IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, December 2025
Impact Factor: 7.67

Assessing the Readiness of Global Supply Chains for Circular Economy Transition: A Multi-Criteria Evaluation Framework

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Abstract: *Global supply chains are increasingly being called upon to transition from traditional linear production and consumption models toward circular economy (CE) practices, driven by rising sustainability pressures, resource scarcity, and evolving regulatory frameworks. Linear supply chains, characterized by the "take, make, dispose" approach, are no longer sufficient to meet the environmental, economic, and social expectations of governments, customers, and other stakeholders. As organizations face growing scrutiny over their environmental footprint and sustainability commitments, adopting circular principles—such as product life-cycle extension, remanufacturing, recycling, and material reuse—has become a strategic imperative. However, despite the widespread recognition of the benefits of circularity, the level of preparedness for such a transition differs markedly across industries, organizational types, and geographical regions, indicating a critical need for systematic assessment of readiness.*

To address this gap, the present study proposes a Multi-Criteria Evaluation Framework (MCEF) that provides a structured approach to evaluating circular economy readiness in global supply chains. The framework is developed through a synthesis of academic literature, established sustainability and circular economy theories, and expert insights from practitioners experienced in supply chain operations and sustainability initiatives. By integrating multiple perspectives, the MCEF captures the multidimensional nature of CE adoption and identifies the factors that enable or constrain successful transition.

The framework organizes readiness into four key dimensions: technological readiness, which assesses digital infrastructure and operational capabilities; organizational readiness, which evaluates leadership, skills, and collaboration with suppliers; environmental readiness, which examines compliance with regulations and resource efficiency; and economic readiness, which considers investment capacity, market demand, and business model innovation. The study argues that digital capabilities, collaborative supplier networks, and strategic leadership commitment are central to achieving circular transformation. By providing both theoretical clarity and actionable guidance, the proposed framework offers value to scholars, managers, and policymakers seeking to accelerate the transition toward more sustainable and circular global supply chains.

Keywords: *Global supply chains*

I. INTRODUCTION

Global supply chains are undergoing considerable transformation as organizations confront tightening sustainability regulations, increased consumer expectations and mounting evidence of environmental degradation. Traditional linear systems—based on extraction, production, consumption and disposal—are increasingly viewed as unsustainable. In response, the circular economy has emerged as a promising alternative that promotes material reuse, remanufacturing,

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recycling and resource efficiency. While circular practices have gained international attention, the extent to which organizations and their supply chain partners are prepared to adopt such practices remains unclear.

Assessing circular economy readiness is essential for understanding capability gaps, planning investments and identifying strategic priorities. Existing readiness models focus on digital transformation or sustainability maturity but do not fully integrate the multidimensional nature of CE adoption in global supply chains. This paper addresses this gap by proposing a comprehensive Multi-Criteria Evaluation Framework to assess readiness across global supply networks. The study aims to enhance conceptual understanding and provide a diagnostic tool that assists decision-makers in planning CE transitions.

II. REVIEW OF LITERATURE

Academic literature consistently emphasizes that the implementation of circular economy (CE) practices requires systemic transformation across supply chains. Studies by Guide and Van Wassenhove (2009) argue that closed-loop supply chains depend on efficient mechanisms for product return, sorting and remanufacturing, while Linder and Williander (2017) stress that design for disassembly is essential for enabling material recirculation and extending product life cycles. Research on industrial symbiosis, particularly the work of Chertow (2000), demonstrates that collaboration between firms enhances material efficiency by linking waste streams to new resource uses. Similarly, scholars such as Rogers and Tibben-Lembke (1999) highlight the importance of reverse logistics in supporting effective material recovery processes. Although existing readiness and maturity modelsincluding digital readiness assessments introduced by Parasuraman (2000), sustainability maturity frameworks proposed by Dyllick and Muff (2016), and green supply chain capability models developed by Zhu and Sarkis (2004)offer valuable insights, they do not fully capture the integrated technological, environmental and economic requirements essential for a holistic CE transition.

Theoretical perspectives further contribute to understanding organizational readiness. The Resource-Based View (RBV), originally articulated by Barney (1991), suggests that internal capabilities such as digital infrastructure, employee expertise and innovation capacity significantly influence CE preparedness. Institutional Theory, advanced by DiMaggio and Powell (1983), emphasizes the role of regulatory pressure, stakeholder expectations and global sustainability mandates in shaping circular adoption patterns across industries. Meanwhile, Industrial Ecology, pioneered by Frosch and Gallopoulos (1989), provides the conceptual foundation for optimizing material flows, minimizing waste generation and closing resource loops at the system level. Together, these scholarly contributions underscore the need for a comprehensive, multi-dimensional evaluation framework that integrates technological, organizational, environmental and economic criteria. Such an approach acknowledges the interconnected nature of global supply networks and the complexity inherent in transitioning from linear to circular operations.

III. RESEARCH OBJECTIVES

The purpose of this paper is to develop an integrated framework that assesses the readiness of global supply chains for circular economy implementation. The specific objectives are:

- To identify the critical dimensions that influence CE readiness.
- To organize these dimensions into a structured Multi-Criteria Evaluation Framework.
- To offer conceptual clarity for scholars and strategic insights for practitioners.

IV. METHODOLOGY

This study employs a qualitative and conceptual research methodology. As a first step, a systematic literature review was undertaken, covering peer-reviewed journal articles, established circular economy frameworks, international sustainability standards (e.g. regulations, guidelines), and research on global supply chain practices. The aim of this comprehensive review was to harvest a broad set of potential readiness factors encompassing technical capabilities, environmental compliance, organizational structures, and economic conditions that are relevant for circular economy adoption in supply chains.

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Next, to ensure practical validity and context relevance, the study incorporated expert consultation. Input was solicited from sustainability consultants, supply-chain managers, and other practitioners who have hands-on experience with supply chain operations and sustainability initiatives. Through structured interviews and informal discussions, these experts helped to refine the initial list of factors, discard redundant or less relevant items, and prioritize criteria based on real-world applicability. This step allowed the framework to bridge the gap between theoretical constructs and industry realities.

The refined set of readiness factors were then organized into a coherent Multi-Criteria Evaluation Framework (MCEF). The MCEF comprises four principal dimensions technological readiness, organizational readiness, environmental readiness, and economic readiness each containing several evaluation criteria that together represent the critical enablers and inhibitors of circular supply chain implementation. The resulting framework is conceptual in nature; it does not derive from primary quantitative data but serves as a diagnostic and planning tool. Organizations can use the MCEF to assess their current readiness status, identify gaps, and develop road-maps for circular economy transition.

Recognizing the diversity of industries and geographic contexts, the framework is intentionally designed to be flexible and adaptable. While it provides a structured baseline for assessment, firms are encouraged to calibrate the relative importance (weights) of criteria according to their specific sector, region, and strategic priorities. In this way, the methodology aims to balance academic rigor with practical usefulness, providing both a theoretically informed and practitioner-oriented tool for evaluating supply chain readiness for circular economy adoption.

V. PROPOSED MULTI-CRITERIA EVALUATION FRAMEWORK

The Multi-Criteria Evaluation Framework (MCEF) is designed to provide organizations with a structured, diagnostic tool to measure their readiness for transitioning toward circular supply chain models. By examining four interdependent dimensiontechnological, organizational, environmental, and economic readinessthe framework offers a holistic analysis of the capabilities, constraints and enabling conditions necessary for circular transformation. Each dimension encompasses distinct yet complementary evaluation criteria that allow firms to identify current strengths, gaps and strategic priorities.

i) Technological Readiness

Technological readiness refers to the digital and operational capabilities required to implement circular practices such as reverse logistics, product recovery, material tracking and resource optimization. At its core, this dimension assesses whether an organization possesses the digital infrastructure needed to support real-time visibility and data-driven decision-making. This includes enterprise resource planning (ERP) systems, cloud-based platforms and data integration tools that allow seamless coordination across internal departments and supply chain partners.

Equally important are traceability and transparency systems, which enable firms to track materials across their lifecycle. Technologies such as blockchain, RFID, QR coding and digital twins enhance the ability to monitor product origins, usage patterns, environmental impacts and end-of-life pathways. IoT-enabled tracking systems further strengthen these capabilities by generating continuous data from sensors embedded in products or assets.

Reverse logistics technologiessuch as automated sorting systems, advanced inspection tools, and remanufacturing machineryare also critical for enabling product take-back, reuse, refurbishment and recycling. A high level of technological readiness reduces operational uncertainty, increases efficiency and ensures that circular processes can be executed reliably and at scale.

ii) Organizational Readiness

Organizational readiness captures leadership vision, culture, skills and collaborative mechanisms that shape the firm's ability to embed circular principles into everyday operations. Leadership commitment plays a pivotal role, as executive-level support is essential for allocating resources, setting strategic priorities and overcoming resistance to change. Leaders act as champions who steer the transition toward long-term sustainability goals rather than short-term financial considerations.

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The organization's human capital, including employee expertise, training programs and technical competence, determines operational consistency and innovation potential. Skilled employees are essential for managing complex circular processes such as waste valorization, eco-design, material assessment and digital tool adoption.

Collaboration is another vital criterion. Circular supply chains are inherently interconnected, requiring strong supplier partnerships, joint innovation initiatives and shared standards. When suppliers display a willingness to engage in circular strategiessuch as material recovery agreements, sustainable sourcing practices and information sharingthe success of the overall ecosystem is significantly enhanced.

iii) Environmental Readiness

Environmental readiness assesses the alignment of organizational practices with ecological objectives and regulatory demands. One of its central elements is regulatory compliance, which ensures that firms meet environmental standards, product stewardship requirements and waste management laws. Compliance not only minimizes risk but also builds stakeholder trust.

Monitoring systems, including environmental performance tracking and lifecycle assessment tools, are essential for evaluating emissions, waste generation, water usage and material flows. These environmental monitoring systems provide evidence-based insights for optimizing resource use and reducing ecological impact.

Another crucial element is the presence of resource efficiency initiatives, such as energy-efficient production, waste minimization strategies and circular product design. These measures demonstrate the organization's proactive stance toward sustainability and its ability to integrate circular thinking into operational processes.

iv) Economic Readiness

Economic readiness identifies the financial capabilities and market dynamics that support or inhibit circular transformation. Organizations must have the investment capacity to adopt new technologies, redesign products and reconfigure supply chains. Without sufficient financial resources, even strong strategic intentions may remain unrealized.

Market-oriented criteria assess the demand for circular products, customer willingness to pay and competitive pressures. Rising consumer awareness and regulatory incentives can create favorable market environments that accelerate circular adoption.

Finally, the ability to innovate business modelssuch as product-as-a-service models, leasing systems or take-back programsis a key determinant of economic readiness. Firms that can creatively redesign value propositions are better positioned to capture circular benefits such as recurring revenue, reduced material dependency and improved customer loyalty.

VI. DISCUSSION

The proposed framework demonstrates that the readiness of global supply chains for circular economy implementation is fundamentally shaped by three interrelated enablers: digital capabilities, supplier collaboration, and leadership commitment. First, digital capabilities emerge as a foundational requirement for effective circular operations. Organizations equipped with advanced technological infrastructuresuch as integrated data platforms, traceability systems, and IoT-enabled monitoringare better positioned to map material flows, ensure transparency, and manage end-of-life processes. These technologies reduce uncertainty, enhance information accuracy and enable the closed-loop systems necessary for reuse, remanufacturing and recycling activities across geographically dispersed supply networks.

Second, supplier collaboration plays a pivotal role, as circular economy adoption involves systemic transformation that extends beyond the internal boundaries of a single firm. Circularity requires suppliers to align on product design specifications, material selection, take-back agreements, and information exchange protocols. The framework underscores that multi-tier collaboration can reduce transaction costs, improve coordination and create shared incentives for circular innovation. In global supply chains where partners may operate under different regulatory and cultural contexts, collaboration also helps harmonize expectations and reduces resistance to change.

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Third, leadership commitment functions as an overarching driver that integrates technological and relational capabilities into a cohesive strategic direction. Leadership determines resource allocation, prioritizes sustainability investments, and fosters an organizational culture receptive to circular thinking. Firms with committed leadership demonstrate greater willingness to redesign business models, engage in cross-industry partnerships and invest in long-term capability-building. Leadership commitment also enhances organizational resilience by aligning sustainability goals with competitive strategy.

Beyond internal enablers, the framework highlights the significant influence of international regulatory systems, environmental policies and consumer market trends. Varying national approaches to circularitysuch as extended producer responsibility (EPR) schemes, eco-design directives and waste management regulationsaffect how quickly and uniformly global supply chains can transition. The lack of harmonization in global circular economy standards creates operational complexity for multinational firms, suggesting the need for greater policy convergence and international collaboration.

Additionally, growing consumer demand for sustainable and circular products is reshaping market expectations. As consumers increasingly prefer environmentally responsible alternatives, firms must adapt by ensuring product transparency, reducing waste and demonstrating credible environmental performance. This trend reinforces the importance of circular readiness as a source of strategic differentiation.

Overall, the discussion suggests that circular economy readiness is a multidimensional construct requiring alignment of technological, organizational, environmental and economic capabilities. The framework emphasizes that circular transformation is not merely a technical or operational challenge but a strategic endeavor shaped by internal leadership, external partnerships and global policy landscapes.

VII. IMPLICATIONS

For managers, the proposed framework provides a structured diagnostic tool that enables organizations to benchmark their current level of circular readiness, identify capability gaps and prioritize strategic investments. By highlighting high-impact areas such as digital transformation, supplier capability-building and eco-design initiatives, the framework guides managers in developing phased roadmaps that align operational improvements with long-term sustainability goals. It also encourages cross-functional collaboration among procurement, operations, IT and sustainability teams, thereby fostering a more integrated approach to circular implementation.

For policymakers, the findings underscore the importance of developing coherent regulatory environments, cross-border harmonization and incentive structures that support circular transition. Policies promoting reverse logistics infrastructure, resource recovery industries, transparent reporting requirements and sustainable product standards can significantly accelerate adoption across global supply chains. Additionally, public–private partnerships, international collaboration platforms and capacity-building programs can strengthen institutional support for circular economy practices, ensuring that firms of varying sizes and regions can participate effectively in circular value creation.

VIII. LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

This study is conceptual in nature and relies primarily on secondary literature and expert insights, which may limit the generalizability of the proposed framework. While the framework offers theoretical value, its practical applicability would be strengthened through empirical validation across diverse industries, organizational sizes and geographical regions. Future research should incorporate field studies, case analyses and cross-regional comparisons to assess how contextual factors—such as regulatory environments, cultural norms and technological maturity—influence readiness for circular economy implementation.

Further methodological advancement could be achieved by applying multi-criteria decision-making tools such as AHP, fuzzy logic, TOPSIS or machine learning algorithms to quantify and prioritize readiness criteria. Industry-specific adaptations of the framework—for electronics, textiles, automotive, pharmaceuticals or FMCG supply chains—would allow for more nuanced assessments aligned with sectoral characteristics. Additionally, researchers can explore the development of digital dashboards or decision-support systems that operationalize the readiness assessment, enabling real-time monitoring, benchmarking and strategic planning for circular transformation.

DOI: 10.48175/IJARSCT-30521

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IX. CONCLUSION

This paper presents a structured Multi-Criteria Evaluation Framework (MCEF) designed to assess circular economy readiness within global supply chains. By integrating technological, organizational, environmental and economic dimensions, the framework offers a holistic approach to identifying capability gaps and strategic enablers that influence circular economy adoption. The study emphasizes that successful circular transformation is contingent upon robust digital infrastructure, strong and transparent supplier relationships, effective resource monitoring systems, and sustained strategic leadership commitment.

Beyond synthesizing multiple theoretical perspectives, the framework contributes to academic discourse by providing conceptual clarity on the multidimensional nature of circular readiness. For practitioners, it offers a practical diagnostic tool that can guide investment decisions, capability development and long-term sustainability planning. Overall, the model supports ongoing global efforts aimed at accelerating the transition toward regenerative, resource-efficient and resilient supply chains, thereby advancing the broader agenda of sustainable development and responsible production.

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