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Evaluating and Prioritizing ESG Decision Factors in Traditional Manufacturing Industries: An Analytic Hierarchy Process Approach

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Abstract

This study examines how experts in traditional manufacturing prioritize environmental, social, and governance (ESG) factors, and what these perceived priorities imply for sustainable-development strategy. Rather than measuring competitiveness outcomes directly, it captures the relative importance that experienced managers assign to ESG criteria. Drawing on a systematic literature review and two rounds of focus group discussions (FGD) with ten

industry and academic experts, a hierarchical framework of three criteria and nineteen sub-criteria was constructed and evaluated through an analytic hierarchy process (AHP) survey of 26 experienced managers in the textile, machine-tool, and hardware-component industries. Aggregating pairwise judgments by the geometric mean, the environmental dimension received the highest weight (0.5657), followed by the social (0.2600) and corporate governance (0.1742) dimensions, with all comparison matrices satisfying the consistency criterion (C.R. ≤ 0.10). At the sub-criterion level, effective energy management (global weight 0.1607), pollution prevention (0.1252), toxic-waste management (0.0860), resource recycling and reuse (0.0840), and employee rights and well-being (0.0741) ranked highest, indicating that experts prioritize energy efficiency, pollution control, regulatory compliance, and workforce stability. A sensitivity analysis confirms that environmental primacy is robust to moderate re-weighting of the three dimensions. A notable divergence between the qualitative emphasis on governance during the FGD and its comparatively low AHP weight is interpreted as a sequencing of managerial attentionfrom urgent environmental compliance and cost efficiency, through workforce resilience, toward longer-term governance optimization rather than as evidence of a causal effect on competitiveness. Grounded in the resource-based and stakeholder perspectives, the study contributes an empirically based, theory-informed prioritization framework for an under-researched sector and offers managers, policymakers, and investors a reference for staged ESG implementation and resource allocation.

Keywords: ESG, Traditional manufacturing industries, Corporate competitiveness, Analytic hierarchy process (AHP), Sustainable development strategy, Focus group discussion, ESG Prioritization, Multi-criteria decision-making (MCDM)

Nomenclature

Abbreviation	Full term / meaning
ESG	Environmental, social, and governance (framework for evaluating corporate sustainability)
AHP	Analytic hierarchy process (multi-criteria decision method; produces dimensionless relative weights, 0-1)
MCDM	Multi-criteria decision-making
FGD	Focus group discussion (qualitative method used to construct the framework)
C.I. /C.R. /R.I.	Consistency index / consistency ratio / random index (AHP consistency measures; C.R. ≤ 0.10 acceptable)
λmax	Maximum (principal) eigenvalue of a pairwise-comparison matrix (dimensionless)
CSR / TBL	Corporate social responsibility / triple bottom line
RBV /NRBV	Resource-based view / natural-resource-based view of the firm
SDGs	United Nations Sustainable Development Goals
CBAM	Carbon Border Adjustment Mechanism (EU)
CSRD /ESRS	Corporate Sustainability Reporting Directive / European Sustainability Reporting Standards (EU)
TCFD /TNFD	Task Force on Climate-related / Taskforce on Nature-related Financial Disclosures
GRI	Global Reporting Initiative
ISSB /IFRS /SASB	International Sustainability Standards Board / International Financial Reporting Standards / Sustainability Accounting Standards Board
PRI	Principles for Responsible Investment (UN)
SMEs	Small and medium-sized enterprises
ISO 9001	International quality-management-system standard

1. Introduction

In recent years, accelerating climate change, resource depletion, and rising awareness of corporate social responsibility have made sustainable development an unavoidable strategic issue for business management. Driven by the United Nations Sustainable Development Goals (SDGs), firms are expected not only to pursue financial performance but also to address environmental protection, social responsibility, and corporate governance simultaneously; ESG has consequently become a core indicator for measuring overall corporate performance. Through the adoption of ESG, firms can demonstrate the robustness and sustainability of long-term operations while responding to the needs of society and the natural environment, thereby enhancing their market competitiveness. The SDGs, however, are only one of several converging pressures: mounting regulatory requirements, investor and lender expectations, customer and stakeholder scrutiny, and competitive dynamics jointly push firms to integrate sustainability into strategic decision-making (Freeman, 1984; DiMaggio & Powell, 1983; Carroll, 1991; Friede et al., 2015).

The tightening of global sustainability regulations has raised the bar considerably. The European Union has introduced the Carbon Border Adjustment Mechanism (CBAM) and more stringent sustainability reporting requirements such as the Corporate Sustainability Reporting Directive (CSRD), which require firms exporting to Europe to disclose carbon emission data and pay additional levies according to embedded carbon content. Export-oriented traditional industries in Taiwan, particularly supply-chain-driven sectors such as textiles, machine tools, and hardware components, are directly exposed to these measures; firms that fail to implement effective carbon management and environmental responsibility face international trade barriers and rising costs. In addition, international frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD) and the Taskforce on Nature-related Financial Disclosures (TNFD) have become key references for multinational corporations and financial institutions and are increasingly regarded as a prerequisite for investment and financing decisions. Domestically, the government is actively promoting net-zero and green finance policies that require firms to improve energy efficiency and information transparency. For small and medium-sized traditional manufacturers with limited resources, adopting ESG and meeting disclosure requirements has become a highly challenging task.

Prior research has concentrated largely on high-technology or financial service industries, focusing on the extent of ESG disclosure, the transparency of sustainability reporting, or the relationship between socially responsible investment and firm performance. Research on the relationship between ESG practices and competitiveness in traditional industries remains clearly insufficient. Traditional industries such as textiles, machine tools, and hardware components occupy important positions in Taiwanese and global manufacturing, yet they frequently confront sustainability challenges arising from high energy consumption, pollution intensity, and labor dependence. Large-scale syntheses of the ESG-performance literature likewise draw predominantly on listed firms in high-technology and financial sectors (Friede et al., 2015; Liang et al., 2025), whereas energy- and labor-intensive traditional manufacturers despite their direct exposure to carbon-border and disclosure regimes—remain

comparatively under-examined (Xu, 2025).

This study focuses on the textile, machine tool, and hardware component industries because they jointly exhibit the typical characteristics of traditional manufacturing—high energy consumption, labor intensity, and export orientation while facing distinct transformation pressures, and thus best reflect the overall situation of Taiwanese traditional manufacturing under the ESG wave. In the textile industry, dyeing and finishing processes involve substantial water use and chemical discharge; European and American brands now require suppliers to disclose carbon emissions, water consumption, and chemical management, and are gradually introducing carbon footprint certification, making the balance between emission reduction and product competitiveness a critical issue (Das et al., 2025). The machine tool industry, as the "mother machine" of manufacturing, must respond to digitalization and smart manufacturing while strengthening environmental management and worker safety, and given its heavy reliance on European export markets directly faces the impact of the EU CBAM and customers' decarbonization requirements. The hardware component industry, under global supply chain restructuring, increasingly relies on ESG practices to secure supply chain stability, product quality control, and international market expansion (Hana & Tarik, 2025). Together, these three industries constitute an essential segment of Taiwan's export-oriented manufacturing supply chain, and their ESG decision logic is highly representative.

A further gap in the existing literature is methodological. Many studies rely on secondary data or financial indicators, which reflect capital market performance but say little about the substance and depth of ESG practices. The few studies that collect perspectives through questionnaires or interviews generally lack a rigorous hierarchical framework and decision analysis method, making it difficult to portray comprehensively the interrelationship between ESG dimensions and corporate competitiveness. Constructing an analytical framework that combines theoretical grounding with practical applicability therefore constitutes an important motivation of this study.

Taken together, three gaps motivate this study. Empirically, the ESG priorities of traditional manufacturing as perceived by the managers who actually make sustainability decisions—remain poorly documented. Methodologically, few studies apply a rigorous multi-criteria decision-making (MCDM) framework that jointly and comparably weights environmental, social, and governance factors. Theoretically, the ESG-competitiveness relationship is frequently asserted rather than grounded in an explicit conceptual lens. This study addresses these gaps by combining focus group discussions with the AHP to elicit and prioritize expert judgments, and by interpreting the resulting priorities through the resource-based and natural-resource-based views, stakeholder theory, institutional and legitimacy theory, and the dynamic-capabilities perspective (Barney, 1991; Hart, 1995; Freeman, 1984; DiMaggio & Powell, 1983; Suchman, 1995; Teece, 2007). Because the AHP captures perceived relative importance rather than realized competitive outcomes, we frame the contribution as an exploratory prioritization of ESG decision factors, not as a causal test of their effect on competitiveness.

To address these gaps, this study applies the analytic hierarchy process (AHP), a structured

multi-criteria decision-making method that decomposes complex problems into hierarchical levels and derives the relative weights of criteria and sub-criteria through expert pairwise comparisons, thereby integrating qualitative and quantitative analysis (Saaty, 1980). Based on a literature review and focus group discussions, a hierarchical framework for ESG decision evaluation in traditional manufacturing was constructed, comprising the three criteria of environment, social, and corporate governance and their nineteen sub-criteria. An AHP questionnaire survey was then conducted to compute the weights and rankings of all key factors, so as to identify the ESG factors that most strongly influence the competitiveness of traditional industries, deepen academic understanding of the ESG-competitiveness linkage, and provide practitioners with concrete recommendations for sustainable development strategies.

1.1 Research Purposes

This study aims to investigate the key factors in ESG decision evaluation for traditional manufacturing industries. Consistent with the exploratory nature of the AHP, the research questions concern perceived relative importance rather than measured competitive effects: (1) Which ESG factors do experienced managers in traditional manufacturing perceive as most important for sustaining competitiveness? (2) How do the relative weights and rankings of different ESG factors shape the priorities of traditional industries in sustainable-development strategy and resource allocation?

Accordingly, the purposes of this study are: (1) to construct a hierarchical framework for ESG decision evaluation in traditional manufacturing through a literature review and focus group discussions, covering the three dimensions of environment (E), social (S), and corporate governance (G) and their sub-criteria; and (2) to apply the AHP questionnaire survey and analysis to calculate the weights of all criteria and sub-criteria, and thereby propose priority directions and practical recommendations for sustainability strategy planning and decision-making in traditional industries.

1.2 Research Process

The study first established the research background and purposes, collected and synthesized relevant domestic and international literature to identify the key factors of ESG decision evaluation in traditional manufacturing, and constructed the hierarchical framework accordingly. Next, a questionnaire was designed based on the dimensions and sub-dimensions derived from the literature, and experts in traditional industries were invited to focus group discussions to confirm the reasonableness and completeness of the framework. An AHP pairwise-comparison questionnaire was then distributed to collect expert judgments, and empirical analysis was conducted to compute the weights and rankings of all dimensions and sub-dimensions. Finally, managerial implications and concrete recommendations were derived from the results to provide practical references for sustainable development and competitiveness enhancement in traditional industries.

2. Literature Review

This chapter reviews and synthesizes relevant domestic and international literature to trace

how ESG influences corporate competitiveness. It comprises five parts: global ESG development and practice; traditional industries and ESG; definitions of the evaluation criteria; ESG and corporate competitiveness; and the AHP in ESG research.

2.1 Global ESG Development and Practice

The ESG concept originated from the deepening of corporate social responsibility (CSR) thinking. From the 1970s onward, firms worldwide began to emphasize social responsibility and ethical management; as climate change intensified and environmental disasters became frequent, the international community gradually recognized the pivotal role of business in global sustainable development. In 2004, the United Nations Global Compact and the World Bank jointly published the report Who Cares Wins, formally proposing the ESG concept and advocating that investors and firms incorporate environmental, social, and governance factors into decision-making to balance economic returns with sustainable value; in 2006, the United Nations further launched the Principles for Responsible Investment (PRI), institutionalizing ESG as a common language of international investment and corporate management.

Conceptually, ESG represents the latest stage in a longer evolution of corporate-responsibility thinking. Carroll's (1991) pyramid articulated the economic, legal, ethical, and philanthropic responsibilities of firms, while Elkington's (1997) “triple bottom line” reframed corporate performance around the simultaneous pursuit of economic, environmental, and social value. ESG operationalizes and extends this tradition by adding an explicit governance pillar and by translating these responsibilities into measurable, investor-facing disclosure (Friede et al., 2015). Recognizing this lineage clarifies that the environmental, social, and governance dimensions evaluated here are not an ad hoc checklist but the institutionalized descendants of the CSR and sustainability debates.

To implement corporate sustainability disclosure, countries have successively introduced international standards, among which the TCFD (climate-related financial disclosures), the TNFD (nature-related financial disclosures), and the GRI (Global Reporting Initiative) standards are the most representative, constructing an international disclosure architecture from the perspectives of climate change, natural capital, and overall sustainability performance, respectively (Thomas & Bruckner, 2025). The TCFD, established by the Financial Stability Board (FSB), requires firms to disclose the financial impacts of climate change across four core elements—governance, strategy, risk management, and metrics and targets; the TNFD extends the disclosure scope to biodiversity and natural resource risks; and the GRI provides the most widely adopted comprehensive framework covering economic, environmental, and social performance.

More recently, integrated and legally binding disclosure standards have emerged. The International Sustainability Standards Board (ISSB) issued the IFRS Sustainability Disclosure Standards S1 and S2 in 2023, integrating the spirit of the TCFD and SASB to establish a globally consistent baseline for sustainability-related financial disclosure; S1 requires disclosure of all material sustainability-related risks and opportunities affecting financial reporting, while S2 focuses on climate-related disclosure. The EU Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting

Standards (ESRS) impose disclosure obligations with legal force and, through supply chain linkage effects, extend their influence to non-EU firms (Carungu et al., 2025). These institutionalization trends indicate that sustainability disclosure has shifted from voluntary initiative to a mandatory operating threshold, with particularly profound implications for export-oriented manufacturers embedded in global supply chains.

2.2 Traditional Industries and ESG

Traditional industries have long been an important pillar of Taiwan's economic development. Sectors such as textiles, machine tools, hardware components, steel, plastics, and food constitute essential links in the export-oriented supply chain. These industries have accumulated deep technical experience and production capacity, formed stable upstream-downstream cooperation systems and international trade networks, and, in B2B supply chain contexts, built long-term trust through CSR practices and customer satisfaction (Hana & Tarik, 2025). However, as global sustainability issues intensify and ESG becomes institutionalized, traditional industries characterized by high energy consumption, labor intensity, and export orientation face unprecedented structural transformation pressure. Their past competitive advantages derived mainly from cost control and production efficiency, but under global decarbonization and the restructuring of energy markets, low-price competition has gradually lost its edge (Raineri, 2025); international markets impose increasingly strict requirements on supply chain environmental responsibility, social ethics, and governance transparency, and firms must balance sustainability with competitiveness to maintain their position in global markets (Hana & Tarik, 2025).

At the individual industry level, dyeing and finishing in textiles involve heavy water use and chemical discharge; European and American brands now require suppliers to disclose carbon emissions, water use, and chemical management and are introducing carbon footprint certification, forcing small and medium-sized textile firms with limited resources to readjust their operating strategies in the face of global decarbonization (Das et al., 2025). The machine tool industry, export-oriented and serving as the mother machine of manufacturing, must respond to the CBAM and customer decarbonization demands by investing in process optimization, energy-saving retrofits, and smart manufacturing upgrades. The hardware component industry, amid global supply chain restructuring, faces multiple international customer requirements regarding quality, delivery, and carbon management, and its net-zero transition involves systemic challenges to energy structure and manufacturing processes (Raineri, 2025).

Social challenges are equally pressing. Traditional industries have long faced workforce aging, insufficient youth entry, and interrupted skill transmission, resulting in imbalanced labor structures and weakened innovation momentum; global ESG development has also incorporated human rights, labor protection, and social participation into sustainability evaluation. On the other hand, the diffusion of digital transformation and low-carbon technologies creates new opportunities: firms that proactively adopt environmental management systems, build sustainable supply chains, and combine smart manufacturing with circular resource models can convert their formerly energy-intensive structures into

environmentally resilient business models, gaining easier access to investor favor and international cooperation; re-examining new product development from an ESG perspective can also open new opportunities in green manufacturing and the circular economy (Das et al., 2025). Overall, ESG represents both transformation pressure and an opportunity for industrial upgrading and value reshaping for traditional industries.

2.3 Definitions of the Evaluation Criteria

Based on domestic and international literature, this section defines the meanings of the three criteria and nineteen sub-criteria adopted in this study, providing the theoretical foundation for the subsequent construction of the hierarchical framework and questionnaire design. The definitions and supporting references of all evaluation indicators are summarized in Table 1.

Table 1. Definitions and supporting references of the evaluation criteria and sub-criteria

Criterion / Sub-criterion	**Definition and implications**	**References**
Environmental	All corporate behaviors and impacts related to natural resources, ecosystems, and environmental protection; the core objective is to balance economic growth with ecological conservation by reducing pollution, improving energy efficiency, and using resources rationally.	Koval et al. (2021)
Effective energy management	For traditional industries, energy management is the foundation of environmental strategy; energy efficiency affects not only operating costs but also the control of greenhouse gas emissions.	Andrei and Johnsson (2025); Chen et al. (2024)
Implementation of pollution prevention measures	Production in traditional industries is often accompanied by waste gas, wastewater, and solid waste; improper treatment causes environmental pollution, reputational damage, and penalty risks, necessitating pollution prevention measures to reduce production impacts.	El-Halwagi (2025); Deshmukh et al. (2025)
Resource recycling and reuse	A key step in shifting from a linear to a circular economy; facing resource scarcity and rising material costs, firms can build a "reduce-reuse-remanufacture" production model through recycled materials and by-product recovery.	Das et al. (2025)
Toxic waste management	As international carbon governance tightens, toxic waste management and carbon emission management have become core issues in corporate responses to global climate change.	Etukudoh et al. (2024); Körner et al. (2025)
Compliance with environmental regulations	With domestic and international regulations tightening, Taiwan has enacted the Climate Change Response Act, the Renewable Energy Development Act, and the Resource Circulation Promotion Act, requiring disclosure of energy use and environmental governance; regulatory compliance is the prerequisite for the long-term implementation of corporate sustainability actions.	Awewomom et al. (2024)
Effective reduction of production waste	Traditional industries can reduce material and energy waste and improve process efficiency through lean production and process redesign.	Alemede (2025)
Social	The core spirit lies in promoting people-centered sustainable development, ensuring that firms attend to employee well-being, community prosperity, and social fairness while pursuing economic benefits.	Cheshmehzangi et al. (2025)
Emphasis on employee rights and well-being	Employees are the most important stakeholders; working conditions, pay structures, and welfare systems directly affect productivity and organizational stability. Sound labor contracts,	Rosa et al. (2025); Talukder et al. (2025)

	health insurance, and career planning create a safe and respectful workplace.	
Assisting in resolving community issues	Symbolizes the evolution of the corporate role from a purely profit-seeking producer to a partner of local society; participating in community development programs and local public-interest or environmental education activities strengthens mutual trust with the locality.	Harinurdin et al. (2025); Korol and Korol (2025)
Emphasis on healthy workplaces and employee safety	Production lines in traditional industries often involve occupational risks such as high temperature, noise, and machine operation; health-oriented management reduces operational risks and strengthens organizational resilience.	Farmanesh et al. (2025)
Emphasis on product quality and customer safety	The bridge of trust between firms and customers; rigorous quality management systems (e.g., ISO 9001) ensure the reliability of materials, processes, and final products.	Asamoah (2025)
Sound talent cultivation and training	Cooperation with academic institutions to develop professional training courses, or the introduction of digital learning and re-skilling systems, helps employees keep pace with technological and sustainability transitions.	Awewomom et al. (2024)
Smooth labor-management communication	Institutionalized communication channels and grievance mechanisms maintain workforce stability and reduce labor disputes during transformation.	Rosa et al. (2025)
Corporate governance	The institutional architecture and decision mechanisms established to achieve business objectives and protect stakeholder interests, covering board operation, internal supervision, information transparency, and accountability.	Immanuel and Sinambela (2025)
Effective allocation of board responsibilities	The starting point of good governance; a clear division of authority and responsibility avoids decision overlap and ambiguous accountability, allowing the board to focus on strategic planning and supervision while management executes and manages performance.	Bettington and Nicholson (2025)
Emphasis on board independence and accountability	Key to ensuring governance fairness; family-dominated structures are common in Taiwanese traditional industries, and introducing outside independent directors and audit committees balances decision-making power.	Singh et al. (2025)
Risk management systems	An important line of defense in corporate governance; traditional industries face multiple risks including raw material price volatility, rising energy costs, environmental regulation, and international carbon taxes, requiring forward-looking early-warning and management mechanisms.	Liang et al. (2025)
Protection of shareholder rights	An important indicator of governance soundness; robust shareholder protection enhances corporate trust and market valuation.	Xu (2025)
Efficient top management team	Represents whether the organization can translate governance concepts into action; senior executives should balance performance and ethics in strategy execution and cultivate managers with sustainability mindsets and international vision.	Atef and Ramachandran (2025)
Regular internal and external audit mechanisms	Periodic internal and external audits safeguard the reliability of financial and non-financial information and the effectiveness of internal control.	Chisacova (2025)
Emphasis on corporate strategy and vision	Integrating sustainability into core decision processes and establishing a long-term, vision-oriented direction for the firm.	Liang et al. (2025)

2.4 ESG and Corporate Competitiveness

Corporate competitiveness is the ultimate indicator of overall performance and sustainable operation. According to Porter's (1990) theory of competitive advantage, competitiveness refers to a firm's ability to create, maintain, and enhance economic value in a given market, encompassing product innovation, market expansion, brand value, operational efficiency, and talent development. For Taiwanese traditional industries, competitiveness is reflected not only in production efficiency and cost control but also in the ability to sustain differentiated advantages amid the waves of sustainable development and digital transformation.

Several complementary theoretical lenses explain why, and through which mechanisms, ESG practices may bear on competitiveness. The resource-based view treats rare, valuable, and hard-to-imitate capabilities as sources of sustained advantage (Barney, 1991; Hall, 1993), and its natural-resource-based extension argues that pollution prevention, product stewardship, and sustainable development can themselves become such capabilities (Hart, 1995; Russo, 2003). The dynamic-capabilities perspective frames ESG adoption as the sensing, seizing, and reconfiguring of resources in response to a changing regulatory and market environment (Teece et al., 1997; Teece, 2007; Bansal, 2005). Stakeholder theory explains how attending to employees, customers, communities, and regulators builds the trust and legitimacy on which long-term performance depends (Freeman, 1984; McWilliams & Siegel, 2011), while institutional and legitimacy theory account for the coercive, normative, and mimetic pressures CBAM, CSRD, and customer codes of conduct that push traditional manufacturers toward convergent ESG practices (DiMaggio & Powell, 1983; Suchman, 1995). These lenses jointly connect the mechanisms invoked in this study cost reduction, regulatory compliance, workforce stability, stakeholder trust, and market access to the environmental, social, and governance factors evaluated below.

For Taiwanese firms, the substance of competitiveness has shifted from early manufacturing efficiency toward value creation that emphasizes stakeholder balance and long-term value. Traditional industries previously relied mainly on OEM contract manufacturing, lacking brand identity and international visibility; as ESG awareness rises, brand image becomes closely tied to corporate integrity, and firms can strengthen brand trust through sustainability report disclosure, environmental certification, and supply chain transparency. Good reputation management enhances market loyalty and attracts green investment and international cooperation. For small and medium-sized enterprises, fulfilling ESG obligations and disclosure practices within sustainable supply chains has become a key condition for maintaining supply chain positions and obtaining financing (Hana & Tarik, 2025).

Regarding the linkage between ESG and competitiveness, the environmental dimension directly affects cost structure, regulatory risk, and international market access; the social dimension shapes organizational stability and customer trust through employee well-being, workplace safety, talent cultivation, and product responsibility; and the governance dimension supports the implementation of long-term strategy through board operation, risk management, and information transparency. However, previous literature has concentrated on high-technology and financial industries and has relied heavily on secondary data and

financial indicator correlations; the scoring methods of external ESG rating agencies also suffer from inconsistent standards and insufficient transparency, making it difficult to reflect the decision priorities of individual industries. Studies that systematically measure the relative importance of ESG factors for traditional manufacturing using rigorous multi-criteria decision-making methods remain limited, and this is the gap the present study seeks to fill.

At the same time, the ESG-competitiveness relationship should not be read uncritically. The evidence is heterogeneous: a synthesis of more than two thousand empirical studies reports a predominantly non-negative but context-dependent association between ESG and financial performance (Friede et al., 2015), and any benefits are conditioned by costs, industry materiality, and time horizon. It is also important to distinguish ESG disclosure from ESG performance and from substantive ESG practice, since high reporting visibility need not imply real operational change. Accordingly, the present study treats the elicited weights as expert perceptions of relative importance for competitiveness, not as measured competitive effects.

2.5 The AHP in ESG Research

The analytic hierarchy process, proposed by Saaty in the 1970s and formalized as a systematic decision analysis tool in 1980 (Saaty, 1980), decomposes unstructured complex problems hierarchically into goal, criteria, and alternative levels, quantifies the relative importance of factors through expert pairwise comparisons, and computes weights using the principal eigenvector. Its distinctive feature is the consistency test, which safeguards the logical rationality of expert judgments; following Saaty's recommendation, the number of elements at each level should be limited to about seven to maintain judgment precision and consistency. Owing to its simple operation, clear structure, and comparable results, the AHP has become one of the most representative methods in multi-criteria decision-making (MCDM) and is widely applied in business management, strategic planning, resource allocation, supply chain management, sustainable development, and public policy analysis.

In ESG research, the AHP can bring heterogeneous environmental, social, and governance dimensions into a single decision framework for measurement and comparison, combining expert experience with quantitative rigor, and is particularly suitable for decision contexts with incomplete information or highly complex evaluation dimensions. This study therefore adopts the AHP as the primary analytical method and combines it with focus group discussions to construct the hierarchical framework and systematically identify the key ESG factors affecting the competitiveness of traditional manufacturing.

3. Research Methodology

This study constructs an analytical framework for ESG decision evaluation in traditional manufacturing. In the first stage, a literature review and focus group discussions were used to derive and confirm three criteria and nineteen sub-criteria as the basis of the evaluation model; in the second stage, the AHP expert questionnaire survey was conducted to measure the relative importance and rankings of all dimensions and sub-dimensions and to identify the key factors affecting corporate competitiveness. This chapter comprises three parts: the focus

group discussion method; the research framework and hierarchical questionnaire design; and the AHP procedure.

3.1 Focus Group Discussions

This study adopted focus group discussion (FGD) as an important method for constructing the research framework and collecting expert opinions. FGD is a classic qualitative research tool in which participants with professional backgrounds exchange experience, provide feedback, and clarify concepts through group interaction; it is particularly suitable for issues that are structurally complex, interdisciplinary, and dependent on professional judgment, and it compensates for the limitations of quantitative research in the early stage of construct formation (Neuman, 2000).

Purposive sampling was employed, targeting professionals with more than ten years of industrial or academic experience, including senior executives from the textile, machine tool, and hardware component industries, corporate ESG program leaders, sustainability consultants, industry association representatives, and scholars specializing in ESG issues, so that the discussions combined practical perspectives with academic depth. Two focus group sessions were held in April and May 2026, each with six to ten expert participants. Semi-structured facilitation guided the experts to identify the main factors affecting the sustainability and competitiveness of traditional industries from the perspectives of industrial trends, policy requirements, and business operations. Before each session, participants were informed of the research purpose, procedure, and confidentiality principles, and written consent was obtained; the sessions were recorded and transcribed verbatim in compliance with research ethics. In total, ten experts took part across the two sessions, comprising senior managers from the textile, machine-tool, and hardware-component industries together with corporate ESG programme leaders, sustainability consultants, an industry-association representative, and academic specialists; each session lasted approximately two to two and a half hours. The semi-structured guide was organized around four guiding questions: (i) which sustainability issues most affect your firm's operations and competitiveness; (ii) how do regulatory and customer requirements (e.g., CBAM, CSRD, and brand codes of conduct) shape your ESG priorities; (iii) which practices deliver tangible operational or cost benefits; and (iv) which governance arrangements enable or constrain ESG implementation. To preserve a degree of independence between framework development and framework evaluation, the focus-group experts and the AHP respondents were treated as largely separate samples drawn from the same expert pool. The two sessions were held in the conference room of ISC Sustainability Co., Ltd. and Table 2 profiles the ten participants (six men and four women; 8-25 years of professional experience): five from academia covering sustainability management and corporate governance, environmental policy and resource management, industrial economics and energy management, and sustainable supply chains, together with a methodological consultant specializing in AHP/ANP and five from industry, comprising senior managers from the machine-tool and hardware-component sectors, an R&D manager from the textile sector, a chief sustainability officer, and a human-resources manager; verbatim transcripts are provided in Appendix 1. Consistent with this design, the ten focus-group experts and the 26 AHP respondents (Table 5) were largely distinct: the AHP

survey targeted practising managers in the three focal industries, whereas the focus groups additionally engaged academics and a methodological consultant.

Table 2. Profile of the focus-group participants

ID	Type	Gender	Age	Experience (yrs)	Position / area of expertise
A1	Academic	M	50	15	University professor (sustainability management; corporate governance)
A2	Academic	F	45	12	Associate professor (environmental policy; resource management)
A3	Academic	M	55	20	Professor (industrial economics; energy management)
A4	Industry	F	48	18	Chief Sustainability Officer, traditional manufacturing (ESG strategy)
B1	Industry	M	52	25	Senior manager, machine-tool industry
B2	Industry	M	49	22	Vice-president, hardware-components company
B3	Industry	F	38	10	R&D manager, textile industry
B4	Academic/Consultant	M	47	17	ESG consultant (AHP/ANP expert)
C1	Industry	M	42	14	Human-resources manager
C2	Academic	F	40	8	Professor (sustainable supply chain)

For data analysis, open coding was first applied to annotate and classify the transcripts, and axial coding was then used to integrate related concepts into higher-order thematic categories, which were mapped against the environmental (E), social (S), and governance (G) dimensions to confirm correspondence. Cross-expert comparison was conducted to contrast the views of scholars and industry practitioners and identify commonalities and differences, and triangulation—combining cross-session comparison, interdisciplinary integration, and validation against the literature—was used to ensure the credibility of the data and the robustness of the results. After collation, comparison, and induction, three main criteria and nineteen sub-criteria were finalized as the basis for the subsequent AHP hierarchical questionnaire. Open and axial coding were performed independently by two members of the research team, and coding discrepancies were reconciled through discussion until consensus; the resulting themes were then validated against the literature (triangulation). Table 3 summarizes the progression from the principal focus-group themes to the three criteria and nineteen sub-criteria, improving the traceability of the framework.

Table 3. From focus-group themes to ESG evaluation criteria

Focus-group theme (recurring emphasis)	ESG dimension	Mapped sub-criteria
Regulatory compliance as the non-negotiable "survival bottom line"	Environmental	E_{15} (compliance with environmental regulations)
Energy efficiency as cost control + market/order access	Environmental	E_{11} (effective energy management)
Pollution and toxic-waste as high-risk-control items	Environmental	E_{12} (pollution prevention); E_{14} (toxic-waste management)
Resource recycling / waste reduction as direct cost savings	Environmental	E_{13} (resource recycling and reuse); E_{16} (reduction of production waste)
Labor shortage, retention,	Social	S_{21} (employee rights and well-being);

and employee care		S_{23} (healthy, safe workplaces); S_{25} (talent cultivation); S_{26} (labor-management communication)
Product quality and customer safety as core of B2B trust	Social	S_{24} (product quality and customer safety)
Community relations (salient mainly in siting/expansion)	Social	S_{22} (assisting in resolving community issues)
Strategic vision and long-term direction; top-management effectiveness	Governance	G_{37} (corporate strategy and vision); G_{35} (efficient top-management team)
Risk management as forward-looking early warning	Governance	G_{33} (risk-management systems)
Board oversight: "form vs. substance" problem	Governance	G_{31} (board responsibility allocation); G_{32} (board independence and accountability); G_{36} (internal/external audit)
Shareholder protection	Governance	G_{34} (protection of shareholder rights)

3.2 Research Framework and Hierarchical Questionnaire Design

Following the qualitative analysis of the focus group discussions, this study established three core dimensions E1: Environmental, S2: Social, and G3: Corporate governance—with nineteen sub-criteria in total, comprehensively representing the diverse issues firms face in pursuing sustainable development and competitiveness. The hierarchical framework is shown in Figure 1. The meaning of each sub-criterion was defined according to the literature review and expert opinions: the environmental dimension covers energy efficiency, pollution prevention, resource circulation, toxic waste and carbon management, regulatory compliance, and lean production; the social dimension covers employee rights and well-being, community prosperity, workplace health and safety, product quality and customer safety, talent cultivation, and labor-management communication; and the governance dimension covers board responsibility allocation and independence, risk management, shareholder rights, top management effectiveness, internal and external audit, and strategic vision.

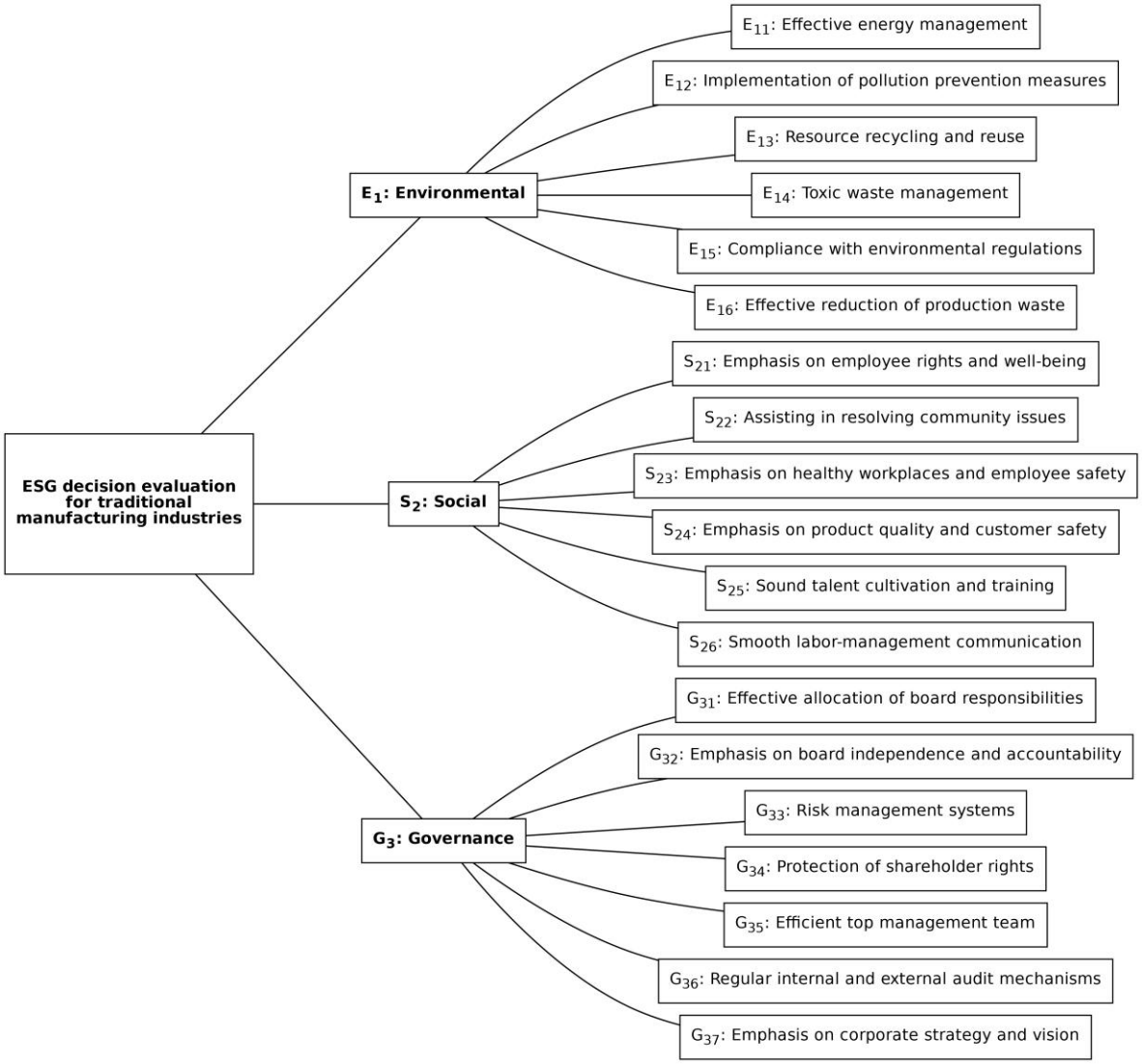

Figure 1. The hierarchical framework of this study

The questionnaire was designed with a structured logic of cognitive calibration, evaluative judgment, weight computation, and source verification. Basic background questions first confirmed respondent attributes so that the cognitive consistency of criterion interpretation across groups could be examined; a worked example then introduced analogical contexts drawn from TCFD, GRI, and green supply chain procurement practice to help experts understand the matrix comparison logic. The pairwise comparison scale of 1-9 proposed by Saaty (1980) was adopted (Table 4), and respondents judged the relative influence of each criterion and sub-criterion on corporate competitiveness according to their professional experience, allowing environmental, social, and governance factors to be measured and compared within a single decision framework. All items were derived from the consensus of the earlier focus groups and the synthesis of international disclosure frameworks, and were reviewed by experts to ensure a reasonable hierarchical structure amenable to consistency testing (Saaty, 1980).

Table 4. The AHP evaluation scale

Scale	Definition	Explanation
1	Equal importance	The two elements contribute equally to the objective.
3	Moderate importance	Experience and judgment slightly favor one element.
5	Strong importance	Experience and judgment strongly favor one element.
7	Very strong importance	One element is favored very strongly over another.
9	Extreme importance	The evidence favoring one element is of the highest possible order.
2, 4, 6, 8	Intermediate values	Compromise judgments between adjacent scale values.

3.3 The AHP Procedure

The AHP is a representative multi-criteria decision support method in decision science, particularly suitable for contexts with incomplete information or highly complex evaluation dimensions (Saaty, 1980). Its core procedure is as follows: after hierarchical decomposition of the problem, a pairwise comparison matrix C = [aij] is established using the 1-9 scale, where aij denotes the importance ratio of element i relative to element j; approximate weights are obtained by normalizing the geometric means of the matrix rows, from which the maximum eigenvalue λ max is computed (Saaty & Vargas, 2001). Following common AHP practice, the individual pairwise-comparison matrices were aggregated into a single group matrix by taking the element-wise (weighted) geometric mean of the entries before deriving the group priority vector an aggregation of individual judgments (AIJ) rather than of individual priorities. Group weights, the maximum eigenvalue, and the consistency indices were obtained by the row-geometric-mean (logarithmic least-squares) method, and can be reproduced in standard spreadsheet software or dedicated AHP packages.

To prevent inconsistent judgments from generating erroneous weight information, the AHP tests judgment consistency using the consistency index (C.I.) and the consistency ratio (C.R.), where C.I. = (λ max − n) / (n − 1) and C.R. = C.I. / R.I., with R.I. being the random index that increases with matrix order. A C.R. of 0.10 or below indicates acceptable consistency.

This study adopted C.R. ≤ 0.10 as the acceptance standard. If the aggregated group matrix exceeded this threshold, the following adjustment procedure was applied: first, the individual C.R. value of each expert questionnaire was examined to identify questionnaires exceeding the consistency threshold; second, for the items in those questionnaires with the largest pairwise comparison deviations (i.e., the most severe departures from consistency), the original respondents were asked to review and revise their judgments; finally, the revised judgments were re-aggregated into the group pairwise comparison matrix using the geometric mean method and the consistency ratio was recomputed, iterating until the consistency standard was met. This adjustment logic follows Saaty's (2003) recommendations on handling consistency in the AHP.

4. Results

This chapter presents the empirical results. First, the focus group discussions collected academic and practitioner views on the environmental, social, and governance dimensions; second, the AHP quantified the criteria and sub-criteria induced from the discussions,

computing the weights and rankings of all dimensions; finally, the qualitative and quantitative results are integrated to derive practical implications. The integrated interpretation of these results, together with their theoretical and practical implications, is developed separately in Section 5 (Discussion).

4.1 Analysis of the Focus Group Discussions

Through in-depth discussions with ten experts, this study analyzed the three ESG criteria. Overall, the participants generally agreed that traditional manufacturers promote ESG not merely out of ideals or image considerations, but far more strongly in response to practical drivers such as regulatory requirements, cost pressure, market competition, and risk management.

Regarding the environmental dimension, participants consistently viewed compliance with environmental regulations as the most fundamental and non-negotiable premise: failure to meet environmental requirements exposes firms not only to penalties and shutdown risks but also to the loss of customer trust and supply chain partnerships. Building on that foundation, effective energy management was regarded as the environmental strategy most relevant to competitiveness, because traditional manufacturing is largely energy-intensive and energy efficiency directly shapes cost structure and profitability; with carbon fee systems taking shape and supply chain requirements for carbon management rising, energy management is no longer merely an energy-saving measure but a strategic combination of cost control and market access. Resource recycling and waste reduction win corporate support relatively easily because they deliver direct cost savings and efficiency gains; pollution prevention and toxic waste management may not generate immediate returns, but they are high-risk-control items whose mishandling would cause far greater damage and must therefore be implemented through institutionalized management.

Regarding the social dimension, labor shortage was the core issue most consistently raised. With declining willingness of young workers to enter the industry and an increasingly evident skills gap, the social strategy of traditional manufacturing has shifted from external philanthropy toward internal workforce stability and employee care. Most participants regarded employee rights and well-being and healthy, safe workplaces as the most critical social factors; meanwhile, in B2B manufacturing, product quality and customer safety were viewed as the core of business operations, since any quality or safety incident would shake long-established customer trust. Community participation was assigned relatively lower priority under normal operations but remains significant in contexts such as plant siting and expansion.

Regarding the governance dimension, participants generally held that the most important premise for genuine sustainability transformation is a clear strategic direction and long-term vision, with the efficiency of the top management team being the key to execution. The importance of risk management systems was repeatedly emphasized: under sustainability trends, supply chain risk, environmental regulatory risk, and climate risk have become core governance content that must shift from ex-post remediation to forward-looking early warning and management. As for board independence and audit mechanisms, participants

considered them theoretically important, but traditional industries often exhibit the problem of "formally possessing systems whose supervisory functions are not substantively exercised," indicating that the real governance challenge lies in whether institutions are implemented in actual operation.

Synthesizing the three dimensions, traditional manufacturers exhibit a decision logic of "compliance as the foundation, benefit as the orientation": firms typically start from avoiding violations and reducing risks, and then consider which practices can bring cost savings, efficiency gains, workforce stability, and competitive advantage. Participants also unanimously noted the pervasive "easier said than done" problem in ESG implementation, whose key lies in whether ESG can be effectively integrated with core business strategy, management systems, and organizational culture. The induced results formed the AHP hierarchical framework of three criteria and nineteen sub-criteria shown in Figure 1.

4.2 AHP Results

4.2.1 Descriptive Statistics of the Sample

A total of 26 valid questionnaires were collected, and respondents' pairwise judgments were aggregated using the geometric mean method. The sample comprised 13 men and 13 women; by industry, textiles accounted for the largest share with 10 respondents (38.5%), followed by machine tools and hardware components with 8 each (30.8%). Ages concentrated in the 46-54 bracket, followed by 55-65; educational attainment was evenly split between bachelor/college and graduate level; department managers formed the largest position group; and 65.4% of respondents had more than 21 years of work experience. The respondents are thus predominantly experienced middle and senior managers with substantial understanding of traditional manufacturing operations and ESG issues, and the sample structure is representative, as shown in Table 5. Respondents were selected purposively against three inclusion criteria: (i) at least ten years of managerial experience in one of the three focal industries; (ii) direct involvement in, or responsibility for, the firm's sustainability, environmental, quality, or governance functions; and (iii) familiarity with ESG-related regulatory or customer requirements. These criteria ensured that professional seniority was accompanied by substantive ESG exposure rather than seniority alone.

Table 5. Descriptive statistics of the sample

Variable	Category	Frequency (n)	Percentage (%)
Industry	Textiles	10	38.5
	Machine tools	8	30.8
	Hardware components	8	30.8
Gender	Male	13	50.0
	Female	13	50.0
Age	30-40	3	11.5
	41-45	1	3.8
	46-54	11	42.3
	55-65	9	34.6
	66-70	2	7.7
Education	Bachelor / college	13	50.0
	Graduate or above	13	50.0
Position	Business owner	2	7.7
	Department manager	14	53.8
	Unit supervisor	10	38.5
Work experience	11-15 years	1	3.8
	16-20 years	8	30.8
	Over 21 years	17	65.4
Annual income (NT$10,000)	101-150	16	61.5
	151-200	4	15.4
	201-250	6	23.1

4.2.2 Weights and Ranking of the Main Criteria

The C.R. of the original aggregated matrix for the main criteria was 0.1497, above the acceptable threshold of 0.10. Following the consistency adjustment procedure described in Section 3.3, the individual C.R. values of the 26 expert questionnaires were examined one by one, the experts concerned were asked to revise the items with the largest deviations, and the judgments were re-aggregated using the geometric mean method; the C.R. of the main criteria matrix then fell within the consistency standard. Because the consistency of the aggregated judgments was extremely high, no difference could be displayed within four decimal places, and the C.R. is reported as 0.0000. For transparency, this exactly zero value should be read as a rounding artifact: after re-aggregation the residual inconsistency of the group matrix fell below 0.00005 and therefore rounds to 0.0000 at four decimal places; it does not indicate that every individual respondent was perfectly consistent. The adjustment affected only those individual questionnaires whose main-criteria C.R. exceeded 0.10, involved revising the one or two most inconsistent comparisons in each, and changed the aggregated weights only marginally without altering the environmental > social > governance rank order.

According to the adjusted results, the weight ranking of the three main criteria is environmental, social, and governance. The environmental dimension carries the highest weight at 0.5657, indicating that environmental issues remain the most central consideration in ESG decision-making in traditional manufacturing; the social dimension ranks second at 0.2600; and corporate governance ranks third at 0.1742, as shown in Table 6. This result

reflects that, in the process of sustainability transformation, traditional manufacturers first attend to environmental issues directly related to production activities and only then extend gradually to social responsibility and the strengthening of governance institutions.

Table 6. Weights and ranking of the main criteria

Rank	Code	Criterion	Weight	Percentage (%)
1	E_1	Environmental	0.5657	56.57
2	S_2	Social	0.2600	26.00
3	G_3	Governance	0.1742	17.42

4.2.3 Weights of the Environmental Sub-criteria

The C.R. of the six environmental sub-criteria was 0.0691, indicating good judgment consistency. Effective energy management obtained the highest local weight (0.2840; global weight 0.1607), showing that energy management is the environmental item traditional manufacturers value most; it was followed by implementation of pollution prevention measures (local weight 0.2212; global weight 0.1252) and toxic waste management, with resource recycling and reuse, compliance with environmental regulations, and effective reduction of production waste ranked next, as shown in Table 7. Environmental items directly linked to cost control, production efficiency, pollution risk, and regulatory pressure thus exert stronger influence on corporate competitiveness.

Table 7. Weights and ranking of the environmental sub-criteria

Rank	Code	Sub-criterion	Local weight	Global weight
1	E_{11}	Effective energy management	0.2840	0.1607
2	E_{12}	Implementation of pollution prevention measures	0.2212	0.1252
3	E_{14}	Toxic waste management	0.1520	0.0860
4	E_{13}	Resource recycling and reuse	0.1484	0.0840
5	E_{15}	Compliance with environmental regulations	0.1197	0.0677
6	E_{16}	Effective reduction of production waste	0.0746	0.0422

4.2.4 Weights of the Social Sub-criteria

The C.R. of the six social sub-criteria was 0.0647, meeting the consistency requirement. Emphasis on employee rights and well-being obtained the highest local weight (0.2852; global weight 0.0741), followed by emphasis on healthy workplaces and employee safety (0.2266; global weight 0.0589) and emphasis on product quality and customer safety (0.1584; global weight 0.0412), with S22, S25, and S26 ranked next, as shown in Table 8. Firms therefore prioritize social issues directly related to employees and products—first securing internal workforce stability and safety, then extending to responses to external communities. Because manufacturing depends heavily on shop-floor operations and technical labor, employee rights and workplace safety naturally take priority, while product quality and customer safety are closely tied to brand trust and market competitiveness.

Table 8. Weights and ranking of the social sub-criteria

Rank	Code	Sub-criterion	Local weight	Global weight
1	S_{21}	Emphasis on employee rights and well-being	0.2852	0.0741
2	S_{23}	Emphasis on healthy workplaces and employee safety	0.2266	0.0589
3	S_{24}	Emphasis on product quality and customer safety	0.1584	0.0412
4	S_{22}	Assisting in resolving community issues	0.1272	0.0331
5	S_{25}	Sound talent cultivation and training	0.1221	0.0317
6	S_{26}	Smooth labor-management communication	0.0806	0.0210

4.2.5 Weights of the Governance Sub-criteria

The C.R. of the seven governance sub-criteria was 0.0506, indicating good consistency. Effective allocation of board responsibilities obtained the highest local weight (0.1873; global weight 0.0326), followed by risk management systems (0.1820; global weight 0.0317) and emphasis on board independence and accountability (0.1717; global weight 0.0299), with G34, G35, G36, and G37 ranked next, as shown in Table 9. Overall, the governance dimension emphasizes institutional responsibility allocation, supervisory mechanisms, and risk management: the first-ranked division of board responsibilities indicates that firms still regard governance efficiency and decision clarity as the basic premise of sustainability transformation, while the closely following risk management systems and board independence reflect growing attention to supervisory functions and risk prevention.

Table 9. Weights and ranking of the governance sub-criteria

Rank	Code	Sub-criterion	Local weight	Global weight
1	G_{31}	Effective allocation of board responsibilities	0.1873	0.0326
2	G_{33}	Risk management systems	0.1820	0.0317
3	G_{32}	Emphasis on board independence and accountability	0.1717	0.0299
4	G_{34}	Protection of shareholder rights	0.1380	0.0240
5	G_{35}	Efficient top management team	0.1312	0.0229
6	G_{36}	Regular internal and external audit mechanisms	0.1107	0.0193
7	G_{37}	Emphasis on corporate strategy and vision	0.0791	0.0138

4.2.6 Overall Priority Ranking

Weighting the local weights of the sub-criteria by the weights of the three main criteria yields the overall priority ranking of the nineteen sub-criteria, as shown in Table 10. The top four positions are all occupied by the environmental dimension—effective energy management, implementation of pollution prevention measures, toxic waste management, and resource recycling and reuse. Emphasis on employee rights and well-being, ranked fifth, is the most important social item, underscoring that workforce stability and employee care are also critical for firms. The highest-ranked governance item, effective allocation of board responsibilities, appears in eleventh place, indicating that governance issues, though necessary, are perceived as less urgent overall than environmental and social concerns.

Table 10. Overall priority ranking of the ESG sub-criteria for traditional manufacturing

Overall rank	Criterion	Code	Sub-criterion	Global weight
1	E_1	E_{11}	Effective energy management	0.1607
2	E_1	E_{12}	Implementation of pollution prevention measures	0.1252
3	E_1	E_{14}	Toxic waste management	0.0860
4	E_1	E_{13}	Resource recycling and reuse	0.0840
5	S_2	S_{21}	Emphasis on employee rights and well-being	0.0741
6	E_1	E_{15}	Compliance with environmental regulations	0.0677
7	S_2	S_{23}	Emphasis on healthy workplaces and employee safety	0.0589
8	E_1	E_{16}	Effective reduction of production waste	0.0422
9	S_2	S_{24}	Emphasis on product quality and customer safety	0.0412
10	S_2	S_{22}	Assisting in resolving community issues	0.0331
11	G_3	G_{31}	Effective allocation of board responsibilities	0.0326
12	S_2	S_{25}	Sound talent cultivation and training	0.0317
13	G_3	G_{33}	Risk management systems	0.0317
14	G_3	G_{32}	Emphasis on board independence and accountability	0.0299
15	G_3	G_{34}	Protection of shareholder rights	0.0240
16	G_3	G_{35}	Efficient top management team	0.0229
17	S_2	S_{26}	Smooth labor-management communication	0.0210
18	G_3	G_{36}	Regular internal and external audit mechanisms	0.0193
19	G_3	G_{37}	Emphasis on corporate strategy and vision	0.0138

In summary, the AHP results show that traditional manufacturers clearly assign top priority to the environmental dimension in ESG decision evaluation, focusing on energy management, pollution prevention, waste management, and resource circulation—issues directly connected to manufacturing processes. The social dimension centers on employee well-being, workplace safety, and product quality, while the governance dimension emphasizes institutional factors such as board responsibility allocation, risk management, and board independence. Traditional manufacturers thus prioritize factors that directly affect operational efficiency, regulatory risk, and competitiveness, and then progressively extend to the refinement of social responsibility and governance systems.

4.2.7 Sensitivity Analysis

To assess whether the prominence of the environmental dimension is robust rather than a mechanical consequence of its high initial weight, the main-criteria weights were varied while the sub-criteria local weights were held constant, and the overall ranking was recomputed. Table 11 reports five scenarios. Effective energy management (E11) remains the single most important factor in every scenario except equal weighting of the three dimensions, where it is effectively tied with employee rights and well-being (0.0947 vs. 0.0951). The four leading environmental items stay within the top six under all but the equal-weighting case, and employee rights and well-being is consistently the most robust social factor. Governance items rise materially only when the three dimensions are weighted equally (board responsibility allocation reaching fifth); under the baseline and moderate re-weightings they remain in the lower half of the ranking. The analysis therefore indicates that environmental primacy is substantively robust, while also showing that the size of the gap between the environmental and social factors is partly amplified by the high initial environmental weight.

Table 11. Sensitivity of the overall ranking to the main-criteria weights

Scenario	E/S /G weights	Top-3 sub-criteria (global weight)	E_{11} rank	S_{21} rank	First governance rank
Baseline (reported)	0.566 /0.260 / 0.174	E_{11} (.161), E_{12} (.125), E_{14} (.086)	1	5	11
Equal weighting	0.333 /0.333 / 0.333	S_{21} (0.095), E_{11} (0.095), S_{23} (0.076)	2	1	5
Environmental −20% (redistributed)	0.453 /0.328 / 0.220	E_{11} (0.129), E_{12} (0.100), S_{21} (.094)	1	3	10
Governance emphasized	0.400 /0.300 / 0.300	E_{11} (0.114), E_{12} (0.089), S_{21} (0.086)	1	3	7
Environmental dominant	0.700 /0.180 / 0.120	E_{11} (0.199), E_{12} (0.155), E_{14} (.0106)	1	7	11

5. Discussion

5.1 From Compliance to Competitiveness: An Integrated, Theory-informed Interpretation

Synthesizing the literature review, the focus group discussions, and the AHP results, this study finds that traditional manufacturers promote ESG with a pronounced decision logic of "starting from compliance, orienting toward benefits, and targeting competitiveness." This finding resonates with international developments: as ESG moves from advocacy to institutionalization, firms must simultaneously confront disclosure and governance requirements including the CBAM, TCFD, TNFD, ISSB standards, and CSRD/ESRS; for export-oriented, energy-intensive traditional manufacturing in particular, sustainability has shifted from an add-on condition to a basic operating threshold.

In the environmental dimension, the primacy of environmental factors stems not purely from sustainability ideals but from their direct bearing on production costs, regulatory risk, and order-winning capability; the focus group views that "regulatory compliance is the survival bottom line" and "effective energy management is the competitiveness core combining cost control with market access" are highly consistent with the AHP weights. In the social dimension, the social issues valued by traditional manufacturers have shifted from philanthropic participation to internal workforce stability and product responsibility: labor shortage, skills gaps, and retention pressure are the principal structural problems, and the real significance of the social dimension lies in strengthening firms' basic capabilities to "retain people, deliver quality, and sustain trust." In the governance dimension, the discussions indicated that strategic vision, management team efficiency, and risk management are the most critical governance items, yet the overall importance of governance in the AHP ranking remains below the environmental and social dimensions. This divergence does not imply that governance is unimportant; rather, it reflects that in actual decision-making traditional firms first address short-term and urgent environmental compliance and workforce issues before gradually extending to medium- and long-term governance optimization—governance functions more as the foundational engineering that supports the long-term embedding of ESG.

Taken together, ESG implementation in traditional manufacturing does not unfold evenly across the three dimensions but exhibits clear stages: the first stage begins with environmental regulatory compliance, energy efficiency improvement, and pollution risk management, constituting "must-do" bottom-line management; the second stage extends to social issues such as employee safety, retention systems, training, and product quality, constituting resilience building for operational stability; and the third stage advances to governance optimization including strategic integration, risk governance, board supervision, and disclosure, completing the path from compliance to competitive advantage. In practical terms, firms may start with high-risk, high-cost, and high-external-pressure items (energy management, pollution prevention, waste treatment, and regulatory compliance), then progressively strengthen employee safety, talent cultivation, labor-management communication, and product quality management, and finally embed ESG in board governance, risk management, and long-term strategic planning. This staged strategy fits the realities of limited resources, high transformation costs, and gradually adjusting management models in traditional industries. For policymakers, consulting institutions, and financial institutions, ESG counseling for traditional manufacturers should not adopt a single standardized model but should provide differentiated support according to industry characteristics and firm size. Interpreted through the natural-resource-based and dynamic-capabilities views, this staged pattern reflects firms first building compliance-based environmental capabilities, then workforce-based resilience, and finally the governance capabilities that allow ESG to be sensed, integrated, and reconfigured into long-term strategy (Hart, 1995; Teece, 2007).

5.2 Reconciling the Focus-group and AHP Findings: The Governance Divergence

A salient feature of the results is the divergence between the qualitative and quantitative findings for governance. In the focus groups, participants repeatedly stressed strategic vision, top-management effectiveness, and risk management as preconditions for genuine sustainability transformation; yet in the AHP the governance dimension received the lowest weight (0.1742), and its highest-ranked item appeared only eleventh overall. Three explanations, not mutually exclusive, help reconcile this gap. First, a salience-versus-urgency distinction: experts recognize governance as foundationally important but, when forced into pairwise trade-offs, prioritize the environmental and workforce issues that carry immediate regulatory, cost, and continuity consequences. Second, a form-versus-substance perception: participants themselves observed that traditional firms often "possess systems whose supervisory functions are not substantively exercised," so governance mechanisms may be discounted as already nominally in place. Third, a framing effect of the pairwise-comparison task, which elicits perceived importance for near-term competitiveness rather than long-run enabling conditions. This contrast between stated priorities (FGD) and revealed priorities (AHP) is itself an informative finding about managerial decision-making: it suggests that governance functions less as an urgent lever than as the institutional infrastructure that sustains environmental and social gains over time, and it cautions against reading the low governance weight as evidence that governance is unimportant.

5.3 Managerial and Policy Implications

For managerial practice in traditional manufacturing, the most important insight of this study is that ESG implementation should not remain at the level of institutional declarations or sustainability report preparation, but should return to core business problems and begin with the most urgent and executable items. Given the highest weight of the environmental dimension, most traditional manufacturers should start with energy management, pollution prevention, waste management, and resource circulation, thereby reducing costs, mitigating regulatory risk, and strengthening supply chain competitiveness—that is, the first step of ESG adoption is to internalize environmental issues as part of process and cost management rather than treating them as an extra burden.

In the social dimension, employee rights, workplace safety, and product quality carry critical significance. Firms that emphasize only equipment upgrading or environmental compliance while neglecting retention, occupational safety, and skill transmission will struggle to build long-term competitiveness; under labor shortage and workforce aging, talent cultivation, labor-management communication, healthy workplaces, and product responsibility should be treated as core content of sustainable operation. In the governance dimension, governance should not stop at board formation, audit procedures, or formal institutional construction, but should be implemented as a governance culture of strategic integration, risk management, and responsibility allocation; for family-owned and small and medium-sized traditional manufacturers in particular, the common problem is not the absence of institutions but institutions that exist without genuinely exercising supervisory and integrative functions.

Moreover, from the practical perspective of business valuation, ESG factors already substantively affect earning capacity and risk levels when firms undertake asset revaluation, equipment investment, plant configuration, financing and credit assessment, business valuation, or operational risk judgment: energy-efficient equipment and processes typically raise asset utilization and lower operating costs; inadequate pollution prevention or incomplete regulatory compliance may trigger shutdowns, fines, or remediation costs that impair asset value and operational stability; and labor shortages, skill gaps, or opaque governance likewise affect operational continuity and market credibility. ESG has thus gradually become an important basis affecting corporate asset value, risk assessment, and investment and financing conditions. For policymakers, sustainability consultants, and financial institutions, counseling should not be one-size-fits-all: energy-intensive industries should first be assisted in building energy management, carbon inventory, and pollution prevention capabilities; labor-intensive industries deserve greater attention to workplace safety, talent cultivation, and labor relations; and for small and medium-sized enterprises with weaker governance foundations, board functions, risk management, and disclosure mechanisms should be strengthened.

These recommendations should be differentiated by firm type and ESG maturity rather than applied uniformly. For small and medium-sized enterprises with limited resources, a focused sequence—beginning with energy and pollution management that pay back through cost savings, then workplace safety and retention offers the highest leverage, whereas large

corporations can pursue the three dimensions in parallel and lead supply-chain decarbonization. For firms at an early stage of ESG maturity, the priority is compliance and basic measurement (carbon inventory, energy monitoring, and ISO-based quality and safety systems); more advanced firms can progress toward Scope 3 management, science-based targets, and board-level ESG integration. Competitive strategy also matters: cost leaders gain most from energy efficiency, lean production, and resource circulation that lower unit costs, whereas differentiators can convert environmental certification, product stewardship, and transparent governance into brand trust and premium market access. This contingency perspective avoids the one-size-fits-all counseling that the review process rightly cautions against.

5.4 Adapting the Framework to Emerging ESG Issues

The proposed framework is a snapshot of current priorities and should be updated as the ESG landscape evolves. Four developments warrant explicit incorporation in future iterations. First, Scope 3 emissions and supply-chain decarbonization are becoming decisive for export-oriented manufacturers, extending the environmental dimension beyond the firm's own boundary to its suppliers and logistics. Second, biodiversity and nature-related risks, formalized by the TNFD, add a natural-capital sub-dimension that is especially material for water- and chemical-intensive textile processing. Third, artificial intelligence and digital transformation smart metering, digital measurement, reporting and verification, and AI-assisted process control are emerging as cross-cutting enablers of both environmental efficiency and governance transparency (Körner et al., 2025). Fourth, social-justice and equity considerations, including a “just transition” for aging traditional-industry workforces, connect the social dimension to broader questions of fairness in decarbonization. Incorporating these issues would require adding or re-specifying sub-criteria and re-eliciting weights, and represents a natural extension of the present study.

6. Conclusions, Limitations, and Future Research

6.1 Conclusions

Focusing on an under-researched but economically important sector, this study combined focus group discussions with the analytic hierarchy process to elicit and prioritize the ESG decision factors that experts in Taiwanese traditional manufacturing perceive as most important for sustaining competitiveness. Experts prioritized the environmental dimension most strongly, followed by the social and then the corporate-governance dimension, and favored factors tied to energy efficiency, pollution and waste control, regulatory compliance, and workforce stability.

These priorities are best understood as a staged logic of managerial attention from environmental compliance and cost efficiency, through workforce resilience, toward governance optimization and as evidence of a gap between stated and revealed priorities, rather than as a causal account of competitive performance. The framework offers managers, policymakers, and investors a transparent basis for sequencing ESG action and allocating scarce resources, while inviting extension to other sectors, larger and more diverse samples,

and emerging issues such as Scope 3 emissions, nature-related risk, and a just transition.

6.2 Research Scope and Limitations

The scope of this study focuses on Taiwanese traditional industries particularly textiles, machine tools, and hardware components—which are characterized by high energy consumption, labor intensity, and export orientation and face the challenges of international sustainability regulations and carbon border mechanisms. Several limitations should be noted. First, regarding industry representativeness, other traditional industries such as food processing, papermaking, and petrochemicals may face different ESG challenges, so the findings may not be fully generalizable. Second, the AHP relies on expert judgments, and the results may be constrained by respondents' subjective assessments and background differences. Third, ESG norms and international policies (e.g., CBAM, CSRD, TCFD, and TNFD) continue to evolve, so the conclusions are time-sensitive. Finally, the questionnaire sample, drawn mainly from experts and industry practitioners, is limited in size, which may affect the breadth of applicability. Two further limitations deserve emphasis. First, the expert panel is relatively homogeneous in age, seniority, and industry background; such homogeneity may bias the elicited priorities toward the incumbent managerial worldview and underweight the perspectives of younger employees, newer firms, or other stakeholder groups. Second, the AHP's 1-9 pairwise-comparison scale, while tractable, compresses complex and sometimes non-linear ESG trade-offs into unidimensional judgments and assumes preference independence among criteria; interdependencies among ESG factors are therefore not captured a limitation that methods such as the ANP or DEMATEL could address.

6.3 Suggestions for Future Research

Regarding research subjects, future studies may extend to food processing, plastics, petrochemicals, papermaking, or other traditional industries to compare differences in ESG criterion weights and decision logic across sectors, thereby improving generalizability and external validity. Regarding methods, future research may combine fuzzy AHP, ANP, DEMATEL, or structural equation modeling to explore possible interactions and causal structures among ESG criteria, moving beyond weight rankings to reveal the interdependencies and dynamic influences among dimensions.

Regarding data collection, future studies may enlarge the sample and compare different roles business owners, senior executives, middle managers, sustainability consultants, and investment evaluators to examine whether stakeholder groups differ significantly in their ESG priority rankings; incorporating samples that vary in firm size, export share, or degree of family governance would further capture the heterogeneity of ESG decision-making in traditional manufacturing. In addition, because ESG-related regulations change rapidly, longitudinal designs could track how corporate weights and strategies adjust across policy stages; linking the framework with financial performance, export performance, investment efficiency, or changes in asset value would provide more concrete verification of the substantive connection between ESG dimensions and corporate competitiveness. In particular, sector-specific weight comparisons across textiles, machine tools, and hardware components pooled here for reasons of sample size should be pursued once larger per-sector samples permit, in order to

test whether ESG decision logics differ meaningfully across these industries.

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Author contributions

Wen-Tsung Wu (corresponding author) and Ching-Hsing Chang conceived and designed the study; Cheng-Fu Wang and Wen-Tsung Wu organized the focus group discussions and collected the AHP questionnaire data; Ching-Hsing Chang and Chun-Hsien Wang performed the AHP analysis and interpreted the results; Wen-Tsung Wu drafted the manuscript, and Chun-Hsien Wang and Ching-Hsing Chang revised it critically. All authors read and approved the final manuscript.

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No additional data are available.

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