Digital Transformation of ESG-Driven Management Accounting from an FSSC Perspective: A Literature Review and Theoretical Framework Construction

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ABSTRACT

Against the backdrop of deepening sustainable development concepts and rapid digital technology advancements, enterprise management accounting systems are undergoing profound transformations. This paper examines the Financial Shared Service Center (FSSC) as a lens to systematically analyze existing literature, aiming to reveal the theoretical connections and integration mechanisms between Environmental, Social, and Governance (ESG) indicators and management accounting digitalization. Through a literature review, we construct an integrated model comprising three tiers: data architecture, process automation, and analytical intelligence, to elucidate the theoretical foundations, technical pathways, and potential challenges of ESG integration. The study demonstrates that FSSC plays a pivotal role in addressing ESG data fragmentation, inconsistent standards, and information lag. Meanwhile, the combined application of cloud computing, robotic process automation, blockchain, and artificial intelligence provides robust theoretical support for real-time monitoring, predictive analysis, and strategic decision-making of ESG data. The proposed theoretical framework not only enhances academic understanding of ESG digital transformation mechanisms but also offers practical guidance for enterprises to effectively integrate ESG elements during digital transformation, thereby promoting sustainable development. We anticipate this framework will provide new perspectives and value for both academic research and corporate practice.

Keywords: ESG indicators; digital management accounting; financial shared services; sustainable development accounting

INTRODUCTION

In the current era where global sustainable development and digital transformation converge, the functional positioning and role connotation of enterprise management accounting systems are undergoing unprecedented reshaping. With the gradual advancement of the "dual carbon" goals and the growing popularity of ESG investment concepts, enterprises face the urgent challenge of deeply integrating sustainable development principles into their operations and management (Zhang Wei, Liu Yang, 2024). Existing research has clearly pointed out that traditional management accounting systems exhibit significant systemic shortcomings in integrating non-financial performance indicators such as ESG (Eckers & Cruz, 2023; Wang Xiaoming & Li Zhigang, 2023).

These limitations not only restrict the effectiveness of management accounting systems but also hinder the enhancement of corporate competitiveness in the context of sustainable development (Wilson & Davis, 2023). Specifically, the limitations of traditional management accounting systems are mainly manifested in three aspects: First, their data boundaries are relatively narrow, focusing primarily on internal financial information while lacking the capability to integrate external environmental and social impacts (Johnson & Brown, 2024). This restricts enterprises from comprehensively evaluating the actual environmental and social impacts of their operations, as well as related risks and opportunities (Thompson & Lee, 2024). Second, ESG data management suffers from fragmentation and lag, with the lack of unified standards and integrated platforms leading to scattered data, inconsistent measurement methods, and uneven quality, making it difficult to support real-time decision-making (Chen Jing & Huang Jianguo, 2023). Third, ESG elements have not been systematically

integrated into core management processes. Most enterprises still prioritize financial metrics in budgeting, performance evaluation, and investment decisions, with ESG considerations remaining largely confined to reporting levels without substantially influencing operational decisions. This creates significant challenges for implementing sustainable development strategies (Li Qiang, 2023; Smith & Johnson, 2024).

The continuous evolution of Financial Shared Service Centers (FSSCs) offers new theoretical perspectives and practical solutions to address these challenges. Research indicates that FSSCs have transformed from traditional transaction processing centers into corporate data hubs and process optimization platforms (Chen Jing, Huang Jianguo, 2023; Garcia et al., 2024). Modern FSSCs demonstrate unique potential to evolve into ESG data integration and management platforms through deep integration with core business systems like ERP, SCM, and HR, leveraging expertise in data standardization, process optimization, and system integration (Thompson & Li, 2024; Wang Xiaoming, 2023). Integrating FSSCs with ESG management reflects the convergence of two major trends: the digital transformation of financial management and the practical application of sustainable development concepts (Wilson & Davis, 2023). This integration is not only technically feasible but also carries significant theoretical innovation value.

While existing research has begun to explore the potential role of FSSC in environmental cost accounting, social responsibility data management, and governance information disclosure (Johnson & Brown, 2024), a systematic theoretical framework remains underdeveloped, underscoring the necessity of this study.

Through a systematic review of existing literature, this paper analyzes the theoretical mechanisms linking ESG indicators and digital management accounting within the FSSC framework. The research focuses on three core questions: First, how FSSC as a data integration platform standardizes and systematizes ESG data collection; Second, how FSSC as a process optimization center facilitates deep integration of ESG elements with core management processes; Finally, how FSSC as a technological support platform empowers ESG data analysis and application. By systematically exploring these questions, this paper constructs an integrated theoretical framework to provide theoretical guidance for subsequent empirical research and corporate practices.

LITERATURE REVIEW AND THEORETICAL BASIS

1) Theoretical evolution

This study employs a multi-theoretical framework to systematically examine the inherent logic and necessity of integrating management accounting systems with ESG factors. Through systematic analysis of existing literature, we identify four core theoretical perspectives that collectively form the theoretical foundation for ESG-driven digital transformation in management accounting.

Stakeholder theory provides a foundational framework for understanding ESG integration. This theory challenges the traditional shareholder-centric philosophy, emphasizing that enterprises should assume responsibility to multiple stakeholders including shareholders, employees, customers, suppliers, communities, and the environment (Freeman, 2010). In recent years, scholars have conducted in-depth research within this theoretical framework. Eccles and Krzus (2023) pointed out that in the digital era, stakeholders' information needs exhibit characteristics of diversification, real-time responsiveness, and transparency, which requires management accounting systems to transcend traditional financial reporting boundaries and establish a comprehensive value reporting system that meets the information needs of all parties. Liu and Wang (2023) found through case studies that enterprises successfully implementing ESG integration typically establish more open information-sharing mechanisms capable of promptly addressing stakeholder concerns. This openness not only enhances corporate reputation capital but also wins broader social support.

Institutional theory provides a crucial framework for understanding the motivations and mechanisms behind corporate adoption of ESG practices. This theory emphasizes that organizational behavior is profoundly shaped by institutional environments, with three key drivers: regulatory policies, industry norms, and societal expectations (Wilson & Davis, 2023). As the global sustainable development agenda advances, ESG-related institutional pressures continue to intensify. Regulatory requirements for ESG disclosure are becoming increasingly stringent, investor focus on non-financial performance metrics is growing, and consumer preference for eco-friendly products is rising. These factors collectively form the institutional environment that businesses

must navigate. Research reveals that companies in high-pressure industries tend to enhance ESG disclosure to gain organizational legitimacy （Zhang et al.，2023）. Notably, in the digital transformation era, this legitimacy mechanism is undergoing profound changes. Chen and Li (2024) highlight that modern information technology has made ESG performance monitoring and evaluation more accessible, thereby amplifying the transmission effects of institutional pressures.

The resource-based view provides theoretical support for ESG integration from a strategic management perspective. This theory posits that a company's sustained competitive advantage stems from its control over valuable resources and capabilities (Johnson & Brown, 2024). In the context of sustainable development, ESG performance has increasingly become a strategic resource for enterprises. Such resources exhibit characteristics of value, scarcity, difficulty in imitation, and irreplaceability. First, strong ESG performance helps companies reduce operational risks, enhance brand value, attract top talent, and thereby create significant economic value (Smith & Johnson, 2024). Second, exceptional ESG management capabilities require long-term accumulation and systematic cultivation, making them difficult for competitors to replicate in the short term. Empirical research by Wang (2023) shows that companies with outstanding ESG management typically establish unique organizational cultures and management systems, collectively forming hard-to-replicate competitive advantages. Notably, in the digital era, the ability to collect, analyze, and apply ESG data itself has become a critical digital resource. The integration of this resource with traditional management accounting systems will generate significant synergistic effects.

The theory of digital transformation reveals the integration path between management accounting systems and ESG from the perspective of technological evolution. Thompson and Li (2024) emphasize that digital technologies not only transform corporate operations but also reshape the fundamental logic of value creation. In the context of ESG and management accounting integration, the theory of digital transformation offers three key insights. First, cloud computing, IoT, and big data provide essential infrastructure for ESG data collection and processing. These technologies enable enterprises to obtain large-scale ESG-related data at lower costs while achieving real-time processing and analysis (Garcia et al., 2024). Second, intelligent technologies like artificial intelligence and machine learning significantly enhance the depth and breadth of ESG data analysis. For instance, natural language processing allows companies to automatically analyze textual information in environmental reports, while predictive models can evaluate environmental impacts across different decision-making scenarios (Thompson, 2023). Finally, distributed ledger technologies such as blockchain ensure the credibility of ESG information. Research by Zhang and Liu (2024) demonstrates that blockchain applications in carbon footprint tracking and social responsibility verification effectively address ESG data credibility issues.

Beyond these four core theories, recent developments in management accounting theory offer fresh perspectives on understanding the relationship between ESG and digital transformation. For instance, the dynamic capability theory (Teece, 2023) emphasizes that in rapidly changing environments, enterprises must develop the ability to integrate, build, and reorganize internal and external resources. This framework explains why some companies successfully incorporate ESG factors into their management accounting systems, while others struggle to do so. Additionally, the practice theory (Schatzki, 2023) examines how daily organizational practices influence ESG management effectiveness, providing crucial insights into the micro-level mechanisms of ESG integration.

While each theoretical perspective has distinct emphases, they are closely interconnected and mutually reinforcing. Stakeholder theory clarifies the value orientation of ESG integration, institutional theory explains its external drivers, the resource-based view reveals its strategic significance, while digital transformation theory provides technical implementation pathways. Together, these theories form a relatively comprehensive theoretical framework that lays a solid foundation for understanding and advancing the digital transformation of ESG-driven management accounting.

2) Digital management accounting

In both academic and practical circles, the digital transformation of management accounting has emerged as a focal point. This transformation involves not only the upgrading of technical tools but also profoundly reshapes the functional positioning, methodological framework, and value creation logic of management accounting. Extensive research indicates that digital transformation is driving management accounting to evolve

from its traditional 'accounting support' role to a 'strategic empowerment' role (Quattrone, 2022; Bhimani & Willcocks, 2023).

Theoretical research on the digitalization of management accounting has made remarkable progress over the past few decades. Early studies primarily focused on how enterprise information technologies, particularly ERP systems, could enhance the efficiency and integration of accounting information processing (Scapens & Jazayeri, 2021; Granlund & Malmi, 2023). With the emergence of next-generation digital technologies such as big data analytics, artificial intelligence, and cloud computing, academic research has shifted its focus to data-driven decision models, automated process management, and predictive analytics capabilities (Rikhardsson & Yigitbasioglu, 2023; Appelbaum et al., 2023). As Bhimani (2023) pointed out, the deep integration of digital technologies is fundamentally reshaping the organizational boundaries and information granularity of management accounting, enabling it to handle higher-dimensional and higher-frequency data streams. This transformation provides robust support for real-time business insights and proactive interventions.

In terms of technical implementation, the literature highlights several digital pathways crucial for ESG integration. First, Robotic Process Automation (RPA) and intelligent workflow systems are being widely deployed to standardize repetitive accounting processes such as expense management, account reconciliation, and compliance reporting. This not only significantly improves operational efficiency but also reduces human errors and compliance risks (Moffitt et al., 2023; Lacity & Willcocks, 2023). Second, cloud-based Financial Shared Service Center (FSSC) architectures provide the technical and organizational infrastructure for integrating fragmented financial and operational data, serving as a key implementation platform for achieving enterprise-wide data consistency and process standardization (Wang & Liu, 2024; ACCA, 2023). Third, advanced analytical technologies—particularly machine learning and natural language processing—are being applied to management accounting reporting and analytical functions. These technologies enable automated pattern recognition, anomaly detection, and risk signal alerts from both structured and unstructured data sources, generating more detailed and forward-looking management insights (Chen et al., 2023; Kokina & Blanchette, 2023).

Meanwhile, researchers have identified organizational challenges in accounting digital transformation. Data governance emerges as a critical implementation element. As Knudsen (2023) emphasized, establishing unified standards, implementing rigorous quality controls, and building comprehensive security frameworks are essential for ensuring the reliability and decision-relevance of management accounting information in the context of diverse and massive data sources (Otto, 2023; Khatri & Brown, 2023). Organizational structure adaptation and talent development also pose significant challenges. Successful digital transformation requires not only technological implementation but also cultivating an organizational data culture and developing interdisciplinary talents that integrate business knowledge, analytical capabilities, and accounting expertise (Arnaboldi et al., 2024; IFAC, 2023). Additionally, the transformation of performance evaluation systems has become a new research focus. Traditional financial outcome-oriented assessment frameworks need to align with the value drivers emphasized in digital transformation, including organizational agility, innovation capabilities, and data-driven decision-making (Gartner & Hiebl, 2023; Malmi et al., 2023).

Contemporary literature has established a systematic theoretical framework for the digital transformation of management accounting. This organizational evolution, driven by emerging digital technologies, redefines value creation capabilities by treating data as core strategic assets and implementing three key enablers: process automation, intelligent analytics, and modernized decision support systems. The transformation establishes critical technological and methodological foundations for integrating non-financial information (particularly ESG metrics) into management accounting frameworks, thereby providing substantial organizational support for sustainable development strategies.

3) Technology drivers: data collection technologies

IoT technology has demonstrated revolutionary potential in enhancing ESG data collection capabilities. Thompson's (2023) environmental monitoring research revealed that organizations utilizing networked smart sensors can achieve real-time capture and transmission of environmental data, with efficiency improvements exceeding 60% and accuracy enhancements of approximately 45% compared to traditional methods. Particularly in carbon emission monitoring applications, distributed sensor networks can precisely track the entire carbon

footprint across the value chain from raw material extraction to product delivery (World Economic Forum, 2023). Specifically, the deployment of environmental sensors facilitates continuous monitoring of key sustainability indicators, including energy consumption patterns, wastewater discharge parameters, and air quality metrics (International Energy Agency, 2023). In industrial applications, the integration of smart meters with energy management systems enables equipment-level energy consumption monitoring, providing a data foundation for systematic energy efficiency optimization (Zhang et al., 2023). Regarding social dimension data collection, employee safety sensors and workplace environmental monitoring devices have significantly improved the accuracy and responsiveness of occupational health and safety management systems (International Labour Organization, 2023).

Blockchain technology provides unique and increasingly indispensable capabilities for ensuring the credibility and verifiability of ESG information. Wang's (2023) supply chain survey indicates that organizations implementing blockchain solutions achieve approximately 30% higher ESG report credibility ratings than traditional methods. This improvement primarily stems from three distinctive blockchain characteristics: a distributed storage architecture preventing unauthorized data modifications, an encrypted timestamp mechanism ensuring chronological integrity, and smart contract functionality enabling automated verification processes (Tapscott & Tapscott, 2023). In the context of ESG management across supply chains, blockchain technology demonstrates exceptional value in addressing traceability challenges within complex multi-level supply chain networks. By establishing distributed supply chain information platforms, organizations can monitor critical sustainability parameters in near real-time, including raw material sourcing, environmental performance during production processes, and compliance with labor rights (WBCSD, 2023). This operational transparency not only enhances corporate ESG performance but also strengthens trust among consumers, investors, and regulatory bodies (Accenture, 2023).

Artificial intelligence has made remarkable strides in ESG data processing and interpretation. Chen and Li (2024) developed a natural language processing system that automatically parses unstructured ESG documents, identifies material issues, and evaluates disclosure quality with approximately 85% accuracy. Its implementation in financial institutions has significantly enhanced the efficiency and consistency of ESG risk assessments (Chen & Li, 2024). Specifically, natural language processing applications in ESG encompass three key areas: automated ESG report analysis, which rapidly extracts and categorizes material information to boost analysts' productivity; social media sentiment analysis, providing real-time monitoring of public perception regarding corporate ESG performance to support reputation risk early warning systems; and regulatory text analysis, which automatically identifies and interprets evolving ESG compliance requirements to reduce regulatory uncertainty and implementation costs (Deloitte, 2023).

In the field of predictive analytics, Liu's (2024) machine learning model demonstrates remarkable capabilities by analyzing historical patterns and external contextual variables to forecast ESG risk events approximately six months in advance, achieving over 80% accuracy. This modeling approach specifically addresses social risk factors such as labor rights disputes and community tensions—challenging dimensions often overlooked by traditional quantitative models (Liu, 2024). Machine learning algorithms also excel in environmental risk prediction. By processing multidimensional data streams including historical environmental performance, meteorological information, and production schedules, these models can accurately estimate future environmental impacts, enabling proactive management interventions (McKinsey, 2023). For instance, machine learning-based emission prediction systems in manufacturing help optimize production scheduling while ensuring environmental compliance (BCG, 2023).

Big data technology empowers organizations to process vast and diverse ESG information that was once unimaginable. Johnson's (2024) research demonstrates that enterprises implementing big data analytics can complete comprehensive ESG impact assessments within hours—compared to traditional processes that take weeks or even months. This efficiency breakthrough stems from three technological innovations: enhanced processing capabilities through distributed computing frameworks, real-time analytical capabilities enabled by stream processing technologies, and the ability to identify relational patterns through graph database applications (White, 2023). Specifically, big data applications in ESG management manifest in three capability dimensions: multi-source data integration, which effectively combines internal operational data, external environmental information, and social feedback mechanisms; real-time analytical capabilities, supporting instant processing

and interpretation of continuously generated ESG data streams; and pattern recognition capabilities, identifying performance trends and relational patterns within complex sustainability datasets (Manyika et al., 2023).

Following the discussion on technology drivers such as IoT, blockchain, and AI, Figure 1 offers a macro-level view, illustrating how these technologies work together to form a cohesive ecosystem for ESG data application.
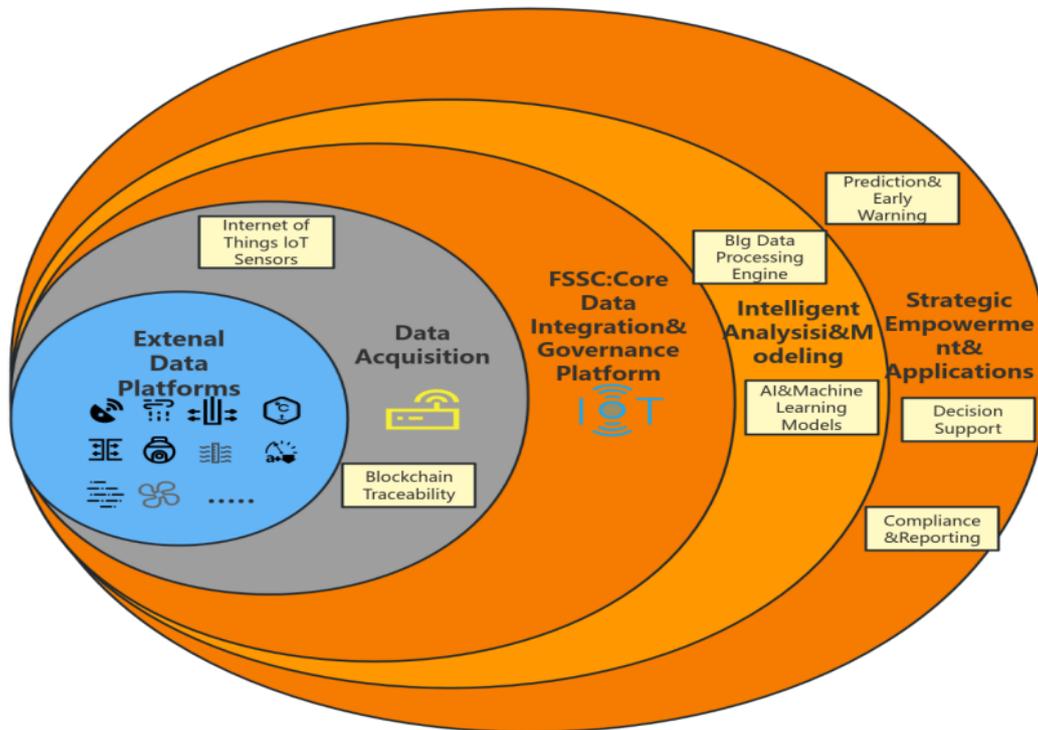

Figure 1. ESG Data Technology Application Ecosystem Architecture

This figure depicts the end-to-end flow of ESG data,from collection to decision-making support. As shown, data originates from various sources, including internal systems like ERP and HR, as well as external IoT sensors and third-party platforms. This raw data converges into a technology ecosystem centered around the Financial Shared Service Center (FSSC), where it is processed and analyzed using key technologies like big data and AI. Ultimately, this ecosystem transforms fragmented and unstructured data into strategic insights that directly serve corporate risk management, performance evaluation, and strategic planning. The architecture clearly demonstrates the FSSC's role as the central hub, coordinating the entire data value chain.

4)FSSC evolution and ESG integration

The evolution of FSSC and its integration with ESG play a crucial role in promoting ESG integration. Chen Jing and Huang Jianguo (2023), based on a survey study of China enterprises, revealed three key dimensions of FSSC's functional transformation: the shift from transaction processors to data hubs, the evolution from cost centers to value creators, and the transition from standardized service providers to personalized solution designers. Specifically, the new functions of FSSC in ESG digital transformation are reflected in four key areas: First, as an ESG data management center, it is responsible for establishing unified data standards and governance norms; Second, as an ESG process optimization center, it drives the standardization and automation of relevant business processes; Third, as an ESG analysis service center, it provides professional data analysis and decision support; Finally, as an ESG reporting center, it ensures the accuracy and timeliness of information disclosure.

The four-stage transformation model proposed by Wang Xiaoming and Li Zhigang (2023) further refines the evolutionary path of FSSC supporting ESG management. This model emphasizes that successful transformation requires achieving four key breakthroughs: cloud-based upgrades of technical architecture to ensure system resilience, standardized data governance to guarantee data quality, enhanced intelligent analytical capabilities to strengthen decision support, and deepened business integration to create synergistic value. Their follow-up study shows that enterprises completing these four transformation stages achieved a reduction of ESG

management costs by over 25%, an improvement in management efficiency by 40%, and a 35% enhancement in decision quality.

In practice, FSSC's support for ESG management capacity building should include: establishing dedicated ESG data management teams to develop standards and ensure quality control; creating an integrated ESG management platform for unified data collection, processing, and analysis; developing an ESG indicator system to incorporate ESG factors into existing management accounting reporting frameworks; and cultivating interdisciplinary professionals with expertise in financial, environmental, social, and governance (ESG) fields. To elaborate on how the FSSC itself should evolve to support ESG management, we summarize a four-stage transformation model in Table 1.

Table 1: FSSC Support for ESG Management: Four-Stage Transformation Model

Phase	Core tasks	Technology	Expected results
Cloud-based technical architecture	Cloud transformation of infrastructure; System integration and interface standardization	Cloud computing platform; API joggle	Elastic scaling; Enhanced data processing capability
Standardize data governance	Establish ESG data standards; Quality Management Standard;	Smart ETL Tools Data Governance Platform	Data quality improved significantly; Enhanced report reliability
Intelligent analysis capability	Deploy AI analytics tools; Create a prediction model	Machine learning algorithm; Natural language processing	Improved decision support capabilities; Improved accuracy of risk warnings
Deepen business integration	ESG embedded in core processes to establish collaborative mechanisms	RPA Digital Twin	Reduce management costs by more than 25%; Improved decision quality by 35%

Table 1 details the four transformation stages the FSSC needs to undergo to fulfill its ESG enabling role. The model indicates that transformation begins with the cloud-upgrading of the technical architecture to achieve sufficient scalability and data processing power. Building on this, the second stage requires establishing a standardized data governance system, which is critical for ensuring ESG information quality and credibility. The third stage involves developing intelligent analysis capabilities, using tools like machine learning to transform data into forward-looking insights. The final stage achieves deep integration with business operations, making ESG management a core element for creating synergistic value. The table clearly lists the core tasks, key technologies, and expected outcomes for each stage, providing a detailed blueprint for the FSSC's transformation planning.

B. Implementing challenges: multidimensional analysis

Through systematic literature review, this study identifies three primary challenges affecting ESG-driven management accounting transformation: technical integration complexity, organizational adaptation barriers, and economic implementation constraints.

Understanding these multidimensional challenges is crucial for developing effective implementation strategies and academic research agendas.

1) Technical Integration Complexity

Data standardization remains the foremost technical barrier in ESG digital transformation. The World Business Council for Sustainable Development (WBCSD) 2023 Global Assessment revealed significant variations among major ESG reporting frameworks in indicator definitions, measurement methodologies, and disclosure requirements. This fragmentation in regulatory and methodological standards poses substantial implementation challenges for organizations in collecting, processing, and reporting sustainability information. Specifically, data standardization challenges manifest in three key dimensions: inconsistent measurement methods, divergent reporting requirements, and conflicting validation criteria. System compatibility issues are particularly pronounced in traditional industries. Smith and Johnson (2024) found that over 60% of manufacturing enterprises encounter technical integration obstacles during legacy system modernization. These barriers primarily emerge through three technical dimensions: incompatible data interfaces leading to information silos and integration failures; differing system architectures hindering process integration and data flow; and conflicting technical standards compromising interoperability and collaboration efficiency.

2) Organizational Adaptation Barriers

Organizational cultural transformation is a critical factor for the success of ESG digital initiatives. Successful digital transformation typically involves profound cultural evolution, requiring changes to deeply rooted assumptions, values, and behavioral patterns（Chen，2024）. This cultural transformation must overcome three major obstacles: departmental silos leading to information hoarding and collaboration resistance; traditional mindsets hindering innovation implementation; and existing organizational structures and interest distribution causing resistance to change. The talent capability gap is growing increasingly severe in rapidly evolving technological environments. Global assessment found that there is a 40% shortage of professionals with both ESG knowledge and digital technology skills (Liu &Zhang,2024)). This capability gap is particularly evident in three professional fields: limited ESG understanding in data science; technical implementation gaps in environmental engineering functions; and insufficient analytical capabilities in sustainability management units.

3) Economic constraints: Uncertainty about return on investment impacts corporate decision-making.

Wang's (2023) financial analysis reveals that while ESG digital investments demonstrate significant long-term value, their short-term returns remain highly uncertain. This uncertainty primarily stems from three factors: the complexity of measuring returns, difficulties in cost allocation, and the time lag in realizing value. Cost pressures pose particular challenges for small and medium-sized enterprises (SMEs).

According to calculating, a medium-sized enterprise requires an investment of $2 million to $5 million to implement a comprehensive ESG digital system, equivalent to 15%-30% of its annual profits (Johnson,2024). Such large-scale investments represent a substantial financial burden for many SMEs. Another manifestation of cost pressures is the continuous rise in operational expenses. ESG digital systems not only demand upfront investments but also require ongoing maintenance and upgrade costs. Through literature review, we have identified multidimensional challenges and summarized them alongside potential countermeasures in Table 2.

Table 2: ESG Digital Transformation Implementation Challenges and Response Strategies

Category	Specific challenges	Impact level	Potential response strategies
Technical integration complexity	Data standards are not uniform、 Poor system compatibility; Difficult to upgrade legacy systems	High	Establish enterprise-level data standards using middleware technology
Resistance to organizational change	Departmental culture differences; Talent skill gaps; Performance evaluation mismatch	Medium High	Phase-based system upgrades; Establish cross-departmental collaboration mechanisms; Strengthen the cultivation of interdisciplinary

			talents; Optimize the performance evaluation system
Economic constraints	Uncertain return on investment; Significant cost pressure; Long realization cycle of returns	Middle	Establishing a value assessment framework; seeking policy support; adopting a phased investment strategy

Table 2 systematically categorizes the major obstacles enterprises might face during ESG digital transformation. These challenges are grouped into three categories: Technical Integration Complexity, Resistance to Organizational Change and Economic Constraints. For each specific challenge, the table not only assesses its impact level but also proposes corresponding response strategies. For instance, strategies for technical integration include establishing enterprise-wide data standards and utilizing middleware technology; for talent gaps, the focus is on cultivating interdisciplinary professionals. This table serves as a "diagnosis and action" checklist for enterprises, helping them anticipate challenges and formulate more comprehensive implementation plans.

C. *Establish a theoretical framework*

Based on literature analysis, this paper constructs a three-level theoretical framework composed of data layer, process layer and intelligent layer, and systematically expounds the theoretical path of ESG-driven digital transformation of management accounting.

Figure 2. Theoretical framework

1). Data layer

Existing literature emphasizes that the data layer serves as the cornerstone of the entire theoretical framework, with its core mission being to establish a unified and reliable ESG data management platform (Johnson & Brown, 2024). Given its capability to process multi-structured data, enterprise-level data lake architectures have become the preferred solution for ESG data management (Thompson & Lee, 2024). In terms of data collection, the literature generally supports integrating ESG data from various channels: internal structured data originates from business systems such as ERP, human resources (HR), and environmental, health, and safety (EHS); internal unstructured data is obtained through IoT sensors and intelligent document processing technologies; while external data can be acquired via API interfaces from supplier databases, government platforms, and third-party institutions (Chen Jing & Huang Jianguo, 2023).

Data governance is vital for ensuring the quality of ESG data. Research indicates that companies should establish unified ESG data standards and quality management systems, while adopting intelligent ETL (Extract, Transform, Load) tools to automate data processing (World Business Council for Sustainable Development, 2023). Existing studies confirm that a robust ESG data governance framework can significantly enhance data reliability, thereby improving decision-making relevance (Eccles & Krzus, 2023).

2). Process layer integration

Literature analysis indicates that the process layer primarily focuses on integrating ESG factors into daily operations. This integration requires the application of various digital technologies, including robotic process automation (RPA), business process management (BPM), and blockchain systems (Johnson & Brown, 2024; Van der Aalst, 2023). The study proposes several theoretical implementation pathways: automating carbon emission accounting and reporting through RPA applications; integrating ESG risk assessment nodes into procurement workflows; linking ESG performance metrics to financing conditions via smart contracts; and incorporating environmental resource constraints into budget control systems (Thompson & Lee, 2024; ACCA, 2023).

Extensive evidence demonstrates that these process integration mechanisms can transform ESG management from passive compliance to proactive value creation (Wilson & Davis, 2023; Porter & Kramer, 2023). Existing research provides theoretical validation for the critical role of process-level integration in enhancing ESG management effectiveness and organizational influence (Zhang & Liu, 2024).

3). Smart layer applications

Research analysis demonstrates that the intelligent layer leverages advanced technologies such as artificial intelligence, machine learning, and predictive analytics to transform ESG data into strategic organizational insights (Thompson & Lee, 2024; Davenport, 2023). Current studies explore various theoretical applications: using machine learning algorithms to predict energy demand patterns and emission trajectories; employing natural language processing to monitor emerging ESG risks; simulating ESG performance under different scenarios through digital twin technology; and developing integrated reporting systems that combine ESG and financial performance metrics (Johnson & Brown, 2024; Iansiti & Lakhani, 2023).

Extensive evidence indicates that these advanced analytical capabilities theoretically enable organizations to proactively manage ESG risks and opportunities (Wang & Li, 2023). Existing research provides theoretical validation for the critical value of intelligent layer applications in enhancing the foresight and strategic responsiveness of ESG management (Eccles & Krzus, 2023).

II) ESG-FSSC Integration Roadmap

To translate the above theoretical framework into practical guidance, we further propose a phased implementation roadmap, as shown in Figure 3.
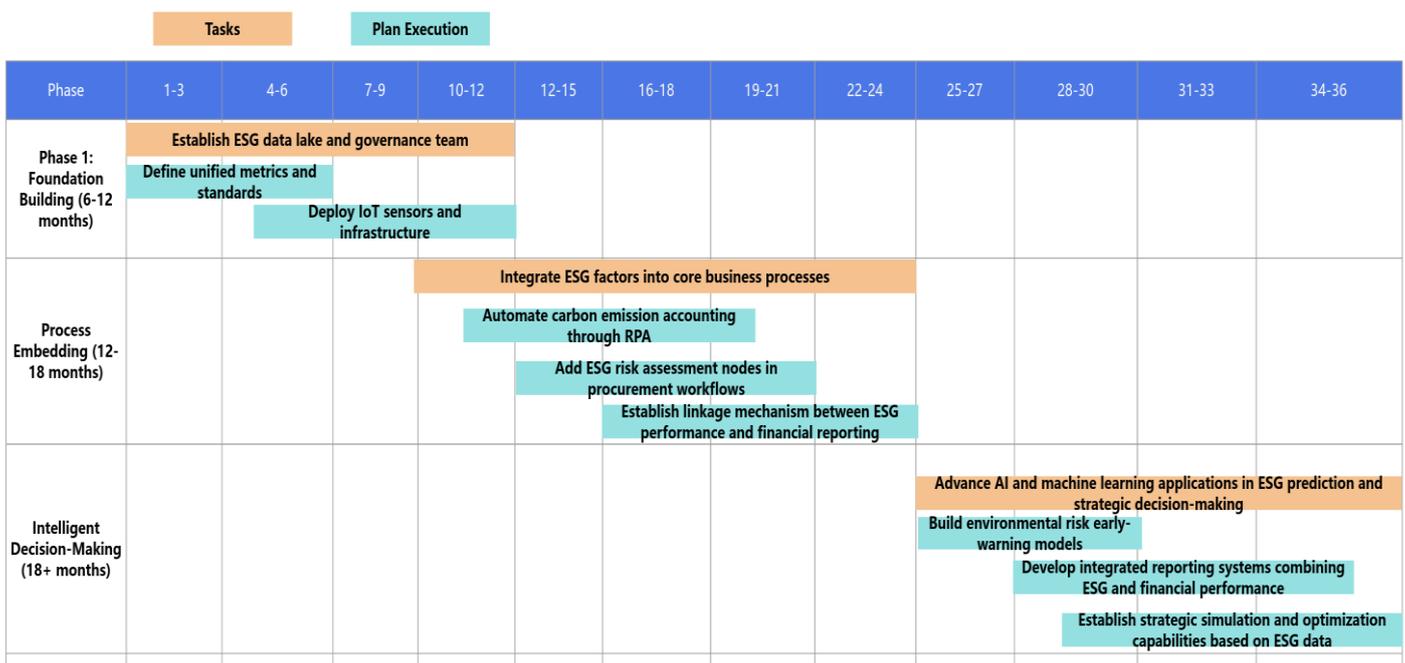

Figure 3: ESG-FSSC Integrated Implementation Roadmap

Figure 3 outlines a clear, three-stage journey for integrating ESG into the FSSC, providing actionable guidance for enterprises:

Phase 1 (Infrastructure Development), estimated at 6-12 months, focuses on "laying the groundwork," including building an ESG data lake, establishing a unified metrics framework, and deploying data collection devices.

Phase 2 (Process Integration), following closely and lasting 12-18 months, centers on "weaving" ESG factors into existing processes like procurement, accounting, and reporting to achieve automated management.

Phase 3 (Intelligent Decision-Making) is the long-term goal, aiming to widely apply AI technologies for ESG risk prediction and strategic simulation, ultimately enabling data-driven sustainable strategic decisions.

Each phase defines specific key tasks, tools, and quantifiable Key Performance Indicators (KPIs), ensuring a controllable implementation process and measurable outcomes.

CONCLUSION

1）Conclusions

This study systematically reviews and synthesizes existing literature to establish a theoretical framework for ESG-driven digital transformation of management accounting under the FSSC framework. The framework elaborates on the theoretical connections between ESG principles and management accounting digitalization across three architectural dimensions: data infrastructure, process integration, and intelligent applications. The theoretical contributions of this research are reflected in three key aspects: First, it integrates multiple theoretical perspectives to provide a comprehensive understanding of ESG-driven management accounting transformation. Second, it systematically synthesizes existing research findings while clarifying the limitations of current knowledge systems and theoretical frameworks. Finally, it proposes actionable roadmaps that offer practical guidance for organizational implementation.

2）Limitations

Although this study has developed a FSSC-based theoretical framework for ESG-driven management accounting digital transformation through systematic literature review, certain limitations remain.

• Methodological limitations: This study employed a literature review methodology. While effectively synthesizing existing theoretical perspectives, it fundamentally lacks empirical validation. The proposed three-tier theoretical framework and practical roadmap require empirical testing to validate their effectiveness and applicability in real-world organizational settings.

• Limitations of literature: The existing literature on FSSC-ESG integration remains in its developmental phase. Most studies focus on large enterprises and manufacturing environments, with insufficient discussion on its applicability to SMEs and service industries.

• Insufficient policy integration depth: While this paper incorporates policy and regulatory analysis, it does not thoroughly examine the varying ESG regulations across jurisdictions and their implications on the FSSC framework.

3)Future research directions

Based on the theoretical framework constructed in this study, the following promising directions are worth exploring for future research:

• Empirical verification and industry adaptation research: Use case studies, questionnaires and other methods to verify the effectiveness of the framework, and develop customized implementation paths for different industries such as finance, energy and manufacturing.

• Policy-driven FSSC architecture research: Analyze the impact of global ESG disclosure regulations (e.g., CSRD, SEC Climate Disclosure Rules) on FSSC data architecture and process design, and develop compliance-oriented technical implementation solutions.

• Human-machine collaborative decision-making mechanism research: Explore the application patterns of new technologies such as generative AI in ESG report analysis and decision support, and study the optimal collaboration mode between human professional judgment and AI automated analysis.

• Lightweight Solutions for SMEs: Develop modular, low-cost, and rapid-deployment ESG-FSSC integration solutions to address resource constraints in SMEs, enhancing the inclusiveness and applicability of the theoretical framework.

• ESG Digital Maturity Model Development: Create a comprehensive evaluation framework that assesses ESG digital maturity across multiple dimensions, including technical capabilities, process integration, decision support, and value creation, to help enterprises identify their current status and chart development strategies.

This study enhances theoretical understanding of ESG-driven digital transformation in management accounting, thereby advancing the development and refinement of conceptual frameworks in this emerging field. Furthermore, the proposed theoretical framework and practical roadmap provide substantial conceptual and operational guidance for organizational implementation, facilitating the effective execution of digital transformation and sustainable development strategies for management accounting systems across diverse industry contexts and organizational scales.

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