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Scenarios and Trends of Internal Control-ESG Integration in China's Small and Medium-Sized Manufacturing Enterprises

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ABSTRACT

This study investigates the integration of internal control and ESG (Environmental, Social, and Governance) within China's small and medium-sized manufacturing enterprises, analyzing practical applications and developmental trajectories from 2015 to 2025. Findings reveal a strategic shift from "passive compliance" to "active value creation," driven by technological diffusion and policy evolution. Technology adoption demonstrates a distinct "trickle-down" effect, with IoT and AI solutions becoming accessible to SMEs through government subsidies and "small, fast, lightweight, and precise" toolkits. The policy landscape has evolved significantly, particularly with the 2025 Green Factory initiative, which replaces third-party mandates with stringent carbon footprint tracking requirements, thereby incentivizing firms to develop proprietary data management systems. Despite progress, SMEs face persistent challenges, including dynamic compliance burdens, technological integration barriers, and fragile governance frameworks. Case analyses highlight divergent outcomes: while firms like Lenovo Group and Sunwoda Energy have achieved success through supply chain collaboration and data monetization, others, such as Jiuyou Investment, have faced severe risks due to the misalignment of ESG initiatives with financial controls. Looking ahead, ESG internal control is expected to become more democratized, regionally coordinated, supply-chain-centric, and globally standardized. To navigate this landscape efficiently, SMEs are advised to adopt a hybrid strategy combining phased implementation, policy leverage, and ecosystem partnerships. This research contributes a theoretical framework and actionable insights for building ESG-centric internal control systems in the manufacturing sector.

Keywords: Internal Control; ESG Integration; Manufacturing Industry; Small and Medium-sized Enterprises (SMEs); Green Factory; Technology Application

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1. Introduction

1.1 Research Background and Significance

Against the backdrop of global economic green transformation and the deepening concept of sustainable development, Environmental, Social, and Governance (ESG) has become a critical metric for assessing corporate sustainability capabilities. China's 14th Five-Year Plan explicitly proposes the strategic goal of "promoting green development and fostering harmonious coexistence between humanity and nature." The 2020 update of the Paris Agreement further reinforces the ESG responsibilities of Chinese manufacturing enterprises. Meanwhile, as the core mechanism for enterprise risk management, the integration of internal control with ESG has become an inevitable choice for companies to enhance governance standards, prevent compliance risks, and achieve sustainable development.

The manufacturing sector serves as the backbone of China's economy, accounting for over 27% of GDP. However, the degree of integration between ESG practices and internal control systems varies significantly. Leading enterprises have achieved systematic ESG internal control, whereas SMEs often remain at the stage of "tick-box compliance." This divergence not only affects the overall competitiveness of China's manufacturing industry but may also trigger supply chain restructuring risks under "green trade barriers." Particularly with the formal implementation of the EU Carbon Border Adjustment Mechanism (CBAM) in 2025, higher demands are placed on the ESG performance of manufacturing enterprises. SMEs urgently need to explore integration pathways for ESG and internal control that align with their unique characteristics.

1.2 Research Status and Gaps

In recent years, academic interest in the integration of internal control and ESG has grown both domestically and internationally. From a theoretical perspective, research in this domain is

primarily grounded in sustainable development theory, stakeholder theory, and risk management theory. On the practical side, however, scholarly focus has largely centered on large enterprises or listed companies exemplified by case studies of ESG frontrunners like Alibaba and Tencent. While research dedicated to ESG-internal control integration within manufacturing SMEs remains relatively scarce.

The limitations of existing studies are evident in three key areas: First, there is a lack of specialized research addressing the integration of ESG and internal control in manufacturing SMEs, with insufficient consideration given to their resource constraints and unique characteristics. Second, systematic analyses of the new features emerging post-2020, such as technological trickle-down, policy shifts, and supply chain collaboration are inadequate. Third, empirical studies exploring the implementation pathways and lessons learned from SMEs' ESG-internal control initiatives are limited. This paper aims to bridge these research gaps, providing theoretical guidance and practical references for the integration of ESG and internal control in China's manufacturing SMEs.

1.3 Research Methodology and Framework

This study employs a mixed-methods approach, integrating literature review, case analysis, and comparative research to systematically analyze the integration of ESG and internal control in China's manufacturing SMEs from 2015 to 2025. The research framework is structured as follows: First, it reviews the theoretical foundations of integrating internal control with ESG. Second, it analyzes the current status, policy environment, and challenges facing manufacturing SMEs in this integration process. Third, it explores emerging characteristics and trends observed in the past two years. Subsequently, it examines practical pathways and lessons learned through representative case studies. Finally, it proposes future development trends and strategic recommendations.

2. Theoretical Foundation of Internal Control and ESG Integration

2.1 Theoretical Association between ESG and Internal Control

The integration of ESG and internal control is grounded in a solid theoretical foundation. From a governance perspective, ESG embeds itself into corporate governance through board supervision, ethical leadership, and risk management, aligning closely with the control environment element of internal control. From a risk management perspective, ESG risks (such as environmental violations and labor rights issues) require identification and management through the internal control mechanism of “risk assessment and response.” From a compliance standpoint, ESG requirements have become a critical compliance domain that enterprises must adhere to, such as the EU’s CSRD and the U.S. SEC’s ESG disclosure requirements.

The COSO framework provides a systematic approach for ESG internal control integration. In 2023, COSO released the Internal Control Framework for Sustainability Reporting (ICSR), incorporating ESG into the five elements of internal control (Control Environment, Risk Assessment, Control Activities, Information and Communication, and Monitoring). Specifically, the environmental dimension corresponds to integrity and ethical values within the “Control Environment”; the social dimension is related to supply chain risks in “Risk Assessment”; and the governance dimension is directly associated with the “Control Environment” and “Monitoring” elements. This framework provides theoretical guidance for the integration of ESG internal control in manufacturing SMEs.

2.2 Sustainable Development Theory and ESG Internal Control

Sustainable development theory emphasizes that while creating economic value, enterprises must also balance environmental and social benefits. The

integration of ESG into internal control is a practical manifestation of this theory. By incorporating ESG risks into the internal control system, companies can systematically identify, assess, and manage ESG-related risks, while simultaneously seizing opportunities arising from sustainable development.

Stakeholder theory provides theoretical support for ESG internal control integration. Manufacturing SMEs need to balance the expectations of multiple stakeholders, including shareholders, employees, customers, suppliers, and communities. Through the integration of ESG and internal control, enterprises can better meet stakeholders’ expectations, thereby enhancing their corporate image and market competitiveness. For instance, Changzhou Power Electric has incorporated suppliers’ green performance into its annual evaluation system, resulting in 112 national-level green factories joining its supply chain network, with a raw material recycling rate reaching 99%.

2.3 Specificity of ESG Internal Control in Manufacturing SMEs

Significant differences exist in ESG internal control between manufacturing SMEs and large enterprises. From the perspective of resource constraints, SMEs face limitations in funding, technology, and talent, necessitating low-cost strategies such as “step-by-step compliance.” Regarding governance structure, most SMEs have not established dedicated ESG departments, often relying on low-cost approaches like “integrating ESG clauses into corporate charters.” In terms of technology application, SMEs struggle to afford the deployment costs of large-scale ERP systems and must achieve ESG internal control through “small, fast, lightweight, and precise” solutions.

Agile governance theory provides a new approach for ESG internal control integration in manufacturing SMEs. This theory emphasizes that under conditions of limited resources, enterprises should respond to ESG challenges through flexible and rapid governance mechanisms. For example, COSCO Shipping Guangdong solved the VOCs

treatment challenge in the shipbuilding industry by independently developing wall-climbing eco-friendly painting robots, accumulating over 10 national environmental patents.

3. Current Status and Challenges of ESG Internal Control Integration in China's Manufacturing SMEs

3.1 Evolution of the Policy Environment

The policy landscape for ESG internal control integration in China's manufacturing sector has transitioned from an "exploratory phase" to a "mandatory phase." In 2015, the State Council released Made in China 2025, introducing the concept of green manufacturing. In 2020, the Ministry of Ecology and Environment and fifteen other departments jointly issued the Implementation Plan for Establishing a Carbon Footprint Management System. In 2023, the Shanghai, Shenzhen, and Beijing stock exchanges released the Guidelines for Sustainable Development Reporting of Listed Companies, promoting ESG disclosure. In 2024, the General Office of the State Council issued the Action Plan for Green and Low-Carbon Development of the Manufacturing Industry (2025–2027), clarifying the "dual carbon" goals. In 2025, the Ministry of Industry and Information Technology (MIIT) and two other departments released the Several Opinions on Promoting High-Quality Development of Environmental Protection Equipment Manufacturing, driving the mandatory standardization of environmental protection equipment.

The 2025 Green Factory policy is a pivotal turning point. It abolished the mandatory third-party evaluation report requirement, shifting to a self-declaration plus dynamic audit model, thereby reducing compliance costs for SMEs. However, it simultaneously strengthens carbon footprint tracking requirements, driving enterprises to build proprietary data systems. Furthermore, the policy landscape exhibits regional differentiation: Wuhan offers a 1 million RMB reward, Anhui offers 500,000

RMB, while Shenzhen allows micro-enterprises to transition via municipal-level green factory accreditation, reflecting regional adaptability in policy implementation.

3.2 Current Status Analysis

The integration of ESG and internal control within manufacturing SMEs exhibits a "stratified" characteristic. Leading enterprises have achieved systematic integration; for example, By-health was recognized by the Ministry of Ecology and Environment's Education and Communication Center as an outstanding 2025 ESG case study for its "Transparent Factory," which promotes full lifecycle environmental management through open production. Lenovo Group has established a "Global Supply Chain ESG Digital Platform" covering 95% of its production suppliers, creating a replicable industry model. Sunwoda Energy has built a three-tier governance structure comprising the General Manager, an ESG Committee, and a Sustainable Development Department, achieving reductions of 15.0%, 22.3%, and 14.8% in Scope 1, 2, and 3 greenhouse gas emissions respectively in 2024 compared to 2023.

SMEs are adopting a strategy of "low-cost initiation + leveraging policy support" for ESG integration. According to the 2025 Corporate ESG Blue Book, while China's total ESG investment scale reached approximately 40.31 trillion RMB in 2024, SMEs' ESG disclosure and implementation rates remain significantly lower than those of large enterprises. Specifically, the ESG reporting disclosure rate for A-share industrial companies in Sichuan was only 35%, far below the national average of 46%. SMEs primarily rely on basic certifications (e.g., ISO 14001), utilize government templates for report compilation, join industry alliances to share audit resources, and seek "Environmental Performance Level A" certification for additional benefits.

In terms of technology application, 60% of mandatory disclosure enterprises adopt dual materiality analysis; however, only 50% of SMEs disclose stakeholder engagement, and their analytical

methods are often rudimentary. While leading enterprises deploy advanced technologies such as AI energy-saving systems and blockchain traceability, SMEs rely on basic tools (e.g., carbon accounting software) and government subsidies (e.g., rooftop photovoltaic subsidies).

3.3 Major Challenges Faced

The integration of ESG and internal control in manufacturing SMEs faces three core challenges:

Increasing Dynamic Compliance Pressure The 2025 Green Factory policy stipulates that national green factories ranking in the bottom 5% for three consecutive years will be delisted. Simultaneously, international regulations such as the EU CBAM are forcing enterprises to establish carbon footprint tracking systems. Due to weak data management, SMEs are vulnerable to the risk of “achieving compliance but subsequently slipping back.” For example, an automotive parts company was removed from a German client’s supplier list because it could not provide carbon footprint data for its production processes, resulting in a direct loss of 30% of its annual revenue.

Obvious Technology Adaptation Bottlenecks Integrating ESG and internal control requires support from technologies such as the Internet of Things (IoT), AI, and blockchain, but SMEs struggle to afford the adaptation costs. According to data from ICAS Intertek Certification, the average cost for ESG compliance assessments in the manufacturing sector in 2023 ranged from 150,000 to 800,000 RMB, a dispersion far exceeding that of other industries. Data collection costs account for 35%-45% of the budget in the electronics manufacturing industry, whereas traditional equipment manufacturing requires only 15%-25%. When a new energy battery company disclosed its ESG report for the first time, the audit fee was as high as 820,000 RMB, whereas a machinery manufacturing company of similar scale completed its compliance disclosure for only 280,000 RMB.

Weak Governance Structures Restricting Integration Most SMEs have not established

dedicated ESG departments, and board oversight of ESG matters is insufficient. Among mandatory disclosure entities in Zhejiang Province in 2025, only 90.6% of companies disclosed their board’s supervision of ESG matters, while 10% did not disclose this information at all. This weak governance structure leads to a disconnect between ESG and internal control, resulting in “tick-box compliance” issues.

4. New Characteristics and Trends in ESG-Internal Control Integration for Manufacturing SMEs in Recent Years

4.1 Technology Democratization: From Large Enterprises to Inclusive Adoption by SMEs

In recent years, the integration of ESG and internal control within manufacturing SMEs has been characterized by the “trickling down” of advanced technologies. IoT has transitioned from being exclusive to large enterprises to becoming a core tool for SMEs. Enterprises in the Changzhou Economic Development Zone have achieved energy visualization through a “solar-storage microgrid + digital twin” technology, reaching an energy self-sufficiency rate of 14.3%. Zhejiang Shengzhong Machinery utilized the Trina Solar storage system to reduce energy costs and meet international carbon traceability requirements, shortening its investment payback period to 2.3 years. Hunan Taixin Ceramics implemented an IoT platform, achieving annual energy cost savings of 4.4 million RMB, recycling 33,316 GJ of industrial waste heat annually, and reducing CO2 emissions by 5,806.5 tons.

The adoption of AI and industrial internet platforms is accelerating. Sinotech has built an industrial internet cloud platform covering edge, IaaS, PaaS, and SaaS layers. Driven by AI, this platform facilitates intelligent upgrades across the entire production chain, directly serving 21 enterprises and indirectly benefiting over 900, helping partner firms improve production efficiency by over 2% and reduce operating costs by over 2%.

Yonyou, in collaboration with Shuangliang Group, implemented a smart O&M platform for energy equipment via a public cloud model, helping clients reduce operational energy consumption by 30% and save 1.38 million RMB in electricity costs annually.

4.2 Policy-Driven Transformation: From “Formal Compliance” to “Substantive Integration”

The 2025 Green Factory policy has propelled the integration of ESG and internal control in manufacturing SMEs from “formal compliance” toward “substantive integration.” By eliminating the requirement for third-party reports while mandating carbon footprint tracking, the new policy drives enterprises to build proprietary data systems (such as energy management platforms), demonstrating a significant regulatory forcing effect. Simultaneously, the policy environment exhibits regional differentiation: Jiangsu Province offers bonus points for “Specialized, Refined, Unique, and Innovative” enterprises applying for green factory status; Guangdong Province reduces transformation costs via “small, fast, lightweight, and precise” domestic software; while central and western provinces attract SME participation through high-percentage subsidies.

The new green factory standards have strengthened quantitative indicators. The 2025 General Rules for Green Factory Evaluation introduced mandatory metrics such as “carbon footprint tracking” and “energy decarbonization,” which collectively account for 60% of the total weight, setting higher requirements for SMEs’ ESG internal control systems. Policy orientation has also shifted from “broad-spectrum cultivation” to “key breakthroughs,” focusing support on 53 specific key industries and directing resources toward sectors with significant impact on the national economy, high carbon emissions, and urgent needs for green transformation.

4.3 Innovation in Cost Control Strategies: From “One-time Investment” to “Phased Implementation”

Manufacturing SMEs are actively exploring innovative cost control strategies in the process of integrating ESG and internal control. The “step-by-step compliance” model has become mainstream. For example, a machinery plant in Changzhou completed its green factory certification at a cost 40% lower than the industry average over three years: conducting an ISO 14064 greenhouse gas verification in the first year, deploying a photovoltaic + energy storage system in the second year, and obtaining an Environmental Product Declaration (EPD) through eco-design in the third year.

Technology sharing and ecosystem collaboration are reducing transformation costs. Models such as Trina Solar’s “consulting-construction-operation” approach with channel partners and Sinotech’s industrial internet platform, which serves 21 enterprises, reflect the trend of SMEs sharing technology costs through external cooperation. A predictive model jointly released by ICAS Intertek Certification and Tsinghua University indicates that as the penetration rate of IoT monitoring devices increases, ESG data governance costs in the manufacturing sector are expected to decrease by 18%-22% by 2025.

The assetization of ESG data is creating additional revenue. Leading enterprises are beginning to convert ESG data into digital assets. For instance, a photovoltaic company developed a carbon asset management system using historical emissions data, which not only meets disclosure requirements but also generates additional revenue in the carbon trading market, increasing the return on investment (ROI) of ESG initiatives by over 40%. Haier Smart Home improves resource utilization through product recycling data, while LiuGong reduces 15,700 tons of carbon annually through its photovoltaic power station, transforming ESG outcomes into direct economic benefits.

5. Typical Case Analysis: Practical Pathways and Lessons Learned

5.1 Successful Case: The Integrated Path of Technology-Driven Innovation and Policy Leverage

Case 1: Liugong Machinery – “Empowering Green Transformation with Intelligence, Building a New Manufacturing Paradigm”

Guangxi LiuGong Machinery Co., Ltd. has deeply integrated ESG principles into the core of its corporate strategy, utilizing technological innovation as an engine. Through the dual-driven approach of “intelligence and green,” the company has established a smart and eco-friendly manufacturing system. The loader intelligent factory deploys 102 robots and 82 AGVs, applying laser cutting and digital twin technologies, increasing production capacity by 15% and shortening the manufacturing cycle by 50%; the excavator smart factory achieves an automation rate exceeding 70%. In terms of energy optimization, the company has built a photovoltaic power station with a capacity of approximately 29 MW, generating 27.77 million kWh annually, reducing unit painting energy consumption by 16%, and cutting carbon emissions by 15,700 tons per year. Regarding closed-loop resource recycling management, the remanufacturing program achieves an 85% recovery rate of old parts with performance reaching 95% of new products, comprehensive wastewater reuse exceeds 60%, and electroplating wastewater is 100% regenerated. This case was recognized as an outstanding ESG case by the Ministry of Ecology and Environment’s Education and Communication Center in 2025, with its Wind ESG rating upgraded to A and its Hua Zheng ESG rating upgraded to AA.

Analysis of Practical Pathways: Liugong’s success is primarily reflected in three aspects. First, it deeply integrates ESG governance mechanisms with intelligent manufacturing by establishing an ESG leadership group headed by senior executives and cross-departmental execution teams to ensure the step-by-step implementation of ESG goals.

Second, it focuses on tackling key technologies such as mixed gas shielded welding and dry cutting technology to achieve source-level carbon reduction. Finally, it leverages policy dividends, such as the new green factory application policy, reducing compliance costs through the self-declaration and dynamic audit model while simultaneously enjoying government subsidies.

Case 2: Hunan Taixin Ceramics Co., Ltd. — IoT Platform Drives Refined Energy Management

Hunan Taixin Ceramics addressed the challenges prevalent in the ceramics industry, such as low digitalization in manufacturing, incomplete energy usage data, information opacity, a lack of precise energy consumption metrics, and high energy costs by implementing an IoT platform. This initiative promotes refined energy management, emission reduction controls, and digital carbon management throughout the production process.

Key measures include:

- **Refined Energy Management:** Real-time energy monitoring via the IoT platform and cloud computing for data processing, achieving visualization of energy consumption data.
- **Emission Reduction Control:** Enhancing data collection and analysis capabilities through a smart energy-saving “Dual-Carbon” platform and an integrated monitoring management system.
- **Digital Carbon Management:** Deploying automated monitoring devices to track energy consumption and carbon emissions in real-time, optimizing carbon management through data collection and management.

These measures have enabled the company to recover and utilize 33,316 GJ of industrial waste heat annually, achieve a 42% power load regulation capacity, reduce annual energy costs by 4.4 million RMB, save 1,908.61 tons of standard coal equivalent (tce), and reduce CO₂ emissions by 5,806.5 tons. This has driven industrial upgrading, cost reduction, and efficiency gains.

Analysis of Practical Pathways: The success of

Hunan Taixin Ceramics lies in the deep integration of ESG internal control with production operations. By utilizing the IoT platform for real-time data collection and analysis, the company translates ESG requirements into specific production parameter optimizations. It adjusts equipment operating parameters based on energy consumption data via the MES system to lower energy use and implements pollution and emission reduction controls through the smart energy-saving “Dual-Carbon” platform, closely aligning ESG with actual business operations. This case validates the effectiveness of the “technology tools + policy leverage” model.

5.2 Failure Case: The Risk of Disconnection between ESG and Financial Internal Control

Case 1: The Contradiction between Jiu You Investment’s ESG Report and Financial Fraud

Hubei Jiu You Investment Co., Ltd. was forced into delisting due to its organization, instigation, and participation in financial fraud over three consecutive years, resulting in the overstatement of profits in its annual reports by more than 34.36 million RMB. From an ESG perspective, the company’s ESG report claimed “adherence to compliant operations” and boasted of a “sound risk control system,” a reality that stood in stark contradiction to the facts of financial fraud. Its supply chain segment failed to disclose fictitious self-circulating businesses, and the report’s content, lacking substantive data support, was questioned by investors as “vague and general.” This case exposed a systemic failure at the governance level. Chairman Li Ming, as the actual controller, used his power to lead the fraud, reflecting a hollow internal control mechanism where independent directors and auditing institutions failed to fulfill their duties effectively.

Analysis of Lessons Learned: The failure of Jiu You Investment reveals the risks of a disconnection between ESG and financial internal control. Once a company formally discloses ESG or sustainability information, it constitutes an official “declaration” to its stakeholders. Failure to fulfill these commitments can lead to negative impacts on legal, financial, and

reputational standing. This case serves as a warning to manufacturing SMEs: ESG internal control must be deeply integrated with financial internal control to avoid “greenwashing” and discrepancies between reports and reality. Enterprises need to establish a board supervision mechanism for ESG matters to ensure the implementation and oversight of ESG strategies.

Case 2: The Contradiction between Fuan Dongfang’s ESG Report and Subsidiary Pollution Issues

Fuan Dongfang claimed “zero-carbon logistics” in its ESG report released in April 2024. However, the company faced pollution issues at its subsidiary and failed to establish a cross-verification mechanism between ESG data and financial data, leading to regulatory penalties and a collapse of market trust. In 2025, the company received a “Pre-Penalty Notice” from the Guangdong Securities Regulatory Bureau for two years of financial fraud and will be fined 6.5 million RMB; simultaneously, its stock ticker changed to “ST Fuan.”

Analysis of Lessons Learned: The failure of Fuan Dongfang reveals the systemic risk of ESG internal control being disconnected from actual business operations. This case indicates that ESG internal control must permeate all departments and processes, establishing a linkage mechanism between ESG data and financial data to ensure report authenticity. Simultaneously, enterprises need to establish an ESG risk early-warning mechanism to promptly identify and address ESG-related risks, avoiding discrepancies between ESG performance and actual operations.

5.3 Case Study on Regional Disparities: Innovative Practice of a Shared Smart Manufacturing Ecosystem

Case: Chongqing Saihang Wire Mesh’s “Shared Smart Manufacturing” Ecosystem

Facing the bottlenecks of outdated equipment and extensive production methods prevalent in the wire mesh industry, Chongqing Saihang Wire Mesh

Manufacturing Co., Ltd. benefited from the local government's "external introduction and internal cultivation" policy. The government established R&D platforms, upgraded and retrofitted over 3,000 high-end devices, and fostered a group of benchmark enterprises for industrial upgrading. Simultaneously, building a "shared smart manufacturing" ecosystem at its core, the region constructed shared pilot plants, shared testing platforms, and shared standard workshops. This allowed small and micro enterprises to "move in ready-made," achieving green production with low costs and high efficiency. Today, Saihang's wire mesh products have entered high-end fields such as aerospace and semiconductors, serving as supporting components for the nation's major equipment.

Analysis of Practical Pathways: The case of Chongqing Saihang Wire Mesh demonstrates the role of regional policies in promoting the integration of ESG and internal control in manufacturing SMEs. The "government guidance + enterprise leadership + shared platform" model solved the problems of high R&D costs and technical barriers for SMEs. Shared infrastructure such as pilot plants and testing platforms lowered the technical threshold for ESG and internal control integration. Furthermore, shared standard workshops addressed the issue of insufficient investment in environmental protection facilities by SMEs. This case provides a replicable regional collaboration model for the integration of ESG and internal control in manufacturing SMEs in central and western regions.

6. Future Development Trends and Recommendations

6.1 Future Development Trends

Accelerated Technology Democratization

Industrial internet platforms (e.g., the Sinotech case) and AI tools (e.g., Haili Electric's carbon footprint analysis system) will accelerate their penetration, driving automation and real-time data processing in ESG internal control. It is estimated that by 2028, China will have built over 450 industrial internet

platforms, with equipment connections surpassing 120 million units and a platform penetration rate exceeding 55%, providing SMEs with low-cost, high-efficiency technical solutions for ESG internal control.

Regionalized Policy Orientation The policy environment will continue to exhibit regional differentiation. Central and western provinces will attract SME participation through high-percentage subsidies (e.g., Sichuan's subsidy of 35% on energy expenditure and Henan's 20% subsidy on equipment investment for specialized, refined, unique, and innovative enterprises). Coastal regions, on the other hand, will promote ESG internal control integration through green finance innovations (e.g., Guangdong's "One Platform, Three Systems" and Jiangsu's "Step-by-step Compliance" model). SMEs need to select the most suitable policy leverage path based on their geographical characteristics.

Normalized Chain-based ESG Management

"Chain-based ESG management," led by core enterprises, will become a core path for SMEs to reduce costs and increase efficiency. Lenovo Group has utilized its "Global Supply Chain ESG Digital Platform" to cover 95% of its production suppliers, driving suppliers representing 42% of procurement value to commit to or implement science-based carbon targets. XPeng Motors improved suppliers' carbon data reporting efficiency by 80% and reduced supply chain carbon intensity by 15% through a digital carbon management system and collective training. In the future, chain-based ESG management will extend from leading enterprises to SMEs, forming a collaborative ecosystem of "core-enterprise-led + SME participation."

Internationalized Compliance Requirements

The EU CSRD will require medium-sized enterprises to disclose supply chain ESG data starting in 2026, forcing Chinese manufacturing SMEs to enhance their ESG internal control levels. France and the United States have already criminalized "greenwashing," with potential fines of up to 2 million euros for environmental misinformation in advertising or communications. This means that

Chinese manufacturing SMEs, especially export-oriented ones, need to deploy blockchain traceability or introduce international certification bodies in advance to meet international ESG compliance requirements.

6.2 Practical Recommendations for Manufacturing SMEs

Technology Adaptation Strategy Manufacturing

SMEs should select ESG internal control tools tailored to their specific characteristics. It is recommended to prioritize modular, low-cost ESG solutions (such as Yonyou SaaS platforms) and combine them with government subsidies (e.g., Hunan's digital transformation subsidies) to reduce investment. Energy-intensive enterprises can deploy IoT energy monitoring systems to replace 60% of manual record-keeping, reducing data collection costs by 18%-22%. Export-oriented enterprises should consider introducing blockchain traceability technology to ensure supply chain ESG data traceability and avoid international "greenwashing" risks.

Policy Leverage Pathways SMEs should select the most suitable policy leverage pathways based on their geographical location. Enterprises in central and western regions can fully utilize local energy subsidies (e.g., Sichuan's 35% subsidy) and equipment renewal grants (e.g., Henan's 20% subsidy). Enterprises in the Yangtze River Delta can finance through financial instruments such as green bonds (per the joint notice from MIIT and the PBOC) and green credit (e.g., interest rate reductions of 15%-20% for "Little Giant" enterprises in Jiangsu). Enterprises in the Pearl River Delta can leverage government-built digital platforms (e.g., Guangdong's "One Platform, Three Systems") to lower the technological barriers to ESG internal control.

Participation in Chain-based Management

SMEs should actively integrate into the ESG systems of leading enterprises to reduce transformation costs through "chain-based ESG management." It is recommended to cooperate with core enterprises

such as Lenovo and BYD, participate in their ESG training programs, and obtain technical support. Collaboration with channel partners like Trina Solar to adopt a "consulting-construction-operation" model for deploying photovoltaic and storage systems is also advised. Additionally, partnering with specialized institutions such as Shanghai Chaowang can provide access to carbon data integration and HIGG verification services at a cost controlled within 3.5 million RMB. Through chain-based collaboration, SMEs can leverage the resources and experience of core enterprises to lower the technological and cost barriers to ESG internal control integration.

Governance Structure Optimization SMEs should optimize their governance structures to ensure the effective implementation of ESG internal control. Establishing dedicated ESG positions or partnering with external consultants is recommended. For example, Heritage family businesses hired consulting firms specializing in developing ESG strategies for family manufacturing enterprises, starting with a comprehensive materiality assessment to identify ESG issues most relevant to business and stakeholder expectations. Establishing a board-level supervision mechanism for ESG matters can improve ESG reporting quality. Incorporating ESG goals into executive performance evaluations and incentive mechanisms ensures the execution and supervision of ESG strategies. Through governance optimization, SMEs can enhance the systematic nature and effectiveness of their ESG internal control integration.

7. Conclusion and Outlook

Through an analysis of the theoretical foundations, current status, challenges, new characteristics, and typical cases regarding the integration of internal control and ESG for small and medium-sized enterprises (SMEs) in China's manufacturing sector, this paper draws the following conclusions:

First, the integration of ESG into internal control has become an inevitable choice for the

sustainable development of manufacturing SMEs. Theoretically, the COSO framework provides a systematic methodology for this integration. From a practical standpoint, changing policy environments and international ESG compliance requirements are forcing enterprises to enhance their ESG internal control. In terms of competitive advantage, strong ESG performance has become a crucial means for companies to secure orders, financing, and market recognition.

Second, the integration of ESG and internal control in manufacturing SMEs exhibits a “stratified” characteristic. Leading enterprises have established systematic ESG internal control frameworks, whereas SMEs generally remain at the stage of “low-cost initiation + policy leverage.” Regarding technology application, while IoT and AI technologies are trickling down from large enterprises to SMEs, the latter still face the challenge of high adaptation costs. Concerning the policy environment, the 2025 Green Factory policy eliminates third-party reports but mandates carbon footprint tracking, pushing enterprises to build their own data systems. Furthermore, the policy landscape continues to show distinct regional differences.

Third, the integration of ESG and internal control in manufacturing SMEs has exhibited three new characteristics in the past two years: the decentralization of technology application, policy-driven transformation, and innovative cost-control strategies. The decentralization of technology is evidenced by the accelerated popularization of IoT and AI technologies via government subsidies and “small, fast, light, and precise” solutions. Policy-driven transformation is shifting the focus from “formal compliance” to “substantive integration,” with the new Green Factory standards emphasizing quantitative indicators. Innovations in cost control are manifested in “step-by-step compliance” models, technological sharing and ecosystem collaboration, and the assetization of ESG data.

Finally, the analysis of typical cases reveals the key success factors and potential risks of ESG internal control integration. Successful cases

demonstrate that technology-driven initiatives and policy leverage are vital paths to integration. Failed cases warn of the risks of a disconnect between ESG and financial internal control. Cases highlighting regional differences indicate that shared smart manufacturing ecosystems can provide low-cost, high-efficiency solutions for SMEs.

Looking ahead, the integration of ESG and internal control in manufacturing SMEs will follow four major trends: accelerated technology democratization, regionalized policy orientation, normalized chain-based ESG management, and internationalized compliance requirements. SMEs should adopt a strategy of “phased implementation + policy leverage + ecosystem cooperation” to achieve a low-cost, efficient transformation.

As the “Dual Carbon” goals and the global ESG standard system mature, the integration of ESG into internal control will shift from “compliance-driven” to “value-creation” for manufacturing SMEs, becoming a core mechanism for enhancing competitiveness, reducing risks, and achieving sustainable development. Enterprises must view ESG internal control as a long-term strategy rather than a short-term task. By leveraging technological innovation, policy support, ecosystem collaboration, and governance optimization, SMEs can build ESG internal control systems tailored to their specific characteristics, seizing opportunities and mitigating risks to achieve high-quality development amidst the green transformation wave.

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