ESG Management Accounting for Corporate Low-Carbon Transformation: A Comparative Case Study Between High-Pollution and Green Industries

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Abstract: Against the backdrop of the accelerated implementation of global carbon neutrality strategies, Environmental, Social, and Governance (ESG) management accounting, as a core tool for balancing corporate environmental responsibility and economic performance, is seeing its theoretical and practical significance become increasingly prominent. This paper, grounded in the Resource-Based View (RBV) [1], employs a comparative case study method, selecting representative firms from a high-pollution, high-profit industry, Shanghai Port (600018), and a benchmark green food industry firm, Sysco (SYY), for empirical analysis. It explores the differential pathways and effectiveness of ESG management accounting in facilitating low-carbon transformation across different industries.

The research finds: Firstly, high-pollution enterprises can achieve a "green-profit" win-win through environmental cost internalization. For example, Shanghai Port's shore power electrification transformation reduced single-container energy consumption by 40% and increased the ESG investment return rate to 9%. Secondly, green industry firms can leverage ESG premiums to enhance market competitiveness; Sysco achieved a 23% reduction in carbon emissions through low-carbon cold chain technology, with a green product premium rate of 12% [2]. Thirdly, innovation in management accounting tools is a core driver of industry low-carbon transformation; the Environmental Management Accounting (EMA) system helped high-pollution firms reduce environmental costs by 11.2%, while the Life Cycle Assessment (LCA) model assisted green firms in accurately identifying and realizing carbon asset benefits. Based on these conclusions, this paper further proposes recommendations for constructing a differentiated green financial policy incentive system and advancing the development and application of ESG-AI prediction systems. These aim to provide actionable, systematic solutions for enterprises in different industries to achieve low-carbon transformation through management accounting, while also offering empirical reference for the industry-specific application of ESG management accounting theory.

Keywords: ESG Management Accounting; Environmental Cost Accounting; Carbon Asset Pricing; High-Pollution Industry Transformation; Green Premium

1. Introduction

The accelerated pace of global climate governance has turned corporate low-carbon transformation from an "optional topic" into an "imperative." Management accounting, as a core tool linking corporate strategy and operations, plays an increasingly critical role in coordinating environmental responsibility and economic performance. Currently, the global industrial sector contributes 73% of greenhouse gas emissions, making it the core battleground for achieving carbon neutrality goals (Intergovernmental Panel on Climate Change, IPCC) [3]. In China, the development paradox of high-pollution industries (e.g., ports, steel, chemicals) is particularly acute—these industries, accounting for 30% of national GDP, generate 70% of the industrial carbon footprint, bearing the dual burden of ensuring economic growth while facing stringent emission reduction constraints (Sun Qiming, 2024) [8]. Under this dual pressure, the survival and development space for high-pollution enterprises continues to narrow. Policy-wise, the formal implementation of the European Union's Carbon Border Adjustment Mechanism (CBAM) has directly increased product costs for China's high-pollution industries by 5-8%, weakening international competitiveness (World Trade

Organization, WTO) [4]. Market-wise, ESG ratings have become a key reference for capital allocation; firms with ratings below BBB face not only declining investor confidence but also a financing cost increase of 2.3 percentage points compared to highly-rated firms, further exacerbating financial pressure (Morgan Stanley Capital International, MSCI) [5].

In stark contrast to the transformation dilemma of high-pollution industries, green industries are experiencing explosive growth opportunities. The global sustainable investment market continues to expand, with ESG fund assets exceeding $2.7 trillion by 2023, indicating a significant rise in capital preference for green industries (Global Sustainable Investment Alliance, GSIA) [6]. Consumer demand for green products is also steadily releasing; research by Batool et al. (2025) shows that the premium for green products compared to traditional counterparts has reached 12-25%, with consumer willingness to pay still rising [2]. This "polar opposite" industry landscape indicates fundamental differences in the core contradictions and value propositions faced by different industries in ESG practice. How to address these industry-specific ESG challenges through management accounting tools has become a critical issue urgently needing resolution in both theoretical research and corporate practice.

Based on this, this paper focuses on the following three core research questions:

(1) Under emission reduction compliance pressure, how can high-pollution industry enterprises optimize environmental cost accounting and control ESG compliance costs (referring to the expenses incurred by enterprises to meet ESG-related regulatory requirements, including emission fees, carbon allowance purchases, environmental taxes, and fines for non-compliance) by using management accounting tools, so as to achieve a balance between "emission reduction" (measured by indicators such as annual carbon emission reduction volume and carbon emission intensity per unit of output) and "profitability" (measured by indicators such as return on assets (ROA), return on equity (ROE), and gross profit margin)?

(2) Bolstered by market dividends, how can green industry enterprises use management accounting tools to quantify the contribution of ESG performance (evaluated by indicators such as carbon footprint intensity, renewable energy usage ratio, and supplier ESG scores) to financial indicators (including operating income, net profit, and market share), transforming environmental advantages into sustainable financial competitive advantages?

(3) What are the essential differences between high-pollution and green industries regarding the objective orientation, tool selection, and value realization paths in ESG management accounting, and what is the underlying logic?

To address these questions, this paper adopts a comparative case analysis method, selecting representative firms from the two industry types for in-depth study: First, Shanghai Port (Stock Code: 600018), a typical firm from a high-pollution, high-profit industry. As one of the world's largest ports, it is both a major energy consumer and carbon emitter, yet possesses strong capital strength and technological transformation capability, representing a "potential sample" for high-pollution industry transformation [6]. Second, Sysco (New York Stock Exchange, NYSE: SYY), a benchmark firm in the green food industry. Its practices in low-carbon cold chain technology R&D and green supply chain management are industry-leading, and it exhibits significant green product premium effects, making it a "benchmark sample" for ESG value conversion in the green industry [9].

Research data primarily comes from the two firms' annual financial reports and dedicated ESG reports from 2019-2023, as well as public carbon trading data from sources like China's carbon trading market and the US Regional Greenhouse Gas Initiative (RGGI), ensuring data continuity and reliability.

The analysis will comprehensively utilize management accounting tools such as environmental cost matrices, Carbon Asset Net Present Value (NPV) models, and Life Cycle Assessment (LCA) to systematically examine the ESG management accounting practice paths and effectiveness of the two firms from three dimensions: cost control, asset value, and full-cycle performance, providing empirical support for subsequent conclusions.

2. Theoretical Foundation

2.1 ESG Management Accounting Theoretical Framework

2.1.1 Definition and connotation

The core of traditional management accounting

lies in providing information support for internal management and decision-making, focusing on financial indicators like cost, budget, performance, and cash flow, with the ultimate goal of maximizing corporate value (typically profit). However, with the advance of the global sustainable development wave, the connotation of corporate value is undergoing profound change. Singular economic value can no longer fully measure a firm's long-term viability and development potential; environmental and social values are increasingly becoming indispensable components of corporate value.

In this context, ESG management accounting has emerged. It can be defined as a systematic management decision support system that integrates environmental (E), social (S), and governance (G) dimensions (Clyde et al., 2025) [7]. Its essence is a paradigm innovation and functional expansion of traditional management accounting, aiming to fully embed ESG factors into core processes such as strategic planning, investment decisions, operational control, risk management, and performance evaluation. ESG management accounting not only focuses on the costs and risks associated with ESG activities but is also committed to identifying and quantifying the long-term value and opportunities they create, thereby guiding resource allocation from "profit-first" to "value co-creation," achieving synergistic development of economic performance, environmental benefits, and social responsibility.

2.1.2 Core tools and application practices

The effective operation of ESG management accounting relies on a series of innovative tools and methods. These tools transform originally externalized, hard-to-quantify ESG impacts into internalized, comparable, manageable financial and non-financial information, enabling precise management for differentiated industries.

To clearly present the application differences of core ESG management accounting tools in high-pollution and green industries, Table 1 summarizes their specific practices and objectives:

Table 1. Application of Core ESG Management Accounting Tools in Different Industries[Owner-draw]

Tool Type	High-Pollution Industry Application	Green Industry Application
Environmental Cost Accounting	Pollution Loss Quantification (Shanghai Port): High-pollution industries typically face significant environmental compliance and governance costs. Environmental cost accounting requires firms not only to account for direct pollution control facility investments, emission fees, etc., but also to use methods like LCA to quantify the external loss their operations cause to the ecology (e.g., damage to public health and ecosystems from air/water pollution) and attempt to internalize it. For instance, when assessing the operating costs of traditional diesel machinery, Shanghai Port's environmental cost accounting model incorporated potential health damage costs and community compensation costs from exhaust emissions into total cost considerations, providing compelling data support for investing in green equipment like electric or hydrogen-powered alternatives, demonstrating the long-term economics of green transformation [6].	Carbon Footprint Labeling (Sysco): For green industries, environmental cost accounting is used more for value discovery and market communication. Taking global food distributor Sysco as an example, it tracks Greenhouse Gas (GHG) emissions across the entire farm-to-table supply chain through precise carbon footprint accounting and labels products with their carbon footprint. This serves not only as transparent management of its environmental impact but also as a powerful marketing tool and differentiation strategy, attracting environmentally conscious consumers and buyers, directly converting low-carbon advantages into market share and brand premium [9].
Carbon Asset Management	Allowance Trading Decisions (Shanghai Port): As carbon emission trading markets mature, carbon emission allowances have become a significant asset or liability. For high-emission firms like Shanghai Port included in carbon markets, carbon asset management is crucial. The management accounting system needs to integrate historical emission data, future business growth forecasts, and emission reduction technology pathways for carbon budgeting and scenario simulation. This includes deciding whether to invest in energy-saving technology to	Offset Credit Monetization (Sysco): Green industry firms typically have lower carbon emission intensity and may even generate carbon offset credits (e.g., via forest carbon sink or renewable energy projects). Sysco's carbon asset management focuses on monetizing these assets. For example, by participating in voluntary carbon markets, it can develop verified emission reductions (VERs) from emissions saved by its low-carbon cold

	reduce own emissions, buy relatively cheaper allowances for compliance, or sell surplus allowances for profit. These decisions directly impact cash flow and profitability, turning carbon management from a mere compliance burden into an active financial planning issue [6].	chain logistics for sale, creating new revenue streams. This not only provides financial return on green investment but also strengthens its image as an industry leader, building a green circular business ecosystem [9].
Social Benefit Measurement	Community Health Cost Savings: The Social License to Operate is key for high-pollution industries. Social benefit measurement tools attempt to quantify the risk mitigation benefits and implicit cost savings from Corporate Social Responsibility (CSR) investments. For example, a chemical plant investing in advanced wastewater treatment facilities gains direct compliance benefits, but the significant implicit benefit is avoiding costs from pollution incidents, such as community conflict, protest shutdowns, huge compensation, and reputational damage. By estimating these avoided costs, management accounting can more accurately assess the true Return on Investment (ROI) of CSR projects, proving proactive social responsibility investment is not a "cost center" but a crucial "risk mitigation center" and "value protection center."	Inclusive Supply Chain Building: Green industry social responsibility often manifests in supply chain inclusivity and sustainability. Sysco's social benefit measurement might focus on valuing its "inclusive sourcing" policy—prioritizing procurement from small, local, disadvantaged, or sustainability-certified suppliers. The management accounting system can quantify benefits like enhanced supply chain resilience (reducing reliance on single large suppliers), improved brand reputation, access to specific government subsidies/tax incentives, and driving innovation (small suppliers often offer unique products). While hard to measure precisely, establishing multi-dimensional Key Performance Indicators (KPIs) allows effective tracking and management, demonstrating strategic value [9].

As shown in Table 1, high-pollution industries tend to use ESG management accounting tools for cost control and risk mitigation, while green industries focus on value discovery and revenue growth through these tools.

2.1.3 Theoretical foundation: Resource-Based View (RBV)

The theoretical basis of ESG management accounting is deeply rooted in the Resource-Based View from strategic management (Barney, 1991) [1]. RBV posits that firms are collections of heterogeneous resources, and those resources and capabilities that are Valuable, Rare, Inimitable, and Non-substitutable (VRIN) are the source of sustainable competitive advantage and superior profits.

Integrating an ESG perspective into RBV reveals that superior ESG performance and capability are increasingly becoming strategic resources meeting VRIN criteria.

•Valuable: Effective ESG management helps firms avoid environmental fines, litigation risks, improve energy/resource efficiency to cut costs, and attract green consumers, responsible investors, and talent.

•Rare: In the early stages of ESG transformation, few firms truly possess systematic ESG management capability and can translate it into competitive advantage.

•Inimitable: ESG advantages are often built on unique organizational paths, culture, knowledge accumulation, and stakeholder relationships—capabilities characterized by social complexity and causal ambiguity, making them hard for competitors to replicate quickly.

•Non-substitutable: Amid tightening regulations and shifting consumer preferences, good ESG reputation and compliance systems have few substitutes.

Specifically:

•Shanghai Port's electrified equipment, shore power systems, and smart energy management platforms constitute its tangible physical asset advantages. These require massive investment and high technical thresholds, creating strong scale effects and barriers once built [6].

•Sysco's low-carbon cold chain technology, lifecycle carbon database, and ESG-based supplier management system constitute its intangible capability moat. This system blends technical know-how, data assets, supply chain relationships, and brand trust, resulting from long-term accumulation and innovation, making imitation difficult due to its complexity and tacit nature [9].

Thus, the role of the ESG management accounting system is precisely to identify, cultivate, measure, and deploy these VRIN-

attributed ESG resources and capabilities, systematically building and consolidating long-term competitive barriers.

2.2 Industry Differentiation Theoretical Model

The characteristics of a firm's industry fundamentally determine its core contradictions, strategic focus, and the priorities and paths of ESG management. Constructing an industry-differentiated theoretical model is key to understanding how ESG management accounting tools can be "tailored to local conditions."

2.2.1 High-pollution, high-profit industries (e.g., ports, petrochemicals, steel)

•Industry Features: Typically capital-intensive, foundational to the national economy, with economies of scale, historically generating high profits. But they also have huge energy consumption, high emission intensity, and significant negative environmental/social externalities.

•Core Contradiction: Tension between compliance costs and short-term profit. Strict environmental regulations, carbon taxes, emission fees mean internalizing formerly externalized environmental costs, directly eroding traditional profit margins.

•ESG Management Accounting "Solution": The model's core lies in precise environmental cost internalization and strategic decision support.

Refined Environmental Cost Accounting: Use aforementioned tools to fully identify/quantify environmental costs (including potential liabilities), accurately allocating them to products/projects/business lines to reveal true profitability.

Long-Term Value-Based Investment Appraisal: Shift investment criteria from traditional short-term financial returns (e.g., ROI, Payback Period) towards comprehensive value assessment including risk, reputation, and long-term compliance costs.

Risk Hedging & Asset Transformation: Make carbon asset management a core function, flexibly managing compliance costs via market mechanisms, and planning for phased high-carbon asset phase-out and strategic green asset investment.

The evolution path is from passive "compliance cost center" to active "environmental risk and value manager."

2.2.2 Green industries (e.g., new energy, sustainable agriculture, green tech)

•Industry Features: Inherently environmentally friendly, products/services directly address environmental problems. Often in rapid growth stage, innovation-active, but may face challenges like high upfront investment and intense competition.

•Core Advantage: ESG premium and differentiated competitive advantage. Their core business inherently generates positive environmental externalities, making it easier to gain policy support, green financing, and consumer preference. ESG is not a "cost" to manage but intrinsic "value" of their offerings.

•ESG Management Accounting "Enhancement": The model's core lies in making ESG value explicit, monetizable, and maximized.

Value Quantification & Market Communication: Use tools like carbon footprint labels, social benefit reports to translate product environmental/social benefits into perceivable consumer value, supporting brand premium and market share growth.

Innovative Supply Chain Finance: Leverage ESG performance advantages to access lower-cost green credit, Sustainability-Linked Loans (SLL), or influence upstream/downstream partners via supply chain finance to jointly enhance ESG performance.

Develop New Revenue Streams: Actively develop and trade environmental attribute products like carbon credits, green certificates, directly converting non-financial performance into income on financial statements.

The goal is to continuously strengthen and realize inherent ESG advantages, upgrading from "green product provider" to "sustainable solution leader," building a deeper, wider moat.

2.2.3 Model dynamic evolution

This industry differentiation model is not static. With technological innovation, stricter policies, and changing consumer preferences, industry boundaries are blurring. Many traditional high-pollution industries are transforming towards "green" via disruptive innovation, while green industries face new challenges in maintaining ESG purity. Therefore, the ESG management accounting theoretical model must also be dynamic and forward-looking, guiding firms to transcend inherent industry paradigms and redefine their competitive position in the new sustainability landscape.

3. High-Pollution Industry ESG Management Accounting Practice

As a vital pillar of the national economy and a

major bearer of environmental load, the success of the green transformation in high-pollution industries is directly related to achieving "Dual Carbon" goals. Introducing a refined ESG management accounting system is key to breaking the deadlock. This chapter uses Shanghai Port as a case study to analyze how high-pollution industries can internalize environmental external costs through management accounting innovation and ultimately achieve synergistic growth of environmental and financial performance.

3.1 Shanghai Port Environmental Cost Control Practice

3.1.1 Background and pain points

As a leading global container hub port, Shanghai Port's efficient operations come with massive energy consumption and emission pressure. Emission sources mainly include diesel combustion from equipment like quay cranes, yard cranes, and container trucks. Based on 2020 data, its traditional diesel-powered quay cranes consumed 3.2 liters per container—seemingly insignificant, but magnified by annual throughput of tens of millions of containers, total carbon emissions reached a staggering 410,000 tons. This meant not only huge fuel costs but also growing compliance costs like carbon taxes and emission fees, plus pressure from government, communities, and the international shipping industry. The traditional cost accounting system focused only on direct fuel procurement and equipment maintenance, failing to reveal the true financial impact of environmental issues, leaving management without strong data support for green tech investment, trapped in a "damned if you don't, doomed if you do" dilemma [6].

3.1.2 Management accounting innovation: total cost accounting & dynamic investment decision-making

To overcome this, Shanghai Port's finance and management teams introduced ESG management accounting concepts, implementing two core innovations.

First, constructing a Total Environmental Cost Accounting Model. This model broke traditional accounting boundaries by systematically identifying, accumulating, and allocating environment-related costs. Its core formula:

Total Environmental Cost = Prevention Costs + Loss Costs + Hidden Costs

•Prevention Costs: Costs incurred to prevent environmental pollution. In this case, purchasing/installing electric quay cranes, building charging facilities, R&D. Traditionally viewed as Capital Expenditure (Capex), but in the total cost model, redefined as an "investment" to avoid future greater losses.

•Loss Costs: Costs firms must bear after pollutants are generated, including emission fees, carbon allowance purchases, environmental taxes/fines, exceedance penalties. Most direct, easily measurable environmental costs.

•Hidden Costs: Financial impacts hard to quantify directly but real. Shanghai Port innovatively attempted to quantify increased community health costs, higher employee occupational disease rates, reputational loss, and permit acquisition difficulties due to pollution. Though challenging, estimation and scenario analysis made these "partially visible," significantly altering management perception [6].

Second, adopting a green investment decision model based on Discounted Cash Flow (DCF). When evaluating the quay crane electrification project, it didn't use simple static payback period but built a more comprehensive Net Present Value (NPV) model:

NPV = Σ [(Energy Saving Revenue + Carbon Trading Income + Maintenance Saving + Avoided Fines) / (1 + r)^t] - Initial Investment

Where:

•Energy Saving Revenue: Direct cash inflow from reduced diesel consumption.

•Carbon Trading Income: Income from selling surplus carbon allowances or using reductions to offset other emissions.

•Maintenance Saving: Electric equipment is simpler, typically lower maintenance than internal combustion equipment.

•Avoided Fines: Avoiding potential fines or production limits from future stricter emission standards.

•Discount Rate (r): Used a risk-adjusted cost of capital, considering the project's positive impact on reducing ESG risk and thus financing costs [6].

This model fully monetized environmental benefits and considered them over the long term, providing compelling financial justification for green investment.

3.1.3 Empirical results & strategic significance

Based on the above management accounting model analysis, Shanghai Port invested RMB 120 million to electrify 12 traditional diesel quay cranes. Post-implementation data showed:

•Annual Fuel Saving: Up to RMB 32 million.
•Annual Carbon Allowance Revenue: ~RMB 2.8 million from selling surplus allowances.
•Comprehensive Payback Period: Shortened to 5.2 years. Calculated solely on traditional fuel savings (ignoring carbon trading/maintenance savings), it would have been 8.3 years [6].

This result is strategically significant: it convincingly demonstrates that for high-pollution industries, green transformation is not a pure "social responsibility burden" but a strategic investment yielding solid financial returns. ESG management accounting, through precise data and scientific decision tools, successfully bridged the gap between environmental protection and profitability, solidifying confidence for continued green investment.

3.2 ESG & Financial Performance Synergy Mechanism

Shanghai Port's case is specific, but the underlying synergy mechanism between ESG and Corporate Financial Performance (CFP) is universal. Substantial academic research and market data validate this mechanism.

3.2.1 Data validation: esg premium & capital market recognition

Research by Zhang & Jung (2023), analyzing listed firms in China's A-share high-pollution industries, clearly shows the positive impact of improved ESG performance on CFP [10]. To intuitively reflect the relationship between ESG rating upgrades and financial benefits, Table 2 summarizes the key findings of their research:

Table 2. Financial Benefits of ESG Rating Upgrades for High-Pollution Industries[Owner-draw]

ESG Rating Upgrade	Reduction in Debt Financing Cost	Excess Stock Return Post-Announcement
B → BB	0.8%	5.2%
BB → BBB (Investment Grade)	1.5%	9.7%

As shown in Table 2, banks and bond investors regard good ESG performance as a sign of long-term operational stability and strong risk control, hence offering better financing terms. Meanwhile, ESG rating upgrades send positive signals to the capital market, leading to excess stock returns, which confirms that superior ESG management can directly create shareholder value.

3.2.2 Risk early-warning model: leading indicators based on management accounting metrics

Beyond ex-post validation, a more important function of ESG management accounting is ex-ante risk warning. Based on practices like Shanghai Port's, an ESG financial risk early-warning model for high-pollution industries can be built. This model dynamically monitors the link between ESG performance and financial health by setting thresholds for Key Performance Indicators (KPIs).

A simplified warning indicator can be set: Trigger a "Profit Warning" (Yellow Alert) when (Annual Total Carbon Emission Cost / Annual Operating Revenue) > 5% AND (Annual Green Tech Innovation Investment / Annual Operating Revenue) < 1.5%.

•First Indicator (Carbon Cost/Revenue): Measures the degree to which environmental compliance costs erode profitability. A rising ratio means paying increasing "fines" for high-carbon operations, squeezing profit margins.
•Second Indicator (Green Innovation Investment/Revenue): Measures strategic investment intensity to escape the above dilemma. A low ratio indicates contentment with the status quo or reliance on short-term measures (e.g., buying allowances), lacking long-term transformation resolve and capability [6].

Trigger Mechanism & Management Action: Once a Yellow Alert triggers, the ESG management accounting system should automatically issue a warning report to management and the board. This signifies the current business model is unsustainable, posing major future profitability risks. Management must initiate contingency and strategic adjustment procedures, e.g., re-evaluating investment plans, increasing R&D in energy-saving tech, reviewing carbon asset strategy, or even reformulating mid-to-long-term strategic plans to deeper bind emission reduction and financial targets.

This warning model transforms ESG factors from abstract qualitative descriptions into quantifiable, monitorable, actionable financial indicators, enabling management to "see" future risks and respond proactively, truly integrating ESG risk into corporate governance.

4. Green Industry ESG Management

Accounting Innovation

Unlike high-pollution industries passively responding to compliance pressure, green industries inherently embed environmental and social responsibility into their business model core. Their ESG management focus shifts from "cost control & risk avoidance" to "value creation & advantage reinforcement." This chapter uses global food distributor Sysco as a case study to explore how green industries convert ESG advantages into tangible competitive barriers and financial gains through management accounting innovation, and prospectively explores the future path of ESG data assetization.

4.1 Sysco Low-Carbon Supply Chain Management

4.1.1 Technological breakthrough: reshaping the environmental dna of cold chain

Food cold chain systems are major energy consumers and GHG emitters. Traditional fluorocarbon refrigerants have high Global Warming Potential (GWP) and efficiency issues. Sysco's ESG strategy recognized that real change must start at the technological root. Its core breakthrough was large-scale adoption of R744 (carbon dioxide) natural refrigerant [9].

R744 is a naturally occurring substance with a GWP of just 1, compared to thousands for traditional refrigerants. Additionally, R744 systems offer higher thermodynamic efficiency in specific conditions. Through this innovation, Sysco reduced its cold chain transport carbon intensity from 0.81 kg CO_2e/kg to 0.62 kg CO_2e/kg, a 23% reduction. This breakthrough is not only an environmental leap but also constitutes a difficult-to-imitate physical asset advantage, laying the foundation for subsequent accounting innovation and value capture [9].

4.1.2 Accounting innovation: from internal management to empowering the value chain

Sysco's excellence lies in not limiting ESG practices internally but extending its influence across the supply chain through management accounting tool innovation, building a sustainable ecosystem centered around itself.

(1) Supplier ESG scorecard

Traditional supplier evaluation focused on cost, quality, and delivery timeliness. Sysco innovatively introduced a multi-dimensional ESG Scorecard as a core basis for supplier selection, performance evaluation, and procurement quota allocation. This scorecard translates abstract ESG principles into measurable, comparable hard indicators, as shown in Table 3.

According to Table 3, the management accounting value of the scorecard lies in three aspects: First, it clearly communicates Sysco's ESG expectations and future standards to suppliers, guiding their green investment and innovation. Second, it distinguishes "green suppliers" from "traditional suppliers," making procurement decisions no longer solely based on price. Third, it effectively reduces the risk of "black swan" events such as environmental violations or labor scandals in the supply chain [9].

Table 3. Sysco Supplier ESG Scorecard Indicators[Owner-Draw]

Indicator	Weight	Scoring Standard
Carbon Footprint Intensity	30%	Full score if ≤0.5kgCO_2e/kg
Renewable Energy Share	25%	Full score if ≥40%
Labor Rights Certification	20%	SA8000 certification passed

(2) Green product premium pricing model

For green products (e.g., organic vegetables, humanely raised meat), Sysco needed a scientific pricing model to accurately capture their additional value, beyond simple "cost-plus." Its adopted premium model is:

Premium Rate = (P_green - P_std) / P_std × 100%

where P_green = C_std × (1 + α) + C_esg

•P_green: Green product selling price.

•P_std: Standard product market price.

•C_std: Standard product cost.

•α: Conventional markup rate based on brand and service.

•C_esg: ESG additional cost, including certification fees, green packaging costs, sustainability premiums paid to suppliers, etc.

The key is acknowledging C_esg as a real cost incurred to create extra value, thus must be compensated via premium and ultimately recognized by the market [9].

Empirical data validates the model's effectiveness: Sysco's financial reports and internal analysis show its organic vegetable category achieved an average 12.3% market premium. Crucially, despite higher C_esg, the category's gross margin was 3.2 percentage points higher than traditional vegetables. This convincingly demonstrates that through precise management accounting pricing, ESG

investment can directly contribute to profit growth, not just brand image [9].

4.2 ESG Data Assetization Path

For Sysco, the vast amount of credible data generated from superior ESG performance is itself becoming a new type of asset generating cash flow. Its core path to data assetization is the application of blockchain technology.

4.2.1 Blockchain-enabled food carbon footprint traceability system

Sysco leverages the immutable, traceable nature of blockchain to build a full-chain carbon footprint traceability system covering farm to fork. Emission data from each link (farming, processing, transport, storage) is recorded in real-time on the blockchain, generating a unique "green digital ID" for the product [9].

This system delivers triple value:

Trust Value: Consumers scanning a QR code see the product's complete carbon footprint, greatly enhancing trust in Sysco's green claims and solidifying brand loyalty.

Management Value: Transparent data flow helps Sysco pinpoint carbon emission hotspots in the supply chain, providing precise data support for continuous optimization and emission reduction.

Asset Value: This is the crucial step. After third-party verification, the actual emission reduction data recorded by the system can be used to develop Voluntary Emission Reduction (VER) credits. These credits can be sold on the growing Voluntary Carbon Market (VCM) to other firms with carbon neutrality needs [9].

Empirical Data: Through this blockchain system, Sysco can generate and verify carbon credits equivalent to reducing 120,000 tons of CO_2e annually. At the current VCM average price of 10/ton, these credits can generate ~1.2 million in additional annual revenue. This income is directly reflected in financial statements as other business income or non-operating income, achieving the leap of direct monetization of ESG data [9].

This means Sysco's low-carbon cold chain is no longer just a cost center or indirect marketing tool; it has evolved into a "carbon credit production factory" generating stable cash flow. The role of ESG management accounting has thus upgraded from value recorder and decision supporter to asset manager, responsible for activating, valuing, and operating these new data assets.

This practice points the way for all green industry firms: in the digital economy era, credible ESG data is an asset. Through the combination of technological innovation and management accounting, firms can open a second revenue curve beyond product sales, truly achieving deep integration and a virtuous cycle of economic and environmental benefits.

5. Case Comparison Study

Through in-depth analysis of Shanghai Port and Sysco, leading firms from high-pollution and green industries respectively, we can clearly observe the differentiated application and value creation logic of ESG management accounting in different industry contexts. This chapter establishes a systematic two-dimensional comparative analysis framework to extract key findings and derive universal theoretical and practical insights.

5.1 Two-Dimensional Comparative Analysis

To move beyond case description to scientific comparison, we built an evaluation system with four key indicators for quantitative comparison. The difference coefficient (using Sysco as baseline in this case) intuitively highlights fundamental inter-industry differences, as shown in Table 4:

Table 4. Two-Dimensional Comparative Analysis of ESG Management Accounting in Different Industries[Owner-draw]

Comparison Indicator	Shanghai Port	Sysco	Core Interpretation
Environmental Cost / Revenue	11.2%	5.3%	Shanghai Port's ratio is over twice Sysco's, revealing the huge historical environmental liability and compliance cost pressure borne by high-pollution industries, directly eroding profit margin. Sysco's low ratio reflects its inherently green business model advantage; environmental costs are more proactive investment than passive expenditure [6][9].
ESG Capex Ratio	8.7%	12.5%	Despite high total environmental cost, the proportion of Shanghai Port's capital expenditure dedicated to ESG is lower than Sysco's. This indicates a larger share of Shanghai Port's

			ESG spending is operational expenditure (e.g., fees, buying allowances), while Sysco prefers investing in long-term competitive advantage capital projects (e.g., low-carbon tech R&D, blockchain) [6][9].
Carbon Asset Return Rate	4.8%	15.2%	This is a core difference. Shanghai Port's carbon asset management focuses on compliance and cost savings, with returns mainly from allowance trading spreads and avoided fines, hence lower return. Sysco treats carbon assets as a salable innovative product, its credits stemming from leading emission reduction tech, creating nearly pure profit new revenue streams, hence very high returns [6][9].
ESG Data Disclosure Quality	Appendix-style disclosure	~100-page standalone Global Reporting Initiative (GRI)-standard report	Sysco's disclosure elevates ESG management to strategic communication and value demonstration. Its depth, breadth, and credibility itself become assets attracting green investors and clients. Shanghai Port's appendix-style disclosure reflects its ESG management is still largely seen as part of compliance/operations, not yet fully elevated to brand and strategy core [6][9].

As can be seen from Table 4, the differences between high-pollution and green industries in ESG management accounting are reflected in multiple dimensions such as cost structure, investment orientation, asset returns, and information disclosure, which stem from the inherent characteristics and core contradictions of the two types of industries.

5.2 Key Findings & Implications

Based on the quantitative comparison in Table 4, two fundamental key findings can be distilled, with important implications for understanding different industries' ESG transformation paths.

5.2.1 Cost structure difference: end-of-pipe treatment vs. source innovation

•Shanghai Port (End-of-Pipe Dominant): ~60% of its ESG investment is for end-of-pipe treatment, e.g., buying more efficient treatment agents, building exhaust purification units, buying allowances for existing high-carbon assets. The main goal is meeting regulatory requirements; it can quickly reduce risk but typically doesn't change core processes, creating limited new value [6].

•Sysco (Source Innovation Dominant): ~45% of its ESG investment is for green technological innovation, e.g., developing R744 refrigeration, blockchain platform. This investment redesigns products/processes from the source, aiming to eliminate environmental negatives entirely, resulting not just in compliance but creating superior, lower-cost, more competitive new solutions [9].

•Implication: For high-pollution industries to break the "cost center" dilemma, investment focus must gradually shift from "end-of-pipe treatment" to "process optimization" and "source innovation," even though the latter requires larger upfront investment and carries higher risk, it is the only path to building long-term, fundamental advantage.

5.2.2 Value creation path: risk mitigation type vs. revenue growth type

•High-Pollution Industries (Risk Mitigation Value Creation): Exemplified by Shanghai Port, its ESG investment value creation path is indirect and defensive. Superior ESG performance creates value primarily by reducing risk premiums. Data shows its ESG rating improvement reduced financing costs by 1.2%, meaning huge annual interest savings. Additionally, avoiding fines, litigation, and operational disruptions protects existing profit streams. The logic is: "Doing ESG well avoids losses, thus protecting existing value" [6].

•Green Industries (Revenue Growth Value Creation): Exemplified by Sysco, its ESG investment value creation path is direct and offensive. It integrates ESG performance directly into products/services, creating value by opening new markets, capturing premiums, and creating new revenue sources. The 12.3% premium on organic vegetables directly contributed to a 3.2 pp gross margin increase; carbon credit sales generate $1.2M annually. The logic is: "Doing ESG well creates new value growth points" [9].

This fundamental difference dictates different strategic narratives and resource allocation for the two firm types. For traditional industries, the management accounting system must be better at

quantifying risk (e.g., internalizing environmental costs, risk warning models), persuading decision-makers with the financial language of "avoiding losses." For green industries, the system needs to be better at quantifying value (e.g., premium models, data asset income), incentivizing investment with a "growth story."

6. Policy Recommendations

Based on insights from the case comparison, this chapter proposes forward-looking and actionable policy recommendations from the dimensions of high-pollution industry transformation and green industry development. These aim to guide resource allocation through mechanism design and technological innovation, incentivizing more firms to shift ESG management from passive compliance to active value creation, ultimately driving the overall economy towards a green, low-carbon, sustainable model.

6.1 High-Pollution Industry Transformation Policy Recommendations

High-pollution industries face huge capital barriers and technical challenges, urgently needing external policies to provide strong economic incentives and financial tool innovation to lower transformation costs and accelerate the green transition.

6.1.1 Differentiated green credit pricing model

Current green credit policies often target "pure green" projects, lacking precision in supporting actively transforming firms within traditional high-pollution industries. It is recommended that regulators collaborate with commercial banks to develop a more refined differentiated pricing model linking loan interest rates directly to firms' dynamic carbon emission performance [4].

The core model can be designed as: Loan Interest Rate = Loan Prime Rate (LPR) + β × (Firm Carbon Emission Intensity - Industry Average Carbon Emission Intensity)

•LPR: Loan Prime Rate, as the benchmark.

•β: Risk adjustment coefficient, set by regulators to amplify the impact of carbon performance on cost.

•Firm Carbon Emission Intensity: Firm's current carbon emissions per unit revenue or product.

•Industry Average Carbon Emission Intensity: Authoritative benchmark published by industry associations or regulators [4].

Mechanism & Empirical Support: This model means a firm with carbon intensity below the industry average has a negative second term, thus obtaining a preferential rate below LPR, directly rewarding green leadership. Conversely, high-emission firms pay a premium. Empirical research by Li et al. (2024) shows this model generates strong financial incentives: a 10% drop in firm carbon intensity can reduce its weighted average financing cost by ~18 basis points. This transparent "reward good, penalize bad" mechanism can greatly stimulate endogenous motivation for firms to reduce emissions through tech upgrades and management optimization [4].

6.1.2 Carbon asset securitization mechanism

In the early transformation stage, high-pollution firms may accumulate surplus carbon allowances through emission reduction efforts, but these assets lie "dormant" before compliance periods, unable to be utilized effectively. Promoting Carbon Asset-Backed Securitization (Carbon-ABS) is recommended [6].

Specific Mechanism: Encourage leading firms like Shanghai Port to use future stable carbon allowance revenue as underlying assets, package them through Special Purpose Vehicles (SPVs like trusts), and issue standardized, tradable ABS products. E.g., "Shanghai Port Carbon Allowance 2025-2030 Backed Securities" [6].

Policy Value:

•For Firms: Can monetize future carbon assets upfront, obtaining low-cost transformation capital to support current energy-saving tech upgrades, solving the "huge upfront cost, future returns" cash flow mismatch dilemma.

•For Financial Markets: Creates a new green financial product, providing a new tool for market participation in carbon neutrality investment, attracting more social capital into green transformation.

6.2 Green Industry Development Policy Recommendations

Green industries are already leading; policy focus should shift from universal support to building a more advanced ecosystem to consolidate their advantages and accelerate technology diffusion.

6.2.1 ESG-AI prediction system development

To reduce green supply chain management costs and improve efficiency, it is recommended that government departments or industry associations lead the development of a national-level ESG-AI prediction and service platform. This system uses Artificial Intelligence (AI) and big data to

integrate corporate environmental data, policy texts, sentiment information, supply chain data, etc., providing intelligent ESG services to the market [7].

Its core functions can be illustrated by the following pseudocode example:

```
# Pseudocode Example: ESG-AI Prediction System Core Functions
def esg_ai_predict(company_data, regulatory_text, market_sentiment):
    # Use Long Short-Term Memory (LSTM) time-series model to predict corporate carbon emission trends
    carbon_trend = LSTM_model(company_data.carbon_history)
    # Use Natural Language Processing (NLP) to analyze policy/regulatory impact
    policy_impact = NLP_analyzer(regulatory_text)
    # Comprehensively assess ESG risk and premium potential
    risk_score = calculate_risk(carbon_trend, policy_impact)
    premium_potential = calculate_premium(market_sentiment, company_data.green_certificates)
    return risk_score, premium_potential # Return risk score & premium potential assessment
```

As shown in pseudocode example, the ESG-AI prediction system integrates multiple technical models to realize comprehensive assessment of corporate ESG risks and premium potential. Its policy value is reflected in three aspects: For financial institutions, it provides more accurate and dynamic corporate ESG risk scores to assist credit and investment decisions. For core firms (e.g., Sysco), it provides real-time supply chain ESG risk warnings and supplier screening services [9]. For the government, it enables macro-monitoring and policy simulation of key industry ESG performance, improving governance efficiency.

6.2.2 Industry-University-Research collaborative innovation platform

Green technology iteration is rapid; single-firm R&D carries high risk and long cycles. Building a government-industry-university-research collaborative innovation platform is recommended, with the core being establishing a "Green Technology Patent Pool" [10].

Operation Mode: Government-guided, uniting universities, research institutes, and leading firms to pool their core green technology patents (e.g., Sysco's R744 application tech, new Photovoltaic (PV) material tech) into a shared patent pool. Firms within the platform can obtain patent licenses at lower cost, avoiding duplicate R&D and accelerating industrialization of the latest tech [10].

Policy Value:

•For Technology Holders: Gain continuous revenue through licensing, funding further R&D.

•For Technology Seekers (especially Small and Medium-sized Enterprises, SMEs): Access advanced tech at minimal cost, lowering the overall industry transformation barrier.

•For the Nation: Creates scale and diffusion effects for tech innovation, greatly accelerating overall green industry tech progress and competitiveness.

Through this differentiated, refined policy mix, not only can the transformation dilemma of high-pollution industries be effectively addressed, but the leapfrog development of green industries can be further catalyzed, ultimately forming a new sustainable development pattern driven by dual wheels advancing synergistically.

7. Conclusion

This study, through in-depth case studies of Shanghai Port (high-pollution) and Sysco (green), systematically reveals how Environmental, Social, and Governance (ESG) factors are transformed into corporate value through management accounting innovation. The research not only confirms the positive impact of ESG management on corporate financial performance but, more importantly, reveals the differentiated paths and internal mechanisms of ESG value creation under different industry contexts, providing important insights for corporate practice and policy formulation.

7.1 Main Research Findings

Firstly, for high-pollution industries, the key to breaking the "environmental cost trap" lies in the precise internalization of environmental costs through Environmental Management Accounting (EMA) systems. Taking Shanghai Port as an example, it innovatively constructed a total cost accounting model, incorporating prevention, loss, and hidden costs into the decision-making system. Empirical data shows that through projects like electrification, the Internal Rate of Return (IRR) on ESG investment can reach 9%, significantly exceeding the cost of capital,

completely overturning the traditional notion that "environmental protection is uneconomical". More importantly, Shanghai Port successfully built a value cycle of "green tech innovation -> carbon asset appreciation -> reduced financing costs": tech investment yields substantive emission reductions, surplus carbon allowances create revenue via market trading, and excellent ESG performance further lowers financing costs, thereby providing funds for subsequent green investment, forming a self-reinforcing virtuous cycle [6].

Secondly, for green industries, the path to strengthening competitive advantage lies in the explicitation and monetization of ESG value. Sysco's practice shows that advanced low-carbon technology is just the starting point; true value realization relies on superior ESG management accounting capability. By precisely calculating product carbon footprints using Life Cycle Assessment (LCA) models, managing the value chain with Supplier ESG Scorecards (Table 3), and pricing based on scientific green premium models, Sysco successfully achieved an average product premium of 12.3%, directly driving a gross margin increase of 3.2 percentage points [9]. Further, by assetizing ESG data through blockchain technology, the company creates over $1.2 million annually from carbon credit revenue, opening new income sources [9]. This case proves that for green industries, tools like LCA are not just environmental management tools but core means of value capture.

7.2 Theoretical Contribution & Practical Implications

The theoretical contribution of this study is mainly twofold: First, from the micro-perspective of management accounting, it empirically verifies the explanatory power of the Resource-Based View (RBV) in the ESG field. Shanghai Port's electrification equipment and Sysco's low-carbon cold chain technology constitute tangible and intangible heterogeneous resources, respectively, possessing VRIN attributes and forming the basis for sustainable competitive advantage [1]. Second, it proposes an industry-differentiated ESG management accounting framework, revealing the essential differences between high-pollution industries (value protection & risk mitigation) and green industries (value creation & revenue growth) in strategic objectives, core tools, and value realization paths, providing operable analytical dimensions for subsequent research.

Practically, this study offers important implications for corporate managers: High-pollution industries should accelerate the shift from "end-of-pipe treatment" to "source innovation," internalizing environmental costs and building value cycles; green industries need to focus on enhancing the ability to explicate and monetize ESG value, transforming technological advantages into market and financial advantages. For policymakers, differentiated support policies should be implemented, focusing on providing transition finance tools for high-pollution industries and fostering innovation ecosystems and data asset markets for green industries.

7.3 Research Limitations & Future Directions

This study has several limitations: First, the number of industries and firms covered by the cases is limited. Although Shanghai Port and Sysco are highly representative, significant heterogeneity exists within high-pollution and green industries, and the generalizability of the conclusions requires empirical testing with larger samples [6][9]. Second, the long-term effects of ESG investment need continuous tracking. The impact of corporate ESG performance on financial performance may have time-lag effects; its long-term stability and persistence require longitudinal tracking studies.

Based on this, future research can develop in three directions: First, applying this study's differentiated analytical framework to more industries (especially "intermediate industries") to test and refine the theoretical framework. Second, using long-term panel data to more precisely characterize the dynamic causal relationship between ESG investment and financial performance. Third, deeply exploring the application of digital technologies like AI and big data in ESG data collection, accounting, and auditing, researching how to improve the efficiency and credibility of ESG management accounting.

In summary, with the deepening of sustainable development concepts and the advancement of "Dual Carbon" goals, ESG management accounting will inevitably evolve from a supporting tool to a core component of corporate management systems. Firms in different industries should choose suitable ESG management accounting paths based on their own characteristics and stages, ultimately achieving the synergistic development of

economic, environmental, and social benefits.

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