



(REVIEW ARTICLE)



## Sustainable operations management: Integrating environmental and economic performance

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### Abstract

Sustainable Operations Management (SOM) has become an important area of research and practice as organizations increasingly face pressure to improve environmental sustainability while maintaining economic competitiveness. This literature review examines how sustainable operational strategies contribute to the integration of environmental and economic performance across manufacturing and service industries. The study synthesizes recent peer-reviewed literature published from Scopus, Web of Science, and Google Scholar databases. Key themes identified include green supply chain management (GSCM), circular economy practices, eco-efficient manufacturing, Industry 4.0 technologies, sustainable innovation, and organizational performance outcomes. The review reveals that sustainable operational practices generally improve resource efficiency, reduce waste generation, lower operational costs, and strengthen long-term competitiveness. Internal sustainability initiatives such as eco-design, waste minimization, and cleaner production systems often generate stronger environmental and economic benefits than external sustainability collaborations. The findings also indicate that technological advancements such as artificial intelligence, big data analytics, blockchain, and Internet of Things (IoT) technologies support sustainability integration by improving operational transparency, predictive monitoring, and decision-making capabilities. However, the effectiveness of sustainable operations management varies according to organizational size, institutional context, technological readiness, and financial capability. Large firms often demonstrate stronger sustainability outcomes due to greater access to technological and financial resources, while small and medium enterprises (SMEs) face implementation barriers including limited capital and insufficient technical expertise. This review contributes to the growing SOM literature by integrating recent theoretical and empirical developments into a unified framework. The study highlights the importance of combining environmental responsibility with operational efficiency and emphasizes the strategic role of sustainability in achieving long-term organizational resilience and competitiveness.

**Keywords:** Sustainable operations management; Environmental performance; Economic performance; Green supply chain management; Circular economy; eco-efficiency; Meta-analysis, Industry 4.0; Porter Hypothesis

### 1. Introduction

Operations management has traditionally focused on improving efficiency, productivity, cost reduction, and quality control within production and service processes. However, the escalating environmental challenges associated with industrial activities have substantially transformed the role of operations management in contemporary organizations. Issues such as climate change, environmental degradation, and resource depletion have compelled firms to reconsider how operational decisions affect the environment and society. Consequently, companies are under increasing pressure to implement operational methods that simultaneously accomplish environmental sustainability and financial success

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The concept of sustainable operations management (SOM) has emerged as a response to these challenges. Sustainable operations management refers to the integration of environmental and social considerations into traditional operations management practices while maintaining economic performance (Gunasekaran et al., 2022). Rather than focusing exclusively on efficiency and cost minimization, SOM emphasizes the development of operational processes that minimize environmental impacts, improve resource utilization, and support long-term organizational viability.

The Natural Resource-Based View (NRBV) of the firm represents one of the most influential theoretical perspectives supporting sustainable operations management. This framework posits that environmental capabilities including sustainable innovation, product stewardship, and pollution prevention that can develop into strategic assets that generate competitive advantage (Hart, 1995). Organizations that invest in environmentally responsible practices may enhance operational effectiveness, reduce waste, and strengthen their market positioning. Another important theoretical framework relevant to sustainable operations management is the circular economy model. Traditional industrial systems follow a linear production model in which resources are extracted, transformed into products, and eventually disposed of as waste. In contrast, the circular economy promotes closed-loop production systems that encourage recycling, remanufacturing, and resource recovery (Geissdoerfer et al., 2017). By reducing material waste and improving resource efficiency, circular economy practices enable firms to achieve both environmental and economic objectives simultaneously.

Recent technological developments have further strengthened the integration of sustainability within operations management. Digital technologies associated with Industry 4.0 including artificial intelligence, big data analytics, and the Internet of Things (IoT) enable organizations to monitor energy consumption, track emissions, and optimize supply chain operations in real time (Kamble et al., 2018). These technologies improve operational transparency and provide data-driven insights that support sustainable decision-making.

Despite the growing scholarly and practitioner interest in sustainable operations, the relationship between environmental sustainability and economic performance remains contested. While some scholars argue that environmental regulations impose additional costs and weaken competitive positioning, others contend that sustainability initiatives can stimulate innovation, improve resource efficiency, and enhance product quality. Early work by Porter and van der Linde (1995) demonstrated that cleaner production practices can create competitive opportunities rather than constraints, suggesting that environmental protection and profitability can be complementary objectives under certain conditions. Nevertheless, empirical findings remain inconsistent, and the mechanisms through which sustainability integration enhances both environmental and economic outcomes within operations management are not yet fully understood.

Although individual studies have examined green supply chain management, eco-efficient manufacturing, and circular economy practices in isolation, limited research has synthesized these diverse operational strategies within a unified framework to explain how sustainability simultaneously enhances environmental and economic performance. Existing literature tends to treat these strategies as separate phenomena, leaving a critical gap in understanding their interdependencies, synergistic effects, and collective impact on organizational outcomes. Furthermore, while theoretical frameworks such as the NRBV and circular economy model provide conceptual foundations, empirical evidence examining the integration of these perspectives within comprehensive operations management systems remains fragmented and underdeveloped.

### **1.1. Empirical Evidence on Performance Integration**

Empirical research generally supports the idea that sustainable operational practices can enhance both environmental and economic performance, but this relationship is neither uniform nor automatic. Studies on green supply chain management suggest that firms adopting environmentally responsible procurement and production systems often achieve improvements in operational efficiency and financial outcomes (Zhu & Sarkis, 2004). However, rather than indicating a direct causal link, these findings increasingly suggest that performance gains are mediated by firm capability, organizational learning, and process maturity.

Similarly, evidence from sustainable manufacturing shows that practices such as energy efficiency and waste reduction can lower production costs while improving environmental outcomes. Yet, these benefits are typically incremental rather than transformational, implying that sustainability functions more as a continuous improvement mechanism than a radical cost-reduction strategy.

Digital technologies further complicate this relationship. While big data analytics and predictive systems enhance visibility and efficiency (Dubey et al., 2019), their impact depends heavily on how well organizations integrate these

tools into decision-making structures. In other words, technology does not independently create sustainability gains; it amplifies existing operational capabilities. Circular economy research reinforces this conditional logic. Closed-loop systems can improve long-term resource efficiency and cost stability (Geissdoerfer et al., 2017), but only when firms possess the financial capacity and infrastructure to manage reverse logistics and redesign production systems. This reveals a key synthesis across the literature: sustainability-performance integration is capability-dependent rather than universal.

Overall, the evidence challenges the simplistic assumption that sustainability naturally leads to superior financial performance. Instead, outcomes are shaped by internal capability development, technological readiness, and system-level integration.

### **1.2. Implementation Challenges**

Despite the growing recognition of sustainable operations management, implementation remains constrained by structural and organizational barriers that limit its effectiveness in practice. A primary constraint is the high initial investment required for sustainable technologies and system redesign. While long-term efficiency gains are often cited, many firms—particularly SMEs—face liquidity and risk limitations that prevent them from realizing these future benefits. This creates a temporal mismatch between costs (immediate) and returns (long-term), which weakens adoption incentives.

Organizational resistance also plays a significant role. Resistance is not merely behavioral but structural, often rooted in existing performance metrics and incentive systems that prioritize short-term efficiency over long-term sustainability. As a result, sustainability initiatives may be implemented superficially without full operational integration.

In developing economies, these challenges are intensified by limited technological infrastructure and weak institutional support. This reinforces a persistent inequality in sustainability adoption, where advanced economies benefit disproportionately from innovation-driven sustainability systems.

Finally, the lack of standardized performance measurement frameworks creates epistemic uncertainty. Without consistent metrics, firms struggle to evaluate whether sustainability initiatives are genuinely effective or simply symbolically adopted. This measurement gap contributes to fragmented implementation and limits cross-industry comparability.

Collectively, these barriers indicate that the main challenge in SOM is not conceptual acceptance but operational feasibility and institutional alignment.

### **1.3. Research Gaps and Future Directions**

Although Sustainable Operations Management has developed into a mature field, current literature still reflects several unresolved tensions and methodological limitations. First, sustainability performance measurement remains fragmented. Existing frameworks often prioritize either environmental or economic indicators but fail to integrate both in a standardized and dynamic manner. This limits the ability to conduct cross-contextual comparisons and weakens the generalizability of findings.

Second, the role of digital transformation remains under-theorized. While technologies such as AI, blockchain, and advanced analytics are widely recognized as enabling tools, the literature rarely explains how these technologies reshape decision-making structures and organizational behavior. This suggests a gap between technological optimism and operational reality.

Third, SMEs remain underrepresented in sustainability research. Existing studies disproportionately focus on large corporations, which limits understanding of how resource constraints shape sustainability adoption. This creates a bias in the literature toward high-capacity organizational contexts. Finally, there is limited longitudinal evidence on sustainability outcomes. Most studies rely on cross-sectional data, which restricts understanding of whether sustainability leads to sustained competitive advantage or only short-term efficiency gains. Future research must therefore move beyond correlation to examine dynamic and time-dependent effects. Overall, the field would benefit from more integrative models that link capability development, institutional conditions, and technological change in explaining sustainability outcomes.

## 1.4. Managerial Implications

From a managerial perspective, the literature suggests that sustainability should not be treated as a cost-centered compliance activity but as a capability-building process that unfolds over time. First, managers should recognize that sustainability investments yield uneven returns depending on internal readiness. Rather than adopting broad sustainability programs immediately, firms may achieve better outcomes by strengthening internal operational capabilities such as process efficiency, waste management, and product design. Second, sustainability should be embedded across the entire operational lifecycle—from procurement to production to distribution. However, this integration is not simply structural; it requires alignment of incentives, performance metrics, and supplier relationships. Without such alignment, sustainability initiatives risk becoming fragmented and symbolic. Third, while digital technologies offer powerful tools for sustainability monitoring and optimization, their effectiveness depends on organizational absorptive capacity. Firms that lack data literacy or integration systems may experience limited benefits despite high technological investment.

Finally, cultural transformation is a critical but often underestimated factor. Sustainability cannot be sustained solely through systems and technology; it requires behavioral alignment across all organizational levels. However, culture change should be understood not as a motivational slogan but as a gradual institutional shift supported by consistent policies and incentives. In synthesis, managerial success in sustainability depends less on adoption and more on integration depth, capability development, and organizational coherence.

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## 2. Methodology

### 2.1. Objective of the Study

The objective of this study is to analyze existing academic literature to understand how sustainable operations management contributes to the integration of environmental and economic performance. Specifically, the study aims to: (1) identify the key operational practices that support sustainability integration; (2) examine the theoretical frameworks that explain this integration; and (3) evaluate empirical evidence regarding the performance outcomes of sustainable operational strategies.

### 2.2. Research Design

This review adopts a structured literature review approach, following established protocols for systematic evidence synthesis in management research. The methodology was designed to ensure transparency, reproducibility, and comprehensive coverage of the relevant literature while maintaining focus on the research objectives.

### 2.3. Database Search and Keywords

Relevant academic articles were identified through systematic searches of major scholarly databases, including Scopus, Web of Science, and Google Scholar. The search process employed a combination of keywords and Boolean operators to capture the breadth of literature on sustainable operations management. The primary search strings included:

- "sustainable operations management" AND ("environmental performance" OR "economic performance")
- "green supply chain management" AND ("financial performance" OR "operational efficiency")
- "circular economy" AND "operations management" AND "empirical"
- "eco-efficiency" AND "manufacturing" AND "cost reduction"
- ("Industry 4.0" OR "digital transformation") AND "sustainability" AND "operations"
- "Porter Hypothesis" AND "environmental regulation" AND "innovation"

Additional search terms were iteratively refined based on preliminary screening results and citation tracking of seminal articles. The search was not restricted by publication date to ensure comprehensive historical coverage, though priority was given to peer-reviewed articles published between 1995 and 2024.

### 2.4. Screening Process and Inclusion Criteria

The literature selection process involved a rigorous three-stage screening protocol:

Stage 1: Initial Database Search. The initial database search generated a broad set of articles related to sustainability and operations management. Duplicate records across databases were identified and removed using reference management software.

Stage 2: Title and Abstract Screening. Articles were screened based on relevance to the research topic, publication quality, and contribution to the field of sustainable operations management. Inclusion criteria required that articles: (a) address both environmental and economic dimensions of operations management; (b) present empirical evidence, theoretical frameworks, or comprehensive reviews; (c) be published in peer-reviewed academic journals or reputable edited volumes; and (d) be written in English. Exclusion criteria eliminated: (a) purely conceptual papers without theoretical or empirical grounding; (b) industry reports and non-academic publications; (c) articles focusing exclusively on either environmental or economic performance without integration; and (d) publications with insufficient methodological transparency.

Stage 3: Full-Text Analysis and Thematic Categorization. The remaining articles were analyzed in detail and categorized according to research themes, including sustainability strategies, operational practices, technological innovations, theoretical frameworks, and performance outcomes. Cross-referencing of bibliographies was conducted to identify additional relevant studies not captured in the initial database search.

## **2.5. Number of Articles Reviewed**

The systematic search and screening process yielded a final sample of approximately 85–100 peer-reviewed articles for detailed analysis. This included seminal theoretical contributions (e.g., Hart, 1995; Porter & van der Linde, 1995; Elkington, 1997), influential review articles (e.g., Seuring & Müller, 2008; Fahimnia et al., 2015), and recent empirical studies and meta-analyses. The structured review approach allowed the identification of key trends and patterns in the literature and facilitated comparison across multiple studies examining sustainability integration in different industries and geographic contexts.

## **2.6. Analytical Approach**

The review employed a thematic synthesis approach, integrating findings across studies to identify convergent evidence, contradictory results, and theoretical gaps. Particular attention was paid to moderating variables, boundary conditions, and contextual factors that influence the sustainability-performance relationship. Where available, meta-analytic evidence was prioritized over individual studies to provide more robust conclusions.

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## **3. Results and Discussion**

### **3.1. Main Discoveries**

The literature review reveals several important findings about sustainable operations management, which are interpreted below in terms of their theoretical and practical implications.

### **3.2. Sustainability Practices and Operational Efficiency**

One of the most crucial discoveries is the strong relationship between sustainability practices and operational efficiency. Organizations that adopt environmentally responsible practices often achieve cost savings through improved resource efficiency, reduced energy consumption, and minimized waste generation (Zhu & Sarkis, 2004). However, this relationship is not automatic or universal. The meta-analytic evidence demonstrates that the effect size varies significantly across practice types, with internal practices such as investment recovery and eco-design generating substantially stronger environmental performance improvements than external practices like supplier collaboration (Fahimnia et al., 2015). This finding challenges the prevailing emphasis on supply chain-wide sustainability initiatives and suggests that firms should first strengthen internal environmental capabilities before extending sustainability requirements to suppliers. The implication is that resource-constrained firms can achieve meaningful environmental improvements by focusing on high-impact internal practices rather than attempting comprehensive supply chain transformation.

### **3.3. Green Supply Chain Management as a Critical Strategy**

GSCM has been identified as a critical strategy for improving both environmental and economic performance. By incorporating environmental considerations into supplier selection, procurement processes, and logistics operations, organizations can reduce environmental impacts while improving supply chain efficiency (Sarkis, 2003). However, the interpretation of this finding requires nuance. While the overall GSCM-CEP relationship is positive and significant ( $r = 0.398$ ), the effect is moderated by firm size, measurement methodology, and national context (Fahimnia et al., 2015). Large firms in environmentally aware countries with self-reporting measurement systems show the strongest effects, while SMEs in developing economies with external ratings demonstrate weaker relationships. This pattern suggests that GSCM effectiveness is contingent upon organizational resources and institutional support rather than inherent in

the practices themselves. For managers, this implies that GSCM implementation should be calibrated to organizational capabilities and contextual conditions rather than adopted as a standardized blueprint.

### **3.4. Technological Innovation in Sustainable Operations**

Industry 4.0 technologies allow firms to monitor environmental performance indicators and optimize operational processes using real-time data. These technologies contribute to improved decision-making and resource management, thereby enhancing both sustainability and productivity (Dubey et al., 2019). The integration of GRI metrics with process mining represents a particularly promising development, enabling granular, activity-level sustainability assessment that addresses the limitations of traditional retrospective reporting (Dubey et al., 2019). However, the discussion must acknowledge the digital divide: while large firms in developed economies can leverage these technologies, SMEs and developing economy firms face significant barriers including financial constraints, infrastructure deficiencies, and skills gaps (Junge & Straube, 2020). The implication is that technological solutions to sustainability challenges may inadvertently exacerbate inequalities between resource-rich and resource-constrained organizations unless accompanied by targeted support mechanisms.

### **3.5. Circular Economy Practices and Long-Term Value Creation**

Circular economy practices such as recycling, remanufacturing, and product life-cycle management have been shown to reduce material costs and improve environmental performance. Firms that adopt circular production systems can achieve long-term economic benefits by reducing reliance on raw material extraction and improving resource productivity (Geissdoerfer et al., 2017). However, the discussion must recognize that circular economy implementation requires substantial upfront investment and organizational transformation. Research on the integrated waste sector indicates that investment preparedness including equity management, sector knowledge, and governance quality—is a critical enabler of circular economy success (Kirchherr et al., 2017). Firms lacking these capabilities may find circular practices economically unviable despite their environmental appeal. This finding suggests that circular economy adoption follows a capability-dependent trajectory, with early movers possessing complementary resources capturing disproportionate benefits.

### **3.6. Comparative Analysis and Contextual Variation**

Several studies demonstrate that the impact of sustainability initiatives varies across industries and organizational contexts. Manufacturing industries often demonstrate stronger environmental and economic benefits from sustainable operations due to the resource-intensive nature of their production processes. However, this industry effect may reflect selection bias—manufacturing firms have greater scope for resource efficiency improvements, making sustainability investments more visible and measurable compared to service sectors where environmental impacts are less direct.

Large organizations typically possess greater financial resources and technological capabilities to implement advanced sustainability practices, whereas SMEs face financial and organizational barriers that constrain their adoption. The meta-analytic evidence confirms this size effect, with large firms showing significantly stronger GSCM-CEP relationships than SMEs (Fahimnia et al., 2015). This disparity raises equity concerns: if sustainability practices generate competitive advantages, the inability of SMEs to adopt them may concentrate market power among large corporations, potentially reducing industry competition and innovation diversity.

Firms operating in developed economies often benefit from stronger regulatory frameworks and greater access to sustainability technologies. In contrast, organizations in developing economies face challenges related to limited infrastructure and institutional support. The Porter Hypothesis literature provides important nuance here: while environmental regulation stimulates green innovation overall, command-and-control regulation proves more effective in developing countries where market institutions are less mature, while market-based instruments show stronger effects in developed economies (Ambec et al., 2013). This contextual variation suggests that sustainability policy must be tailored to institutional capacity rather than imported from advanced economies without adaptation.

### **3.7. Critical Interpretation of Findings**

Despite the overall positive evidence, several interpretive cautions are warranted. First, the predominance of correlational research designs limits causal inference. The positive association between sustainability practices and performance may reflect reverse causality—high-performing firms simply have more resources to invest in sustainability—rather than sustainability driving performance. Second, publication bias toward positive findings may inflate the apparent strength of sustainability-performance relationships. Studies reporting null or negative results are less likely to be published, creating an overly optimistic impression of sustainability benefits. Third, the reliance on self-

reported performance data in many studies introduces potential bias, as the significantly stronger correlations found with self-reported versus externally rated measures suggest (Fahimnia et al., 2015).

Fourth, the theoretical frameworks reviewed (NRBV, TBL, CE, Institutional Theory) provide complementary but partially conflicting explanations for sustainability-performance integration. The NRBV emphasizes firm-level capabilities, while Institutional Theory focuses on external pressures; the CE model prioritizes system redesign, while the TBL advocates balanced performance measurement. These frameworks have not been adequately integrated, leaving unresolved questions about their relative explanatory power and interaction effects.

### **3.8. Implications for Theory and Practice**

The findings carry several implications. Theoretically, future research should move beyond single-framework analyses to examine how NRBV capabilities interact with institutional pressures, how circular economy practices are enabled or constrained by dynamic capabilities, and how the TBL can be operationalized without sacrificing analytical rigor. Practically, managers should adopt a phased approach to sustainability integration, beginning with high-impact internal practices before expanding to supply chain-wide initiatives. Policymakers should recognize that one-size-fits-all regulatory approaches are suboptimal and instead design context-sensitive instruments that account for firm size, industry characteristics, and institutional capacity. Finally, the evidence suggests that sustainability investments require realistic time horizons—while some benefits materialize quickly, the full competitive advantages predicted by the NRBV and Porter Hypothesis may take years to develop.

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## **4. Conclusion**

This review demonstrates that sustainable operations management, through strategic practices including green supply chain management, eco-efficient manufacturing, digital transformation, and circular economy implementation, enables organizations to integrate environmental and economic performance. However, this integration is neither automatic nor universal as it is contingent upon organizational capabilities, institutional contexts, and the specific practices adopted.

First, the evidence indicates that sustainability initiatives can create benefits by improving resource efficiency, reducing costs, and enhancing competitiveness, rather than forcing a binary choice between environmental and financial goals. These benefits are driven by innovation, operational efficiency, and improved stakeholder engagement. Second, internal sustainability practices consistently outperform external practices in generating environmental performance improvements, challenging the prevailing emphasis on supply chain-wide sustainability initiatives. Third, the relationship between sustainability and performance is moderated by firm size, measurement methodology, and national context, indicating that context-sensitive strategies are essential. Fourth, digital technologies serve as powerful enablers of sustainability integration but may exacerbate capability gaps between large and small enterprises if not accompanied by targeted support.

This review contributes to the sustainable operations management literature by synthesizing diverse theoretical perspectives (NRBV, TBL, CE, Institutional Theory) and identifying their complementary insights and unresolved tensions. It highlights the need for integrative theoretical frameworks that account for the interaction between firm-level capabilities, institutional pressures, and technological enablers. Additionally, by incorporating recent meta-analytic evidence, this review provides more robust conclusions than previous narrative reviews that relied on individual studies.

For managers, this review suggests that sustainability investments should be prioritized based on practice-specific impact (investment recovery and eco-design yielding the strongest effects), organizational readiness, and realistic time horizons. For policymakers, the evidence supports the use of environmental regulation to stimulate green innovation, but emphasizes that regulatory design must be context-sensitive as command-and-control approaches may be more effective in developing economies, while market-based instruments suit developed economies. For SME support organizations, the findings underscore the need for simplified standards, financial incentives, and capability-building programs to prevent sustainability from becoming a barrier to SME competitiveness.

### **4.1. Limitations and Future Research**

This review is subject to limitations inherent in the literature it synthesizes, including publication bias, reliance on self-reported data, and predominance of cross-sectional designs. Future research should address these limitations by employing longitudinal and experimental designs, developing standardized performance measurement frameworks, investigating the long-term economic impacts of sustainability investments across diverse industries and geographic contexts, and examining how emerging technologies such as artificial intelligence and blockchain can democratize

access to sustainability solutions. Additionally, the field would benefit from greater attention to SME-specific sustainability strategies and the potential for collaborative approaches to overcome resource constraints.

Ultimately, sustainable operations management represents not merely a compliance requirement or corporate social responsibility initiative, but a strategic imperative for organizational resilience and competitive positioning in an increasingly resource-constrained and environmentally conscious global economy.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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