engineering audits are predominantly ex post in nature and mainly focus on compliance verification and outcome-based inspection. In practice, project processes are distributed across multiple stages and organizations, and relevant data are often fragmented across different systems, resulting in limited real-time accessibility and traceability (Vasarhelyi et al., 2021). As a result, audit activities frequently face delayed risk identification, weak process monitoring, and difficulties in continuously tracking the execution of internal controls, which constrains the improvement of sustainable audit quality (SAQ) (Appelbaum et al., 2020).

With the rapid advancement of digital technologies, Artificial Intelligence Utilization (AIU) has increasingly been introduced into engineering management and auditing practices (Raisch & Krakowski, 2021). AI-based systems, supported by data analytics, machine learning, and intelligent anomaly detection, enable real-time data collection, continuous monitoring, and proactive risk identification (Moll & Yigitbasioglu, 2019; Kroon et al., 2021). Compared with traditional audit approaches, AI-supported auditing offers significant advantages in terms of information processing efficiency, risk responsiveness, and process transparency (Vasarhelyi et al., 2020). Nevertheless, existing studies have primarily focused on the direct effects of AI utilization on audit efficiency or audit outcomes, while limited attention has been paid to the governance mechanisms through which AI contributes to the sustained improvement of audit quality (Baldwin et al., 2023).

1.2. *Research Problem*

In the governance context of large-scale power engineering projects, audit quality is not determined solely by the adoption of advanced technologies, but is closely associated with the operation and effectiveness of internal control mechanisms (DeFond & Zhang, 2014; Chen et al., 2020). Internal control serves as a key institutional arrangement that links managerial decision-making with project execution. Its effectiveness depends not only on the completeness of control system design, but also on whether control procedures can be consistently and effectively implemented in practice (COSO, 2017; Krishnan et al., 2021). In many engineering projects, a persistent gap exists between formal internal control systems and their actual execution, which weakens the long-term effectiveness of audit supervision (Doyle et al., 2021).

The utilization of artificial intelligence provides new opportunities to enhance the functioning of internal controls. On the one hand, AI technologies improve data integration, information sharing, and process transparency within internal control activities, thereby enhancing traceability and real-time monitoring (Sun et al., 2023). On the other hand, AI-enabled automated monitoring and intelligent alert mechanisms can reduce execution bias caused by excessive human intervention and strengthen control enforcement (Tang et al., 2022). From this perspective, the impact of AI utilization on sustainable audit quality may not be limited to a direct effect, but may operate through an intermediate governance mechanism—namely, AI-Enabled Internal Control Effectiveness (AI-ICE).
Based on this reasoning, this study raises the following core research question:

Can AI utilization enhance sustainable audit quality in large-scale power engineering projects by improving AI-enabled internal control effectiveness?

More specifically, does AI utilization influence sustainable audit quality primarily through a direct pathway, or does it also exert an indirect effect through AI-ICE? Addressing these questions contributes to a deeper understanding of AI-enabled audit governance mechanisms (Rikhardsson & Yigitbasioglu, 2018; Sutton et al., 2021).

1.3. *Research Objectives and Significance*

To address the above research question, this study focuses on large-scale power engineering projects in

China and empirically examines the relationships among AI utilization, AI-enabled internal control effectiveness, and sustainable audit quality using survey data and structural equation modeling. The specific objectives of this study are as follows.

First, the study aims to examine the direct effect of AI utilization on sustainable audit quality in large-scale power engineering projects, thereby assessing the overall governance impact of AI adoption in the auditing context.

Second, it seeks to analyze the influence of AI utilization on AI-enabled internal control effectiveness, with particular emphasis on how AI reshapes the execution and monitoring of internal controls.

Third, the study aims to test the mediating role of AI-enabled internal control effectiveness in the relationship between AI utilization and sustainable audit quality, in order to reveal the underlying mechanism through which AI affects audit outcomes.

From a theoretical perspective, this study extends the literature on AI and auditing by integrating AI utilization into the governance framework of internal control and sustainable audit quality. By emphasizing the mediating role of AI-enabled internal control effectiveness, the study moves beyond a purely technological perspective and contributes to a more comprehensive understanding of the "technology-institution-audit quality" relationship. From a practical perspective, the findings provide valuable insights for project managers, auditors, and regulators involved in large-scale power engineering projects, offering guidance on how AI applications can be strategically deployed to strengthen internal control execution and support the continuous improvement of audit quality.

2. LITERATURE REVIEW & HYPOTHESES

2.1. Artificial Intelligence Utilization and Sustainable Audit Quality

With the increasing scale and complexity of engineering projects, traditional audit approaches characterized by periodic and ex post inspections have become insufficient to meet the governance and risk management requirements of large-scale power engineering projects (Appelbaum et al., 2020; Vasarhelyi et al., 2021). Sustainable audit quality (SAQ) emphasizes the continuity, forward-looking nature, and feedback-oriented improvement of audit activities throughout the project lifecycle (Rikhardsson & Yigitbasioglu, 2020). Rather than focusing solely on the accuracy of audit outcomes, sustainable audit quality (SAQ) highlights whether audit processes can continuously identify risks, support managerial decision-making, and facilitate governance improvement (Baldwin et al., 2023). In this context, artificial intelligence utilization (AIU) has been widely recognized as a key technological driver for transforming audit practices (Kokina et al., 2021; Appelbaum et al., 2020).

Artificial intelligence utilization (AIU) provides dynamic and real-time support for audit activities through systematic data integration and intelligent analysis (Appelbaum et al., 2020). AI-based audit systems, supported by machine learning, data mining, and anomaly detection technologies, enable continuous monitoring of project operations and automatic identification of potential risks and irregularities (Sun et al., 2023; Vasarhelyi et al., 2021). Such data-driven auditing approaches help overcome the limitations of traditional audits that rely heavily on sampling and manual judgment, thereby improving the timeliness and comprehensiveness of audit information and shifting audit practices from static inspection toward process-oriented supervision (Baldwin et al., 2023).

From a governance perspective, artificial intelligence utilization (AIU) also enhances the transparency and traceability of audit activities (Vasarhelyi et al., 2021). By digitally recording and analyzing audit trails, control logs, and corrective actions, audit outcomes are no longer confined to periodic reports but are embedded within continuous monitoring and feedback mechanisms (Rikhardsson & Yigitbasioglu, 2020; Sun et al., 2023). This continuous audit support strengthens the enforceability and practical relevance of audit findings, contributing to the stable improvement of audit quality over time (Baldwin et al., 2023).

Although existing studies generally suggest that artificial intelligence utilization (AIU) can significantly improve audit efficiency and risk detection capability, further empirical evidence is needed to examine its role in sustaining audit quality in complex engineering project settings. In large-scale power engineering projects, artificial intelligence utilization (AIU) reduces information asymmetry, enhances data processing capacity, and improves the speed of risk response, thereby providing institutionalized and routine technical support for auditing activities. Accordingly, this study argues that artificial intelligence utilization (AIU) not only improves individual audit outcomes but also contributes to the enhancement of sustainable audit quality throughout the project lifecycle.

Based on the above discussion, the following hypothesis is proposed:

H1: Artificial intelligence utilization (AIU) has a significant positive effect on sustainable audit quality (SAQ) in large-scale power engineering projects.

2.2. *Artificial Intelligence Utilization And AI-Enabled Internal Control Effectiveness*

In large-scale power engineering projects, internal control serves as a fundamental governance mechanism for ensuring standardized operations and risk prevention (Zhao, Yan, & Ji, 2023; Cheng, Li, & Zhao, 2024). However, traditional internal control systems often face practical challenges, including difficulties in execution, heavy reliance on manual judgment, and delayed information feedback (Cheng et al., 2024). Although control systems may be well designed in form, the complexity of project processes and the involvement of multiple stakeholders often lead to deviations in implementation, thereby weakening the effectiveness of internal control (Zhao et al., 2023). As a result, the core issue of internal control lies not in the existence of formal systems, but in whether control measures can be consistently and effectively executed throughout project implementation (Zhao et al., 2023; Cheng et al., 2024).

Artificial intelligence utilization (AIU) provides a new technological pathway for enhancing the execution effectiveness of internal controls (Kokina & Davenport, 2025; Leocádio, Gomes, & Leal, 2024). By embedding AI technologies into internal control processes, project management and auditing systems can continuously monitor key operational activities and provide real-time feedback on control execution (Kokina & Davenport, 2025). AI systems supported by machine learning and data analytics can automatically detect abnormal behaviors and potential risks in control implementation, reducing dependence on human experience and subjective judgment, and improving the stability and consistency of internal control execution in complex engineering environments (Leocádio et al., 2024).

Moreover, artificial intelligence utilization enhances information transparency and traceability within internal control processes (Zhao et al., 2023; Cheng et al., 2024). Through the digital recording and analysis of control records, operational logs, and exception-handling procedures, internal control activities can generate a complete and verifiable data trail (Cheng et al., 2024). This data-driven control approach helps reduce information asymmetry between management and operational levels and strengthens the enforcement of internal controls in practice (Zhao et al., 2023).

Based on these considerations, this study conceptualizes internal control as AI-Enabled Internal Control Effectiveness (AI-ICE), emphasizing the role of artificial intelligence in improving the quality, stability, and sustainability of control execution. Compared with traditional internal control concepts, AI-ICE focuses more on the effectiveness of control implementation in practice rather than the completeness of system design. Accordingly, as the level of artificial intelligence utilization increases, the execution effectiveness of internal controls is expected to improve significantly. Based on the above discussion, the following hypothesis is proposed:

H2: Artificial intelligence utilization (AIU) has a significant positive effect on AI-enabled internal control effectiveness (AI-ICE).

2.3. *AI-Enabled Internal Control Effectiveness and Sustainable Audit Quality*

In large-scale power engineering projects, the achievement of sustainable audit quality (SAQ) depends not only on the adoption of advanced auditing technologies but also on the effectiveness with which internal controls are executed throughout the project lifecycle (Krishnan, Wen, & Zhao, 2021). As an essential governance mechanism linking organizational objectives with operational activities, internal control execution directly affects the reliability of audit evidence, the timeliness of risk identification, and the feasibility of audit recommendations (Kim, 2023). Consequently, sustainable audit quality is closely associated with whether internal control activities can be implemented in a stable, continuous, and traceable manner.

AI-Enabled Internal Control Effectiveness (AI-ICE) enhances the institutional foundation of auditing by embedding artificial intelligence technologies into control execution processes (Sun, Liu, & Hu, 2023). Through continuous monitoring and automated analysis, AI-ICE reduces the likelihood of control failures arising from human error, subjective judgment, or delayed information feedback. At the same time, data-driven control execution improves the completeness and consistency of audit evidence, thereby strengthening the credibility of audit outcomes (Chen, Jiang, & Chen, 2021).

From a governance perspective, AI-ICE strengthens the transmission role of internal control within the auditing process. By improving the transparency and traceability of control activities, AI-

ICE enables auditors to more effectively identify risk sources, control deficiencies, and their evolution over time (Tang, Norman, & Vendrzyk, 2022). This supports a shift in auditing practices from outcome-oriented inspection toward process-oriented supervision, which is essential for maintaining audit quality across extended project durations.

Moreover, AI-enabled internal control effectiveness（AI-ICE）enhances the enforceability of audit findings. When control execution processes are systematically recorded and continuously monitored, audit recommendations are more likely to be translated into concrete managerial actions, forming a closed-loop mechanism of identification, feedback, rectification, and re-monitoring (Sun et al., 2023). Such a mechanism not only improves the effectiveness of individual audit engagements but also contributes to the sustained improvement of audit quality throughout the project lifecycle.

Although prior studies have emphasized the importance of internal control effectiveness for audit outcomes, emerging evidence suggests that the integration of artificial intelligence into control execution further amplifies this relationship (Chen et al., 2021; Kim, 2023). Accordingly, this study posits that higher levels of AI-enabled internal control effectiveness (AI-ICE) are associated with higher levels of sustainable audit quality (SAQ) in large-scale power engineering projects.

Based on the above discussion, the following hypothesis is proposed:

> **H3:** AI-enabled internal control effectiveness（AI-ICE） has a significant positive effect on sustainable audit quality（SAQ） in large-scale power engineering projects.

2.4. The Mediating Role Of AI-Enabled Internal Control Effectiveness

Although artificial intelligence utilization (AIU) has been shown to directly enhance sustainable audit quality (SAQ), its influence is not limited to a direct technological effect. In complex project environments such as large-scale power engineering projects, the impact of AI utilization on audit outcomes is more likely to be realized through governance mechanisms that translate technological capabilities into effective organizational practices.

As discussed in the preceding sections, AI utilization improves the execution effectiveness of internal controls by enabling continuous monitoring, automated risk detection, and real-time feedback. These improvements strengthen AI-Enabled Internal Control Effectiveness (AI-ICE), which serves as an essential mechanism linking technological adoption with governance outcomes. Effective internal control execution enhances the reliability of audit evidence, supports timely risk identification, and facilitates the implementation of audit recommendations, thereby contributing to the sustained improvement of audit quality.

From a process-oriented perspective, AI-ICE represents a critical transmission channel through which AI utilization affects sustainable audit quality. Rather than improving audit outcomes solely through isolated analytical tools, AIU enhances SAQ by embedding intelligence into routine control execution and supervision processes. This mechanism-based perspective suggests that the benefits of AI utilization are realized not only through direct audit applications but also through its role in strengthening internal governance structures (Sun, Liu, & Hu, 2023; Chen, Jiang, & Chen, 2021).

Moreover, the mediating role of internal control effectiveness aligns with governance-oriented auditing theories, which emphasize that sustainable audit quality depends on the continuous functioning of internal control mechanisms rather than one-time audit interventions. When AI-enabled internal controls operate effectively, auditing shifts from episodic inspection toward continuous supervision and feedback, supporting long-term audit quality improvement (Krishnan, Wen, & Zhao, 2021).

Accordingly, this study proposes that AI-enabled internal control effectiveness mediates the relationship between AIU and SAQ in large-scale power engineering projects. In other words, AI utilization (AIU) enhances sustainable audit quality（SAQ）not only directly but also indirectly by strengthening the execution effectiveness of internal controls.

Based on the above discussion, the following hypothesis is proposed:

> **H4:** AI-enabled internal control effectiveness (AI-ICE) mediates the relationship between artificial intelligence utilization（AIU）and sustainable audit quality（SAQ) in large-scale power engineering projects.

3. METHODOLOGY

3.1. Sample And Data Collection

This study focuses on large-scale power engineering projects in China and employs a questionnaire-based survey to collect empirical data. The target respondents include professionals who are directly involved in, or have substantial knowledge of, the management and auditing of large-scale power engineering projects, such as project owners' representatives, internal auditors, personnel from third-party auditing institutions, and other project-related managerial and technical staff. This sample structure ensures that the collected data adequately reflect practical conditions related to artificial intelligence utilization (AIU), AI-enabled internal control effectiveness (AI-ICE), and sustainable audit quality (SAQ) in real project environments.

The questionnaires were distributed using a combination of targeted sampling and snowball sampling methods. All respondents possessed relevant experience in large-scale power engineering projects and were therefore capable of providing informed evaluations of the survey items. Prior to the formal survey, a pilot test was conducted to assess the clarity and appropriateness of the questionnaire, and minor revisions were made accordingly.

A total of 480 questionnaires were collected. After excluding incomplete and invalid responses, 430 valid questionnaires were retained for subsequent analysis. The final sample size meets the requirements for structural equation modeling and provides sufficient statistical power for reliability, validity, and mediation analyses.

3.2. *Measurement Of Variables*

This study employs a structured questionnaire to measure the core research variables. All measurement items are assessed using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The survey items were adapted to the context of large-scale power engineering projects to ensure contextual relevance and clarity.

Artificial Intelligence Utilization (AIU) measures the extent to which artificial intelligence technologies are applied in auditing and management activities of large-scale power engineering projects. This construct focuses on the application of AI in areas such as data integration, intelligent analysis, risk identification, and process monitoring.

AI-Enabled Internal Control Effectiveness (AI-ICE) captures the effectiveness of internal control execution supported by artificial intelligence. Rather than emphasizing the formal design of control systems, AI-ICE reflects the stability, consistency, and traceability of internal control implementation throughout project execution.

Sustainable Audit Quality (SAQ) assesses the sustainability-oriented characteristics of audit activities across the project lifecycle. This construct emphasizes whether auditing practices can continuously identify risks, support managerial decision-making, and contribute to long-term governance improvement.

All measurement items were pre-tested prior to the formal survey, and minor revisions were made to enhance clarity and internal consistency.

3.3. *Reliability And Validity*

Prior to conducting structural equation modeling, the reliability and validity of the measurement model were assessed to ensure adequate measurement quality.

Internal consistency reliability was evaluated using Cronbach's Alpha and Composite Reliability (CR). Generally, values greater than 0.70 for both Cronbach's Alpha and CR indicate acceptable reliability.

Convergent validity was assessed using the Average Variance Extracted (AVE). An AVE value exceeding 0.50 suggests that a latent construct explains a substantial proportion of variance in its measurement items, indicating adequate convergent validity.

Discriminant validity was examined using the Fornell–Larcker criterion by comparing the square root of AVE for each construct with its correlations with other constructs. Discriminant validity is supported when the square root of AVE is greater than the corresponding inter-construct correlations.

These reliability and validity assessment procedures provide the methodological foundation for subsequent structural model estimation and mediation analysis.

3.4. *Structural Equation Modeling and Mediation Analysis*

After establishing the reliability and validity of the measurement model, this study employs Structural Equation Modeling (SEM) to test the proposed hypotheses. SEM is well suited for examining complex relationships among latent variables while accounting for measurement error, particularly in models involving mediation effects.

The structural model specifies Artificial Intelligence Utilization (AIU) as the independent variable, AI-Enabled Internal Control Effectiveness (AI-ICE) as the mediating variable, and Sustainable Audit Quality (SAQ) as the dependent variable. This model is designed to examine both the direct effect of AIU on SAQ and the indirect effect of AIU on SAQ through AI-ICE. Model estimation is conducted using the maximum likelihood method.

Model fit is assessed using multiple goodness-of-fit indices, including the chi-square to degrees of freedom ratio (χ^2/df), the Comparative Fit Index (CFI), the Tucker–Lewis Index (TLI), and the Root

Mean Square Error of Approximation (RMSEA). Acceptable model fit is determined based on commonly recommended threshold values.

To examine the mediating effect of AI-ICE, this study applies the bootstrap resampling technique to estimate the indirect effects and their confidence intervals. This approach does not rely on the assumption of normality and provides a robust assessment of mediation effects.

4. RESULTS

4.1. *Descriptive Statistics*

Before conducting structural model estimation, descriptive statistical analysis was performed to examine the sample composition and the overall distribution of the survey data.

The sample includes respondents from multiple stakeholder groups involved in large-scale power engineering projects, including internal auditors of project owners, suppliers and contractors, artificial intelligence experts, government representatives, financial institutions, and third-party auditing institutions. In addition, respondents were drawn from different regional branches, reflecting geographical diversity.

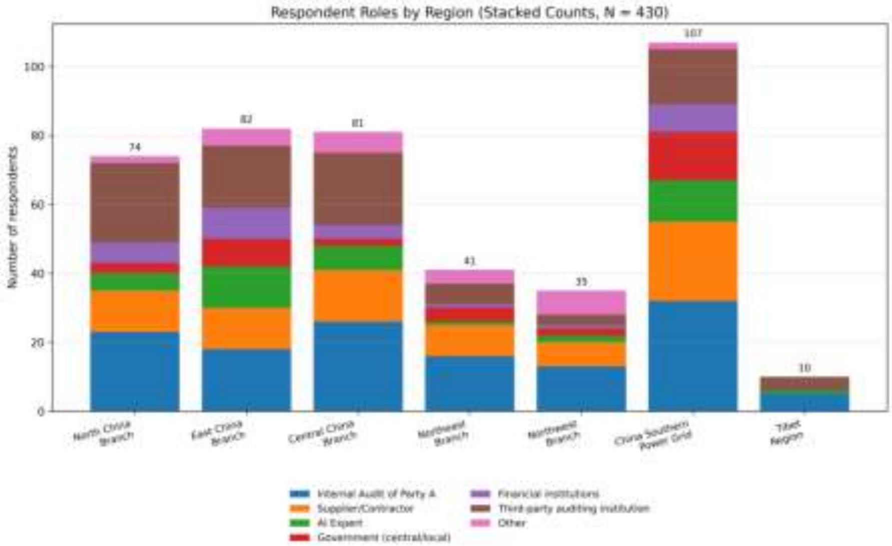

Figure 1: Distribution of Respondents by Role Across Regions.

Figure 1, titled Distribution of Respondents by Role Across Regions, illustrates the distribution of respondent roles across regions. The figure shows that each regional branch includes respondents from multiple stakeholder categories, indicating a diversified sample structure.

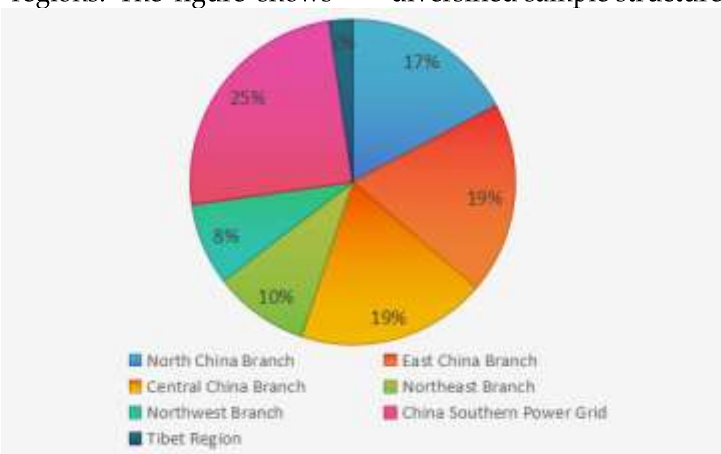

Figure 2: Regional Project Distribution.

Figure 2, titled Regional Project Distribution, presents the proportion of projects represented in each regional branch. The results indicate that the survey data cover major regional branches of large-scale power engineering projects in China, providing broad geographical representation.

To assess the reliability of the measurement instruments, Cronbach’s alpha coefficients were calculated for all constructs. As shown in Table 1, the Cronbach' s alpha values for Artificial Intelligence Utilization (AIU), AI-Enabled Internal Control Effectiveness (AI-ICE), and Sustainable Audit Quality (SAQ) range from 0.87 to 0.92, exceeding the commonly accepted threshold of 0.70. The overall scale also demonstrates high internal consistency.

Table 1: Cronbach's Alpha.

Dimension	Items	Cronbach's Alpha
AIU	9	0.87
AI-ICE	9	0.9
SAQ	12	0.92
Total	30	0.94

Construct validity was further examined using composite reliability (CR) and average variance extracted (AVE). As reported in Table 2, all CR values exceed 0.70, and all AVE values are above the recommended threshold of 0.50, indicating satisfactory convergent validity for all constructs.

Table 2: Ave and Cr.

Construct	Number of Items	AVE	CR
AIU	9	0.59	0.88
AI-ICE	9	0.53	0.91
SAQ	12	0.55	0.93

Overall, the descriptive statistics and measurement model assessment suggest that the sample demonstrates diversity in respondent roles and regional distribution, and that the measurement instruments exhibit adequate reliability and validity. These results provide a necessary data basis for subsequent model fit assessment, path coefficient analysis, and mediation testing.

4.2. *Model Fit Indices*

To evaluate the overall adequacy of the structural equation model, a set of commonly used goodness-of-fit indices was examined. The model fit was assessed using the chi-square to degrees of freedom ratio (χ^2/df), Goodness-of-Fit Index (GFI), Normed Fit Index (NFI), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA).

Table 3: Model Fit Indices.

Indicator	χ^2/df	GFI	NFI	IFI	TLI	CFI	RMSEA
Acceptable	<3.0	>0.80	>0.90	>0.90	>0.90	>0.90	<0.08
Good	<2.0	>0.90	>0.95	>0.95	>0.95	>0.95	<0.05
Excellent	<1.5	>0.95	>0.95	>0.97	>0.97	>0.97	<0.03
Model Score	1.18	0.933	0.935	0.989	0.988	0.989	0.021

As reported in Table 3, the χ^2/df value of the model is 1.18, which is well below the recommended threshold of 3.0, indicating a satisfactory level of overall model fit. The incremental and comparative fit indices also demonstrate strong model performance, with GFI = 0.933, NFI = 0.935, IFI = 0.989, TLI = 0.988, and CFI = 0.989. All these values exceed the commonly accepted cutoff values suggested in the literature.

In addition, the RMSEA value of 0.021 is substantially lower than the recommended upper limit of 0.08, indicating a close fit between the proposed model and the observed data. Taken together, these results suggest that the proposed structural model exhibits an overall good fit and is suitable for subsequent path coefficient estimation and mediation analysis.

4.3. *Path Coefficient Analysis and Hypothesis Testing*

After confirming satisfactory model fit, the structural paths among Artificial Intelligence Utilization (AIU), AI-Enabled Internal Control Effectiveness (AI-ICE), and Sustainable Audit Quality (SAQ) were examined. The standardized and unstandardized path coefficients, along with their significance levels, are reported in Table 4.

Table 4: Path Coefficients and Hypothesis Testing Results.

Hypothesis	Paths	Unstandardized path coefficients	S.E.	C.R.	P	Standardized path factor	Result
H1	AIU→AI-ICE	0.31	0.062	5.049	<0.001	0.307	Supported
H2	AI-ICE→SAQ	0.22	0.057	3.794	<0.001	0.202	Supported
H3	AIU→SAQ	0.35	0.068	5.115	<0.001	0.319	Supported

As shown in Table X, Artificial Intelligence Utilization has a significant positive effect on AI-Enabled Internal Control Effectiveness (β = 0.307, p < 0.001), supporting H1. This result indicates that higher levels of AI utilization are associated with stronger effectiveness in AI-enabled internal control execution.

In addition, AI-Enabled Internal Control Effectiveness is positively associated with Sustainable Audit Quality (β = 0.202, p < 0.001), providing support for H2. This finding suggests that effective AI-enabled internal control execution contributes to the sustained improvement of audit quality in large-scale power engineering projects.

Table 5: Bootstrap Results for the Mediation Effect.

Hypothesis	Path	Effect (Indirect)	S.E.	P	95% CI (LB)	95% CI (UB)
H4	AIU→ AI-ICE→SAQ	0.067	—	<0.001	0.032	0.116

Furthermore, Artificial Intelligence Utilization also exerts a significant direct effect on Sustainable Audit Quality (β = 0.319, p < 0.001), supporting H3. This result indicates that AI utilization enhances sustainable audit quality not only through governance mechanisms but also through direct technological effects.

To further examine the mediating mechanism, a bootstrap analysis was conducted to test the indirect effect of AI-Enabled Internal Control Effectiveness. The results of the mediation analysis are reported in Table Y. The indirect effect of AI utilization on sustainable audit quality via AI-ICE is significant (indirect effect = 0.067, p < 0.001), with the 95% bias-corrected confidence interval excluding zero (95% CI [0.032, 0.116]). These findings provide empirical support for H4, indicating that AI-enabled internal control effectiveness partially mediates the relationship between AI utilization and sustainable audit quality.

5. DISCUSSION AND CONCLUSIONS

5.1. *Discussion*

This study empirically examines the relationships among Artificial Intelligence Utilization (AIU), AI-Enabled Internal Control Effectiveness (AI-ICE), and Sustainable Audit Quality (SAQ) in the context of large-scale power engineering projects. The findings provide several important insights into how artificial intelligence contributes to audit quality through both technological and governance mechanisms.

First, the results indicate that AIU has a significant positive effect on SAQ. This finding suggests that the application of artificial intelligence technologies enhances audit quality not merely by improving efficiency, but by supporting continuous monitoring, real-time risk identification, and process-oriented supervision throughout the project lifecycle. In complex engineering projects characterized by long durations and multiple stakeholders, such technological capabilities are particularly critical for sustaining audit quality over time.

Second, the findings show that AIU significantly improves AI-ICE. This result highlights the role of artificial intelligence in strengthening the execution of internal controls rather than merely supporting audit tasks. By embedding intelligence into control processes, AIU enhances the consistency, traceability, and timeliness of internal control execution, reducing reliance on manual judgment and mitigating execution deviations in complex project environments.

Third, AI-ICE is found to have a significant positive effect on SAQ. This finding underscores the importance of internal control execution as a governance mechanism that links technological adoption with audit outcomes. Effective AI-enabled internal controls improve the reliability of audit evidence, facilitate timely risk responses, and support the implementation of audit recommendations, thereby contributing to the sustained improvement of audit quality.

Finally, the mediation analysis demonstrates that AI-ICE partially mediates the relationship between AIU and SAQ. This result suggests that the impact of AIU on sustainable audit quality operates not only through direct technological effects but also through its role in strengthening internal control execution. From a governance perspective, AI-ICE functions as a critical transmission mechanism that translates AI capabilities into durable audit quality improvements.

Overall, these findings emphasize that the contribution of artificial intelligence to sustainable audit quality should be understood as a combined effect of technological enablement and governance enhancement, rather than as a purely technical upgrade.

5.2. Theoretical Implications

This study offers several important theoretical implications for the literature on artificial intelligence-enabled auditing, internal control, and sustainable audit quality.

First, this study extends the existing literature on Artificial Intelligence Utilization (AIU) in auditing by moving beyond efficiency-oriented perspectives. Prior studies have predominantly examined AIU in terms of audit automation, data processing speed, and anomaly detection accuracy. By explicitly linking AIU to Sustainable Audit Quality (SAQ), this study highlights that the contribution of artificial intelligence lies not only in short-term performance improvements but also in its ability to support continuous, process-oriented, and governance-driven audit quality enhancement.

Second, this study contributes to internal control theory by conceptualizing AI-Enabled Internal Control Effectiveness (AI-ICE) as a distinct governance mechanism. Traditional internal control research has largely focused on system design and formal control structures. In contrast, this study emphasizes control execution effectiveness in AI-enabled environments, thereby shifting theoretical attention from the existence of control systems to their dynamic operation in practice. By demonstrating the significant role of AI-ICE in influencing SAQ, the findings enrich the understanding of how internal control effectiveness functions in digitally enabled project settings.

Third, this study advances the theoretical understanding of the relationship between technology and governance by empirically establishing the mediating role of AI-ICE between AIU and SAQ. The results suggest that AIU does not affect sustainable audit quality solely through direct technological effects, but also through governance mechanisms that translate technological capabilities into effective control execution. This mediation perspective contributes to a more nuanced explanation of how digital technologies interact with organizational control systems to produce sustained audit outcomes.

Overall, by integrating AIU, AI-ICE, and SAQ into a unified analytical framework, this study provides a clearer theoretical explanation of how artificial intelligence enables sustainable audit quality through governance-oriented mechanisms rather than through isolated technical applications.

5.3. Practical Implications

The findings of this study provide several practical implications for stakeholders involved in large-scale power engineering projects, particularly project owners, auditors, and regulators seeking to enhance sustainable audit quality through digital transformation.

First, for project owners and senior managers, the results suggest that investments in Artificial Intelligence Utilization (AIU) should not be limited to isolated audit tools or post-event inspection technologies. Instead, AI applications should be strategically embedded into routine project management and control processes. By integrating AIU into data collection, process monitoring, and risk early-warning systems, project owners can strengthen AI-Enabled Internal Control Effectiveness (AI-ICE) and support continuous supervision throughout the project lifecycle, thereby contributing to higher levels of Sustainable Audit Quality (SAQ).

Second, for internal auditors and auditing institutions, the findings highlight the importance of shifting audit practices from periodic, ex post inspections toward process-oriented and continuous auditing approaches. Effective use of AIU enables auditors to monitor control execution in real time, identify control deviations promptly, and enhance the traceability of audit evidence. By leveraging AI-enabled internal control data, auditors can improve the timeliness and enforceability of audit recommendations, which is essential for sustaining audit quality in complex engineering projects.

Third, for regulators and policymakers, the results indicate that promoting AI adoption in auditing should be accompanied by institutional guidance on internal control execution rather than focusing solely on technological deployment. Regulatory frameworks and audit standards may encourage organizations to align AIU initiatives with internal control objectives, emphasizing transparency, data integrity, and accountability. Such alignment can help ensure that AI technologies contribute to governance improvement and sustainable audit outcomes rather than functioning as standalone technical solutions.

Overall, these practical implications suggest that the effective enhancement of sustainable audit quality depends not only on the adoption of advanced AI technologies, but also on the integration of AIU into internal control execution and governance structures. By strengthening AI-ICE, stakeholders can translate AI capabilities into durable improvements in audit quality across the lifecycle of large-scale power engineering projects.

5.4. Limitations And Future Research Directions

Despite its merits, this work has numerous drawbacks that may suggest future research.

The study's cross-sectional survey data makes causal inferences between AIU, AI-ICE, and sustained audit quality difficult. Future research may use longitudinal designs to track AI-enabled internal control efficacy and sustainable audit quality throughout project stages. Incorporating objective or historical data like audit reports, internal control documents, or system-generated records can reduce self-reported biases and increase causal validation.

Second, large-scale Chinese power engineering projects are used for empirical analysis. This context is suited for studying AI-enabled audit oversight, but generalising the findings to other businesses or institutions is risky. Future research may apply the paradigm to additional infrastructure sectors or cross-country scenarios to improve external validity.

Third, while this study defines AI usage (AIU) as a single construct, different AI applications may affect internal control execution and audit quality differently. Future research may divide AIU into application types to examine governance and performance differences.

5.5. Conclusion

This study investigates how Artificial Intelligence Utilization contributes to Sustainable Audit Quality through the mediating role of AI-Enabled Internal Control Effectiveness in large-scale power engineering projects. By integrating AIU, AI-ICE, and SAQ into a unified analytical framework, the study demonstrates that artificial intelligence enhances audit quality not only through direct technological effects but also by strengthening internal control execution as a governance mechanism.

Overall, the findings suggest that the sustainable improvement of audit quality in complex engineering projects depends on the effective integration of AI technologies with internal control and governance processes. This study provides both theoretical insights and practical guidance for advancing AI-enabled audit governance and offers a foundation for future research on digital transformation in auditing.

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