International Journal of Education and Social Development
ISSN: 3078-9931 (Print), ISSN: 3078-2287 (Online) | Vol. 4, No. 2, 2025

Research on the Early Warning Function and Implementation Path for Sustainability Accounting in Corporate Governance

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Abstract: As global sustainable development progresses, businesses face increasing challenges in the areas of environmental, social, and governance (ESG). Against this backdrop, sustainability accounting, through the systematic integration of non-financial information, provides crucial support for companies to establish forward-looking risk early warning mechanisms. This article focuses on the risk identification, assessment, and early warning functions of this mechanism within the corporate governance framework. Research shows that by quantifying ESG performance, identifying key influencing factors, tracking long-term trends, and analyzing them in conjunction with financial data, sustainability accounting can provide early signals of a variety of potential risks, such as pressure to comply with environmental regulations, a lack of social responsibility in the supply chain, damaged corporate reputation, and declining sustainable competitiveness. However, the mechanism remains plagued by a number of bottlenecks in its practical application, including a lack of unified data standards, insufficient management attention, an inadequate audit mechanism, and weak governance embedding. To address these issues, this article proposes a systematic, phased approach: first, defining material issues, establishing unified indicators, and strengthening the integration of internal and external information; then, incorporating sustainability risks into strategic decision-making and establishing independent verification procedures; and ultimately, achieving a deep integration of sustainability performance and corporate value creation. Comprehensively integrating sustainability accounting into corporate governance structures is not only a key measure to enhance organizational resilience and long-term value but also provides a theoretical basis and practical reference for relevant policy formulation and management practices.

Keywords: Sustainability accounting, Corporate governance, Early warning function, ESG risks, Implementation path, Risk governance.

1. Introduction

Against the backdrop of growing global warming, resource scarcity, and social inequality, businesses are facing unprecedented operational pressures, and traditional financial management models appear insufficient. Frequent non-financial risks such as environmental pollution, labor disputes, supply chain disruptions, and information security incidents not only result in significant economic losses but also severely damage a company's reputation and sustainability capabilities. Against this backdrop, the concept of sustainable development has become central to corporate strategy, and companies urgently need to integrate ESG risks into their governance frameworks for systematic management. Sustainability accounting has emerged as a key component of this effort, transcending traditional accounting to comprehensively measure, record, and report on a company's performance across multiple dimensions: economic, environmental, and social.

Ensuring a company's long-term viability and value creation is the fundamental goal of governance, which in turn requires effective management of all types of ongoing operating risks. However, faced with the inherent long-term, external, complex, and highly uncertain nature of ESG risks, traditional governance mechanisms often lag and fall short. Sustainability accounting, with its unique advantages in information integration and analysis, injects a forward-looking, early-warning perspective into corporate governance[1]. By establishing a system of non-financial indicators, it dynamically monitors the evolution of key ESG factors and identifies potential correlations with a company's financial health, operational resilience, and market position. How to make a company's sustainability accounting to issue early warning signals before risks emerge and help improve the foresight and resilience of corporate governance has become a key issue.

Therefore, it is of great theoretical significance and practical urgency to deeply explore how sustainable development accounting can be integrated with corporate governance structures and effectively build a risk warning mechanism. This article focuses on analyzing the internal operating logic and mechanism of action of this mechanism, identifying the main obstacles it faces in the process of embedding into the corporate governance system, and then proposing a phased, operational and systematic implementation path, which provides a theoretical basis and practical reference for enterprises to enhance organizational resilience and cope with increasingly complex sustainable risks, and has important reference value.

2. The Conceptual Evolution of Sustainable Development Accounting

Sustainable development accounting is not a new product. Its theoretical prototype is rooted in the practical accumulation of social responsibility accounting and environmental accounting in past development stages.

In the 1970s, with the rise of public environmental awareness and the expansion of corporate social influence,

scholars and practitioners began to focus on measuring the environmental and social impacts of corporate activities. This is considered the precursor to sustainable development accounting[2].

In the 1990s, the concept of "sustainable development" gained widespread global recognition. The publication of the Brundtland Report, in particular, prompted the accounting community to consider how to incorporate the economic, environmental, and social triple bottom line into corporate performance evaluation systems. During this period, environmental accounting, encompassing environmental cost accounting, environmental liability recognition, and pollutant emission measurement, and social accounting, focusing on issues such as employee well-being and community contributions, achieved initial development, but the connections between them were relatively weak[3].

Entering the 21st century, the initiatives of the United Nations Global Compact (UNGC) and the continuous updates of the Global Reporting Initiative (GRI) Sustainability Reporting Guidelines significantly promoted the standardization of sustainability reporting frameworks. With the increasing pressure of climate change, sub-fields such as carbon accounting have emerged[4].

Recently, the establishment of organizations such as the International Sustainability Standards Board (ISSB) and the promotion of its standards are accelerating the transformation of sustainability disclosure towards mandatory disclosure, standardized standards, and financial information integration, continuously expanding and deepening the scope and core of sustainability accounting [5].

Sustainability accounting and financial accounting both provide information to decision makers, helping company management, investors, creditors and other stakeholders to more comprehensively assess the company's overall performance, long-term resilience and future development prospects. However, Sustainability accounting goes beyond the scope of traditional financial accounting and expands the accounting boundaries from monetary transactions and historical information to the multidimensional value creation process.It strives to systematically identify, quantify, record, analyze, and report on the positive and negative impacts of an organization's operations, products, and services on the economy, environment, and society throughout their lifecycles, as well as the risks and opportunities these impacts pose to the company's long-term value creation. It is regulated by the International Sustainability Standards Board and focuses on information covering a wide range of topics, including but not limited to: energy and water consumption, greenhouse gas emissions, and waste management; employee health and safety, diversity and inclusion, supply chain labor standards, and community relations; as well as business ethics, anti-corruption, data privacy, risk management, and the effectiveness of governance structures. Sustainability accounting emphasizes the relevance, foresight, and externality of information, which is the theoretical foundation for its integration into corporate governance and its early warning capabilities.

3. Types of Sustainable Development Accounting: Green Accounting, Carbon Accounting

Green accounting, also known as environmental accounting, is a key branch of sustainable development accounting. Currently, it is widely considered by academics to be an emerging accounting discipline that uses currency as its primary unit of measurement and is based on relevant environmental laws and regulations. It studies the relationship between economic development and the environment, measures and records the costs of environmental pollution, environmental prevention and control, and environmental development, and evaluates environmental performance and the impact of environmental activities on corporate financial results. The scope of green accounting encompasses various aspects, including resource consumption, waste disposal, ecological protection, and environmental liabilities. Its core focus is on incorporating environmental factors into the accounting system and using accounting methods to reflect and control corporate environmental activities.

Carbon accounting, a further development of green accounting within the context of a low-carbon economy, is a branch of green accounting that specifically addresses the accounting treatment of economic activities related to carbon emissions. Carbon accounting primarily covers energy-saving investments, low-carbon fixed assets, environmental protection fees payable, low-carbon revenue, low-carbon energy-saving incentives, and carbon costs. With the establishment and development of carbon trading markets, carbon accounting also focuses on the accounting treatment of carbon emission assets, carbon liabilities, and related gains and losses generated by companies participating in carbon trading. Carbon accounting calculations and reporting must adhere to national carbon emission reduction policies and international carbon market rules, requiring a high degree of professionalism and specificity[6].

From a disciplinary perspective, carbon accounting is a crucial component of green accounting, and the two are closely linked. Green accounting provides a fundamental theoretical framework and methodological guidance for carbon accounting, while carbon accounting represents the specific application and practical deepening of green accounting in addressing climate change. Both strive to promote energy conservation and emission reduction, improve resource efficiency, and achieve balanced economic and environmental benefits through accounting methods. However, in terms of specific focus, green accounting emphasizes a comprehensive assessment of a company's overall environmental impact, while carbon accounting focuses more on carbon footprint management and the disclosure of carbon-related risks and opportunities. In practice, companies need to organically integrate the two and incorporate them into a sustainable development accounting system to comprehensively and accurately reflect their environmental performance and fulfillment of their responsibilities.

4. Analysis of the Early Warning Function of Sustainability Accounting within the Corporate Governance Framework

In corporate governance, the core early warning function of sustainable development accounting is reflected in the early identification, assessment and signal transmission of ESG risks, which buys critical time for management and the board of directors to respond to risks and make strategic decisions. This mechanism mainly acts on the following key aspects:

Compliance and Regulatory Risk Early Warning: By continuously tracking and quantifying a company's performance in environmental protection, labor, and business ethics, and by comparing and analyzing it against increasingly stringent domestic and international regulations and industry standards, sustainability accounting can proactively alert companies to potential compliance gaps, administrative penalties, litigation risks, and the resulting financial liabilities and reputational damage. For example, accurate calculation and trend analysis of carbon emissions data can provide early warning of future risks of rising carbon tax costs or insufficient carbon trading quotas[7].

Operational Disruption and Supply Chain Risk Early Warning: Environmental and social factors pose significant threats to the stability and operational continuity of a company's supply chain. By assessing resource dependencies, mapping supply chain ESG risks, and tracking supplier performance data, sustainability accounting can proactively identify vulnerabilities that could lead to production disruptions, raw material shortages, or cost surges, providing early warning signals of insufficient supply chain resilience[8].

Reputational Capital and Market Risk Warning: Stakeholders such as investors, employees and consumers are increasingly concerned about a company's ESG performance. Negative ESG events can quickly damage a company's reputation, leading to customer loss, brand devaluation, increased financing costs, and even investor withdrawal. Sustainability accounting can provide early warning of potential reputational crises and market exclusion risks by monitoring ESG indicators highly correlated with reputation and analyzing the correlation between ESG performance and consumer preferences and investor capital flows[9].

Long-Term Competitiveness and Transition Risk Warning: The global transition to a low-carbon, sustainable economy is an irreversible trend. Sustainability accounting analyzes a company's investment and performance in green technology R&D, clean energy utilization, circular economy model application, and employee future skills training, and compares these with industry benchmarks, technological development trends, and policy guidance. It can assess a company's preparedness for climate change, adapting to the circular economy, and meeting the demands of emerging markets, and can provide early warning of the risk of declining long-term competitiveness due to technological backwardness, rigid business models, or a talent structure unsuitable for future needs [10].

The realization of this early warning function depends on the systematic, quantifiable and comparable ESG data provided by sustainable development accounting, as well as the ability to conduct substantive analysis based on actual situations.

5. Analysis of Current Obstacles to the Early Warning Function of Sustainability Accounting

Despite its significant early warning potential, sustainable development accounting still faces a series of practical obstacles to effectively fulfilling its early warning function in corporate governance:

Information quality and standardization deficiencies: This is one of the most core obstacles. The diverse measurement methods for non-financial data, scattered data sources, and highly subjective collection processes lead to challenges in the reliability, comparability, and consistency of the data. Despite the existence of reporting frameworks and standards provided by multiple organizations such as SASB (now incorporated into ISSB) and GRI, the disclosure of most ESG indicators, with the exception of climate-related information, is still voluntary rather than mandatory, and differences between different standards still exist. This situation makes it difficult to strictly compare data between companies, and external stakeholders face difficulties in using data for cross-company risk assessments. Internal management is also concerned about relying on this data for accurate early warning decisions. The huge "noise" in the data ultimately severely weakens the clarity and credibility of the early warning signals.

Inadequate Management Awareness and Strategic Integration: Many senior executives still view sustainable development as a cost center or a public relations issue, rather than a core strategic issue and source of risk. A lack of understanding of the early warning value of sustainable development accounting leads to insufficient resource investment. ESG information is often separated from financial information and strategic planning processes, and ESG risks are not systematically integrated into a company's overall risk assessment framework and strategic decision-making. Even when early warning information is generated, it rarely reaches decision-makers or triggers substantive action[11].

Weak governance structures and accountability mechanisms: The board of directors and its specialized committees lack clear oversight responsibilities for ESG risks and inadequate professional capabilities. There is a lack of clear accountability for the collection, analysis, early warning reporting, and follow-up of sustainability accounting information. Internal audit departments often lack sufficient expertise and authorization to conduct independent, in-depth audits of the quality of ESG data and the effectiveness of early warning processes. This results in a lack of organizational support and authority for the early warning process, and early warning results may be ignored or shelved[12].

Lack of internal control systems and audit assurance: Compared with mature internal controls over financial reporting, internal control systems for non-financial data are generally inadequate. Inadequate process controls in data collection, processing, and verification increase the risk of data errors and fraud, weakening the reliability of the early warning foundation. Furthermore, external assurance primarily focuses on limited assurance of historical ESG reports, with a serious lack of independent verification of the key data and internal forecasting models supporting early warnings, reducing the credibility of early warning information[13].

Technology and talent bottlenecks: Efficient data collection, integration, and analysis require strong information system support and data analysis capabilities, which many companies' existing IT architectures struggle to support. At the same time, there is a severe shortage of comprehensive talent with both accounting and ESG expertise, risk management capabilities, and data analysis skills, hindering the development of high-quality early warning models and the analysis and interpretation of complex ESG risks[14].

These obstacles are intertwined and seriously hinder the generation, transmission and decision-making application of sustainable development accounting early warning signals.

6. Designing an Implementation Path for Building a Sustainable Development Accounting Early Warning System

To overcome these obstacles and fully leverage the early warning effectiveness of sustainability accounting in corporate governance, a systematic and step-by-step implementation path is necessary:

6.1. Top-Level Drive and Governance Embedding

Leadership must fully recognize the impact of ESG risks on the company's long-term value, elevate the sustainability accounting early warning mechanism to a strategic level, and deeply integrate it into the company's core strategy. Responsibilities should be clearly defined: the board of directors assumes ultimate oversight of ESG risks, while management is responsible for specific implementation. It is also recommended that a dedicated organization be established to spearhead the development of the system and be granted cross-departmental coordination authority to ensure implementation. Furthermore, a sound policy framework should be established, with clear sustainability accounting and risk management policies formulated. The objectives, principles, and structure of the early warning mechanism should be clearly defined to provide institutional support for its effective operation.

6.2. Defining Material Topics and Building an Indicator System:

Materiality assessments must integrate industry characteristics, business models, and stakeholder concerns, systematically identifying ESG issues with significant operational and financial impacts and prioritizing them as early warning areas. Indicator screening should focus on material issues, selecting quantifiable and measurable key performance indicators (KPIs), prioritizing international standards for comparability. Indicator definitions, statistical caliber, data sources, and update frequency should be clearly defined. Early warning thresholds must be set based on the company's historical data, industry standards, policies and regulations, and risk appetite, categorizing risk levels and establishing actionable quantitative or qualitative trigger conditions.

6.3. Data Governance and System Support:

It is necessary to establish a comprehensive ESG data governance system, clarify responsibilities, and establish unified standards for data collection, storage, processing, and verification to ensure data quality and consistency. This will promote cross-departmental collaboration and information sharing, and improve data integration efficiency through centralized storage and integrated management via a unified platform. Information systems should be strengthened to enable automated collection, processing, and visualization. Leveraging big data and artificial intelligence technologies, this will enable intelligent risk identification and automated early warning[15].

6.4. Institutionalize Risk Quantification and Early Warning Processes:

The following specialized analysis models can be applied within the sustainable development accounting early warning system for risk quantification and early warning:

Environmental risk analysis models: Material Flow Cost Accounting (MFCA) model; Life Cycle Assessment (LCA) model.

Social risk analysis models: Social Life Cycle Assessment (SLCA) model; Human Resource Risk Index model.

Comprehensive risk analysis models: ESG rating weighting model; Multi-Criteria Decision Analysis (MCDA) model.

Standardize early warning mechanisms and establish a full-process management system covering triggering, reporting, assessment, response, and tracking. Clarify reporting paths, timelines, and response templates for each risk level. Integrate ESG risks into the enterprise comprehensive risk management (ERM) system, conducting regular assessments, dynamic monitoring, and prioritization.

6.5. Independent Assurance, Performance Linkage, and Continuous Improvement:

Introduce an independent assurance mechanism, incorporate key data and processes within the ESG early warning system into the audit scope, and enhance information credibility and trust among all parties through systematic audits. Tie the management effectiveness of core early warning indicators to the performance of departments and executives, and leverage assessment mechanisms to strengthen accountability. Establish an early warning response tracking and evaluation system, regularly review threshold settings, indicator selection, and process design, and promote continuous optimization of the system, achieving closed-loop management and self-iteration. This approach systematically advances the development of the governance structure, indicator system, and operating mechanism. Through layered implementation and a comprehensive closed-loop approach, it ensures the effective implementation of the ESG system and its continued value creation.

7. Key Mechanisms for Strengthening Early Warning Effectiveness

Sustainability accounting systematically quantifies ESG performance, tracks long-term trends, and correlates financial impacts, providing early warnings for key areas of corporate governance, such as environmental compliance, supply chain disruptions, and reputational risk. This early warning function relies on the systematic collection, classification and quantitative analysis of non-financial information, which can significantly enhance the company's early identification and proactive prevention and control capabilities for environmental, social and governance (ESG) risks. However, its effectiveness remains constrained by inconsistent data standards, insufficient management awareness, unclear accountability, and a shortage of technical talent[16].

Overcoming these obstacles requires a systematic approach: First, the responsibilities of the board of directors and management should be clarified, a standardized indicator system and risk early warning mechanism should be established, data integration and technology application should be strengthened, and ESG risks should be fully embedded in business processes and linked to performance.

Effective early warning relies on five key mechanisms:

Strengthening internal audit controls by incorporating ESG

into the audit system, enhancing internal audit independence and external audit coverage;

Strengthening board oversight by clarifying responsibilities and establishing a challenge mechanism to promote member capacity building;

Enhancing cross-departmental collaboration, breaking down data silos, and building a unified platform for joint response;

Coordinating talent and technology, cultivating a multidisciplinary ESG team, and introducing AI and blockchain to enhance predictive capabilities;

Leveraging external feedback to achieve a closed-loop management system, disclosing ESG performance, incorporating input from all parties, and participating in standard setting.

Companies that deeply integrate sustainability accounting can not only effectively mitigate ESG risks but also build new competitive advantages in their green transformation. Going forward, we should focus on industry-specific indicators, optimize risk quantification models and assessment technologies, and continuously improve our early warning and governance frameworks.

8. Conclusion

By incorporating ESG factors, sustainability accounting provides an important path for companies to establish forward-looking risk prevention and control mechanisms. The key lies in transforming non-financial information into quantifiable decision-making insights, helping companies identify potential risks in areas such as compliance, supply chain, and reputation, thereby enhancing organizational resilience and sustainable competitiveness.

Currently, this field faces numerous constraints, including data quality, governance mechanisms, and professional capabilities. Systematic advancement is needed across four levels: governance structure, data foundation, technical tools, and institutional design, to truly integrate sustainability accounting into a company's core decision-making system.

This article theoretically analyzes its risk early warning mechanism, providing a theoretical basis for improving corporate governance. Future research, based on industry specificities, can explore the application of intelligent technology in risk early warning and promote the further integration of theory and practice in this field.

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