GLOBAL MULTIDISCIPLINARY PERSPECTIVES JOURNAL

Conceptual Framework for Integrating ESG Metrics into SME Supply Chain Decision-Making Processes

Oluchi Zoey Efobi [1*], Oluwafunmilayo Kehinde Akinleye [2], Oladipupo Fasawe [3]
[1] Bumpadeals Nigeria Limited, Lagos, Nigeria
[2] Independent Researcher, United Kingdom
[3] Google LLC, USA

* Corresponding Author: **Oluchi Zoey Efobi**

Article Info

ISSN (online): 3107-3972
Volume: 01
Issue: 06
November-December 2024
Received: 11-09-2024
Accepted: 13-10-2024
Published: 09-11-2024
Page No: 113-131

Abstract
Small and medium-sized enterprises face increasing pressure to incorporate environmental, social, and governance considerations into their supply chain operations, yet they often lack the resources and frameworks available to larger corporations. This research develops a conceptual framework specifically designed for SMEs to integrate ESG metrics into supply chain decision-making processes. The framework addresses the unique constraints of SMEs, including limited financial resources, smaller organizational structures, and reduced bargaining power with suppliers. Through a comprehensive review of existing literature on sustainable supply chain management, ESG integration, and SME-specific challenges, this study identifies critical gaps in current approaches and proposes a scalable, resource-efficient framework. The conceptual model incorporates three core dimensions: materiality assessment tailored to SME contexts, stakeholder engagement mechanisms suitable for smaller organizational scales, and decision-making tools that balance sustainability objectives with operational and financial constraints. The framework emphasizes practical implementation strategies, including phased integration approaches, collaborative industry initiatives, and technology-enabled solutions that reduce the burden of data collection and analysis. By providing a structured yet flexible approach to ESG integration, this framework enables SMEs to enhance supply chain sustainability, meet evolving stakeholder expectations, and build competitive advantage through responsible business practices. The research contributes to both academic understanding and practical application by bridging the gap between comprehensive ESG frameworks designed for large enterprises and the operational realities of small and medium-sized businesses.

DOI: https://doi.org/10.54660/GMPJ.2024.1.6.113-131

Keywords: Small and Medium-Sized Enterprises (SMEs); Environmental, Social, and Governance (ESG); Sustainable Supply Chain Management; ESG Integration; Materiality Assessment; Stakeholder Engagement; Responsible Business Practices; Sustainability Framework; Supply Chain Decision-Making; Competitive Advantage.

1. Introduction

The integration of environmental, social, and governance metrics into corporate decision-making has evolved from a peripheral concern to a central strategic imperative across global business operations. This transformation reflects growing recognition that sustainable business practices are not merely ethical considerations but fundamental drivers of long-term value creation, risk management, and competitive positioning (Kotsantonis and Serafeim, 2019). Large multinational corporations have responded to this shift by developing sophisticated ESG reporting systems, dedicating substantial resources to sustainability initiatives, and embedding ESG considerations throughout their organizational structures and supply chain networks.

However, small and medium-sized enterprises, which constitute the backbone of most economies worldwide, face distinct challenges in adopting similar approaches to ESG integration within their supply chain decision-making processes (Riva *et al*., 2021).

Small and medium-sized enterprises account for over ninety percent of businesses globally and represent significant portions of employment and economic output in both developed and developing economies (Dey *et al*., 2020). Despite their collective economic importance, SMEs have historically received limited attention in academic research on sustainable supply chain management, with most frameworks and tools designed primarily for large corporations with extensive resources and specialized sustainability departments (Jasti and Kodali, 2015). This gap between available knowledge and practical needs has left many SMEs struggling to respond effectively to mounting pressures from customers, investors, regulatory bodies, and society at large to demonstrate responsible supply chain practices (Shalhoob and Hussainey, 2022).

The unique characteristics of SMEs create both obstacles and opportunities for ESG integration. Unlike large corporations, SMEs typically operate with constrained financial resources, limited personnel, and less formalized management structures (Thakkar *et al*., 2008). These constraints can hinder the adoption of resource-intensive sustainability programs and comprehensive ESG reporting systems (Molin, 2021). However, SMEs often benefit from greater organizational agility, closer relationships with stakeholders, and more direct decision-making processes, which can facilitate rapid implementation of sustainability initiatives once appropriate frameworks are established (Palomero and Chalmeta, 2014). The challenge lies in developing approaches that leverage these advantages while addressing the very real resource limitations that SMEs face (D'Angiò *et al*., 2022).

Supply chain decision-making in SMEs encompasses a wide range of activities, including supplier selection and evaluation, procurement processes, logistics and distribution strategies, inventory management, and quality control systems (Soni *et al*., 2022). Each of these decision points presents opportunities to incorporate ESG considerations, yet many SMEs lack structured approaches for doing so (Madiwal and Dulange, 2016). Traditional supply chain decisions in SMEs have predominantly focused on cost minimization, delivery reliability, and quality assurance, with environmental and social factors often treated as secondary concerns or regulatory compliance issues rather than integral components of strategic decision-making (Musso and Francioni, 2012). This narrow focus increasingly exposes SMEs to risks including supply chain disruptions, reputational damage, loss of business opportunities with sustainability-conscious customers, and potential regulatory penalties (Testa *et al*., 2016).

The growing emphasis on supply chain transparency and accountability has intensified pressure on SMEs to demonstrate ESG performance (Todorova and Zyatchin, 2023). Large corporations increasingly require their SME suppliers to meet specific sustainability standards and provide evidence of responsible practices throughout their own supply networks (Cronin and Doyle-Kent, 2022). This cascading effect of ESG requirements down supply chains means that SMEs can no longer avoid sustainability considerations even if they do not face direct pressure from end consumers or investors (Jo and Kwon, 2021). Furthermore, access to finance, government contracts, and participation in certain markets increasingly depends on demonstrated ESG performance, creating both risks for non-compliant SMEs and opportunities for those that proactively embrace sustainable practices (Jones *et al*., 2023).

Despite the clear importance of ESG integration for SMEs, existing conceptual frameworks and practical tools remain largely inadequate for the SME context (Kaddour, 2023). Most frameworks assume organizational capacities, resources, and supply chain leverage that simply do not exist in smaller enterprises (Banomyong and Supatn, 2011). Academic research has provided valuable insights into sustainable supply chain management principles and ESG integration strategies, but the translation of these insights into actionable frameworks for resource-constrained SMEs remains incomplete (Figurek and Thrassou, 2023). There is a critical need for conceptual models that acknowledge SME-specific constraints while providing structured approaches to embedding ESG metrics into supply chain decision-making processes (Whitelock, 2019).

This research addresses this gap by developing a conceptual framework specifically designed for SMEs to integrate ESG metrics into their supply chain decision-making processes. The framework builds on established theories of sustainable supply chain management, stakeholder theory, and resource-based perspectives while incorporating insights from empirical research on SME sustainability practices (Puppim de Oliveira and Jabbour, 2017). The proposed framework emphasizes scalability, resource efficiency, and practical applicability, recognizing that SMEs require approaches fundamentally different from those employed by large corporations (Markopoulos *et al*., 2023). By providing a structured yet flexible model, this research aims to enable SMEs to enhance their supply chain sustainability performance, meet stakeholder expectations, manage ESG-related risks, and potentially achieve competitive advantages through differentiation based on responsible business practices (Cek and Ercantan, 2023).

The framework developed in this research comprises three interconnected dimensions that collectively enable effective ESG integration in SME supply chains. First, the materiality assessment dimension provides guidance for identifying which ESG issues are most relevant to specific SME contexts, enabling focused attention on factors that truly matter for the enterprise and its stakeholders rather than attempting to address all possible sustainability concerns (Nielsen, 2023). Second, the stakeholder engagement dimension outlines approaches for SMEs to understand and respond to ESG expectations from customers, suppliers, employees, communities, and other relevant parties, leveraging the closer stakeholder relationships that often characterize smaller enterprises (Aksoy *et al*., 2022). Third, the decision-making integration dimension presents practical mechanisms for embedding ESG metrics into specific supply chain decisions, from supplier selection to logistics planning, while maintaining focus on operational efficiency and financial viability (Nwokocha *et al*., 2023).

The significance of this research extends beyond academic contribution to practical impact for the substantial population of SMEs navigating the complex landscape of sustainable supply chain management (Kot *et al*., 2020). By providing a conceptual foundation that acknowledges real constraints while outlining feasible pathways for ESG integration, this framework can help bridge the gap between sustainability

aspirations and operational realities in small and medium-sized enterprises (Singh, 2011). The research also contributes to broader efforts to achieve sustainable development goals, as widespread adoption of ESG principles across the SME sector is essential for systemic progress toward environmental protection, social equity, and responsible governance in global supply chains (Zeng *et al*., 2022).

2. Literature Review

The academic literature on sustainable supply chain management has expanded substantially over the past two decades, reflecting growing recognition of the importance of environmental and social considerations in supply chain operations. Early research in this domain focused primarily on environmental management, with particular emphasis on reducing waste, minimizing emissions, and improving resource efficiency within manufacturing and logistics processes (Sarkis, 2003). These initial studies established foundational concepts such as green supply chain management and reverse logistics, demonstrating that environmental considerations could be compatible with, and sometimes even enhance, economic performance (Howarth and Fredericks, 2012). However, this early literature predominantly examined large manufacturing firms in developed economies, with limited attention to the distinct challenges and opportunities facing small and medium-sized enterprises (Tan *et al*., 2006).

The evolution of sustainable supply chain management research has progressively broadened to encompass social and governance dimensions alongside environmental concerns, reflecting the comprehensive perspective embodied in ESG frameworks (Ballester Climent, 2022). Seuring and Müller (2008) provided an influential review that identified two main strategies for sustainable supply chain management: supplier management for risks and performance, and supply chain management for sustainable products. Their analysis highlighted the importance of collaboration, monitoring, and long-term relationships in achieving sustainability objectives, themes that have continued to resonate throughout subsequent research (Hemilä and Vilko, 2015). Carter and Rogers (2008) further advanced theoretical understanding by proposing that truly sustainable supply chain management requires the intersection of environmental, social, and economic performance, supported by organizational culture and transparent communication with stakeholders (Whitelock, 2015).

Research specifically examining ESG integration in supply chains has gained momentum in recent years as investors, regulators, and customers increasingly demand comprehensive sustainability performance data (Atkins *et al*., 2022). Busch *et al*. (2021) analyzed the relationship between corporate ESG performance and supply chain outcomes, finding that stronger ESG practices are associated with improved supply chain resilience and reduced disruption risks (Zhao *et al*., 2023). Their research suggests that ESG considerations serve not merely as ethical obligations but as practical tools for managing complex supply chain challenges in an increasingly volatile global environment (Ali *et al*., 2023). Similarly, Buallay (2019) conducted a comprehensive analysis across multiple sectors and regions, demonstrating that ESG performance correlates positively with operational efficiency and financial outcomes, though the strength of these relationships varies across different contexts and industries (Zioło *et al*., 2023).

The specific challenges facing SMEs in adopting sustainable supply chain practices have received increasing attention from researchers, though this literature remains considerably less developed than research focused on large corporations (Ritchie and Brindley, 2000). Dey *et al*. (2020) examined barriers to sustainable supply chain management adoption among SMEs, identifying resource constraints, lack of knowledge and expertise, limited awareness of sustainability issues, inadequate support from external stakeholders, and insufficient pressure from customers as key obstacles (Huang, 2009). Their findings emphasize that SMEs face fundamentally different challenges than large firms, requiring distinct approaches and support mechanisms rather than simply scaled-down versions of corporate sustainability programs (Saviano and Berardi, 2009).

Johnson and Schaltegger (2016) explored the motivations driving SME engagement with sustainability, distinguishing between reactive responses to external pressures and proactive integration driven by entrepreneurial values or perceived business opportunities (Paro, 2023). Their research revealed considerable heterogeneity among SMEs, with sustainability adoption influenced by factors including owner values, industry sector, geographic location, and position within supply chains (Oyeyipo *et al*., 2023). This heterogeneity suggests that effective frameworks for ESG integration must be sufficiently flexible to accommodate diverse SME contexts while providing clear structure for implementation (Okpala, 2023).

The role of supply chain position and power dynamics in shaping SME sustainability practices has emerged as an important theme in recent literature (Tounsi *et al*., 2009). Testa *et al*. (2016) investigated how SME suppliers respond to sustainability requirements imposed by large corporate customers, finding that while such requirements can drive adoption of environmental and social practices, they may also create tensions when sustainability demands conflict with cost pressures or when SMEs lack the resources to meet complex requirements (Sardanelli *et al*., 2022). This research highlights the importance of collaborative approaches that provide SMEs with support and capacity building rather than simply imposing requirements without corresponding assistance (Tsang *et al*., 2023).

Stakeholder theory provides important theoretical foundations for understanding ESG integration in SME supply chains. Freeman (1984) originally articulated stakeholder theory as an alternative to shareholder primacy, arguing that organizations should consider the interests of all parties affected by business decisions. This perspective has proven particularly relevant for sustainable supply chain management, where decisions impact diverse stakeholders including employees, local communities, customers, suppliers, and future generations (Dako *et al*., 2023). For SMEs, stakeholder relationships often have distinct characteristics compared to large corporations, with owner-managers frequently having direct personal relationships with key stakeholders and greater embeddedness in local communities (Jenkins, 2006).

The application of stakeholder theory to SME sustainability has been examined by several researchers who have identified both advantages and challenges in the SME context (Davidor *et al*., 2023). Spence (2016) argued that SMEs often engage in informal, relationship-based approaches to stakeholder management that differ substantially from the

formalized stakeholder engagement processes common in large corporations (Amini-Philips *et al*., 2023). These informal approaches can be highly effective for understanding and responding to stakeholder concerns, but they may also lack the systematic documentation and communication that external stakeholders increasingly expect (Eyinade *et al*., 2022). The challenge for SMEs lies in developing stakeholder engagement approaches that retain the benefits of close relationships while providing greater structure and transparency (Keeley *et al*., 2022).

Resource-based theory offers another important theoretical lens for understanding ESG integration in SMEs. This perspective, developed by Barney (1991) and others, suggests that competitive advantage derives from valuable, rare, inimitable, and non-substitutable resources and capabilities that firms develop and deploy (Gunasekaran *et al*., 2017). Applied to sustainable supply chain management, resource-based theory suggests that ESG capabilities can potentially serve as sources of competitive advantage if they enable performance improvements or differentiation that competitors cannot easily replicate (Fiaschi *et al*., 2020). However, the resource constraints facing SMEs raise questions about their ability to develop distinctive ESG capabilities without external support (Lanza *et al*., 2020).

Hart (1995) applied resource-based theory specifically to environmental strategy, proposing that environmental capabilities can provide competitive advantages through pollution prevention, product stewardship, and sustainable development initiatives (Didi *et al*., 2021). Subsequent research has explored how these concepts apply to SMEs, with mixed findings regarding whether resource constraints prevent SMEs from developing valuable sustainability capabilities or whether organizational agility and stakeholder relationships provide alternative pathways to competitive advantage through sustainability (Carbonneau *et al*., 2008). Torugsa *et al*. (2012) found evidence that proactive environmental strategies can enhance SME competitiveness, but emphasized that success depends on developing appropriate capabilities and aligning sustainability initiatives with overall business strategy (Büyüközkan and Göçer, 2018).

The practical implementation of ESG metrics in supply chain decision-making has been examined through various lenses, including multi-criteria decision-making approaches, performance measurement systems, and supply chain analytics (Souza, 2014). Govindan *et al*. (2015) reviewed sustainable supply chain management literature and identified multiple criteria decision-making methods as particularly valuable for integrating environmental and social factors into supply chain decisions alongside traditional economic criteria (Tiwari *et al*., 2018). These methods enable systematic consideration of trade-offs among competing objectives and can accommodate both quantitative and qualitative performance indicators (Akinlade *et al*., 2023). However, many of these approaches require substantial data, analytical expertise, and computational resources that may be unavailable to SMEs (Hazen *et al*., 2014).

Performance measurement systems for sustainable supply chains have evolved from simple environmental metrics toward comprehensive frameworks incorporating environmental, social, and economic dimensions (Filani *et al*., 2022). Ahi and Searcy (2015) analyzed sustainable supply chain performance metrics across academic literature, identifying commonly used measures and highlighting inconsistencies in how sustainability performance is defined and assessed (Alao *et al*., 2023). Their analysis revealed that while environmental metrics have become relatively standardized, social performance measurement remains inconsistent and context-dependent (Ejairu *et al*., 2023). For SMEs, the proliferation of potential metrics creates confusion and raises questions about which indicators are most relevant and feasible to track given resource limitations (Onotole *et al*., 2023).

The concept of materiality, borrowed from financial reporting, has gained importance in ESG contexts as a means of focusing attention on issues that truly matter for specific organizations and their stakeholders (Ogunyankinnu *et al*., 2022). The Global Reporting Initiative and other standard-setting bodies have promoted materiality assessment as a foundational step in sustainability reporting, helping organizations identify which environmental, social, and governance topics are most significant based on stakeholder concerns and business impacts (GRI, 2016). However, materiality assessment processes designed for large corporations may be difficult for SMEs to implement without adaptation to their specific circumstances and resource constraints (Okojiev *et al*., 2023).

Digital technologies and data analytics have emerged as potentially transformative tools for enabling ESG integration in supply chains, including for resource-constrained SMEs (Oyeyemi, 2023). Dubey *et al*. (2019) examined how big data analytics capabilities can enhance sustainable supply chain management by improving visibility, enabling better decision-making, and facilitating stakeholder communication (Oyeyemi and Kabirat, 2023). Their research suggests that technological solutions may help overcome some traditional barriers to sustainability adoption, though questions remain about SME access to and capability with advanced analytics tools (Ogundipe *et al*., 2023). Blockchain technology has also received attention as a potential enabler of supply chain transparency and traceability, though practical implementation remains limited, particularly for SMEs (Saberi *et al*., 2019).

Collaborative approaches to sustainable supply chain management have been identified as particularly relevant for SMEs that lack individual resources or bargaining power to drive sustainability improvements independently (Ivanov *et al*., 2019). Vachon and Klassen (2008) demonstrated that collaboration with both suppliers and customers on environmental initiatives can enhance environmental performance and quality simultaneously, creating value for all parties (Hofmann and Rüsch, 2017). Industry-level initiatives, sector-specific standards, and collective action platforms offer mechanisms through which SMEs can access knowledge, share costs of sustainability initiatives, and amplify their influence on supply chain practices (Adesanya *et al*., 2020).

The role of external support in enabling SME sustainability has been examined by researchers studying government policies, industry associations, and non-governmental organizations (Sanusi *et al*., 2019). Klewitz and Hansen (2014) reviewed sustainability-oriented innovation in SMEs and identified external support mechanisms as critical success factors, particularly for overcoming knowledge and resource barriers (Sarrico and Rosa, 2016). Policy instruments including regulations, financial incentives, information provision, and voluntary programs can shape the context within which SMEs make decisions about ESG

integration (Om *et al*., 2007). However, the effectiveness of different policy approaches varies considerably depending on sector, region, and specific policy design characteristics (Pathik *et al*., 2012).

Despite the substantial body of literature on sustainable supply chain management, ESG integration, and SME sustainability challenges, significant gaps remain in understanding how SMEs can effectively incorporate ESG metrics into supply chain decision-making processes (Rainy and Chowdhury, 2022). Most existing frameworks and tools have been developed for large corporations and require adaptation to be relevant for SMEs (Molin, 2021). The literature provides valuable insights into barriers SMEs face and potential enablers of sustainability adoption, but comprehensive conceptual frameworks specifically designed for ESG integration in SME supply chains remain limited (D'Angiò *et al*., 2022). Furthermore, much existing research focuses on either environmental management or social responsibility in isolation, whereas contemporary ESG approaches require integrated consideration of environmental, social, and governance dimensions simultaneously (Whitelock, 2019).

The heterogeneity among SMEs in terms of size, sector, resources, and supply chain positions suggests that one-size-fits-all approaches are unlikely to be effective, yet the literature provides limited guidance on how frameworks should be adapted to different SME contexts (Markopoulos *et al*., 2023). Questions also remain about how SMEs can balance competing demands from multiple stakeholders who may have divergent ESG priorities, particularly when operating with limited resources that constrain the ability to address all stakeholder concerns simultaneously (Sardanelli *et al*., 2022). The practical mechanisms through which ESG metrics can be embedded into specific supply chain decisions such as supplier selection, procurement, logistics planning, and performance evaluation require further development tailored to SME contexts (Nwokocha *et al*., 2023).

This research builds on the existing literature by developing a conceptual framework that addresses these gaps, providing SME-specific guidance for integrating ESG metrics into supply chain decision-making processes while acknowledging resource constraints and leveraging the unique characteristics of smaller enterprises (Tsang *et al*., 2023).

3. Methodology

This research employs a conceptual framework development methodology, drawing on established approaches in management and supply chain research for creating theoretical models that organize knowledge, identify relationships among concepts, and provide guidance for practice. The methodology integrates systematic literature review, theoretical synthesis, and conceptual modeling to develop a framework specifically designed for integrating ESG metrics into SME supply chain decision-making processes. This approach is appropriate for addressing the research objective of creating a structured yet flexible model that bridges existing theoretical understanding and practical implementation needs in the SME context.

The foundation of the methodology consists of a comprehensive literature review that examines multiple streams of relevant research including sustainable supply chain management, ESG integration, SME sustainability practices, stakeholder theory, resource-based perspectives, and supply chain decision-making. The literature review was conducted systematically, beginning with searches in major academic databases including Web of Science, Scopus, and Google Scholar using combinations of keywords related to sustainable supply chains, ESG metrics, environmental social governance, SMEs, small medium enterprises, supply chain decisions, and related terms. The initial search yielded several thousand potentially relevant articles, which were screened based on titles and abstracts to identify those most pertinent to the research focus.

The selection criteria for literature inclusion emphasized peer-reviewed journal articles, though influential books, working papers from reputable institutions, and reports from recognized standard-setting bodies were also considered where they provided important conceptual or empirical contributions. Particular attention was given to recent publications from the past decade, reflecting the relatively recent prominence of comprehensive ESG frameworks and the evolving nature of sustainable supply chain management practices (Kotsantonis and Serafeim, 2019; Atkins *et al*., 2023). However, foundational works that established key theoretical perspectives or empirical findings were included regardless of publication date to ensure the framework builds on solid theoretical foundations (Puppim de Oliveira and Jabbour, 2017; Singh, 2011).

The literature analysis process involved detailed examination of selected works to identify key concepts, theoretical frameworks, empirical findings, and practical implications relevant to ESG integration in SME supply chains. Thematic analysis was employed to organize insights from diverse literature streams, identifying recurring themes, contradictions, and gaps in existing knowledge. Particular attention was paid to frameworks and models proposed in previous research, analyzing their components, underlying assumptions, and applicability to the SME context (Jasti and Kodali, 2015; Büyüközkan and Göçer, 2018). This analysis revealed that while numerous frameworks exist for sustainable supply chain management and ESG integration, most assume organizational characteristics and resources typical of large corporations, creating a clear gap that this research addresses (Thakkar *et al*., 2008; D'Angiò *et al*., 2022).

The theoretical synthesis component of the methodology integrates insights from multiple theoretical perspectives to provide robust foundations for the proposed framework. Stakeholder theory provides the overarching logic for why SMEs should integrate ESG considerations into supply chain decisions, emphasizing the importance of balancing diverse stakeholder interests and recognizing that long-term success depends on managing relationships with all parties affected by business operations (Aksoy *et al*., 2022; Paro, 2023). Resource-based theory informs understanding of how ESG capabilities can potentially create competitive advantages and how resource constraints shape feasible approaches for SMEs (Gunasekaran *et al*., 2017; Fiaschi *et al*., 2020). Institutional theory helps explain external pressures driving ESG adoption and the role of norms, regulations, and collective expectations in shaping organizational behavior (Riva *et al*., 2021; Shalhoob and Hussainey, 2022).

The conceptual modeling process builds on the literature review and theoretical synthesis to develop a framework that addresses identified gaps and meets the specific needs of SMEs seeking to integrate ESG metrics into supply chain decision-making. The framework development followed an

iterative process, beginning with identification of core dimensions that must be addressed for effective ESG integration, then elaborating components within each dimension, specifying relationships among elements, and refining the model to ensure internal consistency and practical applicability (Markopoulos *et al*., 2023; Nwokocha *et al*., 2023). The framework explicitly acknowledges SME constraints including limited financial resources, small organizational structures, and reduced bargaining power while also leveraging potential SME advantages such as organizational agility, closer stakeholder relationships, and more direct decision-making processes (Palomero and Chalmeta, 2014; Molin, 2021).

Validation of the conceptual framework involved several approaches. First, logical consistency was assessed by examining whether the framework's components align coherently with underlying theoretical foundations and whether proposed relationships among elements are logically sound (Zeng *et al*., 2022; Zioło *et al*., 2023). Second, comprehensiveness was evaluated by considering whether the framework addresses the full range of issues identified in the literature as important for ESG integration in SME supply chains, including materiality assessment, stakeholder engagement, and decision-making integration (Figurek and Thrassou, 2023; Okpala, 2023). Third, practical feasibility was assessed by considering whether the framework's recommendations are realistic given typical SME resource constraints and organizational characteristics, drawing on empirical findings from SME sustainability research (Kaddour, 2023; Kot *et al*., 2020). Fourth, alignment with established best practices was examined by comparing framework recommendations with guidance from recognized standard-setting bodies and sustainability frameworks, while ensuring adaptations are appropriate for the SME context (Nielsen, 2023; Keeley *et al*., 2022).

The framework development process also incorporated consideration of implementation challenges and enablers identified in the literature. Research on barriers to SME sustainability adoption informed understanding of obstacles the framework must help address, including resource limitations, knowledge gaps, and inadequate external support (Huang, 2009; Saviano and Berardi, 2009). Literature on success factors and enablers of SME sustainability guided identification of mechanisms the framework should leverage, such as collaborative approaches, phased implementation strategies, and technology-enabled solutions that reduce resource requirements (Hemilä and Vilko, 2015; Tounsi *et al*., 2009).

Throughout the methodology, particular attention was paid to ensuring that the resulting framework would be sufficiently structured to provide clear guidance while maintaining flexibility to accommodate the substantial heterogeneity among SMEs in terms of size, sector, resources, and supply chain contexts (Banomyong and Supatn, 2011; Ritchie and Brindley, 2000). This balance between structure and flexibility is critical for practical utility, as overly rigid frameworks may be inappropriate for many SMEs while excessively vague guidance fails to provide the clarity that resource-constrained organizations need to take action (Musso and Francioni, 2012; Madiwal and Dulange, 2016).

The conceptual framework presented in this research represents a synthesis of theoretical understanding and practical considerations, designed to advance both academic knowledge and real-world practice. While conceptual frameworks do not produce empirical data in the traditional sense, they serve the essential function of organizing existing knowledge, identifying relationships among concepts, and providing structured approaches for addressing complex challenges (Soni *et al*., 2022; Ali *et al*., 2023). The framework developed through this methodology provides a foundation for future empirical research that can test specific propositions, examine implementation experiences, and refine understanding of how ESG metrics can most effectively be integrated into SME supply chain decision-making processes under various conditions (Cronin and Doyle-Kent, 2022; Jo and Kwon, 2021).

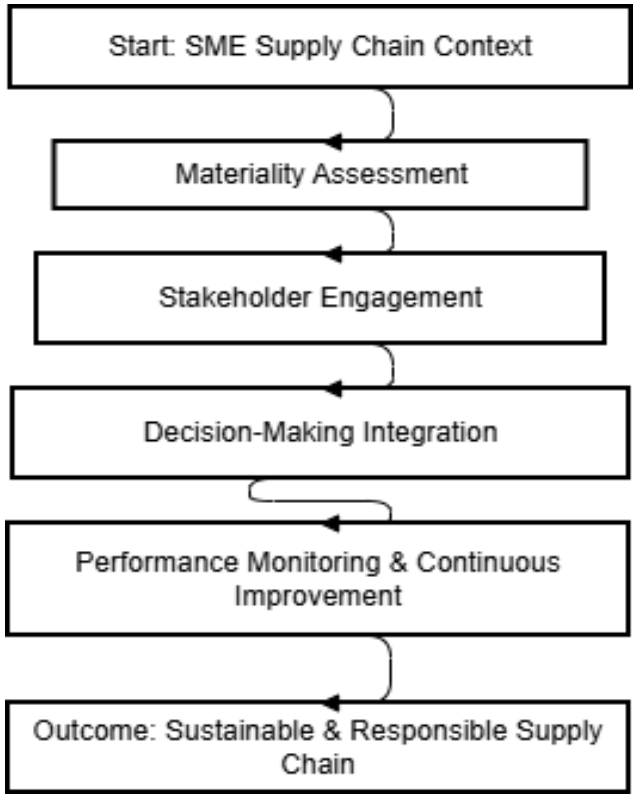
3.1. Framework Dimensions and Core Components

The conceptual framework for integrating ESG metrics into SME supply chain decision-making processes comprises three interconnected dimensions that collectively enable systematic yet practical approaches to sustainability integration. These dimensions emerged from the literature review and theoretical synthesis as essential components that must be addressed for effective ESG integration in resource-constrained contexts. The first dimension, materiality assessment, provides mechanisms for identifying which ESG issues are most relevant to specific SME contexts, enabling focused attention on factors that truly matter rather than attempting to address all possible sustainability concerns with limited resources (Nielsen, 2023; Lanza *et al*., 2020). The second dimension, stakeholder engagement, outlines approaches for understanding and responding to ESG expectations from diverse parties affected by supply chain decisions (Aksoy *et al*., 2022; Davidor *et al*., 2023). The third dimension, decision-making integration, presents practical mechanisms for embedding ESG metrics into specific supply chain decisions while maintaining focus on operational efficiency and financial viability (Nwokocha *et al*., 2023; Soni *et al*., 2022).

The materiality assessment dimension addresses a fundamental challenge facing SMEs attempting to integrate ESG considerations: determining which environmental, social, and governance issues are most significant given specific business contexts, stakeholder concerns, and resource constraints (Keeley *et al*., 2022; Ballester Climent, 2022). Traditional materiality assessment processes developed for large corporations typically involve extensive stakeholder consultations, comprehensive risk analyses, and detailed evaluation of potential impacts across numerous sustainability topics. While these comprehensive approaches are valuable, they require resources and capabilities often unavailable to SMEs (D'Angiò *et al*., 2022; Molin, 2021). The framework therefore proposes a streamlined materiality assessment approach that maintains the core logic of focusing on issues that matter most while adapting the process to SME realities (Okpala, 2023; Kaddour, 2023).

The materiality assessment component of the framework begins with sector-level guidance that helps SMEs identify environmental, social, and governance issues commonly material in their industries. Industry associations, sector-specific sustainability initiatives, and available sectoral guidance provide starting points for understanding typical ESG priorities in manufacturing, services, agriculture, construction, and other sectors (Zioło *et al*., 2023; Zhao *et al*., 2023). This sector-based approach enables SMEs to benefit from collective knowledge rather than starting from scratch, significantly reducing the resources required for initial issue

identification (Riva *et al*., 2021; Shalhoob and Hussainey, 2022). However, the framework emphasizes that sector-level guidance must be adapted to individual SME circumstances, as specific business models, supply chain positions, and stakeholder relationships create unique materiality profiles even within the same industry (Testa *et al*., 2016; Sardanelli *et al*., 2022).



Source: Author

Fig 1: ESG Integration Framework for SMEs in Supply Chain Decision-Making

Stakeholder input forms a second critical element of materiality assessment within the framework. Rather than conducting extensive formal stakeholder consultations that may be resource-intensive, the framework leverages the typically closer stakeholder relationships characteristic of SMEs to gather input through less formal but still systematic mechanisms (Paro, 2023; Whitelock, 2015). Direct customer feedback, employee insights, supplier communications, and community relationships can provide valuable information about which ESG issues stakeholders consider important (Amini-Philips *et al*., 2023; Eyinade *et al*., 2022). The framework suggests that SMEs document and systematically reflect on stakeholder signals they already receive through normal business interactions rather than necessarily creating new consultation processes, though targeted engagement on specific sustainability questions may be valuable for addressing particular uncertainties (Tsang *et al*., 2023; Dako *et al*., 2023).

Business impact analysis constitutes the third element of materiality assessment in the framework. This involves SME owner-managers and relevant personnel considering how different ESG issues might affect business operations, reputation, market access, regulatory compliance, and long-term viability (Jones *et al*., 2023; Cek and Ercantan, 2023). The framework guides this analysis through structured questions about potential risks and opportunities associated with various environmental, social, and governance factors (Atkins *et al*., 2023; Kotsantonis and Serafeim, 2019). For example, SMEs are prompted to consider how climate-related risks might affect their supply chains, whether labor practices could pose reputational or operational risks, how governance practices affect relationships with financial institutions and business partners, and whether specific sustainability attributes could provide competitive differentiation opportunities (Fiaschi *et al*., 2020; Todorova and Zyatchin, 2023). This deeper understanding enables more targeted improvement actions.

The output of the materiality assessment process is a prioritized set of ESG issues on which the SME will focus integration efforts. The framework emphasizes that this prioritization should be dynamic, with periodic review and updating as business circumstances, stakeholder expectations, and external contexts evolve (Rainy and Chowdhury, 2022; Oyeyipo *et al*., 2023). However, stability in priorities is also valuable to enable sustained attention and resource allocation, so the framework suggests annual or biennial formal reviews supplemented by ad hoc adjustments when significant changes occur (Ogundipe *et al*., 2023; Oyeyemi, 2023). The materiality assessment directly informs the other framework dimensions by identifying which ESG metrics are most relevant for stakeholder engagement and decision-making integration (Oyeyemi and Kabirat, 2023; Onotole *et al*., 2023).

The stakeholder engagement dimension of the framework addresses how SMEs understand and respond to diverse ESG expectations while leveraging their typically closer stakeholder relationships as assets rather than viewing stakeholder management as purely an obligation or burden (Ogunyankinnu *et al*., 2022; Davidor *et al*., 2023). The framework recognizes that SMEs often already maintain relatively strong connections with key stakeholders including customers, employees, suppliers, and local communities, but these relationships may not be systematically leveraged for understanding and addressing ESG concerns (Akinlade *et al*., 2023; Adesanya *et al*., 2020). The stakeholder engagement component therefore focuses on making existing relationship strengths more explicit and purposeful in the context of sustainability while adding structured approaches where gaps exist (Okojiev *et al*., 2023; Ejairu *et al*., 2023).

Customer engagement on ESG topics represents a priority within the framework, as customers increasingly influence SME sustainability practices both through direct requirements imposed on SME suppliers and through market preferences that reward responsible business practices (Cronin and Doyle-Kent, 2022; Jo and Kwon, 2021). The framework guides SMEs in proactively understanding customer ESG expectations through direct dialogue, attention to procurement criteria in customer requests for proposals, and monitoring of customer sustainability reports and public commitments that may signal future requirements (Alao *et al*., 2023; Filani *et al*., 2022). For SMEs serving business customers, the framework emphasizes the importance of viewing ESG expectations not merely as compliance obligations but as opportunities to strengthen customer relationships, demonstrate reliability and alignment with customer values, and potentially differentiate from competitors (Sardanelli *et al*., 2022; Tsang *et al*., 2023).

Employee engagement is addressed in the framework through recognition that workers often have important insights about operational sustainability challenges and opportunities, and

that employee satisfaction and retention can be influenced by perceived organizational commitment to responsible practices (Jones *et al*., 2023; Paro, 2023). The framework suggests mechanisms for involving employees in identifying sustainability improvement opportunities, implementing ESG initiatives, and monitoring progress (Becchetti *et al*., 2022; Molin, 2021). These engagement mechanisms can range from informal discussions in small enterprises to more structured suggestion systems or working groups in larger SMEs. The framework also addresses how ESG commitments can be communicated to employees to strengthen organizational culture and potentially enhance attraction and retention of talent who value working for responsible employers (Kaddour, 2023; Okpala, 2023).

Supplier relationships receive particular attention in the stakeholder engagement dimension, as suppliers are both important stakeholders in their own right and critical to SME ability to deliver on ESG commitments (Nwokocha *et al*., 2023; Soni *et al*., 2022). The framework acknowledges the power dynamics in supply chains, recognizing that while SMEs may face requirements from larger customers, they may also have limited leverage over their own suppliers (Testa *et al*., 2016; Ritchie and Brindley, 2000). The engagement approaches therefore emphasize collaborative relationships rather than purely requirements-based interactions (Hemilä and Vilko, 2015; Palomero and Chalmeta, 2014). The framework guides SMEs in communicating ESG expectations to suppliers while also understanding supplier constraints and potentially providing support for improvement (Howarth and Fredericks, 2012; Singh, 2011). Supplier development programs, even if modest in scale, can yield benefits for both SME buyers and their suppliers by building capability and strengthening relationships (Kot *et al*., 2020; Thakkar *et al*., 2008).

Community and civil society engagement is incorporated in the framework with recognition that SMEs often have strong connections to local communities but may not explicitly frame these relationships in ESG terms (Whitelock, 2019; Figurek and Thrassou, 2023). The framework helps SMEs recognize how community relationships relate to social dimensions of sustainability and how local environmental impacts affect the communities in which SMEs operate (Zeng *et al*., 2022; Puppim de Oliveira and Jabbour, 2017). For many SMEs, particularly those led by owner-managers with deep roots in local areas, community considerations naturally influence business decisions, but the framework encourages making these considerations more explicit and systematic (Banomyong and Supatn, 2011; Tan *et al*., 2006). The engagement mechanisms can include participation in local business associations, dialogue with community organizations, attention to local environmental and social concerns, and communication about the SME's contributions to community wellbeing (Huang, 2009; Saviano and Berardi, 2009).

The framework also addresses engagement with enabling stakeholders including financial institutions, government agencies, industry associations, and sustainability-focused non-governmental organizations that can provide resources, knowledge, and support for ESG integration (Riva *et al*., 2021; Shalhoob and Hussainey, 2022). SMEs are encouraged to actively seek out available support rather than attempting to navigate sustainability challenges in isolation (Tounsi *et al*., 2009; Madiwal and Dulange, 2016). Many regions offer government programs supporting SME sustainability improvements, industry associations increasingly provide sector-specific guidance and collective action opportunities, and some financial institutions offer favorable terms for businesses demonstrating ESG performance (Musso and Francioni, 2012; Jasti and Kodali, 2015). The framework guides SMEs in identifying and accessing these support mechanisms as part of their stakeholder engagement strategy (Büyüközkan and Göçer, 2018; Gunasekaran *et al*., 2017).

Throughout the stakeholder engagement dimension, the framework emphasizes authenticity and two-way communication rather than viewing engagement purely as information provision or public relations activities (Aksoy *et al*., 2022; Nielsen, 2023). Genuine engagement involves listening to stakeholder concerns, responding to feedback, acknowledging limitations and challenges, and demonstrating tangible actions rather than merely making claims (Keeley *et al*., 2022; Ballester Climent, 2022). For SMEs, the typically closer and more personal nature of stakeholder relationships provides advantages in building authentic engagement, but also means that failures to deliver on commitments may be more visible and damaging to reputation (Lanza *et al*., 2020; D'Angiò *et al*., 2022).

3.2. ESG Metrics Selection and Measurement Approaches

The identification and measurement of appropriate ESG metrics represents a critical challenge addressed by the framework, as SMEs must balance the desire for comprehensive sustainability assessment against practical constraints on data collection and analysis capabilities (Nielsen, 2023; Atkins *et al*., 2023). The framework provides structured guidance for selecting metrics that align with identified material issues, are feasible to measure with available resources, and provide meaningful information for decision-making and stakeholder communication (Kotsantonis and Serafeim, 2019; Fiaschi *et al*., 2020). Rather than prescribing specific universal metrics, the framework outlines principles and processes for metric selection while providing examples of commonly relevant indicators that SMEs might consider (Lanza *et al*., 2020; Keeley *et al*., 2022).

The metric selection process in the framework begins with the material ESG issues identified through the materiality assessment dimension. For each material issue, the framework guides SMEs in identifying potential metrics that could measure performance or progress related to that issue (Zeng *et al*., 2022; Zioło *et al*., 2023). This process draws on established sustainability reporting frameworks including the Global Reporting Initiative standards, Sustainability Accounting Standards Board industry-specific metrics, and other recognized guidelines, but adapts these comprehensive frameworks to SME contexts by focusing on a limited set of most relevant indicators rather than attempting to report on all possible metrics (D'Angiò *et al*., 2022; Molin, 2021).

Environmental metrics commonly relevant for SMEs typically relate to energy consumption, greenhouse gas emissions, water usage, waste generation and management, and material efficiency (Cek and Ercantan, 2023; Zhao *et al*., 2023). The framework acknowledges that many SMEs may lack sophisticated environmental monitoring systems but emphasizes that even basic metrics can provide valuable information for management and stakeholders (Howarth and Fredericks, 2012; Puppim de Oliveira and Jabbour, 2017). For energy and emissions, the framework suggests beginning with metrics based on utility bills and fuel purchases, which

require minimal additional data collection (Todorova and Zyatchin, 2023; Sardanelli *et al*., 2022). Energy consumption per unit of output, percentage of energy from renewable sources, and estimated carbon emissions based on standard emission factors provide accessible starting points (Tsang *et al*., 2023; Jo and Kwon, 2021). For waste and materials, the framework suggests metrics based on waste disposal records and purchasing data, such as waste generated per unit of output, percentage of waste recycled or reused, and proportion of inputs from recycled or sustainable sources (Cronin and Doyle-Kent, 2022; Whitelock, 2019).

Table 1: Core Dimensions of the ESG Integration Framework

Framework Dimension	Purpose	Key Components
Materiality Assessment	Identify and prioritize ESG issues relevant to SME operations	Relevance analysis, issue prioritization, resource alignment
Stakeholder Engagement	Understand and address expectations from internal and external parties	Communication channels, feedback systems, collaboration tools
Decision-Making Integration	Embed ESG metrics into operational and strategic decisions	KPI alignment, trade-off management, policy integration
Performance Monitoring & Continuous Improvement	Evaluate ESG outcomes and refine processes over time	Data tracking, reporting mechanisms, feedback loops

Social metrics in the framework address labor practices, health and safety, diversity and inclusion, community impacts, and responsible sourcing (Jones *et al*., 2023; Paro, 2023). Many relevant social metrics can be derived from existing human resources and operational records with minimal additional burden (Okpala, 2023; Kaddour, 2023). Employee turnover rates, training hours per employee, health and safety incident rates, gender diversity in workforce and leadership, and employee satisfaction survey results provide insights into social performance (Shalhoob and Hussainey, 2022; Riva *et al*., 2021). For community impacts, the framework suggests metrics such as local employment percentages, community investment levels, and numbers of people reached through community programs (Figurek and Thrassou, 2023; Rainy and Chowdhury, 2022). Responsible sourcing metrics might include percentage of suppliers assessed against ESG criteria and number of suppliers participating in development programs (Nwokocha *et al*., 2023; Soni *et al*., 2022).

Governance metrics encompass board composition and independence, ethics and compliance systems, transparency and reporting practices, and stakeholder engagement mechanisms (Markopoulos *et al*., 2023; Davidor *et al*., 2023). For SMEs, formal governance structures may be less developed than in large corporations, but the framework emphasizes that governance principles of accountability, transparency, and ethical conduct remain highly relevant (Dako *et al*., 2023; Ali *et al*., 2023). Relevant metrics might include existence and enforcement of codes of conduct, hours of ethics training provided, incidence of governance violations, transparency of ownership structures, and frequency of stakeholder engagement activities (Aksoy *et al*., 2022; Ballester Climent, 2022). For SMEs with external investors or aspiring to attract investment, governance metrics may be particularly important for demonstrating responsible management (Oyeyipo *et al*., 2023; Ogundipe *et al*., 2023).

The framework addresses the challenge of data collection feasibility by categorizing metrics according to data requirements and suggesting phased approaches to measurement (Oyeyemi, 2023; Oyeyemi and Kabirat, 2023). Tier one metrics are those requiring only data already collected for other business purposes, such as financial records, utility bills, and basic human resources information (Onotole *et al*., 2023; Ogunyankinnu *et al*., 2022). These metrics can typically be implemented immediately with minimal additional effort. Tier two metrics require some additional data collection but can be achieved with modest effort, such as employee surveys, basic environmental monitoring, or structured recording of information currently observed informally (Akinlade *et al*., 2023; Adesanya *et al*., 2020). Tier three metrics involve more substantial data collection efforts and might be deferred until systems and resources are more developed, or might be addressed through estimation or sampling rather than comprehensive measurement (Okojiev *et al*., 2023; Ejairu *et al*., 2023).

The framework also addresses the qualitative versus quantitative dimension of metrics, acknowledging that while quantitative indicators are valuable for tracking trends and comparing performance, qualitative information can provide important context and may be more feasible for some aspects of ESG performance (Alao *et al*., 2023; Filani *et al*., 2022). Narrative descriptions of policies, programs, and initiatives complement quantitative metrics and can effectively communicate commitment and progress even when precise quantification is challenging (Carbonneau *et al*., 2008; Souza, 2014). The framework encourages SMEs to use mixed approaches that combine quantitative metrics where feasible with qualitative information that provides richness and context (Tiwari *et al*., 2018; Hazen *et al*., 2014).

Benchmarking and target-setting are addressed in the framework as mechanisms for providing context to metric values and driving continuous improvement (Hofmann and Rüsch, 2017; Ivanov *et al*., 2019). The framework acknowledges that external benchmarks may be limited for SME sustainability performance, as most available benchmarks focus on large corporations (Sanusi *et al*., 2019; Sarrico and Rosa, 2016). However, internal benchmarking through year-over-year comparisons can provide valuable perspective on trends and improvement (Om *et al*., 2007; Pathik *et al*., 2012). Industry averages where available, even if based primarily on larger firms, can provide general reference points. The framework suggests that SMEs set improvement targets based on assessment of feasibility and stakeholder expectations, starting with modest incremental improvements and increasing ambition as capabilities develop (Büyüközkan and Göçer, 2018; Jasti and Kodali, 2015).

Technology solutions receive attention in the framework as potential enablers of more sophisticated ESG measurement without proportional increases in resource requirements (Gunasekaran *et al*., 2017; Fiaschi *et al*., 2020). Automated

data collection from equipment sensors, supplier portals for ESG data sharing, sustainability accounting software designed for SMEs, and industry platforms for collective data management can reduce measurement burdens (Lanza *et al*., 2020; D'Angiò *et al*., 2022). The framework emphasizes that technology adoption should be pragmatic and cost-effective, with solutions appropriate to SME scale and needs rather than attempting to implement enterprise-level systems that exceed requirements and budgets (Molin, 2021; Kaddour, 2023).

Data quality and verification considerations are incorporated into the framework with recognition that while third-party verification of ESG data provides credibility, the costs may be prohibitive for many SMEs (Nielsen, 2023; Atkins *et al*., 2023). The framework suggests focusing on internal data quality controls including clear documentation of data sources and calculation methodologies, regular review of data for consistency and plausibility, and segregation of duties where feasible so that data collection and review involve different individuals (Kotsantonis and Serafeim, 2019; Keeley *et al*., 2022). For SMEs seeking external credibility for ESG claims, the framework suggests exploring lower-cost verification options such as industry association certification programs, customer audits that may already occur for quality or compliance purposes, and peer review mechanisms within collaborative sustainability initiatives (Zeng *et al*., 2022; Zioło *et al*., 2023).

3.3. Decision-Making Integration Mechanisms

The decision-making integration dimension represents the framework's core contribution to translating ESG commitments into tangible supply chain actions. This dimension addresses specific supply chain decision points where ESG metrics can and should influence outcomes, providing practical mechanisms for incorporating sustainability considerations alongside traditional criteria of cost, quality, and delivery performance (Nwokocha *et al*., 2023; Soni *et al*., 2022). The framework recognizes that supply chain decisions in SMEs often involve fewer formal processes and procedures than in large corporations, with owner-managers or small management teams making decisions based on experience, relationships, and relatively informal analysis (Madiwal and Dulange, 2016; Musso and Francioni, 2012). The integration mechanisms therefore emphasize practical approaches compatible with existing decision-making styles while introducing greater structure and consistency in ESG consideration (Huang, 2009; Saviano and Berardi, 2009).

Supplier selection and evaluation represent perhaps the most critical decision point for ESG integration, as choices about suppliers fundamentally determine the ESG performance of supply chains (Testa *et al*., 2016; Sardanelli *et al*., 2022). Traditional supplier selection in SMEs typically emphasizes price, quality, delivery reliability, and established relationships, with environmental and social factors considered informally if at all (Tsang *et al*., 2023; Jo and Kwon, 2021). The framework proposes a structured yet practical approach to incorporating ESG criteria into supplier decisions (Cronin and Doyle-Kent, 2022; Whitelock, 2019). The approach begins with defining ESG requirements and preferences based on material issues identified through the materiality assessment (Nielsen, 2023; Atkins *et al*., 2023). Requirements represent minimum standards that suppliers must meet, such as compliance with labor laws, possession of necessary environmental permits, and basic governance practices such as formal business registration (Kotsantonis and Serafeim, 2019; Fiaschi *et al*., 2020). Preferences represent desirable attributes that strengthen supplier candidacy but may not be absolute requirements, such as environmental certifications, demonstrated social responsibility programs, or transparency in ESG reporting (Lanza *et al*., 2020; Keeley *et al*., 2022).

The framework suggests a tiered approach to supplier ESG evaluation that matches evaluation rigor to supplier importance and risk level (Zeng *et al*., 2022; Zioło *et al*., 2023). For critical suppliers representing significant portions of procurement spend or supplying materials essential to product quality or business continuity, more thorough ESG evaluation is warranted and justified (D'Angiò *et al*., 2022; Molin, 2021). This evaluation might include questionnaires covering key ESG topics, requests for relevant documentation such as certifications or audit reports, and potentially site visits to verify conditions (Cek and Ercantan, 2023; Zhao *et al*., 2023). For lower-value or lower-risk suppliers, simpler evaluation approaches such as basic declarations of compliance or review of publicly available information may suffice (Howarth and Fredericks, 2012; Puppim de Oliveira and Jabbour, 2017). This risk-based approach enables SMEs to focus limited resources where ESG risks and opportunities are greatest while still maintaining some level of ESG consideration across the supply base (Todorova and Zyatchin, 2023; Sardanelli *et al*., 2022).

The framework provides guidance on incorporating ESG factors into supplier scorecards or evaluation matrices alongside traditional criteria (Tsang *et al*., 2023; Jo and Kwon, 2021). Rather than treating ESG as a separate consideration, the framework suggests integrated evaluation where environmental, social, and governance performance are weighted alongside price, quality, and delivery (Cronin and Doyle-Kent, 2022; Whitelock, 2019). The appropriate weighting depends on materiality of different factors for specific procurement categories, with higher weights for ESG criteria when purchasing materials with significant environmental or social implications (Jones *et al*., 2023; Paro, 2023). The framework acknowledges that in some cases, particularly when suppliers are largely interchangeable commodities, price may remain dominant, but even modest consideration of ESG factors can shift decisions toward better-performing suppliers when all else is relatively equal (Okpala, 2023; Kaddour, 2023).

For existing supplier relationships, the framework addresses ongoing performance monitoring and supplier development (Shalhoob and Hussainey, 2022; Riva *et al*., 2021). Rather than treating supplier selection as a one-time decision, the framework emphasizes continuous improvement through regular performance review that includes ESG metrics alongside operational and quality indicators (Figurek and Thrassou, 2023; Rainy and Chowdhury, 2022). Supplier scorecards that incorporate ESG performance provide transparency and create incentives for improvement (Nwokocha *et al*., 2023; Soni *et al*., 2022). The framework suggests that SMEs communicate ESG expectations clearly to existing suppliers, provide feedback on performance, and offer support for improvement where feasible (Markopoulos *et al*., 2023; Davidor *et al*., 2023). Collaborative improvement programs, even if informal, can strengthen supplier relationships while advancing ESG objectives, creating value for both the SME and its suppliers (Dako *et*

al., 2023; Ali *et al*., 2023).

Procurement decisions beyond supplier selection also represent opportunities for ESG integration addressed in the framework (Aksoy *et al*., 2022; Ballester Climent, 2022). Choices about materials and components, packaging, order quantities, and delivery frequencies all have environmental and social implications (Oyeyipo *et al*., 2023; Ogundipe *et al*., 2023). The framework guides consideration of factors such as environmental attributes of materials including recycled content, renewable sourcing, and toxicity; social considerations such as fair trade certification or support for minority-owned businesses; packaging choices that minimize waste and use recyclable or biodegradable materials; order quantities and frequencies that balance inventory costs against transportation emissions; and logistics modes that consider environmental impacts alongside speed and cost (Oyeyemi, 2023; Oyeyemi and Kabirat, 2023).

Logistics and distribution decisions are addressed in the framework with attention to environmental impacts of transportation while acknowledging cost and service level requirements (Onotole *et al*., 2023; Ogunyankinnu *et al*., 2022). The framework suggests incorporating carbon emissions estimates into logistics decision-making, using readily available calculators to estimate emissions from different transportation modes and routes (Akinlade *et al*., 2023; Adesanya *et al*., 2020). While transportation cost will necessarily remain important for SMEs operating with tight margins, the framework proposes that when multiple logistics options are available with similar costs and service levels, environmental performance can serve as a tie-breaker (Okojiev *et al*., 2023; Ejairu *et al*., 2023). Furthermore, initiatives to improve logistics efficiency through better route planning, vehicle utilization, and inventory positioning often yield both cost savings and emissions reductions, creating win-win opportunities (Alao *et al*., 2023; Filani *et al*., 2022).

The framework also addresses integration of ESG considerations into product and service design decisions, recognizing that while some SMEs may have limited influence over product specifications set by customers, many have opportunities to incorporate sustainability thinking into design processes (Carbonneau *et al*., 2008; Souza, 2014). Design for environment principles such as material selection for recyclability, design for disassembly, durability and repairability, and minimization of hazardous substances can reduce environmental impacts throughout product lifecycles (Tiwari *et al*., 2018; Hazen *et al*., 2014). Social considerations in design might include user health and safety, accessibility for diverse users, and consideration of impacts on workers involved in manufacturing and end-of-life processing (Hofmann and Rüsch, 2017; Ivanov *et al*., 2019). For SMEs providing services, design considerations include resource efficiency in service delivery, social impacts on service users and workers, and governance aspects such as data privacy and security (Sanusi *et al*., 2019; Sarrico and Rosa, 2016).

Inventory management decisions represent another area where ESG integration is addressed in the framework (Om *et al*., 2007; Pathik *et al*., 2012). While traditional inventory management focuses on balancing holding costs against stockout risks and ordering costs, environmental and social dimensions can be incorporated (Büyüközkan and Göçer, 2018; Jasti and Kodali, 2015). Holding excess inventory ties up working capital but also represents embedded environmental impacts from production and transportation of materials sitting idle (Gunasekaran *et al*., 2017; Fiaschi *et al*., 2020). Conversely, frequent small orders to minimize inventory may increase transportation emissions and supplier administrative burdens (Lanza *et al*., 2020; D'Angiò *et al*., 2022). The framework suggests that SMEs consider these trade-offs explicitly rather than optimizing only for financial costs, recognizing that in many cases efficient inventory management aligned with lean principles also tends to support environmental objectives by minimizing waste and excess (Molin, 2021; Kaddour, 2023).

Investment decisions in supply chain infrastructure and equipment provide opportunities for ESG integration with potentially long-lasting impacts (Nielsen, 2023; Atkins *et al*., 2023). When SMEs invest in vehicles, equipment, facilities, or information systems, choices made affect environmental and social performance for years or decades (Kotsantonis and Serafeim, 2019; Keeley *et al*., 2022). The framework guides consideration of energy efficiency, emissions profiles, worker health and safety features, and lifecycle costs including end-of-life disposal or recycling in investment evaluations (Zeng *et al*., 2022; Zioło *et al*., 2023). While initial purchase prices may be higher for more sustainable options, lifecycle cost analyses often reveal that energy efficiency and other sustainable features provide attractive returns on investment (Cek and Ercantan, 2023; Zhao *et al*., 2023). The framework provides simplified approaches to lifecycle analysis suitable for SME contexts, enabling more informed investment decisions that consider long-term implications (Howarth and Fredericks, 2012; Puppim de Oliveira and Jabbour, 2017).

Throughout the decision-making integration dimension, the framework emphasizes practical implementation that works with rather than against existing SME decision-making processes (Todorova and Zyatchin, 2023; Sardanelli *et al*., 2022). The goal is not to create bureaucratic approval procedures or complex analytical requirements that slow decisions and consume resources, but rather to ensure that ESG considerations are raised, relevant information is available, and sustainability factors are given appropriate weight alongside traditional criteria (Tsang *et al*., 2023; Jo and Kwon, 2021). For many decisions, ESG integration may simply involve asking additional questions, considering additional information, and documenting the rationale for choices (Cronin and Doyle-Kent, 2022; Whitelock, 2019). Over time, as ESG thinking becomes embedded in organizational culture and decision-making habits, integration becomes more natural and requires less conscious effort (Jones *et al*., 2023; Paro, 2023).

3.4. Implementation Strategies and Enablers

The successful implementation of ESG integration in SME supply chains requires attention to practical strategies that address common barriers while leveraging available enablers and support mechanisms (Okpala, 2023; Kaddour, 2023). This component of the framework outlines phased approaches to implementation, identifies critical success factors, and highlights external resources that can facilitate SME sustainability journeys (Shalhoob and Hussainey, 2022; Riva *et al*., 2021). The implementation guidance recognizes that SMEs vary substantially in their starting points, with some already engaged in sustainability practices while others are at early stages of awareness and readiness (Figurek and Thrassou, 2023; Rainy and Chowdhury, 2022). The framework therefore provides flexible pathways rather than

prescriptive step-by-step requirements (Nwokocha *et al*., 2023; Soni *et al*., 2022).

A phased implementation approach is central to the framework's implementation strategy, acknowledging that attempting to address all ESG dimensions simultaneously is likely to overwhelm resource-constrained SMEs and result in superficial rather than meaningful integration (Markopoulos *et al*., 2023; Davidor *et al*., 2023). The framework suggests beginning with a foundation phase focused on awareness building, materiality assessment, and establishment of basic ESG commitments and policies (Dako *et al*., 2023; Ali *et al*., 2023). During this initial phase, SMEs develop understanding of ESG concepts and their relevance, identify material issues through the processes outlined in the materiality assessment dimension, engage stakeholders to understand expectations, and articulate ESG commitments through policy statements or codes of conduct (Aksoy *et al*., 2022; Ballester Climent, 2022). These foundational elements need not be elaborate, but they establish direction and create accountability (Oyeyipo *et al*., 2023; Ogundipe *et al*., 2023).

The development phase builds on the foundation by implementing ESG metrics, integrating considerations into key supply chain decisions, and establishing basic management systems (Oyeyemi, 2023; Oyeyemi and Kabirat, 2023). During this phase, SMEs begin measuring performance on prioritized ESG metrics, incorporate ESG criteria into supplier evaluation and selection processes for new procurement or supplier reviews, and develop internal processes to ensure ESG factors are considered in relevant decisions (Onotole *et al*., 2023; Ogunyankinnu *et al*., 2022). The framework emphasizes starting with areas where integration is most feasible or where business benefits are most apparent, creating momentum and learning that can be applied to more challenging areas subsequently (Akinlade *et al*., 2023; Adesanya *et al*., 2020).

The maturation phase involves expansion to additional ESG topics and supply chain decisions, enhancement of measurement sophistication, and increasing external communication about ESG performance (Okojiev *et al*., 2023; Ejairu *et al*., 2023). As SMEs develop experience and capability, they can address a broader range of sustainability issues, implement more comprehensive metrics, extend ESG requirements deeper into supply chains beyond first-tier suppliers, and begin more formal reporting to stakeholders (Alao *et al*., 2023; Filani *et al*., 2022). The framework emphasizes that maturation is a continuous process rather than a final destination, with ongoing opportunities to deepen and broaden ESG integration as circumstances permit (Carbonneau *et al*., 2008; Souza, 2014).

Leadership commitment represents a critical success factor emphasized throughout the implementation guidance (Tiwari *et al*., 2018; Hazen *et al*., 2014). In SMEs, owner-managers typically have substantial influence over organizational direction and culture, making their personal commitment to ESG integration essential (Hofmann and Rüsch, 2017; Ivanov *et al*., 2019). The framework suggests that this commitment be demonstrated through visible engagement with sustainability topics, allocation of resources even if modest, incorporation of ESG considerations into strategic planning, and accountability for progress through inclusion of sustainability objectives in organizational goal-setting (Sanusi *et al*., 2019; Sarrico and Rosa, 2016). Leadership commitment also involves willingness to make difficult trade-offs when ESG objectives conflict with short-term financial optimization, recognizing that long-term value creation may require accepting some near-term costs (Om *et al*., 2007; Pathik *et al*., 2012).

Employee engagement and capability building are addressed as enablers of successful implementation (Büyüközkan and Göçer, 2018; Jasti and Kodali, 2015). The framework emphasizes that ESG integration should not be seen as solely a management responsibility but rather as involving employees throughout the organization (Gunasekaran *et al*., 2017; Fiaschi *et al*., 2020). Workers often have valuable insights about operational sustainability challenges and improvement opportunities, and their buy-in is essential for successful implementation of ESG initiatives (Lanza *et al*., 2020; D'Angiò *et al*., 2022). The framework suggests approaches for building employee awareness of ESG topics and organizational commitments, providing training relevant to job responsibilities, creating mechanisms for employee input into sustainability initiatives, and recognizing and rewarding contributions to ESG performance (Molin, 2021; Kaddour, 2023). For very small enterprises where formal training may be impractical, informal knowledge sharing and learning-by-doing approaches can be effective (Nielsen, 2023; Atkins *et al*., 2023).

External collaboration and support mechanisms receive substantial attention as implementation enablers particularly important for resource-constrained SMEs (Kotsantonis and Serafeim, 2019; Keeley *et al*., 2022). The framework identifies multiple sources of external support that SMEs can leverage to overcome knowledge and resource barriers (Zeng *et al*., 2022; Zioło *et al*., 2023). Industry associations increasingly offer sector-specific sustainability guidance, tools, and collective action programs that enable SMEs to benefit from shared knowledge and resources (Cek and Ercantan, 2023; Zhao *et al*., 2023). Government programs in many jurisdictions provide technical assistance, financial incentives, or regulatory flexibility to encourage SME sustainability improvements (Howarth and Fredericks, 2012; Puppim de Oliveira and Jabbour, 2017). Non-governmental organizations focused on sustainable business practices often provide free or low-cost resources including guidance documents, tools, training, and sometimes direct assistance (Todorova and Zyatchin, 2023; Sardanelli *et al*., 2022). Academic institutions and consultants may offer pro bono or discounted services to support SME sustainability efforts, particularly for innovative approaches that contribute to research or demonstration projects (Tsang *et al*., 2023; Jo and Kwon, 2021).

Collaborative industry initiatives are highlighted in the framework as particularly promising mechanisms for advancing SME supply chain sustainability (Cronin and Doyle-Kent, 2022; Whitelock, 2019). Collective approaches enable groups of SMEs to achieve together what would be difficult individually, through sharing costs of sustainability assessments, developing common standards or requirements that provide clarity to suppliers, creating supplier development programs that benefit multiple SME buyers, and amplifying influence on supply chain practices through coordinated action (Jones *et al*., 2023; Paro, 2023). The framework provides guidance on identifying and participating in relevant collaborative initiatives while managing the coordination costs and potential competitive sensitivities involved in such collaboration (Okpala, 2023; Kaddour, 2023).

Technology adoption is addressed as an enabler that can

reduce implementation burdens, though the framework emphasizes pragmatic approaches appropriate to SME contexts rather than sophisticated systems that may exceed needs and budgets (Shalhoob and Hussainey, 2022; Riva *et al*., 2021). Cloud-based sustainability management platforms designed specifically for SMEs can provide affordable tools for tracking ESG metrics, managing supplier information, and generating reports (Figurek and Thrassou, 2023; Rainy and Chowdhury, 2022). Industry-specific technology solutions that address common sustainability challenges in particular sectors may offer good value by providing targeted functionality (Nwokocha *et al*., 2023; Soni *et al*., 2022). The framework suggests that SMEs evaluate technology investments carefully, considering not only upfront costs but also ongoing expenses and the effort required for implementation and maintenance (Markopoulos *et al*., 2023; Davidor *et al*., 2023).

The framework also addresses the importance of communication and transparency as both implementation enablers and outcomes of ESG integration (Dako *et al*., 2023; Ali *et al*., 2023). Internal communication about ESG objectives, initiatives, and progress helps build awareness and engagement throughout the organization (Aksoy *et al*., 2022; Ballester Climent, 2022). External communication to customers, suppliers, investors, and other stakeholders demonstrates commitment, builds credibility, and can create business opportunities (Oyeyipo *et al*., 2023; Ogundipe *et al*., 2023). The framework acknowledges that SMEs may be hesitant to communicate extensively about sustainability performance due to concerns about greenwashing accusations, lack of confidence in data quality, or simply discomfort with self-promotion (Oyeyemi, 2023; Oyeyemi and Kabirat, 2023). However, the framework encourages transparency appropriate to SME contexts, emphasizing authenticity and acknowledging limitations rather than attempting to present perfectly comprehensive sustainability reports comparable to those of large corporations (Onotole *et al*., 2023; Ogunyankinnu *et al*., 2022).

3.5. Performance Monitoring and Continuous Improvement

The framework's final structural component addresses how SMEs monitor ESG performance, learn from experience, and drive continuous improvement in supply chain sustainability (Akinlade *et al*., 2023; Adesanya *et al*., 2020). This dimension recognizes that ESG integration is not a one-time project but an ongoing process requiring regular assessment, reflection, and adaptation (Okojiev *et al*., 2023; Ejairu *et al*., 2023). The monitoring and improvement mechanisms outlined in the framework are designed to be sustainable and valuable rather than bureaucratic burdens, providing information that genuinely informs management decisions and stakeholder communication while requiring reasonable rather than excessive effort (Alao *et al*., 2023; Filani *et al*., 2022).

Performance monitoring in the framework centers on the ESG metrics identified through the materiality assessment and metric selection processes described in earlier framework dimensions (Carbonneau *et al*., 2008; Souza, 2014). The framework emphasizes regular measurement according to predetermined schedules appropriate to different metrics, with some tracked continuously or monthly for operational management while others may be assessed quarterly or annually (Tiwari *et al*., 2018; Hazen *et al*., 2014). Consistency in measurement timing and methodology is important for enabling meaningful trend analysis and year-over-year comparisons that reveal whether performance is improving, stable, or declining (Hofmann and Rüsch, 2017; Ivanov *et al*., 2019). The framework suggests documenting measurement procedures to ensure consistency even as personnel change or time passes since initial implementation (Sanusi *et al*., 2019; Sarrico and Rosa, 2016).

Data analysis and interpretation receive attention in the framework with guidance on extracting insights from ESG performance data (Om *et al*., 2007; Pathik *et al*., 2012). Simple statistical analysis including trend calculations, comparison to targets, and identification of significant variations can reveal important patterns and issues (Büyüközkan and Göçer, 2018; Jasti and Kodali, 2015). The framework emphasizes looking beyond individual data points to understand underlying drivers of performance changes, seeking to understand why performance improved or declined rather than simply noting that changes occurred (Gunasekaran *et al*., 2017; Fiaschi *et al*., 2020). Root cause analysis techniques, even if informal, help identify whether performance variations reflect temporary anomalies, changes in business activity levels, effectiveness of sustainability initiatives, or other factors (Lanza *et al*., 2020; D'Angiò *et al*., 2022). This deeper understanding enables more targeted improvement actions (Molin, 2021; Kaddour, 2023).

The framework incorporates regular review processes through which performance data is examined, implications are considered, and decisions are made about future actions (Nielsen, 2023; Atkins *et al*., 2023). For small enterprises, these reviews may be informal discussions among owner-managers and key personnel, while larger SMEs might conduct more structured management reviews (Kotsantonis and Serafeim, 2019; Keeley *et al*., 2022). Regardless of formality level, the framework emphasizes that reviews should occur regularly according to predetermined schedules, should involve relevant decision-makers who can authorize actions, and should result in documented conclusions and action items (Zeng *et al*., 2022; Zioło *et al*., 2023). Review discussions should address what performance data reveals about progress toward ESG objectives, whether current approaches are effective or require adjustment, what new initiatives or investments might be warranted, and how ESG performance should be communicated to stakeholders (Cek and Ercantan, 2023; Zhao *et al*., 2023).

The framework addresses integration of ESG performance into broader organizational management systems and processes (Howarth and Fredericks, 2012; Puppim de Oliveira and Jabbour, 2017). Rather than treating sustainability performance monitoring as entirely separate from financial and operational performance management, the framework suggests incorporating ESG metrics into existing management reporting and review processes where feasible (Todorova and Zyatchin, 2023; Sardanelli *et al*., 2022). This integration reinforces the importance of ESG factors, ensures that sustainability performance receives attention from decision-makers, and enables consideration of relationships and trade-offs among environmental, social, governance, and financial performance (Tsang *et al*., 2023; Jo and Kwon, 2021). Balanced scorecard approaches that incorporate ESG metrics alongside financial and operational indicators provide one mechanism for such integration (Cronin and Doyle-Kent, 2022; Whitelock, 2019).

Stakeholder feedback represents an important input to performance monitoring and improvement emphasized in the

framework (Jones *et al*., 2023; Paro, 2023). Customer feedback on ESG performance, whether through formal assessments, informal comments, or observed purchasing decisions, provides valuable signals about whether sustainability efforts are meeting expectations and creating value (Okpala, 2023; Kaddour, 2023). Employee perspectives on workplace conditions, organizational culture, and sustainability initiatives can reveal implementation challenges and improvement opportunities (Shalhoob and Hussainey, 2022; Riva *et al*., 2021). Supplier feedback may highlight whether ESG requirements and collaboration approaches are effective and reasonable (Figurek and Thrassou, 2023; Rainy and Chowdhury, 2022). Community feedback through various channels can indicate whether the SME's social and environmental impacts are being managed appropriately (Nwokocha *et al*., 2023; Soni *et al*., 2022). The framework encourages SMEs to systematically capture and consider stakeholder feedback rather than allowing it to remain purely informal and unsystematic (Markopoulos *et al*., 2023; Davidor *et al*., 2023).

Continuous improvement approaches adapted from quality management and operational excellence methodologies are incorporated into the framework as mechanisms for driving ongoing enhancement of ESG performance (Dako *et al*., 2023; Ali *et al*., 2023). The plan-do-check-act cycle provides a simple yet powerful structure for systematic improvement, involving planning ESG initiatives based on identified needs and opportunities, implementing planned actions, checking results through performance monitoring, and acting on findings to standardize successful practices or adjust ineffective approaches (Aksoy *et al*., 2022; Ballester Climent, 2022). The framework emphasizes that improvement initiatives need not be elaborate or resource-intensive; even modest incremental improvements can be significant when sustained over time and compounded across multiple areas (Oyeyipo *et al*., 2023; Ogundipe *et al*., 2023). Benchmarking and target-setting for continuous improvement are addressed with practical guidance appropriate to SME contexts (Comoli *et al*., 2023; Oyeyemi and Kabirat, 2023). While external benchmarks for SME ESG performance may be limited, the framework suggests approaches including comparison to industry averages where available even if based primarily on larger firms, participation in collaborative initiatives that enable peer benchmarking among similar-sized enterprises, and primarily reliance on internal year-over-year improvement as the benchmark (Onotole *et al*., 2023; Ogunyankinnu *et al*., 2022). Target-setting is encouraged as a mechanism for creating accountability and driving improvement, with targets based on assessment of what improvements are feasible and meaningful (Akinlade *et al*., 2023; Adesanya *et al*., 2020). The framework suggests starting with achievable targets that build confidence and momentum, then increasing ambition as capability develops (Okojiev *et al*., 2023; Ejairu *et al*., 2023). Learning and knowledge management receive attention as enablers of continuous improvement (Alao *et al*., 2023; Filani *et al*., 2022). The framework emphasizes capturing lessons from both successful initiatives and those that fall short of expectations, ensuring that learning informs future efforts rather than being lost as time passes or personnel change (Carbonneau *et al*., 2008; Souza, 2014). Documentation of sustainability initiatives including objectives, approaches, results, and lessons learned creates organizational memory that can guide future work (Tiwari *et al*., 2018; Hazen *et al*., 2014). For SMEs, this documentation need not be elaborate, but some systematic capture of experience is valuable (Hofmann and Rüsch, 2017; Ivanov *et al*., 2019). The framework also encourages external learning through participation in industry events, sustainability workshops, peer networks, and engagement with knowledge resources provided by industry associations, government agencies, and non-governmental organizations (Sanusi *et al*., 2019; Sarrico and Rosa, 2016).

Innovation in ESG approaches is encouraged in the framework as a source of competitive advantage and continuous improvement (Om *et al*., 2007; Pathik *et al*., 2012). The framework suggests that SMEs remain open to new approaches, technologies, and collaborative mechanisms that might enhance ESG performance or reduce implementation burdens (Büyüközkan and Göçer, 2018; Jasti and Kodali, 2015). Participation in pilot programs testing new sustainability initiatives, early adoption of emerging best practices, and creativity in addressing ESG challenges with limited resources can position SMEs as sustainability leaders within their sectors or regions (Gunasekaran *et al*., 2017; Fiaschi *et al*., 2020). Innovation need not require substantial resources; sometimes novel approaches involve rethinking existing processes or forming unexpected partnerships rather than major investments (Lanza *et al*., 2020; D'Angiò *et al*., 2022).

Table 2: ESG Metrics Selection and Measurement Principles

Selection Principle	Description	Illustrative Example (SME Context)
Material Relevance	Focus on ESG issues that directly affect operations and stakeholders	Energy efficiency, local community impact
Feasibility	Choose metrics measurable with available SME resources	Waste reduction rate, employee turnover
Decision Utility	Provide actionable insights for supply chain decisions	Supplier compliance rate
Transparency	Enable clear communication with stakeholders	ESG disclosure score
Continuous Improvement	Allow benchmarking and progressive enhancement	Year-on-year carbon footprint change

The framework concludes its monitoring and improvement dimension by emphasizing the long-term nature of ESG integration and the importance of patience and persistence (Molin, 2021; Kaddour, 2023). Meaningful change in sustainability performance typically requires sustained effort over months and years rather than quick transformations (Nielsen, 2023; Atkins *et al*., 2023). The framework encourages SMEs to maintain commitment even when progress seems slow, to celebrate incremental achievements that demonstrate movement in the right direction, and to view ESG integration as a journey of continuous learning and improvement rather than a project with a defined endpoint (Kotsantonis and Serafeim, 2019; Keeley *et al*., 2022). This perspective helps sustain motivation and prevents discouragement during inevitable challenges and setbacks (Zeng *et al*., 2022; Zioło *et al*., 2023).

4. Conclusion

This research has developed a comprehensive conceptual framework specifically designed to enable small and

medium-sized enterprises to integrate environmental, social, and governance metrics into supply chain decision-making processes in practical and sustainable ways (Cek and Ercantan, 2023; Zhao *et al*., 2023). The framework addresses a critical gap in existing literature and practice, as most sustainability frameworks and tools have been developed for large corporations and prove inadequate for the distinct contexts of resource-constrained SMEs (Howarth and Fredericks, 2012; Puppim de Oliveira and Jabbour, 2017). By explicitly acknowledging SME characteristics including limited financial resources, smaller organizational structures, reduced bargaining power with suppliers, but also potential advantages such as organizational agility, closer stakeholder relationships, and more direct decision-making processes, the framework provides guidance that is both realistic and actionable for the substantial population of SMEs seeking to enhance supply chain sustainability (Todorova and Zyatchin, 2023; Sardanelli *et al*., 2022).

The framework's three core dimensions of materiality assessment, stakeholder engagement, and decision-making integration provide interconnected approaches that collectively enable systematic ESG consideration throughout supply chain operations (Tsang *et al*., 2023; Jo and Kwon, 2021). The materiality assessment dimension helps SMEs focus limited resources on ESG issues that truly matter in their specific contexts rather than attempting to address all possible sustainability topics simultaneously (Cronin and Doyle-Kent, 2022; Whitelock, 2019). The stakeholder engagement dimension leverages the typically closer relationships characteristic of SMEs while providing structure for understanding and responding to diverse ESG expectations (Jones *et al*., 2023; Paro, 2023). The decision-making integration dimension translates ESG commitments into tangible actions by embedding sustainability considerations into specific supply chain choices from supplier selection to logistics planning, product design, and investment decisions (Okpala, 2023; Kaddour, 2023).

The practical implementation strategies outlined in the framework recognize that ESG integration is a journey requiring phased approaches, leadership commitment, employee engagement, external collaboration, and appropriate technology adoption (Shalhoob and Hussainey, 2022; Riva *et al*., 2021). By providing guidance on how to begin integration even with limited resources, how to build capability over time, and how to leverage external support mechanisms, the framework makes ESG integration accessible to SMEs at various stages of sustainability maturity (Figurek and Thrassou, 2023; Rainy and Chowdhury, 2022). The performance monitoring and continuous improvement components ensure that integration efforts remain dynamic and responsive to changing circumstances, stakeholder expectations, and organizational capabilities (Nwokocha *et al*., 2023; Soni *et al*., 2022).

The research contributions extend to both academic understanding and practical application. Academically, the framework synthesizes insights from multiple literature streams including sustainable supply chain management, ESG integration, stakeholder theory, resource-based perspectives, and SME-specific research to create a coherent model grounded in established theoretical foundations while addressing gaps in existing frameworks (Markopoulos *et al*., 2023; Davidor *et al*., 2023). The explicit focus on SME contexts advances understanding of how sustainability principles apply in resource-constrained environments and how frameworks must be adapted to different organizational realities (Dako *et al*., 2023; Ali *et al*., 2023). The research also contributes to emerging literature on materiality assessment, ESG metrics, and sustainability implementation by providing detailed guidance tailored to SME needs (Aksoy *et al*., 2022; Ballester Climent, 2022).

Practically, the framework provides SME owner-managers, sustainability practitioners, industry associations, and policymakers with structured yet flexible guidance for advancing supply chain sustainability in small and medium-sized enterprises (Oyeyipo *et al*., 2023; Ogundipe *et al*., 2023). The framework can inform development of industry-specific guidance, training programs, support initiatives, and policy interventions aimed at enhancing SME sustainability performance (Oyeyemi, 2023; Oyeyemi and Kabirat, 2023). By enabling more SMEs to effectively integrate ESG considerations into supply chain decisions, widespread adoption of the framework could contribute substantially to achieving broader sustainable development objectives, as the cumulative environmental and social impacts of the SME sector globally are enormous despite individual SME impacts being modest (Onotole *et al*., 2023; Ogunyankinnu *et al*., 2022).

Several implications emerge from this research for different stakeholder groups. For SME owner-managers and practitioners, the framework provides a roadmap for systematically approaching ESG integration without requiring resources comparable to large corporations (Akinlade *et al*., 2023; Adesanya *et al*., 2020). The emphasis on materiality assessment ensures focused effort on issues that matter most, while the phased implementation approach enables starting small and building over time (Okojiev *et al*., 2023; Ejairu *et al*., 2023). For suppliers to SMEs, the framework's emphasis on collaborative approaches and supplier development rather than purely requirement-based relationships suggests opportunities for partnership in advancing sustainability goals (Alao *et al*., 2023; Filani *et al*., 2022). For customers of SMEs, understanding the constraints SMEs face and the structured approaches they can employ to address ESG considerations may inform more realistic and supportive procurement practices (Carbonneau *et al*., 2008; Souza, 2014).

For industry associations and collaborative initiatives, the framework highlights the important role collective action can play in enabling SME sustainability by sharing costs, developing common standards, providing guidance, and amplifying influence on supply chain practices (Tiwari *et al*., 2018; Hazen *et al*., 2014). The framework suggests that industry-level support tailored to specific sector contexts and SME needs represents a particularly promising avenue for advancing sustainability at scale (Hofmann and Rüsch, 2017; Ivanov *et al*., 2019). For policymakers and government agencies, the research emphasizes the importance of SME-specific support mechanisms including technical assistance, financial incentives, and enabling regulatory environments that recognize SME constraints while encouraging continuous improvement (Sanusi *et al*., 2019; Sarrico and Rosa, 2016). Policy approaches that provide flexibility, recognize good-faith efforts, and support capability building are likely to be more effective than rigid requirements that may be unrealistic for resource-constrained enterprises (Om *et al*., 2007; Pathik *et al*., 2012).

For researchers, this framework provides a foundation for future empirical investigation into ESG integration in SME

supply chains (Büyüközkan and Göçer, 2018; Jasti and Kodali, 2015). The conceptual model suggests numerous research questions that could be examined through case studies, surveys, or other empirical methods (Gunasekaran *et al*., 2017; Fiaschi *et al*., 2020). Questions about which framework components are most critical for success, how implementation approaches should be adapted to different SME contexts, what enabling conditions facilitate effective ESG integration, and how ESG integration affects SME performance outcomes all merit further investigation (Lanza *et al*., 2020; D'Angiò *et al*., 2022). Longitudinal research tracking SMEs implementing the framework could provide valuable insights into implementation challenges, success factors, and performance impacts over time (Molin, 2021; Kaddour, 2023).

The framework also raises important questions about the broader ecosystem supporting SME sustainability (Nielsen, 2023; Atkins *et al*., 2023). The research suggests that individual SME efforts, while essential, are insufficient on their own to achieve systemic change in supply chain sustainability (Kotsantonis and Serafeim, 2019; Keeley *et al*., 2022). Collaborative industry initiatives, enabling policies, customer partnership approaches, and innovations in technology and business models that reduce sustainability implementation burdens all play important roles (Zeng *et al*., 2022; Zioło *et al*., 2023). Future research examining these ecosystem factors and how they interact with SME-level implementation efforts could provide valuable insights for accelerating progress toward sustainable supply chains (Cek and Ercantan, 2023; Zhao *et al*., 2023).

Limitations of this research should be acknowledged. As a conceptual framework development study, the research does not provide empirical validation of the framework's effectiveness through implementation experiences (Howarth and Fredericks, 2012; Puppim de Oliveira and Jabbour, 2017). While the framework is grounded in extensive literature review and incorporates insights from empirical research on SME sustainability practices, actual testing through case studies or broader implementation would strengthen understanding of the framework's utility and refinement needs (Todorova and Zyatchin, 2023; Sardanelli *et al*., 2022). The framework also necessarily involves simplification of complex realities, and individual SME circumstances may require adaptations not fully anticipated in the generalized guidance provided (Tsang *et al*., 2023; Jo and Kwon, 2021). The emphasis on providing practical, resource-efficient approaches may mean that the framework does not push SMEs toward the most ambitious possible sustainability outcomes, instead prioritizing feasible first steps and continuous improvement over comprehensive transformation (Cronin and Doyle-Kent, 2022; Whitelock, 2019).

The rapidly evolving nature of sustainability expectations, ESG frameworks, and technological capabilities also means that the framework will require ongoing updating to remain current and relevant (Jones *et al*., 2023; Paro, 2023). Regulatory developments such as expanding mandatory ESG disclosure requirements, evolution of sustainability reporting standards, technological innovations enabling more efficient sustainability management, and shifting stakeholder expectations will all influence the context within which SMEs operate and may require framework adjustments (Okpala, 2023; Kaddour, 2023). Future iterations of the framework should incorporate emerging best practices, new tools and support mechanisms, and lessons learned from implementation experiences (Shalhoob and Hussainey, 2022; Riva *et al*., 2021).

Despite these limitations, this research makes important contributions by developing the first comprehensive conceptual framework specifically designed for integrating ESG metrics into SME supply chain decision-making processes (Figurek and Thrassou, 2023; Rainy and Chowdhury, 2022). By providing structured yet practical guidance that acknowledges SME constraints while leveraging their unique characteristics, the framework enables small and medium-sized enterprises to participate meaningfully in the global transition toward sustainable supply chains (Nwokocha *et al*., 2023; Soni *et al*., 2022). The widespread adoption of systematic approaches to ESG integration across the SME sector is essential for achieving the scale of change required to address pressing environmental challenges, advance social equity, and strengthen governance practices throughout global supply networks (Markopoulos *et al*., 2023; Davidor *et al*., 2023). This framework represents a significant step toward making such adoption feasible and sustainable for the diverse population of small and medium-sized enterprises that collectively play such critical roles in economic systems and supply chains worldwide (Dako *et al*., 2023; Ali *et al*., 2023).

5. References

1. Adesanya OS, Farounbi BO, Akinola AS, Prisca O. Digital Twins for Procurement and Supply Chains: Architecture for Resilience and Predictive Cost Avoidance. Decision-making. 2020;33:34.
2. Ahi P, Searcy C. An analysis of metrics used to measure performance in green and sustainable supply chains. J Clean Prod. 2015;86:360-377.
3. Akinlade OF, Filani OM, Nwachukwu PS. Statistical Approaches for Optimizing Order Promising Accuracy Within Supply Chain Networks. 2023.
4. Aksoy L, Buoye AJ, Fors M, Keiningham TL, Rosengren S. Environmental, Social and Governance (ESG) metrics do not serve services customers: A missing link between sustainability metrics and customer perceptions of social innovation. J Serv Manag. 2022;33(4/5):565-577.
5. Alao OB, Nwokocha GC, Filani OM. Digital Twin Technology Applications for Procurement And Inventory Optimization in Industrial Supply Chains and Manufacturing Operations. 2023.
6. Ali R, Nguia W, Bernard HF. Integrated Framework for Enhancing Resilience and Profitability Across Healthcare, Supply Chains, and SMEs. Es Econ Entrepreneurship. 2023;2(02):157-165.
7. Amini-Philips A, Ibrahim AK, Eyinade W. Supply Chain Risk Management in Global Operations: An Analytical Review of Emerging Approaches. 2023.
8. Atkins J, Doni F, Gasperini A, Artuso S, La Torre I, Sorrentino L. Exploring the effectiveness of sustainability measurement: which ESG metrics will survive COVID-19? J Bus Ethics. 2023;185(3):629-646.
9. Ballester Climent AR. Analysis of ESG practices integration in companies operations. Literary review. 2022.
10. Banomyong R, Supatn N. Developing a supply chain performance tool for SMEs in Thailand. Supply Chain Manag. 2011;16(1):20-31.

11. Barney J. Firm resources and sustained competitive advantage. J Manag. 1991;17(1):99-120.
12. Becchetti L, Bobbio E, Prizia F, Semplici L. Going deeper into the S of ESG: a relational approach to the definition of social responsibility. Sustainability. 2022;14(15):9668.
13. Buallay A. Is sustainability reporting (ESG) associated with performance? Evidence from the European banking sector. Manag Environ Qual. 2019;30(1):98-115.
14. Busch T, Johnson M, Pioch T. Corporate carbon performance data: Quo vadis? J Ind Ecol. 2021;25(4):1272-1291.
15. Büyüközkan G, Göçer F. Digital supply chain: Literature review and a proposed framework for future research. Comput Ind. 2018;97:157-177.
16. Carbonneau R, Laframboise K, Vahidov R. Application of machine learning techniques for supply chain demand forecasting. Eur J Oper Res. 2008;184(3):1140-1154.
17. Carter CR, Rogers DS. A framework of sustainable supply chain management: Moving toward new theory. Int J Phys Distrib Logist Manag. 2008;38(5):360-387.
18. Cek K, Ercantan O. The Relationship between Environmental Innovation, Sustainable Supply Chain Management, and Financial Performance: The Moderating Role of Environmental, Social and Corporate Governance. Int J Organ Leadersh. 2023;12(2).
19. Comoli M, Tettamanzi P, Murgolo M. Accounting for 'ESG'under disruptions: A systematic literature network analysis. Sustainability. 2023;15(8):6633.
20. Cronin M, Doyle-Kent M. Creating value with environmental, social, governance (ESG) in Irish manufacturing SMEs': A focus on disclosure of climate change risks and opportunities. IFAC-PapersOnLine. 2022;55(39):48-53.
21. Dako OF, Onalaja TA, Nwachukwu PS, Bankole FA, Lateefat T. Integrating ESG performance metrics into financial reporting frameworks to strengthen sustainable investment decision-making processes. 2023.
22. Davidor S, Dako OF, Nwachukwu PS, Bankole FA, Lateefat T. An ESG-Integrated Investment Banking Framework for Sustainable Credit Deals and M&A. 2023.
23. Dey PK, Chowdhury S, Rodríguez-Espíndola O, Parkes G, Tuyet NTA, Long DD, Ha TP. Sustainable supply chain performance measurement using SCOR: An integrated approach. Prod Plan Control. 2020;32(15):1320-1335.
24. Didi PU, Abass OS, Balogun O. A strategic framework for ESG-aligned product positioning of methane capture technologies. J Front Multidiscip Res. 2021;2(2):176-185.
25. Dubey R, Gunasekaran A, Childe SJ, Papadopoulos T, Luo Z, Wamba SF, Roubaud D. Can big data and predictive analytics improve social and environmental sustainability? Technol Forecast Soc Change. 2019;144:534-545.
26. D'Angiò A, Acampora A, Merli R, Lucchetti MC. ESG indicators and SME: Towards a simplified framework for sustainability reporting. In: National Congress of Commodity Science. Cham: Springer Nature Switzerland; 2022:325-331.
27. Ejairu E, Filani OM, Nwokocha GC, Alao OB. IoT and Digital Twins in Supply Chains: Real-Time Monitoring Models for Efficiency, Safety, and Competitive Edge. 2023.
28. Eyinade W, Amini-Philips A, Ibrahim AK. Conceptual Model for Sustainable Procurement and Governance Structures in the Built Environment. 2022.
29. Fiaschi D, Giuliani E, Nieri F, Salvati N. How bad is your company? Measuring corporate wrongdoing beyond the magic of ESG metrics. Bus Horiz. 2020;63(3):287-299.
30. Figurek A, Thrassou A. An Integrated Framework for Sustainable Development in Agri-Food SMEs. Sustainability. 2023;15(12):9387.
31. Filani OM, Nwokocha GC, Alao OB. Vendor Performance Analytics Dashboard Enabling Real-Time Decision-Making Through Integrated Procurement, Quality, and Cost Metrics. 2022.
32. Freeman RE. Strategic management: A stakeholder approach. Boston: Pitman; 1984.
33. Govindan K, Khodaverdi R, Jafarian A. A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach. J Clean Prod. 2015;47:345-354.
34. Gunasekaran A, Papadopoulos T, Dubey R, Wamba SF, Childe SJ, Hazen B, Akter S. Big data and predictive analytics for supply chain and organizational performance. J Bus Res. 2017;70:308-317.
35. Hart SL. A natural-resource-based view of the firm. Acad Manag Rev. 1995;20(4):986-1014.
36. Hazen BT, Boone CA, Ezell JD, Jones-Farmer LA. Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications. Int J Prod Econ. 2014;154:72-80.
37. Hemilä J, Vilko J. The development of a service supply chain model for a manufacturing SME. Int J Logist Manag. 2015;26(3):517-542.
38. Hofmann E, Rüsch M. Industry 4.0 and the current status as well as future prospects on logistics. Comput Ind. 2017;89:23-34.
39. Howarth R, Fredericks J. Sustainable SME practice: A reflection on supply-chain environmental management intervention. Manag Environ Qual. 2012;23(6):673-685.
40. Huang X. Strategic decision making in Chinese SMEs. Chin Manag Stud. 2009;3(2):87-101.
41. Ivanov D, Dolgui A, Sokolov B. The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. Int J Prod Res. 2019;57(3):829-846.
42. Jasti NVK, Kodali R. A critical review of lean supply chain management frameworks: Proposed framework. Prod Plan Control. 2015;26(13):1051-1068.
43. Jenkins H. Small business champions for corporate social responsibility. J Bus Ethics. 2006;67(3):241-256.
44. Jo D, Kwon C. Structure of green supply chain management for sustainability of small and medium enterprises. Sustainability. 2021;14(1):50.
45. Johnson MP, Schaltegger S. Two decades of sustainability management tools for SMEs: How far have we come? J Small Bus Manag. 2016;54(2):481-505.
46. Jones B, Rasha A, Dyczkowska J, Dyczkowski T. Sustainable performance management in the EU SME sector. A review and analysis of concepts and methods of strategic management accounting. Theor J Account.

2023;47(4):191-215.
47. Kaddour S. Sustainability performance evaluation for start-ups: defining the characteristics for a tailored ESG assessment tool. 2023.
48. Keeley AR, Chapman AJ, Yoshida K, Xie J, Imbulana J, Takeda S, Managi S. ESG metrics and social equity: Investigating commensurability. Front Sustainability. 2022;3:920955.
49. Klewitz J, Hansen EG. Sustainability-oriented innovation of SMEs: A systematic review. J Clean Prod. 2014;65:57-49.
50. Kot S, Haque AU, Baloch A. Supply chain management in SMEs: Global perspective. Montenegrin J Econ. 2020;16(1):87-104.
51. Kotsantonis S, Serafeim G. Four things no one will tell you about ESG data. J Appl Corp Finance. 2019;31(2):50-58.
52. Lanza A, Bernardini E, Faiella I. Mind the gap! machine learning, ESG metrics and sustainable investment. Bank of Italy Occasional Paper. 2020;(561).
53. Madiwal MG, Dulange SR. Decision making in SMES a review. Int J Innov Eng Res Technol. 2016:1-5.
54. Markopoulos E, Al Katheeri H, Al Qayed H. A decision support system architecture for the development and implementation of ESG strategies at SMEs. In: Proceedings of the 6th International Conference on Intelligent Human Systems Integration (IHSI 2023) Integrating People and Intelligent Systems, February 22–24, 2023, Venice, Italy. Vol 69. AHFE International; 2023:905-915.
55. Molin M. Development of a decision-making framework addressed to SMEs and consultants to support the assessment, adoption and implementation of corporate sustainability. 2021.
56. Musso F, Francioni B. The influence of decision-maker characteristics on the international strategic decision-making process: An SME perspective. Procedia Soc Behav Sci. 2012;58:279-288.
57. Nielsen C. ESG reporting and metrics: From double materiality to key performance indicators. Sustainability. 2023;15(24):16844.
58. Nwokocha GC, Alao OB, Filani OM. Decision-Support System for Sustainable Procurement Combining Lifecycle Assessment, Spend Analysis, and Supplier ESG Performance Scoring. 2023.
59. Ogundipe F, Bakare OI, Sampson E, Folorunso A. Harnessing Digital Transformation for Africa's Growth: Opportunities and Challenges in the Technological Era. 2023.
60. Ogunyankinnu T, Onotole EF, Osunkanmibi AA, Adeoye Y, Aipoh G, Egbemhenghe J. Blockchain and AI synergies for effective supply chain management. 2022.
61. Okojiev JS, Filani OM, Ike PN, Idu JOO, Nnabueze SB, Ihwughwavwe SI. Integrating AI with ESG Metrics in Smart Infrastructure Auditing for High-Impact Urban Development Projects. 2023.
62. Okpala IL. Integrating Sustainability Metrics into Financial Reporting for SMEs in Emerging Economies: A Strategic Framework for Balancing ESG Implementation with Financial Performance. Res J Bus Econ. 2023;1(1):101-188.
63. Om K, Lee J, Chang J. Using supply chain management to enhance industry—university collaborations in IT higher education in Korea. Scientometrics. 2007;71(3):455-471.
64. Onotole EF, Ogunyankinnu T, Osunkanmibi AA, Adeoye Y, Ukatu CE, Ajayi OA. AI-Driven Optimization for Vendor-Managed Inventory in Dynamic Supply Chains. 2023.
65. Oyeyemi BB, Kabirat SM. Forecasting the Future of Autonomous Supply Chains: Readiness of Nigeria vs. the US. Supply Chain Manag Rev. 2023;19(3):187-204.
66. Oyeyemi BB. Data-Driven Decisions: Leveraging Predictive Analytics in Procurement Software for Smarter Supply Chain Management in the United States. 2023.
67. Oyeyipo I, Attipoe V, Mayienga BA, Onwuzulike OC, Ayodeji DC, Nwaozomudoh MO, Isibor NJ, Ahmadu J. A conceptual framework for transforming corporate finance through strategic growth, profitability, and risk optimization. Int J Adv Multidiscip Res Stud. 2023;3(5):1527-1538.
68. Palomero S, Chalmeta R. A guide for supply chain integration in SMEs. Prod Plan Control. 2014;25(5):372-400.
69. Paro PEP. Towards a Conscious Business future: proposal and application of a multidimensional framework and its effects on stakeholders'engagement, financial performance and ESG metrics [Doctoral dissertation]. Universidade de São Paulo; 2023.
70. Pathik BB, Habib MM, Chowdhury MT. Analysis of educational supply chain management model: a case study approach. In: Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management. 2012:9.
71. Puppim de Oliveira JA, Jabbour CJC. Environmental management, climate change, CSR, and governance in clusters of small firms in developing countries: Toward an integrated analytical framework. Bus Soc. 2017;56(1):130-151.
72. Rainy TA, Chowdhury AR. The Role Of Artificial Intelligence In Vendor Performance Evaluation Within Digital Retail Supply Chains: A Review Of Strategic Decision-Making Models. Am J Scholarly Res Innov. 2022;1(01):220-248.
73. Ritchie B, Brindley C. Disintermediation, disintegration and risk in the SME global supply chain. Manag Decis. 2000;38(8):575-583.
74. Riva P, Comoli M, Garelli A. ESG for SMEs: Can the Proposal 2021/0104 for a European Directive Help in the Early Detection of a Crisis? In: Corporate Governance-Recent Advances and Perspectives. 2021:1-13.
75. Saberi S, Kouhizadeh M, Sarkis J, Shen L. Blockchain technology and its relationships to sustainable supply chain management. Int J Prod Res. 2019;57(7):2117-2135.
76. Sanusi A, Irianto SY, Sumiyati L. Model of the empowerment of governance based on the human resource management for supply chains in higher education. Int J Supply Chain Manag. 2019;8(6):671-680.
77. Sardanelli D, Bittucci L, Mirone F, Marzioni S. An integrative framework for supply chain rating: From financial-based to ESG-based rating models. Total Qual Manag Bus Excell. 2022:1-20.
78. Sarkis J. A strategic decision framework for green supply chain management. J Clean Prod. 2003;11(4):397-409.

79. Sarrico CS, Rosa MJ. Supply chain quality management in education. Int J Qual Reliab Manag. 2016;33(4):499-517.
80. Saviano M, Berardi M. Decision-Making Under Complexity. The Case of District SME. 2009:1619-1643.
81. Seuring S, Müller M. From a literature review to a conceptual framework for sustainable supply chain management. J Clean Prod. 2008;16(15):1699-1710.
82. Shalhoob H, Hussainey K. Environmental, social and governance (ESG) disclosure and the small and medium enterprises (SMEs) sustainability performance. Sustainability. 2022;15(1):200.
83. Singh RK. Developing the framework for coordination in supply chain of SMEs. Bus Process Manag J. 2011;17(4):619-638.
84. Soni G, Kumar S, Mahto RV, Mangla SK, Mittal ML, Lim WM. A decision-making framework for Industry 4.0 technology implementation: The case of FinTech and sustainable supply chain finance for SMEs. Technol Forecast Soc Change. 2022;180:121686.
85. Souza GC. Supply chain analytics. Bus Horiz. 2014;57(5):595-605.
86. Spence LJ. Small business social responsibility: Expanding core CSR theory. Bus Soc. 2016;55(1):23-55.
87. Tan EN, Smith G, Saad M. Managing the global supply chain: a SME perspective. Prod Plan Control. 2006;17(3):238-246.
88. Testa F, Miroshnychenko I, Barontini R, Frey M. Does it pay to be a greenwasher or a brownwasher? Bus Strategy Environ. 2016;27(7):1104-1116.
89. Thakkar J, Kanda A, Deshmukh SG. Supply chain management in SMEs: development of constructs and propositions. Asia Pac J Mark Logist. 2008;20(1):97-131.
90. Tiwari S, Wee HM, Daryanto Y. Big data analytics in supply chain management between 2010 and 2016: Insights to industries. Comput Ind Eng. 2018;115:319-330.
91. Todorova A, Zyatchin A. A Sustainability Measurement Framework of Supply Chain Information Flow: The Case of Industry 4.0 Technology Implementation. Contributions to Game Theory and Management. 2023;16:237-270.
92. Torugsa NA, O'Donohue W, Hecker R. Capabilities, proactive CSR and financial performance in SMEs: Empirical evidence from an Australian manufacturing industry sector. J Bus Ethics. 2012;109(4):483-492.
93. Tounsi J, Boissiere J, Habchi G. Multiagent decision making for SME supply chain simulation. In: ECMS2009. 2009:203.
94. Tsang YP, Fan Y, Feng ZP. Bridging the gap: Building environmental, social and governance capabilities in small and medium logistics companies. J Environ Manag. 2023;338:117758.
95. Vachon S, Klassen RD. Environmental management and manufacturing performance: The role of collaboration in the supply chain. Int J Prod Econ. 2008;111(2):299-315.
96. Whitelock VG. Relationship between environmental social governance (ESG) management and performance–the role of collaboration in the supply chain [Doctoral dissertation]. University of Toledo; 2015.
97. Whitelock VG. Multidimensional environmental social governance sustainability framework: Integration, using a purchasing, operations, and supply chain management context. Sustain Dev. 2019;27(5):923-931.
98. Zeng H, Li RYM, Zeng L. Evaluating green supply chain performance based on ESG and financial indicators. Front Environ Sci. 2022;10:982828.
99. Zhao W, Luo Z, Liu Q. Does supply chain matter for environmental firm performance: mediating role of financial development in China. Econ Change Restruct. 2023;56(6):3811-3837.
100. Zioło M, Bąk I, Spoz A. Incorporating ESG risk in companies' business models: State of research and energy sector case studies. Energies. 2023;16(4):1809.