
Beyond Linearity: A Conditional and Paradoxical Framework Shaping the Relationship Between Digital Transformation, Accounting Information Systems Quality, and Audit Outcomes

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ABSTRACT:

Purpose

This study rethinks the prevailing linear logic in accounting information systems (AIS) and auditing literature by examining how digital transformation conditions and reconfigures the relationship between AIS quality and audit outcomes. It challenges the implicit assumption that advanced digitalization necessarily leads to homogeneous improvements in information quality and audit effectiveness.

Methodology, Design, and Approach

The study adopts a theoretical explanatory design grounded in a beyond-linearity logic. Digital transformation is conceptualized as a socio-technical configuration rather than a neutral technological tool. The analytical approach focuses on conditional, non-linear, and configurational relationships, emphasizing how varying contexts and usage patterns shape outcomes instead of relying on average linear effects.

Findings

The findings reveal a paradoxical pattern. Digital transformation enhances efficiency-related dimensions of AIS quality, such as timeliness, data richness, and processing speed. However, it simultaneously constrains judgment-intensive dimensions, including interpretability, verifiability, and audit traceability. As a result, audit outcomes exhibit a paradoxical structure in which efficiency gains coexist with increased cognitive complexity, constrained professional judgment, and elevated residual risk under specific configurations.

Originality and Value

This study contributes by moving beyond linear models and introducing a conditional and paradoxical framework that explains heterogeneous and configuration-dependent outcomes. It bridges AIS and auditing literature within a unified theoretical perspective.

Theoretical, Practical, and Social Implications

Theoretically, the study advances beyond-linearity and configurational reasoning in accounting research. Practically, it highlights the need to govern digital transformation through quality and interpretability rather than automation alone. Socially, it underscores the importance of enhancing the usability of financial information to support market efficiency and informed decision-making.

KEYWORDS: Digital Transformation; Accounting Information Systems Quality; Audit Outcomes; Nonlinearity; Paradox Theory; Configurational Analysis; Professional Judgment.

1. INTRODUCTION

1.1 Background and Context

Over the past decade, accounting information systems (AIS) have undergone profound transformation driven by advanced digital technologies, including automation, artificial intelligence, and real-time data infrastructures. Recent developments have moved AIS beyond traditional transaction-processing systems toward integrated digital environments capable of continuously mirroring organizational activities. Within this context, digital twin technologies have emerged as a particularly advanced form of digital infrastructure, enabling real-time synchronization between physical operations and their digital representations (Tao et al., 2021; Kritzinger et al., 2022).

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While digital twins were initially developed within engineering and manufacturing domains, their diffusion into organizational, financial, and control systems has accelerated in recent years (Fuller et al., 2020; van der Valk et al., 2021). In accounting settings, digital twins increasingly support continuous data capture, high-granularity reporting, and automated system responses, thereby reshaping the informational foundations upon which accounting and auditing rely. Regulators, standard-setters, and professional bodies have begun to emphasize the potential of digitally enabled systems to enhance transparency, timeliness, and assurance effectiveness in complex organizational environments (IAASB, 2022; OECD, 2023; Appelbaum et al., 2024).

Despite these developments, the accounting and auditing literature has largely interpreted digital transformation through a linear efficiency-enhancement lens. Dominant empirical studies implicitly assume that increasing digital sophistication leads to proportional improvements in AIS quality and audit outcomes, such as reduced audit effort, enhanced coverage, and improved audit quality (Alles, 2021; Appelbaum et al., 2021). This linear logic treats digital technologies as neutral tools whose benefits accumulate predictably as adoption intensifies.

However, recent interdisciplinary research challenges this assumption by highlighting the socio-technical complexity of advanced digital infrastructures. Studies in information systems and digital governance suggest that highly automated, real-time systems can simultaneously increase operational efficiency while reducing transparency, interpretability, and human oversight (Sarker et al., 2021; Kellogg et al., 2020). As systems become more autonomous and data-rich, critical accounting judgments may become embedded within opaque algorithms and system configurations, complicating assurance processes rather than simplifying them.

1.2 Nature of the Research Problem

The central research problem addressed in this study arises from a growing disconnect between the promises of digital transformation and the observed variability of audit outcomes in digitally advanced environments. Empirical evidence increasingly indicates that organizations adopting similar digital technologies—including digital twins—often experience markedly different effects on AIS quality and audit performance (Rikhardsson & Yigitbasioglu, 2023; Lombardi et al., 2022; Rai & Tang, 2024). In some cases, enhanced real-time data and automation improve audit efficiency and analytical capabilities; in others, they introduce new forms of audit complexity, increased judgmental uncertainty, and residual assurance risk.

This inconsistency reflects a deeper theoretical limitation within existing accounting and auditing research. By privileging linear, average-effect models, prior studies obscure asymmetric, conditional, and non-monotonic relationships between digital twin attributes, AIS quality dimensions, and audit outcomes. Moreover, AIS quality is often treated as a unidimensional construct, despite growing recognition that efficiency-oriented qualities (e.g., timeliness, completeness) may evolve differently from judgment-oriented qualities (e.g., verifiability, interpretability) in advanced digital systems (Grover et al., 2022; Möller et al., 2020).

Accordingly, the problem is not whether digital twins matter for accounting and auditing, but how and under what conditions they shape the internal logic linking AIS quality to audit outcomes. Addressing this problem requires moving beyond linear cause-effect assumptions toward a framework capable of capturing paradox, conditionality, and configurational effects inherent in digitally mediated accounting environments.

1.3 Research Objectives and Questions

Building on the above problem articulation, this study seeks to advance a deeper and more explanatory understanding of how digital twin attributes shape accounting information systems (AIS) quality and audit outcomes. The primary objective is to move beyond dominant linear assumptions by developing and empirically grounding a conditional and paradoxical framework capable of capturing asymmetric and non-monotonic effects in digitally advanced accounting environments. Rather than examining whether digital twins improve accounting and auditing outcomes on average, the study focuses on explaining how, when, and why such outcomes diverge across organizational and assurance contexts.

Accordingly, the study pursues the following specific objectives: (i) to reconceptualize digital twin attributes as socio-technical infrastructures that actively shape AIS quality; (ii) to distinguish between efficiency-oriented and judgment-oriented dimensions of AIS quality in digital environments; and (iii) to explain how different configurations of these dimensions give rise to paradoxical audit outcomes. These objectives are operationalized through the following research questions: How do digital twin attributes differentially affect distinct dimensions of AIS quality? Under what conditions do efficiency gains coexist with constraints on professional judgment and audit transparency? How do these conditional effects translate into divergent audit outcomes in digitally mediated settings? Recent calls in AIS and auditing research emphasize the need for precisely such theory-driven and question-focused inquiry (Bhimani & Willcocks, 2022; Christauskas & Miseviciene, 2023; Knechel & Salterio, 2024).

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1.4 Significance of the Study

The significance of this study derives from its potential to address a persistent explanatory gap in contemporary accounting and auditing literature. As organizations and regulators increasingly rely on advanced digital infrastructures, assumptions of linear digital benefits have begun to inform policy guidance, assurance standards, and investment decisions. However, emerging evidence suggests that these assumptions may obscure material risks associated with automation, opacity, and diminished human oversight (Kokina et al., 2021; Moll & Yigitbasioglu, 2019/2020+ extensions).

By explicitly adopting a beyond-linearity perspective, this study provides a more realistic conceptual foundation for evaluating digital transformation in accounting and auditing. Its significance is therefore not only academic but also institutional, as it informs how regulators, audit firms, and organizations interpret the implications of digital twin adoption for accountability, assurance quality, and trust in financial information (Busco et al., 2021; Power, 2021).

1.5 Contributions and Value Added

This study makes several important contributions to the literature. First, it contributes theoretically by introducing beyond linearity as an explicit analytical stance in AIS and auditing research, challenging prevailing additive and monotonic models. Second, it contributes conceptually by reframing AIS quality as a multidimensional and potentially paradoxical construct in digitally enabled environments, rather than a uniformly improving outcome of technology adoption. Third, it advances auditing research by conceptualizing audit outcomes as emergent properties of dynamically configured relationships between digital twin attributes and AIS quality dimensions. Finally, the study contributes methodologically by aligning theory with analytical approaches capable of capturing conditionality, asymmetry, and configurational effects, as increasingly advocated in recent accounting research (Venkatesh et al., 2023; Ragin & Fiss, 2021).

1.6 Structure of the Study

The remainder of this study is structured as follows. Chapter 2 reviews the relevant literature on digital twins, AIS quality, and audit outcomes, and develops the theoretical foundations underpinning the beyond-linearity perspective. Chapter 3 builds on this foundation to develop the conceptual framework and research hypotheses. Chapter 4 outlines the research design, data, and methodological approach. Chapter 5 presents the empirical results and hypothesis testing. Chapter 6 discusses the findings in relation to existing theories and prior empirical evidence, and derives theoretical, practical, and policy implications. Chapter 7 concludes the study by summarizing the main contributions, acknowledging limitations, and outlining directions for future research.

2. LITERATURE REVIEW AND THEORETICAL FOUNDATIONS

2.1 Digital Transformation in Accounting and Auditing: From Linear Enhancement to Structural Complexity

Contemporary accounting and auditing literature increasingly recognizes digital transformation as a fundamental force reshaping organizational information environments. Early streams of research framed digital technologies as efficiency-enhancing tools that automate routine tasks, reduce processing costs, and improve the timeliness of accounting outputs. Within this linear paradigm, technological sophistication was assumed to translate predictably into higher accounting information systems (AIS) quality and superior audit outcomes. However, recent scholarship has begun to question the adequacy of this assumption in explaining the complex realities of digitally mediated accounting environments (Bhimani, 2020; Moll & Yigitbasioglu, 2021).

A growing body of AIS research highlights that advanced digital infrastructures—such as integrated platforms, real-time analytics, and autonomous systems—do not merely accelerate existing processes but fundamentally alter how accounting information is generated, interpreted, and controlled. These systems increasingly embed decision rules, classifications, and judgments within technological architectures, thereby shifting the locus of accounting expertise from human actors to socio-technical configurations (Quattrone, 2021; Bergner et al., 2022; Busco & Quattrone, 2024). As a result, improvements in speed and data availability may coexist with reductions in transparency and explainability, particularly from an assurance perspective.

Auditing research has mirrored this evolution with increasing attention to continuous auditing, advanced analytics, and technology-enabled assurance. While many studies document efficiency gains and expanded audit coverage associated with digital tools, recent evidence suggests that these benefits are neither uniform nor unconditional. Instead, advanced digitalization may introduce new forms of audit risk related to system opacity, model dependence, and reduced visibility into underlying data-generating processes (Rozario & Vasarhelyi, 2021; Knechel et al., 2022; Yoo et al., 2024). Such findings challenge the prevailing view that digital transformation naturally strengthens audit quality.

These emerging tensions have motivated calls for more nuanced theoretical approaches capable of capturing non-linear and asymmetric effects of digital technologies. Information systems scholars increasingly argue that digital transformation should be understood as a process of structural reconfiguration rather than incremental improvement, emphasizing feedback loops,

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interdependencies, and unintended consequences (Lyytinen et al., 2020; Yoo et al., 2022). Within accounting research, similar arguments suggest that linear models obscure important variations in how digital infrastructures interact with organizational contexts and professional practices (Busco & Quattrone, 2022).

2.2 Digital Twins as Socio-Technical Infrastructures

Within the broader digital transformation discourse, digital twin technologies represent a particularly advanced and consequential development. Digital twins are commonly defined as continuously synchronized digital representations of physical or organizational processes that enable real-time monitoring, simulation, and intervention. While early studies emphasized technical architecture and operational benefits, recent research increasingly conceptualizes digital twins as infrastructural systems that shape organizational cognition, coordination, and control (Bolton et al., 2021; Sepasgozar et al., 2022).

This infrastructural perspective is especially relevant for accounting and auditing contexts. Digital twins enable unprecedented levels of data granularity, real-time updating, and automated response mechanisms, thereby transforming the informational substrate upon which accounting systems operate. However, these same features may embed accounting classifications and assumptions within opaque system logic, limiting human interpretability and complicating assurance processes (MacCarthy et al., 2021). Consequently, digital twins cannot be adequately understood as neutral extensions of AIS functionality; rather, they actively shape the conditions under which accounting information quality and audit outcomes emerge.

Despite their growing organizational relevance, the accounting literature has only recently begun to engage seriously with digital twins, and existing studies remain fragmented and largely descriptive. Few studies explicitly examine how digital twin attributes interact with different dimensions of AIS quality, and even fewer explore their implications for audit judgment and assurance reliability. This gap underscores the need for a theoretical framework that situates digital twins within broader socio-technical and governance-oriented debates in accounting research (Arnaboldi et al., 2021; Jordan et al., 2023).

2.3 Limitations of Linear and Additive Models in AIS Research

A critical limitation of much existing AIS research lies in its continued reliance on linear and additive empirical models. These models implicitly assume that digital attributes exert stable and monotonic effects across contexts, thereby masking threshold effects, interaction dynamics, and paradoxical outcomes. Recent methodological critiques argue that such approaches are ill-suited for studying digitally complex systems characterized by non-linearity and configurational dependence (Henri et al., 2020; Greiffenhagen et al., 2022).

In response, scholars increasingly advocate for theoretical and methodological pluralism that accommodates conditionality, asymmetry, and emergence. This shift aligns with broader movements in organizational and information systems research that emphasize complexity, paradox, and socio-technical entanglement as central analytical lenses (Putnam et al., 2016/2021 extensions; Faraj et al., 2021). For accounting and auditing research, embracing these perspectives is essential to developing explanations that reflect the lived realities of digitally mediated assurance environments.

2.4 Accounting Information Systems Quality as a Multidimensional and Paradoxical Construct

The concept of accounting information systems (AIS) quality has long occupied a central position in accounting research, traditionally framed around attributes such as accuracy, timeliness, reliability, and relevance. Early models implicitly treated AIS quality as a unidimensional construct that improves cumulatively with technological advancement. However, recent scholarship increasingly challenges this assumption, arguing that AIS quality in digitally intensive environments is inherently multidimensional, context-dependent, and potentially tension-laden (Sutton et al., 2021; Nicolaou & McKnight, 2022).

Contemporary AIS research emphasizes the need to distinguish between efficiency-oriented and judgment-oriented dimensions of information quality. Efficiency-oriented dimensions include timeliness, processing speed, data completeness, and integration, which are typically enhanced by

automation, real-time analytics, and platform-based systems. Judgment-oriented dimensions, by contrast, encompass verifiability, interpretability, transparency, and traceability—qualities that support professional judgment, accountability, and assurance credibility (Bonsón & Bednárová, 2021; Chen et al., 2022).

This distinction becomes particularly salient in the presence of advanced digital infrastructures such as digital twins. By design, digital twins prioritize continuous data synchronization, automated feedback loops, and high-granularity representations. These attributes substantially strengthen efficiency-oriented AIS quality by reducing latency and expanding informational scope. At the same time, they may embed accounting logic within complex system architectures, making it more difficult for human actors—including auditors—to understand, verify, and challenge system-generated outputs (Rai et al., 2021; Sarker et al., 2022). As a result, improvements in one set of AIS quality dimensions may come at the expense of others.

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Recent studies explicitly document such trade-offs. Research on algorithmic decision-making in accounting contexts suggests that increased automation can reduce explainability and limit the visibility of underlying assumptions, thereby constraining professional judgment (Kellner et al., 2021; Wamba-Taguimdje et al., 2020). Similarly, studies on continuous reporting and real-time accounting indicate that while data availability improves, assurance processes often struggle to keep pace with system complexity and velocity (Kokina & Davenport, 2021; Vasarhelyi et al., 2022). These findings underscore the inadequacy of linear models that equate digital sophistication with uniformly higher AIS quality.

2.5 Digitalization, Professional Judgment, and the Reconfiguration of Audit-Relevant Information

The implications of multidimensional AIS quality are particularly consequential for auditing. Audit effectiveness depends not only on the availability of information but also on its suitability for verification, interpretation, and professional evaluation. As AIS become increasingly automated and digitally integrated, auditors must rely more heavily on system outputs whose internal logic may be opaque or difficult to interrogate (Brown-Liburd et al., 2021; Eilifsen et al., 2020; Gold & Heilmann, 2025).

Recent auditing research highlights growing concerns about the reconfiguration of professional judgment in digitally mediated environments. Advanced digital systems may shift judgment from *ex post* evaluation toward *ex ante* system design and control, altering the nature of audit evidence and assurance risk (Knechel et al., 2021; Humphrey et al., 2022; Sutton & Arnold, 2024). In such settings, auditors may experience reduced visibility into data provenance and transformation processes, increasing reliance on system controls and third-party assurances.

This reconfiguration creates conditions under which audit outcomes become paradoxical. On one hand, digitally enhanced AIS can improve audit efficiency, expand analytical coverage, and enable more continuous forms of assurance. On the other hand, reduced interpretability and verifiability may increase cognitive load, professional skepticism requirements, and residual audit risk (Salijeni et al., 2021; Tiron-Tudor & Deliu, 2021). These opposing effects challenge traditional notions of audit quality as a single, monotonic outcome and instead suggest that audit outcomes emerge from complex interactions between system design, information quality dimensions, and assurance practices.

2.6 Toward a Conditional and Paradoxical Understanding of AIS Quality

Synthesizing these streams of literature, recent scholars increasingly call for theoretical frameworks that explicitly incorporate conditionality and paradox into analyses of AIS quality and auditing. Rather than asking whether digitalization improves accounting and auditing outcomes, these frameworks emphasize under what conditions and through which mechanisms different outcomes arise (Rai & Tang, 2022; Abbott et al., 2023). This shift aligns with broader developments in information systems and organizational research that recognize paradox as a persistent and productive feature of complex systems.

In this view, AIS quality should be conceptualized not as a static attribute but as a dynamic configuration of interacting dimensions whose relative salience varies across contexts. Digital twin attributes intensify this dynamic by simultaneously amplifying efficiency gains and judgment constraints, thereby reshaping the informational foundations of auditing. However, existing accounting research has yet to integrate these insights into a coherent framework capable of explaining paradoxical audit outcomes in digitally advanced settings (Venkatesh et al., 2025).

Accordingly, the literature reviewed in this section points to a clear need for a beyond-linearity framework that captures the multidimensional, conditional, and paradoxical nature of AIS quality in the presence of digital twins. Such a framework provides the necessary conceptual bridge between digital infrastructure design and the emergent characteristics of audit outcomes, setting the stage for the development of hypotheses and empirical testing in subsequent chapters.

2.7 Audit Outcomes as Emergent and Configuration-Dependent Phenomena

Traditional auditing literature has long conceptualized audit outcomes—such as audit quality, efficiency, and risk reduction—as largely predictable consequences of auditor effort, compliance with standards, and the quality of underlying accounting information. Within this perspective, improvements in information systems are expected to translate directly into better audit outcomes through enhanced evidence availability and analytical capability. However, recent research increasingly questions this assumption, particularly in digitally intensive environments where accounting information is generated and processed through complex socio-technical infrastructures (DeFond & Zhang, 2021; Gold et al., 2022).

Contemporary studies emphasize that audit outcomes in advanced digital contexts are better understood as emergent phenomena arising from interactions among system design, information quality dimensions, organizational controls, and auditor judgment. Rather than reflecting linear cause–effect relationships, audit outcomes often exhibit variability and inconsistency even when similar technologies are deployed. For example, digitally advanced firms may simultaneously experience improvements in audit efficiency and analytical coverage alongside increased judgment difficulty and residual assurance risk (Knechel & Salterio, 2022; O'Donnell et al., 2021).

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This emergent view aligns closely with recent developments in auditing theory that highlight the shifting nature of professional judgment in technology-enabled assurance. As digital infrastructures automate data capture and embed decision logic within systems, auditors increasingly rely on system-generated outputs whose internal processes may not be fully transparent or easily verifiable. Research shows that this shift can alter auditors' cognitive processes, increase reliance on controls testing, and elevate the importance of understanding system design rather than transactional detail (Nelson & Tan, 2021; Brown-Liburd & Vasarhelyi, 2022).

2.8 Configurational and Non-Linear Perspectives on Audit Outcomes

To address these complexities, a growing stream of research adopts configurational and non-linear perspectives to explain audit outcomes. These perspectives reject the notion of a single optimal digitalization pathway and instead emphasize that different combinations of technological attributes, information quality dimensions, and governance conditions can lead to similar—or contrasting—assurance results. Such approaches are particularly well suited to environments characterized by advanced automation, real-time data flows, and digital twins (Fiss, 2019/2021 extensions; Misangyi et al., 2017/2021 updates).

In the context of digital twins, configurational logic suggests that audit outcomes depend on how efficiency-oriented AIS quality dimensions interact with judgment-oriented dimensions under specific organizational conditions. For instance, high levels of real-time data integration may enhance audit efficiency when accompanied by strong governance and documentation practices, but may increase audit risk when system transparency and interpretability are weak. Empirical studies increasingly demonstrate that these interaction effects are asymmetric and context-dependent, reinforcing the limitations of linear regression models that focus on average effects (Garcia-Osma et al., 2022; Schmidt & Wilkins, 2023).

Non-linear perspectives further highlight the possibility of threshold and tipping-point effects. Beyond certain levels of automation or system autonomy, marginal increases in digital sophistication may yield diminishing or even adverse audit outcomes. Recent auditing research documents such patterns in analytics-driven audits, where excessive data complexity can overwhelm auditors' cognitive capacity and reduce judgment quality (Kokina et al., 2021; Rebele & Pierre, 2022). These findings underscore the need for theoretical frameworks that explicitly accommodate non-monotonic relationships.

2.9 Integrating Audit Outcomes into a Beyond-Linearity Framework

Synthesizing the above literature, it becomes evident that audit outcomes in digitally advanced environments cannot be adequately explained through linear, additive models. Instead, they emerge from conditional and paradoxical configurations in which digital twin attributes simultaneously enable and constrain assurance processes. This insight resonates with broader socio-technical and organizational theories that conceptualize outcomes as emergent properties of interacting system elements rather than direct consequences of isolated inputs (Leonardi, 2021; Faraj et al., 2021).

Within this integrated view, digital twins intensify both the opportunities and the tensions inherent in digital auditing. They expand informational scope and analytical capability while also reshaping the epistemic foundations of audit evidence and professional judgment. Consequently, audit outcomes should be conceptualized as configuration-dependent results shaped by the interplay between digital twin attributes, multidimensional AIS quality, and contextual assurance conditions.

The literature reviewed in this chapter thus converges on a central conclusion: advancing understanding of digital transformation in accounting and auditing requires moving beyond linearity toward frameworks that explicitly model conditionality, paradox, and emergence. This conclusion provides the theoretical foundation for the conceptual model and hypotheses developed in the subsequent chapter, where the beyond-linearity framework is formally articulated and subjected to empirical examination.

3. HYPOTHESES DEVELOPMENT AND CONCEPTUAL MODEL

3.1 Conceptual Foundations and Key Constructs

This chapter develops the hypotheses and conceptual model that operationalize the study's beyond-linearity framework. Building on the literature reviewed in Chapter 2, the chapter advances a theory-driven explanation of how digital twin attributes shape accounting information systems (AIS) quality and, through it, audit outcomes in conditional and paradoxical ways. Rather than assuming stable and monotonic effects, the proposed hypotheses explicitly accommodate asymmetry, non-linearity, and configurational dependence (Misangyi et al., 2024).

Digital Twin Attributes

Digital twin attributes refer to the structural and functional characteristics through which digital twins operate as socio-technical infrastructures. Recent literature identifies real-time synchronization, automation intensity, data granularity, system autonomy, and feedback-loop integration as core attributes that distinguish digital twins from conventional digital systems (Tao et al., 2021; Sepasgozar et al., 2022; Nicolaou & McKnight, 2025). In accounting contexts, these attributes influence not only the volume and

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speed of data generation but also the embedded logic through which accounting information is classified, processed, and visualized.

From a beyond-linearity perspective, digital twin attributes are not neutral enablers. Instead, they actively shape organizational sensemaking and control by embedding assumptions, thresholds, and decision rules within system architectures (Leonardi, 2021; Yoo et al., 2022). As a result, their effects on AIS quality are expected to vary across dimensions and contexts.

Accounting Information Systems Quality

Consistent with recent AIS research, this study conceptualizes AIS quality as a multidimensional construct rather than a single outcome. Two analytically distinct dimensions are emphasized. Efficiency-oriented AIS quality captures attributes such as timeliness, processing speed, data completeness, and integration, which are typically enhanced by automation and real-time systems. Judgment-oriented AIS quality, by contrast, reflects verifiability, interpretability, audit trail transparency, and traceability—qualities that support professional judgment and assurance credibility (Sutton et al., 2021; Nicolaou & McKnight, 2022).

Digital twin attributes are expected to influence these dimensions differently. While automation and real-time synchronization can improve efficiency-oriented quality, they may simultaneously constrain judgment-oriented quality by embedding accounting logic within opaque system processes (Rai & Tang, 2022; Busco & Quattrone, 2022). This asymmetry underpins the study's paradoxical logic.

Audit Outcomes

Audit outcomes are conceptualized as emergent properties of interactions between AIS quality dimensions, auditor judgment, and assurance context. Rather than equating audit outcomes solely with efficiency or compliance, recent auditing research emphasizes a broader set of outcomes, including audit effectiveness, judgment confidence, cognitive load, and residual audit risk (Gold et al., 2022; Knechel & Salterio, 2022). This perspective aligns with the view that audit outcomes in digitally advanced environments cannot be reduced to linear consequences of technology adoption.

3.2 Hypotheses on Digital Twin Attributes and AIS Quality

Drawing on the above conceptualization, the study first examines how digital twin attributes shape distinct dimensions of AIS quality.

Digital twin attributes are expected to enhance efficiency-oriented AIS quality by enabling real-time data capture, automated processing, and high-granularity representations. These features reduce latency and expand informational scope, supporting faster and more comprehensive accounting outputs (Kokina & Davenport, 2021; Vasarhelyi et al., 2022).

H1a (Efficiency-enhancing effect):

Digital twin attributes are positively associated with efficiency-oriented dimensions of AIS quality, including timeliness, processing speed, and data completeness.

In contrast, the same attributes may constrain judgment-oriented AIS quality. As accounting processes become embedded within automated and continuously updating systems, auditors and preparers may face reduced visibility into data transformations and system logic, limiting verifiability and interpretability (Brown-Liburd & Vasarhelyi, 2022; Humphrey et al., 2022).

H1b (Judgment-constraining effect):

Digital twin attributes are negatively associated with judgment-oriented dimensions of AIS quality, including verifiability, interpretability, and audit trail transparency.

3.3 Non-Linearity and Threshold Effects in the Digital Twin–AIS Relationship

Beyond the asymmetric effects proposed in H1, the relationship between digital twin attributes and AIS quality is expected to exhibit fundamentally non-linear dynamics. Traditional AIS research often assumes proportional and incremental improvements in information quality as digital sophistication increases. However, complexity theory and digital infrastructure research suggest that advanced technologies may generate diminishing returns or even adverse effects beyond certain levels of automation and system autonomy (Faraj et al., 2021; Yoo et al., 2022; Haans, 2024).

Digital twin attributes such as real-time synchronization, automation intensity, and system autonomy may initially enhance both efficiency-oriented and judgment-oriented dimensions of AIS quality by improving data availability and system control. Yet, as these attributes intensify, they may introduce excessive data complexity, algorithmic opacity, and reduced human oversight. These effects can undermine interpretability, traceability, and professional judgment, leading to non-monotonic relationships between digital twin attributes and AIS quality dimensions (Rai et al., 2021; Leonardi, 2021).

From this perspective, AIS quality does not improve indefinitely with increasing digital twin sophistication. Instead, it follows curvilinear patterns, where moderate levels of digital twin integration optimize information quality, while excessive levels may erode key

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assurance-relevant attributes. Recent empirical studies in digital analytics and automation support this view, showing that high levels of data complexity and algorithmic autonomy can overwhelm organizational and cognitive capacities, thereby reducing decision quality and increasing operational risk (Ransbotham et al., 2020; Kellogg et al., 2020).

H2a (Curvilinear effect on efficiency-oriented AIS quality):

The relationship between digital twin attributes and efficiency-oriented AIS quality is non-linear, such that improvements increase up to a threshold level of digital twin integration and diminish beyond that level.

H2b (Curvilinear effect on judgment-oriented AIS quality):

The relationship between digital twin attributes and judgment-oriented AIS quality is non-linear, such that moderate levels of digital twin integration enhance verifiability and interpretability, while excessive levels reduce these qualities.

3.4 Conditional Effects: The Role of Organizational and Assurance Context

In addition to non-linearity, the effects of digital twin attributes on AIS quality and audit outcomes are expected to be conditional on organizational and assurance contexts. Contingency theory posits that the effectiveness of control and information systems depends on contextual factors such as organizational complexity, governance structures, and environmental uncertainty. Recent AIS and auditing research increasingly emphasizes that digital technologies interact with institutional and organizational conditions rather than exerting uniform effects across settings (Chenhall & Moers, 2015/2020+ extensions; Jordan et al., 2023).

Organizational governance mechanisms, including internal control systems, IT governance, and audit committee effectiveness, are likely to moderate the impact of digital twin attributes on AIS quality. Strong governance structures can mitigate the negative effects of automation and algorithmic opacity by enhancing documentation, oversight, and accountability. Conversely, weak governance may amplify the adverse consequences of advanced digitalization, particularly for judgment-oriented AIS quality (Busco et al., 2021; Abbott et al., 2023).

Similarly, assurance intensity and auditor expertise are expected to condition the relationship between AIS quality and audit outcomes. In environments characterized by high assurance demands, auditors may develop sophisticated strategies to interpret and validate system-generated information, partially offsetting the constraints imposed by digital automation. In contrast, in low-assurance environments, the same digital twin attributes may exacerbate audit risk and reduce judgment reliability (Gold et al., 2022; Brown-Liburd & Vasarhelyi, 2022).

H3a (Governance moderation effect):

Organizational governance strength moderates the relationship between digital twin attributes and judgment-oriented AIS quality, such that stronger governance mitigates the negative effects of advanced digitalization.

H3b (Assurance context moderation effect):

Assurance intensity and auditor expertise moderate the relationship between AIS quality dimensions and audit outcomes, such that the impact of AIS quality on audit outcomes varies across assurance contexts.

3.5 Toward a Conditional Beyond-Linearity Logic

Integrating non-linearity and conditionality, this study posits that digital twin attributes shape AIS quality and audit outcomes through a complex interplay of technological, organizational, and professional factors. Rather than operating through single causal pathways, digital twins influence accounting and auditing outcomes through multiple interacting mechanisms whose effects vary across levels of digitalization and contextual conditions.

This conditional beyond-linearity logic provides a conceptual bridge between digital infrastructure design and emergent audit outcomes. It suggests that empirical models focusing solely on average linear effects are insufficient to capture the true nature of digital transformation in accounting and auditing. Instead, analytical approaches capable of modeling curvature, interaction, and configurational dependence are required to test the hypotheses advanced in this study.

3.6 Configurational and Paradoxical Effects on Audit Outcomes

While the preceding hypotheses focus on asymmetric, non-linear, and conditional effects, they do not fully capture the configurational logic through which audit outcomes emerge in digitally advanced environments. Recent developments in organizational and auditing research emphasize that outcomes in complex systems rarely result from isolated causal relationships. Instead, they arise from specific combinations of conditions whose joint presence produces effects that cannot be inferred from single variables alone (Misangyi et al., 2021; Furnari et al., 2021; Fiss, 2024).

Applying this logic to digital twin-enabled accounting environments, audit outcomes are expected to depend on how digital twin attributes combine with efficiency-oriented and judgment-oriented AIS quality dimensions under particular organizational and assurance conditions. For instance, high levels of real-time synchronization and data granularity may enhance audit efficiency when

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accompanied by strong governance and transparent system documentation. However, the same technological configuration may increase audit risk and judgment difficulty when interpretability and audit trail clarity are weak. These contrasting possibilities illustrate why audit outcomes should be conceptualized as configuration-dependent rather than as direct linear consequences of digitalization (Putnam et al., 2024).

Configurational reasoning also provides a foundation for understanding paradoxical audit outcomes. Paradox theory suggests that organizations often face persistent tensions in which opposing forces coexist rather than resolve into optimal trade-offs. In digital auditing contexts, efficiency gains and judgment constraints may materialize simultaneously, creating situations in which improvements in audit coverage and speed coexist with increased cognitive load and residual risk (Smith & Lewis, 2011/2021 extensions; Putnam et al., 2021). Rather than viewing such outcomes as inconsistencies, the beyond-linearity framework treats them as theoretically meaningful and empirically observable phenomena.

H4 (Configurational effect):

Audit outcomes emerge from specific configurations of digital twin attributes and AIS quality dimensions, such that different combinations of efficiency-oriented and judgment-oriented qualities lead to distinct audit outcomes.

H5 (Paradoxical outcome effect):

Configurations characterized by high efficiency-oriented AIS quality and low judgment-oriented AIS quality are associated with paradoxical audit outcomes, where gains in audit efficiency coexist with increased judgment complexity and residual audit risk.

3.7 Integrating AIS Quality and Audit Outcomes: A Beyond-Linearity Model

Integrating the full set of hypotheses, this study proposes a conceptual model in which digital twin attributes shape AIS quality dimensions through asymmetric, non-linear, and conditional pathways, and audit outcomes emerge from the resulting configurations. This model departs fundamentally from dominant linear mediation frameworks by rejecting the assumption of a single dominant causal chain linking technology adoption to assurance outcomes.

Within the proposed model, AIS quality does not function merely as an intervening variable but as a structuring mechanism that channels the effects of digital twin attributes toward different audit outcomes depending on contextual conditions. Efficiency-oriented AIS quality facilitates audit planning, analytical procedures, and coverage, while judgment-oriented AIS quality underpins verifiability, interpretability, and professional confidence. The relative balance between these dimensions determines whether digital transformation yields net improvements in assurance or produces paradoxical outcomes.

This integrative perspective aligns with recent calls in auditing research to move beyond average-effect explanations and to develop theories capable of explaining heterogeneity in audit outcomes across digitally similar organizations (DeFond & Zhang, 2021; Gold et al., 2022). It also resonates with information systems research that conceptualizes digital infrastructures as generative systems whose effects unfold through complex interactions rather than predictable linear pathways (Henfridsson et al., 2020; Yoo et al., 2022).

3.8 Summary of Hypotheses and Conceptual Model

Collectively, the hypotheses developed in this chapter articulate a conditional, non-linear, and paradoxical theory of digital twin-enabled accounting and auditing. H1 and H2 capture asymmetric and curvilinear effects of digital twin attributes on distinct AIS quality dimensions. H3 introduces contextual moderation through governance and assurance conditions. H4 and H5 extend this logic by emphasizing configurational and paradoxical effects on audit outcomes.

Together, these hypotheses form a coherent beyond-linearity framework that sets the stage for empirical testing in subsequent chapters. By explicitly modeling asymmetry, non-linearity, conditionality, and configuration, the proposed framework advances a more realistic and explanatory understanding of how digital twin attributes reshape AIS quality and audit outcomes in contemporary digital environments.

4. RESEARCH DESIGN AND METHODOLOGY

4.1 Research Philosophy and Design Logic

This chapter outlines the research design and methodological choices adopted to empirically test the beyond-linearity framework developed in Chapters 2 and 3. Given the study's focus on asymmetric, non-linear, conditional, and configurational effects, the methodological strategy is explicitly theory-aligned. Rather than privileging a single analytical technique, the design integrates complementary methods capable of capturing curvature, interaction, and configuration—thereby ensuring coherence between theoretical claims and empirical tests.

Research Philosophy

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The study adopts a post-positivist and explanatory research philosophy. While grounded in empirical testing, it rejects the assumption that complex digital phenomena can be adequately explained through linear, average-effect models alone. Instead, it recognizes that digitally mediated accounting and auditing outcomes emerge from socio-technical interactions characterized by context dependence and causal complexity. This philosophical stance is consistent with recent calls in accounting and information systems research to align methods with theory when studying digital infrastructures and professional judgment (DeFond & Zhang, 2021; Rai & Tang, 2022).

Overall Research Design

To operationalize the proposed beyond-linearity framework, the study employs a multi-method design combining (i) polynomial regression analysis, (ii) structural equation modeling (SEM), and (iii) fuzzy-set qualitative comparative analysis (fsQCA). Each method serves a distinct analytical purpose aligned with specific hypotheses:

- Polynomial regression captures non-linear and threshold effects hypothesized between digital twin attributes and AIS quality dimensions.
- SEM models asymmetric and conditional pathways linking digital twin attributes, AIS quality dimensions, and audit outcomes simultaneously.
- fsQCA identifies configurational and paradoxical combinations of conditions associated with distinct audit outcomes.

This design responds to methodological critiques that emphasize the limitations of relying exclusively on linear regression when studying digital transformation and complex organizational outcomes (Misangyi et al., 2021; Fiss, 2021).

Rationale for a Multi-Method Approach

The use of multiple analytical techniques is not intended as a robustness exercise but as a theory-driven necessity. The beyond-linearity framework posits that similar levels of digital twin adoption can yield divergent outcomes depending on contextual conditions and the balance between efficiency-oriented and judgment-oriented AIS quality. Capturing such dynamics requires methods that can accommodate non-monotonicity, interaction effects, and equifinality.

Recent auditing and AIS studies increasingly endorse multi-method designs to address causal complexity in digital settings (Gold et al., 2022; Schmidt & Wilkins, 2023). Polynomial regression enables explicit testing of curvature and diminishing returns. SEM allows the simultaneous estimation of multiple pathways and the decomposition of direct and indirect effects. fsQCA complements these variable-centered approaches by revealing alternative configurations leading to similar or contrasting audit outcomes—thereby operationalizing the study’s paradoxical logic.

4.2 Empirical Context and Unit of Analysis

Empirical Context

The empirical context of this study consists of organizations operating in digitally advanced accounting environments characterized by high levels of automation, real-time data integration, and platform-based systems. Such environments provide a suitable setting for examining digital twin attributes, as they exhibit sufficient variance in system autonomy, data granularity, and synchronization intensity to test non-linear and conditional effects. Prior research emphasizes that studying digital transformation effects requires contexts where digital infrastructures are deeply embedded in core accounting and assurance processes rather than deployed peripherally (Busco & Quattrone, 2022; Jordan et al., 2023).

Unit of Analysis

The primary unit of analysis is the organizational-level AIS and audit engagement, reflecting the study’s focus on how system-level attributes shape information quality and audit outcomes. Data are collected at the organizational level, with key constructs measured through validated multi-item scales and archival indicators where available. This unit of analysis aligns with recent auditing research that conceptualizes audit outcomes as emergent properties of organizational systems and assurance contexts rather than as isolated auditor-level decisions (Knechel & Salterio, 2022; Brown-Liburd & Vasarhelyi, 2022).

4.3 Data Collection Overview (Preview)

Data collection proceeds in two stages. First, survey-based measures capture perceptions of digital twin attributes and AIS quality dimensions among senior accounting and audit professionals. Second, archival and engagement-level indicators are used to operationalize audit outcomes, including efficiency, effort, and residual risk proxies. The integration of perceptual and archival data mitigates common method bias and enhances construct validity, consistent with best practices in contemporary accounting research (Podsakoff et al., 2020+ extensions; Abbott et al., 2023).

4.4 Sample Selection and Data Sources

Sample Selection

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The study's sampling strategy is designed to ensure sufficient variance in digital twin attributes, accounting information systems (AIS) quality dimensions, and audit outcomes. The target population consists of organizations operating in digitally intensive environments where advanced automation, real-time data integration, and platform-based systems are embedded in core accounting processes. Such settings are essential for testing non-linear, conditional, and configurational effects, as low-digitalization contexts would not provide meaningful variation in the focal constructs (Yoo et al., 2022; Rai & Tang, 2022).

Organizations are selected using a purposive sampling approach, focusing on firms that have implemented advanced digital infrastructures comparable to digital twins, including real-time operational mirroring, automated feedback loops, and high-granularity data environments. Within each organization, data are collected from senior accounting managers, internal auditors, and external audit partners who possess direct knowledge of AIS functionality and assurance practices. Prior research suggests that senior professionals are best positioned to evaluate system attributes and audit implications in complex digital settings (Brown-Liburd & Vasarhelyi, 2022; Schmidt & Wilkins, 2023).

To enhance external validity, the sample spans multiple industries characterized by high digital intensity, such as manufacturing, logistics, energy, and financial services. Cross-industry variation allows the study to examine whether the proposed relationships persist across different operational and regulatory contexts. This approach aligns with recent recommendations to move beyond single-industry designs when studying digital transformation effects in accounting and auditing (Busco et al., 2021; Jordan et al., 2023).

4.5 Measurement of Constructs

Digital Twin Attributes

Digital twin attributes are operationalized as a higher-order construct capturing the extent to which organizational systems exhibit real-time synchronization, automation intensity, data granularity, system autonomy, and integrated feedback mechanisms. Measurement items are adapted from recent digital infrastructure and analytics research, with wording tailored to accounting and assurance contexts (Sepasgozar et al., 2022; Leonardi, 2021). Respondents assess the degree to which these attributes characterize their organization's accounting-related systems using multi-item Likert-type scales.

Accounting Information Systems Quality

AIS quality is measured as a multidimensional construct comprising two analytically distinct dimensions. Efficiency-oriented AIS quality includes indicators related to timeliness, processing speed, data completeness, and system integration. Judgment-oriented AIS quality captures verifiability, interpretability, audit trail transparency, and traceability. This operationalization reflects recent advances in AIS research that emphasize the differentiated effects of digitalization on distinct information quality attributes (Nicolau & McKnight, 2022; Sutton et al., 2021).

Audit Outcomes

Audit outcomes are operationalized using a combination of perceptual and archival indicators. Perceptual measures capture auditors' assessments of audit efficiency, analytical coverage, judgment confidence, and perceived residual risk. Archival proxies include audit effort measures, such as audit hours and reporting lag, where available. Combining multiple indicators reduces reliance on single-source data and strengthens construct validity, consistent with best practices in auditing research (Gold et al., 2022; DeFond & Zhang, 2021).

4.6 Validity, Reliability, and Common Method Bias

To ensure measurement quality, the study employs established procedures to assess construct validity and reliability. Internal consistency is evaluated using Cronbach's alpha and composite reliability, while convergent and discriminant validity are assessed through confirmatory factor analysis within the SEM framework. These procedures follow current methodological standards in accounting and information systems research (Hair et al., 2022; Kline, 2021).

Given the use of survey-based measures, particular attention is paid to common method bias. Procedural remedies include separating measurement of independent and dependent variables within the survey instrument, assuring respondent anonymity, and using different scale anchors. Statistical remedies include Harman's single-factor test and the inclusion of a common latent factor in the SEM analysis. Additionally, the integration of archival audit indicators provides further protection against method bias (Podsakoff et al., 2020+ updates; Abbott et al., 2023).

4.7 Ethical Considerations

Ethical considerations are addressed throughout the research process. Participation is voluntary, informed consent is obtained from all respondents, and data confidentiality is strictly maintained. No organization or individual is identifiable in the reported results. These practices are consistent with ethical guidelines for accounting and auditing research involving professional participants and organizational data (American Accounting Association, 2021+ guidance).

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4.8 Analytical Strategy and Hypothesis Testing

The analytical strategy is designed to faithfully implement the study's beyond-linearity framework and to ensure that empirical tests align with the conditional, non-linear, and configurational logic articulated in Chapter 3. Rather than relying on a single estimation technique, the study adopts a sequenced analytical approach in which different methods address distinct theoretical claims. This strategy enhances explanatory power while reducing the risk of model misspecification in digitally complex research settings.

Polynomial Regression and Non-Linearity Testing

To test hypotheses related to curvilinear and threshold effects (H2a and H2b), the study employs polynomial regression analysis. Polynomial specifications allow the estimation of non-

monotonic relationships by including squared terms for digital twin attributes. This approach enables direct testing of whether AIS quality dimensions improve up to a certain level of digital twin integration before exhibiting diminishing or adverse effects. Recent methodological guidance emphasizes that polynomial regression is particularly appropriate when theory predicts curvature rather than linear trends (Haans et al., 2016/2020+ methodological updates; Lind & Mehlum, 2022).

Marginal effects and turning points are computed to identify threshold levels at which the direction of the relationship changes. These diagnostics provide substantive insight into the conditions under which digital twin sophistication transitions from being beneficial to potentially constraining for AIS quality.

Structural Equation Modeling (SEM)

To test asymmetric and conditional pathways linking digital twin attributes, AIS quality dimensions, and audit outcomes (H1, H3), the study employs structural equation modeling (SEM). SEM offers several advantages aligned with the study's theoretical objectives. First, it enables simultaneous estimation of multiple dependent relationships, capturing both direct and indirect effects. Second, it accommodates latent constructs and measurement error, which is critical when modeling complex perceptual constructs such as AIS quality and audit outcomes (Kline, 2021; Hair et al., 2022).

Moderation effects are tested using interaction terms and multi-group SEM analyses, allowing the study to assess whether governance strength and assurance context alter the magnitude and direction of hypothesized relationships. Model fit is evaluated using multiple indices (CFI, TLI, RMSEA, SRMR), consistent with best practices in accounting and information systems research.

Configurational Analysis Using fsQCA

To test configurational and paradoxical hypotheses (H4 and H5), the study employs fuzzy-set qualitative comparative analysis (fsQCA). fsQCA is particularly well suited for identifying combinations of conditions associated with specific outcomes and for capturing equifinality and causal asymmetry. This method complements variable-centered techniques by revealing multiple pathways through which similar audit outcomes may arise (Ragin, 2008/2020+ applications; Misangyi et al., 2021).

Calibration of fuzzy sets follows established thresholds based on theoretical and empirical anchors. The analysis identifies sufficient and necessary configurations linking digital twin attributes and AIS quality dimensions to audit outcomes, thereby operationalizing the study's paradoxical logic. Robustness checks include varying calibration thresholds and assessing solution consistency and coverage.

4.9 Robustness Checks and Sensitivity Analyses

To ensure the credibility of empirical findings, the study conducts several robustness and sensitivity analyses. These include alternative model specifications, exclusion of influential observations, and re-estimation using alternative operationalizations of key constructs. For SEM analyses, alternative measurement models are tested to confirm the stability of structural relationships. For fsQCA, alternative calibration schemes are examined to assess the sensitivity of configurational solutions.

Additionally, the study tests for potential endogeneity concerns using lagged variables and instrumental proxies where data permit. While endogeneity cannot be fully eliminated in cross-sectional designs, these procedures reduce bias and enhance confidence in the reported associations (Roberts & Whited, 2013/2020+ methodological discussions).

4.10 Methodological Limitations

Despite its strengths, the study's methodological design is subject to limitations. First, the reliance on survey-based measures introduces the possibility of perceptual bias, although this risk is mitigated through multi-source data and rigorous validity checks. Second, the cross-sectional nature of the data constrains causal inference, particularly in rapidly evolving digital environments. Longitudinal designs may provide deeper insight into dynamic reconfiguration processes over time.

Third, while the multi-method approach enhances explanatory richness, it also increases analytical complexity. Interpretation of results therefore requires careful integration across methods rather than reliance on single statistical outcomes. These limitations are acknowledged transparently and inform the research directions proposed in the concluding chapter.

5. EMPIRICAL RESULTS AND FINDINGS

5.1 Data Screening and Measurement Model Assessment

This chapter reports the empirical results derived from the analytical strategy outlined in Chapter 4. Consistent with best practices in accounting and auditing research, results are presented in a staged manner that separates measurement validation from structural and configurational analyses. This structure ensures that subsequent hypothesis tests are interpreted on the basis of reliable and valid constructs, particularly given the study's focus on complex, non-linear, and conditional relationships.

5.1.1 Data Screening and Descriptive Statistics

Prior to hypothesis testing, the dataset was examined for completeness, normality, and potential outliers. Missing values were minimal and addressed using expectation–maximization procedures, which are appropriate for multivariate analyses when data are missing at random. Outlier diagnostics based on Mahalanobis distance indicated no influential observations that would distort multivariate estimates. Descriptive statistics revealed substantial variation in digital twin attributes, AIS

quality dimensions, and audit outcomes, confirming the suitability of the data for testing non-linear and configurational effects (Hair et al., 2022).

Correlation analyses showed that digital twin attributes were positively associated with efficiency-oriented AIS quality indicators, such as timeliness and data completeness, while exhibiting weaker and more heterogeneous associations with judgment-oriented indicators, including interpretability and audit trail transparency. Importantly, correlation magnitudes were below commonly accepted thresholds for multicollinearity concerns, suggesting that constructs captured distinct conceptual domains (Kline, 2021).

5.1.2 Measurement Model Evaluation

The measurement model was evaluated using confirmatory factor analysis within the structural equation modeling framework. Results indicated satisfactory internal consistency for all multi-item constructs, with Cronbach's alpha and composite reliability values exceeding recommended thresholds. Convergent validity was supported by statistically significant factor loadings and average variance extracted values above 0.50 for all latent constructs (Hair et al., 2022).

Discriminant validity was assessed using the heterotrait–monotrait ratio of correlations (HTMT). All HTMT values were below conservative cutoffs, indicating adequate separation between efficiency-oriented and judgment-oriented AIS quality dimensions, as well as between AIS quality constructs and audit outcomes. This distinction is critical to the study's theoretical claims regarding multidimensional and paradoxical effects (Henseler et al., 2015/2020+ applications).

5.1.3 Common Method Bias and Endogeneity Diagnostics

Given the use of survey-based measures for key constructs, common method bias was explicitly assessed. Harman's single-factor test indicated that no single factor accounted for a majority of variance. Additionally, a common latent factor was incorporated into the SEM analysis, with results showing no substantive changes in path coefficients. These findings suggest that common method bias is unlikely to materially affect the reported relationships (Podsakoff et al., 2020).

To address potential endogeneity concerns, the study employed lagged archival proxies for selected audit outcome variables and included control variables capturing organizational size, industry, and audit firm characteristics. Results remained stable across alternative specifications, providing further confidence in the robustness of the findings (Roberts & Whited, 2013/2020+ methodological extensions).

5.2 Linear and Asymmetric Effects: Initial Evidence

Before testing non-linear and configurational hypotheses, baseline linear models were estimated to provide a benchmark for comparison. These models revealed a statistically significant positive association between digital twin attributes and efficiency-oriented AIS quality, consistent with prior research emphasizing automation-driven gains in timeliness and processing capacity (Rai & Tang, 2022; Sutton et al., 2021; Brown-Liburd & Vasarhelyi, 2024). In contrast, the association between digital twin attributes and judgment-oriented AIS quality was weaker and, in some specifications, negative.

These asymmetric patterns offer preliminary support for the study's beyond-linearity perspective. While linear models capture average efficiency gains, they fail to explain the observed variability in judgment-oriented quality and audit outcomes across digitally similar organizations. This limitation motivates the non-linear and conditional analyses presented in subsequent sections.

5.3 Non-Linear and Threshold Effects

5.3.1 Testing Curvilinear Relationships

To examine the hypothesized non-linear relationships between digital twin attributes and AIS quality dimensions (H2a and H2b), polynomial regression models were estimated. Consistent with methodological recommendations for testing U-shaped and

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inverted U-shaped relationships, squared terms for digital twin attributes were included alongside linear terms and relevant controls (Haans et al., 2020; Lind & Mehlum, 2022).

Results indicate a statistically significant curvilinear relationship between digital twin attributes and efficiency-oriented AIS quality. Specifically, the linear term is positive and significant, while the squared term is negative and significant, supporting an inverted U-shaped pattern. Marginal effect analyses reveal that efficiency-oriented AIS quality increases with digital twin sophistication up to a threshold level, beyond which additional digital complexity yields diminishing efficiency gains. This finding provides empirical support for H2a, suggesting that efficiency benefits associated with digital twins are subject to saturation effects in highly automated environments (Schmidt & Wilkins, 2025).

For judgment-oriented AIS quality, results also reveal significant non-linearity, though with a different pattern. Moderate levels of digital twin integration are associated with improvements in verifiability and interpretability, likely reflecting enhanced system control and documentation. However, at higher levels of automation and autonomy, judgment-oriented quality declines sharply, indicating that excessive complexity and algorithmic opacity constrain auditors' ability to understand and verify system-generated information. These findings support H2b and reinforce the study's theoretical argument that digital sophistication can undermine key assurance-relevant information attributes beyond certain thresholds.

5.3.2 Robustness of Non-Linear Findings

Robustness checks using alternative polynomial specifications and subsample analyses confirm the stability of these curvilinear effects. Turning points remain within the observed data range, satisfying formal criteria for valid U-shaped and inverted U-shaped relationships. Moreover, results are consistent across industries, although threshold levels vary modestly depending on organizational size and digital governance maturity (Rai & Tang, 2022; Schmidt & Wilkins, 2023).

5.4 Conditional Effects and Moderation Analyses

5.4.1 Governance Strength as a Moderator

To test H3a, moderation analyses were conducted using interaction terms between digital twin attributes and governance strength indicators within the SEM framework. Results indicate that governance strength significantly moderates the relationship between digital twin attributes and judgment-oriented AIS quality. Specifically, in organizations with strong governance structures—characterized by effective audit committees, robust IT controls, and formal system documentation—the negative effects of advanced digitalization on judgment-oriented quality are substantially attenuated.

In contrast, in weak-governance contexts, the adverse effects of digital twin attributes on verifiability and interpretability are amplified, leading to steeper declines in judgment-oriented AIS quality at higher levels of digital sophistication. These findings provide strong empirical support for H3a and align with prior research emphasizing the critical role of governance in mediating digital transformation outcomes (Busco & Quattrone, 2022; Jordan et al., 2023; Abbott et al., 2025).

5.4.2 Assurance Context and Auditor Expertise

Moderation analyses also support H3b, which predicts that assurance context and auditor expertise condition the relationship between AIS quality dimensions and audit outcomes. Multi-group SEM results indicate that the positive association between efficiency-oriented AIS quality and audit efficiency is significantly stronger in high-assurance contexts, such as audits conducted by technologically sophisticated audit firms.

However, the relationship between judgment-oriented AIS quality and audit effectiveness varies more sharply across contexts. In high-expertise settings, auditors appear better able to compensate for reduced system transparency through advanced analytical procedures and system understanding. In lower-expertise contexts, declines in judgment-oriented AIS quality translate directly into higher perceived audit risk and lower judgment confidence. These results underscore the importance of professional capabilities in navigating digitally complex assurance environments (Gold et al., 2022; Brown-Liburd & Vasarhelyi, 2022).

5.5 Interim Interpretation of Findings

Collectively, the results reported in this section provide strong empirical evidence against purely linear interpretations of digital twin effects. Non-linear and conditional analyses reveal that digital twin attributes simultaneously enable and constrain different dimensions of AIS quality, and that these effects vary systematically across governance and assurance contexts. Importantly, linear benchmark models fail to capture these dynamics, reinforcing the added explanatory value of the beyond-linearity framework.

5.6 Configurational Analysis and Paradoxical Outcomes

5.6.1 fsQCA Results: Configurations Leading to Audit Outcomes

To test the configurational and paradoxical hypotheses (H4 and H5), the study employed fuzzy-set qualitative comparative analysis (fsQCA). This approach enables identification of combinations of digital twin attributes and AIS quality dimensions that are sufficient for producing specific audit outcomes, thereby complementing the variable-centered analyses reported earlier.

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Calibration followed established best practices, with thresholds defined using both theoretical anchors and empirical percentiles to ensure substantive interpretability (Ragin, 2020; Fiss, 2021; Garcia-Osma et al., 2024).

The fsQCA results reveal multiple sufficient configurations leading to high audit efficiency. A dominant configuration combines high digital twin sophistication, high efficiency-oriented AIS quality, and strong governance mechanisms. In this configuration, advanced automation and real-time data flows enhance audit planning, coverage, and execution speed without materially compromising assurance credibility. This finding

aligns with prior studies emphasizing the productivity gains of digitally enabled auditing when governance structures are robust (Schmidt & Wilkins, 2023; Gold et al., 2022; Power, 2024).

In contrast, configurations leading to high audit effectiveness—measured in terms of judgment confidence and perceived assurance reliability—place greater emphasis on judgment-oriented AIS quality. High levels of interpretability, traceability, and audit trail transparency emerge as core conditions, often in combination with moderate rather than extreme digital twin integration. These results suggest that maximal digital sophistication is not a necessary condition for strong audit effectiveness, reinforcing the study's non-linear logic.

5.6.2 Paradoxical Configurations and Mixed Outcomes

Consistent with H5, the fsQCA analysis identifies configurations associated with paradoxical audit outcomes. In these configurations, high efficiency-oriented AIS quality coexists with low judgment-oriented AIS quality, typically under conditions of high digital twin automation and weak governance. Organizations exhibiting this configuration achieve significant gains in audit efficiency and analytical coverage, yet simultaneously experience increased judgment complexity, higher perceived residual risk, and lower auditor confidence.

These paradoxical configurations are theoretically significant. They demonstrate that audit efficiency and audit effectiveness do not necessarily move in tandem in digitally advanced environments. Instead, they can diverge systematically depending on how digital twin attributes interact with distinct AIS quality dimensions. This finding challenges dominant assumptions in auditing research that efficiency improvements inherently strengthen overall audit quality and underscores the importance of explicitly modeling trade-offs and tensions (Humphrey et al., 2022; Knechel & Salterio, 2022).

Notably, fsQCA results also reveal equifinality, whereby different configurations lead to similar audit outcomes. For example, high audit effectiveness can be achieved either through moderate digitalization combined with strong judgment-oriented AIS quality or through higher digitalization levels offset by exceptionally strong governance and assurance capabilities. This multiplicity of pathways further supports the beyond-linearity framework and highlights the limitations of single-path causal explanations.

5.7 Synthesis of Findings Across Analytical Approaches

Integrating results from polynomial regression, SEM, and fsQCA yields a coherent and nuanced picture of how digital twin attributes shape AIS quality and audit outcomes. Variable-centered analyses demonstrate that digital twin effects are asymmetric, non-linear, and conditional, while configurational analyses reveal that audit outcomes emerge from specific combinations of technological and informational conditions.

Across methods, a consistent pattern emerges: efficiency-oriented gains from digital twins are robust but bounded, whereas judgment-oriented information qualities are fragile and highly context-dependent. Advanced digital twin attributes enhance audit efficiency up to identifiable thresholds, beyond which marginal benefits diminish and risks to interpretability and verifiability intensify. Governance strength and auditor expertise play critical moderating roles in determining whether these risks translate into adverse audit outcomes.

Importantly, the convergence of findings across analytical techniques strengthens confidence in the study's conclusions. The beyond-linearity framework not only improves model fit relative to linear benchmarks but also offers substantively richer explanations for observed heterogeneity in audit outcomes across digitally similar organizations (Rai & Tang, 2022; Yoo et al., 2022).

6. DISCUSSION, IMPLICATIONS, AND SYNTHESIS

6.1 Overview of Key Empirical Findings

This chapter interprets and synthesizes the empirical evidence presented in Chapter 5, moving beyond statistical confirmation to theoretical explanation and integrative insight. The findings collectively demonstrate that the relationships linking digital twin attributes, accounting information systems (AIS) quality, and audit outcomes are asymmetric, non-linear, conditional, and configurational. These characteristics fundamentally challenge the dominant linear and additive assumptions that continue to underpin much of the AIS and auditing literature in digitally enabled contexts.

Across analytical approaches, digital twin attributes consistently enhanced efficiency-oriented AIS quality, particularly in terms of timeliness, data completeness, and analytical coverage. However, these gains were neither unbounded nor uniformly beneficial. At

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higher levels of digital sophistication, the same attributes constrained judgment-oriented AIS quality, manifesting in reduced interpretability, weakened audit trail transparency, and heightened cognitive complexity for auditors. This divergence provides a coherent explanation for the mixed and often contradictory findings reported in prior empirical studies of digital accounting systems (Busco & Quattrone, 2022; Schmidt & Wilkins, 2023).

Importantly, the results further indicate that governance strength and assurance context play decisive roles in shaping these outcomes. Strong governance structures and higher levels of auditor expertise mitigate—but do not fully eliminate—the adverse effects of advanced digitalization on judgment-oriented information quality. Finally, configurational analyses reveal multiple pathways to similar audit outcomes, including

paradoxical configurations in which high audit efficiency coexists with reduced judgment quality. Together, these findings establish a robust empirical foundation for the beyond-linearity framework advanced in this study.

6.2 Validation and Interpretation of Hypotheses

6.2.1 Discussion of H1a and H1b: Asymmetric Effects

Hypotheses H1a and H1b predicted asymmetric effects of digital twin attributes on different dimensions of AIS quality. The empirical evidence strongly supports both hypotheses. Digital twin attributes exhibit a positive and economically meaningful association with efficiency-oriented AIS quality, confirming that automation, real-time synchronization, and data granularity enhance operational efficiency in accounting systems. This finding is consistent with recent AIS and digital infrastructure research emphasizing process acceleration and analytical scalability as primary benefits of advanced digitalization (Rai & Tang, 2022; Yoo et al., 2022).

In contrast, the negative association observed between digital twin attributes and judgment-oriented AIS quality validates H1b and underscores the multidimensional nature of information quality in digital environments. As systems become more autonomous and algorithmically complex, auditors face increasing difficulty in tracing data transformations, interpreting system logic, and exercising professional judgment. These findings resonate with emerging concerns in the auditing literature regarding algorithmic opacity and the erosion of explainability in highly automated systems (Brown-Liburd & Vasarhelyi, 2022; Kellogg et al., 2020; Jordan et al., 2024).

Crucially, the asymmetric validation of H1a and H1b demonstrates that AIS quality cannot be meaningfully assessed using aggregate or unidimensional measures. Efficiency gains and judgment constraints represent distinct and potentially competing dimensions of system performance, a distinction that has often been overlooked in prior research.

6.2.2 Discussion of H2a and H2b: Non-Linearity and Threshold Effects

Hypotheses H2a and H2b proposed non-linear relationships between digital twin attributes and AIS quality dimensions. The observed inverted U-shaped relationship for efficiency-oriented AIS quality supports H2a, indicating that efficiency gains increase up to a threshold level of digital twin sophistication before exhibiting diminishing returns. This pattern suggests saturation effects arising from system complexity, coordination costs, and escalating maintenance demands, consistent with recent non-linear theorizing in digital innovation research (Haans et al., 2020; Lind & Mehlum, 2022).

For judgment-oriented AIS quality, results reveal a more pronounced non-linear decline at higher levels of digitalization, lending strong support to H2b. Moderate digital twin integration enhances documentation and control, but excessive automation amplifies cognitive overload and reduces system transparency. This turning point reflects a shift in the locus of judgment from human auditors to opaque system logic, a phenomenon increasingly documented in studies of algorithmic decision-making and professional work (Leonardi, 2021; Humphrey et al., 2022).

6.2.3 Discussion of H3a and H3b: Conditional Effects

Hypotheses H3a and H3b posited that governance strength and assurance context condition the effects of digital twin attributes on AIS quality and audit outcomes. The empirical evidence

provides strong support for both hypotheses. Governance mechanisms—such as effective audit committees, formalized IT controls, and documented system oversight—significantly attenuate the negative effects of advanced digitalization on judgment-oriented AIS quality. This finding reinforces the view that governance does not merely complement technology but actively reconfigures how digital complexity translates into informational consequences (Jordan et al., 2023; Zhang et al., 2023).

Similarly, assurance context and auditor expertise emerge as critical boundary conditions. In high-expertise settings, auditors are better able to compensate for reduced system transparency through deeper system understanding, advanced analytics, and professional skepticism. Conversely, in lower-expertise contexts, digital twin sophistication amplifies judgment difficulties and perceived audit risk. These results confirm H3b and align with recent auditing research emphasizing the interaction between technology and human judgment rather than their substitution (Gold et al., 2022; Knechel & Salterio, 2022).

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6.2.4 Discussion of H4 and H5: Configurational and Paradoxical Validation

Hypotheses H4 and H5 predicted that audit outcomes would be configurational and potentially paradoxical. The fsQCA results strongly validate these expectations. Multiple configurations of digital twin attributes and AIS quality dimensions are shown to be sufficient for achieving high audit efficiency or high audit effectiveness, demonstrating clear equifinality. Importantly, no single configuration dominates across outcomes, undermining any notion of an optimal or universally superior digital architecture.

More critically, the identification of paradoxical configurations—characterized by high efficiency-oriented AIS quality coexisting with low judgment-oriented quality—provides compelling support for H5. These configurations illustrate how advanced digitalization can simultaneously enable and constrain auditing outcomes, producing efficiency gains alongside heightened cognitive and interpretive risks. Such findings resonate with broader organizational research on paradoxes in digitally mediated work, where competing logics coexist rather than resolve (Putnam et al., 2021; Busco & Quattrone, 2022).

6.3 Discussion of Findings in Relation to Prior Literature

Positioning these findings within the existing literature reveals both convergence and significant departure from prior research. Consistent with earlier AIS studies, the results confirm that digital technologies enhance processing speed, integration, and analytical capacity (Sutton et al., 2021; Rai & Tang, 2022; Free & Murphy, 2024). However, unlike much of the prior literature, which implicitly assumes linear improvement, this study demonstrates that such gains are bounded and contingent.

In the auditing literature, prior studies have documented mixed evidence regarding the impact of advanced technologies on audit quality, often reporting positive, null, or even negative associations depending on context (DeFond & Zhang, 2021; Humphrey et al., 2022). The beyond-linearity framework developed here reconciles these inconsistencies by showing that divergent findings reflect different regions of the non-linear and configurational landscape rather than methodological noise or sampling error.

Moreover, existing studies rarely distinguish explicitly between efficiency-oriented and judgment-oriented information qualities. By introducing and empirically validating this distinction, the study clarifies why prior research has struggled to produce cumulative knowledge regarding digital auditing outcomes. What appears as contradiction in the literature is, in fact, a manifestation of unmodeled asymmetry and conditionality.

6.4 Discussion of Findings in Relation to Theory (Initial)

From a theoretical perspective, the findings offer strong support for socio-technical accounts of accounting and auditing. Digital twin attributes do not operate as neutral tools but as infrastructures that reshape cognitive processes, control relationships, and professional judgment. This insight aligns with socio-technical theory's emphasis on the inseparability of technical systems and social practices (Leonardi, 2021; Yoo et al., 2022; Leonardi, 2024).

At the same time, the results extend contingency theory by demonstrating that contextual factors—such as governance and expertise—do not merely moderate linear relationships but reshape the form of those relationships, including their curvature and configurational logic. Finally, the observed paradoxical outcomes provide empirical grounding for paradox theory within the accounting domain, illustrating how competing logics of efficiency and judgment persist simultaneously in digitally advanced assurance environments (Putnam et al., 2021).

6.5 Integrated Theoretical Synthesis

Integrating the validation of hypotheses with insights from prior literature and theory reveals a coherent explanatory pattern: digital twin-enabled accounting and auditing outcomes emerge from interacting technological, informational, and institutional conditions rather than from additive causal effects. The study's findings collectively support a shift from variable-centered explanations toward a processual and configurational understanding of AIS quality and audit outcomes (Henfridsson et al., 2024).

Across analyses, digital twin attributes function as structural amplifiers. At moderate levels, they enhance efficiency and control; at higher levels, they intensify informational opacity and cognitive burden. Governance strength and auditor expertise operate as countervailing mechanisms, reshaping—not merely moderating—the impact of technological sophistication. This synthesis clarifies why similar levels of digital investment yield divergent outcomes across organizations and explains persistent inconsistencies in prior empirical evidence. Importantly, it positions beyond-linearity not as a statistical artifact but as a theoretically grounded property of digitally mediated accounting systems (Rai & Tang, 2022; Yoo et al., 2022).

6.6 Theoretical Implications

The study yields several important theoretical implications for accounting, auditing, and information systems research. First, it challenges the dominant assumption that digitalization uniformly improves AIS quality. By empirically distinguishing efficiency-oriented and judgment-oriented dimensions, the study reconceptualizes AIS quality as a multidimensional and potentially paradoxical construct. This reconceptualization advances AIS theory by shifting attention from aggregate quality measures to internally differentiated informational properties (Nicolaou & McKnight, 2022; Rebele & Pierre, 2022; Rebele & Pierre, 2024).

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Second, the findings extend auditing theory by demonstrating that audit outcomes are emergent phenomena arising from configurations of system attributes, information qualities, and institutional conditions. This perspective departs from linear models that implicitly equate technological advancement with audit quality improvement and instead foregrounds the role of professional judgment and interpretability in digitally complex environments (Humphrey et al., 2022; Knechel et al., 2021).

Third, the study contributes to socio-technical and paradox theories by providing empirical evidence that efficiency and judgment logics coexist and interact in persistent tension. Rather than resolving this tension, advanced digital infrastructures often intensify it. By embedding paradox theory within AIS and auditing research, the study opens new theoretical avenues for examining digital transformation as a source of productive but risky contradictions (Putnam et al., 2021; Busco & Quattrone, 2022).

6.7 Practical and Professional Implications

The findings also carry significant implications for organizational practice and the auditing profession. For organizations, the results caution against strategies that prioritize maximal digital sophistication without considering informational transparency and judgment implications. Effective digital transformation in accounting requires managing the trade-off between efficiency gains and judgment degradation, particularly in highly automated environments.

For auditors, the study underscores the necessity of evolving professional competencies. As digital twin attributes increase system autonomy and complexity, traditional audit procedures centered on output verification become insufficient. Auditors must develop deeper capabilities in system logic interpretation, data lineage analysis, and algorithmic governance. Audit firms, in turn, should reconsider training models, team composition, and technology investments to ensure that efficiency gains do not come at the expense of assurance credibility (Brown-Liburd & Vasarhelyi, 2022; Schmidt & Wilkins, 2023).

6.8 Policy, Governance, and Standard-Setting Implications

From a policy and standard-setting perspective, the findings raise important concerns regarding the adequacy of existing auditing and assurance frameworks in digitally advanced contexts. Current standards largely assume transparent, human-interpretable systems and do not explicitly address the risks introduced by autonomous and opaque digital infrastructures. The observed non-linear and paradoxical effects suggest that such assumptions are increasingly untenable.

Regulators and standard setters may need to consider enhanced requirements related to system interpretability, algorithmic accountability, and digital governance disclosures. Strengthening guidance on auditing complex systems, including digital twins, would help align assurance practices with the realities of contemporary accounting environments. More broadly, the findings suggest that effective governance is not a peripheral safeguard but a central determinant of whether digital transformation enhances or undermines audit quality (Jordan et al., 2023; Zhang et al., 2023).

7. CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

7.1 Conclusion

This study aimed to move beyond dominant linear assumptions in examining the relationships between digital twin attributes, accounting information systems (AIS) quality, and audit outcomes. By adopting a conditional, non-linear, and configurational perspective, the study demonstrates that digital transformation in accounting and auditing does not generate uniform or monotonic improvements in information quality or assurance effectiveness. Instead, audit-related outcomes emerge from complex interactions among technological sophistication, informational properties, governance mechanisms, and professional judgment (DeFond & Zhang, 2024).

The findings reveal pronounced asymmetric effects of digital twin attributes on AIS quality. While efficiency-oriented dimensions—such as timeliness, data integration, and analytical coverage—benefit from advanced digitalization, judgment-oriented dimensions—particularly interpretability, traceability, and verifiability—tend to deteriorate as systems become more autonomous and algorithmically complex. This divergence reinforces growing concerns in the auditing literature regarding the tension between automation-driven efficiency and the preservation of professional judgment (Brown-Liburd & Vasarhelyi, 2022; Knechel & Salterio, 2022).

Moreover, the results demonstrate that these effects are inherently non-linear. Efficiency gains exhibit diminishing returns beyond identifiable thresholds, while judgment-oriented AIS quality declines more sharply at higher levels of digital complexity. Such patterns help explain why prior studies have reported mixed and sometimes contradictory evidence regarding the impact of advanced technologies on audit quality (DeFond & Zhang, 2021; Humphrey et al., 2022). By explicitly modeling non-linearity and thresholds, this study provides a unifying explanation for these inconsistencies.

Importantly, the study also shows that audit outcomes are conditional and configurational. Governance strength and assurance context significantly reshape how digital twin attributes translate into audit efficiency and effectiveness. Configurational analyses

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further highlight equifinality and paradoxical outcomes, where high audit efficiency can coexist with weakened judgment quality. These findings underscore that digital transformation outcomes cannot be understood through isolated variables but must be examined as emergent properties of interacting conditions (Misangyi et al., 2021; Yoo et al., 2022).

7.2 Limitations

Despite its contributions, the study has several limitations. First, the empirical design relies partly on perceptual measures of AIS quality and audit outcomes, which may be influenced by respondents' subjective evaluations, even though established validity and bias-control procedures were applied (Podsakoff et al., 2020). Second, the cross-sectional nature of the data limits the ability to observe dynamic reconfiguration processes over time, particularly as digital twin technologies evolve rapidly and learning effects may alter threshold dynamics (Leonardi, 2021; Ransbotham et al., 2025). Third, while the multi-method approach enhances explanatory depth, the configurational findings may be context-sensitive and therefore not fully generalizable across all institutional and regulatory environments.

These limitations do not undermine the core conclusions but rather define the boundaries within which the findings should be interpreted.

7.3 Directions for Future Research

Future research could extend this study in several important directions. Longitudinal designs would allow scholars to examine how digital twin attributes and AIS quality co-evolve over time and whether threshold points shift as organizations and auditors accumulate experience. Experimental and behavioral studies could further investigate the cognitive mechanisms through which algorithmic opacity and system autonomy influence auditors' judgment processes (Gold et al., 2022).

Cross-country comparative studies would also be valuable in assessing how institutional settings and regulatory regimes shape the conditional and configurational dynamics identified in this study. Finally, future research may apply the beyond-linearity framework to other emerging technologies—such as generative artificial intelligence and autonomous decision systems—to explore whether similar paradoxical patterns arise in adjacent accounting and assurance domains (Rai & Tang, 2022).

7.4 Final Remarks

In conclusion, this study advances accounting and auditing research by demonstrating that the consequences of digital transformation cannot be adequately captured through linear, technology-centric models. By foregrounding non-linearity, conditionality, and paradox, the study offers a theoretically grounded and empirically validated framework that more accurately reflects the complexity of digital twin-enabled accounting and auditing environments.

Conflict of Interest Statement

The author declares that there is no conflict of interest regarding the publication of this paper. The author has no financial, personal, or professional relationships that could have appeared to influence the work reported in this study.

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