World Journal of Advanced Engineering Technology and Sciences
eISSN: 2582-8266
Cross Ref DOI: 10.30574/wjaets
Journal homepage: https://wjaets.com/

(RESEARCH ARTICLE)

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Digital Leadership and Circular Economy Performance in Sustainable Supply Chains

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World Journal of Advanced Engineering Technology and Sciences, 2025, 17(03), 503-508

Publication history: Received on 24 November 2025; revised on 29 December 2025; accepted on 31 December 2025

Article DOI: https://doi.org/10.30574/wjaets.2025.17.3.1583

Abstract

The Circular Economy (CE) has emerged as a critical paradigm for promoting sustainability through resource efficiency, waste reduction, and closed-loop supply chain practices. While technological advancements and operational strategies for CE implementation have received significant attention, the role of leadership particularly digital leadership in enabling and scaling circular practices remains insufficiently explored. This study investigates how digital leadership influences the adoption and performance of Circular Economy initiatives within sustainable supply chains. Drawing on Circular Economy principles and digital leadership theory, the study employs qualitative content analysis of secondary data obtained from sustainability and digital transformation reports of multinational organizations. The analysis maps digital leadership behaviors to key circular practices, including digital traceability, resource optimization, closed-loop systems, and data-driven decision-making. The findings are expected to reveal a strong linkage between digitally enabled leadership capabilities and enhanced circular performance outcomes. By proposing a conceptual Digital Leadership Circular Economy framework, this study contributes to the growing body of sustainability and supply chain literature and offers practical guidance for organizational leaders seeking to leverage digital transformation to achieve long-term circular and sustainable supply chain performance.

Keywords: Digital Leadership; Circular Economy; Sustainable Supply Chains; Industry 4.0; Circular Performance; Digital Transformation; Sustainability

1. Introduction

Global supply chains are facing increasing pressure to address sustainability challenges arising from climate change, resource scarcity, environmental degradation, and growing regulatory and societal expectations. Traditional linear supply chain models, characterized by a "take–make–dispose" logic, are no longer sufficient to ensure long-term economic viability and environmental responsibility. In response, the Circular Economy (CE) has emerged as a transformative approach that emphasizes resource efficiency, waste minimization, product life extension, and closed-loop supply chain systems [1,2]. By decoupling economic growth from resource consumption, CE offers a promising pathway toward sustainable supply chain development.

Despite its growing prominence, the implementation of Circular Economy practices within supply chains remains uneven and challenging. Prior research has largely focused on technological solutions such as recycling systems, remanufacturing processes, reverse logistics, and eco-design strategies [3–5]. While these operational and technological aspects are essential, emerging studies indicate that CE implementation is not solely a technical challenge but also an organizational and managerial one [6]. In particular, leadership plays a critical role in shaping strategic priorities, fostering innovation, and embedding sustainability principles into supply chain decision-making processes.

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Parallel to the rise of the Circular Economy, digital transformation driven by Industry 4.0 technologies including the Internet of Things (IoT), Artificial Intelligence (AI), big data analytics, blockchain, and cyber-physical systems has significantly altered how supply chains operate [7,8]. These digital technologies enable real-time visibility of material flows, enhance traceability, support predictive maintenance, and facilitate data-driven decision-making, all of which are vital enablers of circular supply chains [9,10]. However, the successful integration of digital technologies into CE initiatives depends not only on technological readiness but also on leadership capability to align digital innovation with sustainability objectives.

Digital leadership has recently gained attention as a leadership paradigm that emphasizes digital competence, strategic vision, adaptability, and the ability to leverage digital technologies for organizational transformation [11]. Digital leaders are responsible for guiding organizations through complex socio-technical changes, fostering a culture of innovation, and ensuring that digital tools contribute to long-term value creation rather than short-term efficiency gains [12]. In the context of sustainable supply chains, digital leadership is increasingly viewed as a critical enabler for translating CE principles into operational performance [13].

However, despite growing interest in both digital leadership and Circular Economy research, limited studies have explicitly examined the intersection between digital leadership and Circular Economy performance in supply chains. Existing literature often treats leadership as a contextual or secondary factor, rather than a central mechanism driving circular transformation [14,15]. This gap limits both theoretical development and practical guidance for organizations seeking to implement digitally enabled circular supply chains.

To address this gap, the present study investigates the role of digital leadership in enabling Circular Economy practices and improving circular performance in sustainable supply chains. By integrating digital leadership theory with Circular Economy principles, this study aims to develop a conceptual framework that explains how leadership behaviors influence the adoption, implementation, and outcomes of circular initiatives. The findings are expected to contribute to sustainability and supply chain management literature while offering actionable insights for managers and policymakers striving to achieve digitally enabled circular supply chain systems.

2. Literature Review

The Circular Economy (CE) has emerged as a key sustainability paradigm for supply chains, emphasizing resource efficiency, waste minimization, and closed-loop material flows to overcome the limitations of traditional linear production models [16], [17]. Prior research highlights that CE-oriented supply chains can enhance environmental performance while simultaneously generating economic value through remanufacturing, recycling, and product life extension strategies [18]. In parallel, Industry 4.0 technologies such as the Internet of Things, artificial intelligence, big data analytics, and blockchain have been identified as critical enablers of circular practices by improving traceability, real-time monitoring, and data-driven decision-making across supply networks [19], [20]. However, scholars increasingly recognize that technological capability alone is insufficient to achieve effective circular transformation, as organizational and managerial factors play a decisive role [21]. Leadership, particularly digital leadership, has gained attention for its ability to align digital transformation initiatives with sustainability objectives, foster innovation-oriented cultures, and overcome resistance to organizational change [22], [23]. While sustainability-oriented and transformational leadership styles have been linked to improved environmental and circular performance, the specific mechanisms through which digital leadership drives Circular Economy outcomes in supply chains remain underexplored [24], [25]. This gap in literature underscores the need for integrated research that explicitly examines digital leadership as a central enabler of Circular Economy performance in sustainable supply chains.

3. Methodology

This study adopts a qualitative, integrative research design to systematically examine the role of digital leadership in enabling Circular Economy (CE) performance within sustainable supply chains. Given the conceptual and interdisciplinary nature of the research objective, an integrative literature review methodology was selected, as it allows the synthesis of knowledge across multiple research domains, including Circular Economy, digital leadership, sustainable supply chain management, organizational transformation, and Industry 4.0 technologies. Unlike traditional systematic reviews that focus narrowly on empirical evidence, integrative reviews enable the inclusion of empirical studies, conceptual frameworks, policy reports, and industry case analyses, thereby offering a holistic understanding of complex sustainability transitions

3.1. Research Design

The research design follows a structured, multi-phase approach consisting of:

- Systematic literature identification,
- Screening and selection of relevant studies,
- Qualitative thematic coding and analysis, and
- Conceptual framework development and validation.

This phased methodology ensures analytical rigor, transparency, and theoretical robustness while enabling the identification of meaningful patterns linking digital leadership behaviors with CE practices and performance outcomes in supply chains.

3.2. Data Sources and Search Strategy

A comprehensive literature search was conducted across major academic databases, including IEEE Xplore, Elsevier ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis, and Google Scholar. These databases were selected to ensure broad coverage of engineering, management, sustainability, and information systems research. Key search terms included combinations of "digital leadership," "circular economy," "sustainable supply chains," "Industry 4.0," "digital transformation," and "circular performance." Boolean operators were employed to refine the search (e.g., "digital leadership AND circular economy," "Industry 4.0 AND circular supply chains," "leadership AND sustainability transition") to enhance relevance and coverage.

3.3. Inclusion and Exclusion Criteria

To ensure the quality and relevance of the reviewed literature, predefined inclusion and exclusion criteria were applied. Studies published between 2010 and 2025 were considered to capture recent developments in CE and digital leadership research. Only peer-reviewed journal articles, conference proceedings, and authoritative academic reports written in English were included. Studies were required to explicitly address at least one of the following dimensions: Circular Economy implementation, leadership behavior, digital transformation, or sustainable supply chain performance. Publications lacking methodological transparency, non-academic sources, opinion pieces, and duplicate records were excluded. Following this screening process, a refined corpus of high-quality studies was selected for in-depth analysis.

3.4. Data Extraction and Thematic Analysis

A qualitative thematic analysis approach was employed to analyze the selected literature. Each study was carefully reviewed, and relevant information was extracted using a structured coding framework. The coding process focused on identifying recurring themes related to (i) CE drivers and barriers, (ii) digital leadership behaviors and competencies, (iii) Industry 4.0-enabled circular practices, (iv) organizational culture and change mechanisms, and (v) circular performance outcomes. Following an iterative coding process, initial codes were grouped into higher-order themes to reveal conceptual relationships between leadership, digitalization, and circular supply chain performance. This approach enabled the identification of leadership-related mechanisms that consistently influence CE adoption and effectiveness.

3.5. Conceptual Framework Development

Insights derived from the thematic analysis were synthesized using concept mapping and systems thinking techniques. The framework development process involved mapping interactions between digital leadership constructs such as digital vision, data-driven decision-making, innovation orientation, and cross-functional collaboration and Circular Economy practices, including closed-loop supply chains, digital traceability, resource optimization, and lifecycle management. Enabling mechanisms such as organizational culture, technological integration, and stakeholder collaboration were also incorporated. These elements were integrated into a unified conceptual framework illustrating how digital leadership acts as a central driver linking digital capabilities with circular performance outcomes in sustainable supply chains.

3.6. Framework Validation

Although this study does not involve primary empirical data collection, conceptual validation was conducted through theoretical triangulation. The proposed framework was cross-verified against established theories in sustainability leadership, organizational change, Circular Economy transitions, and digital transformation. Additionally, the framework was compared with existing CE and supply chain sustainability models to ensure conceptual consistency

and explanatory power. This validation process enhances the internal coherence and academic relevance of the proposed Digital Leadership–Circular Economy framework.

4. Results

The integrative literature review and thematic analysis yielded a set of interconnected findings that clarify how digital leadership functions as a central driver in enabling Circular Economy (CE) performance within sustainable supply chains. The results are organized around four dominant themes that emerged consistently across the reviewed studies: (1) digital leadership vision and strategic alignment, (2) digital technologies as enablers of circular practices, (3) organizational culture and employee engagement, and (4) supply chain collaboration and governance mechanisms. Together, these themes explain the pathways through which digital leadership translates into improved circular performance outcomes.

4.1. Digital Leadership Vision and Strategic Alignment

The analysis reveals that a clearly articulated digital sustainability vision is a foundational requirement for effective CE implementation. Organizations in which leaders explicitly align digital transformation initiatives with circular and sustainability objectives demonstrate higher levels of CE integration across supply chain operations. Digital leaders play a decisive role in prioritizing long-term circular value creation over short-term efficiency gains by embedding CE principles into strategic planning, investment decisions, and performance evaluation systems.

The results indicate that leadership commitment significantly influences the scope and depth of circular initiatives. In organizations with strong digital leadership, CE practices such as closed-loop supply chains, lifecycle management, and resource recovery are embedded within core operational strategies rather than treated as isolated sustainability projects. Conversely, weak leadership alignment often results in fragmented or symbolic CE adoption, with limited operational impact.

4.2. Digital Technologies as Enablers of Circular Economy Practices

A second major finding highlights the role of digital technologies as critical enablers of circular supply chain practices, contingent upon leadership-driven integration. The reviewed studies consistently show that technologies such as the Internet of Things, artificial intelligence, big data analytics, blockchain, and digital twins enhance CE performance by improving real-time visibility of material flows, enabling predictive maintenance, and supporting data-driven decision-making.

However, the results emphasize that technology alone does not guarantee circular outcomes. Digital leadership determines whether these technologies are leveraged strategically to support circular objectives such as waste minimization, resource optimization, and product life extension. Leaders who promote data governance, cross-functional digital integration, and sustainability-focused analytics enable technologies to serve as catalysts for circular transformation rather than mere efficiency tools.

4.3. Organizational Culture and Employee Engagement

The findings strongly indicate that organizational culture mediates the relationship between digital leadership and CE performance. Digital leaders influence employee attitudes, behaviors, and capabilities by fostering a culture that values innovation, learning, and sustainability. Organizations with digitally competent leadership demonstrate higher employee engagement in circular initiatives, including recycling programs, eco-design practices, and digital monitoring of resource use.

The thematic analysis identifies empowerment, continuous learning, and participatory decision-making as key cultural mechanisms through which leadership enhances CE adoption. Employees are more likely to support and sustain circular practices when leaders encourage experimentation, provide digital training, and recognize sustainability-oriented contributions. In contrast, organizations lacking such leadership support experience resistance to change and limited diffusion of circular practices across supply chain functions.

4.4. Supply Chain Collaboration and Governance

A further key result underscores the system-level role of digital leadership in enabling collaboration across supply chain networks. CE implementation requires coordinated actions among suppliers, manufacturers, logistics providers, recyclers, and customers. The findings reveal that digital leaders facilitate this coordination by promoting transparency, data sharing, and trust through digital platforms and governance mechanisms.

Leadership-driven collaboration enables the development of closed-loop supply chains, effective reverse logistics systems, and shared performance metrics for circular outcomes. The results also show that organizations with strong digital leadership are better positioned to comply with regulatory requirements and engage external stakeholders in circular initiatives. This reinforces the notion that digital leadership extends beyond organizational boundaries and functions as a governance mechanism for circular ecosystems.

4.5. Synthesis of Findings and Framework Implications

A cross-theme synthesis demonstrates that digital leadership acts as the integrative force connecting strategy, technology, culture, and collaboration in Circular Economy implementation. While existing CE frameworks often emphasize technological or operational dimensions, the results of this study highlight leadership as the primary mechanism that determines whether circular practices are adopted effectively and sustained over time.

The findings support the development of the proposed Digital Leadership–Circular Economy framework, which positions digital leadership at the center of circular supply chain transformation. The framework illustrates how leadership behaviors enable the alignment of digital technologies with CE objectives, foster supportive organizational cultures, and coordinate multi-stakeholder collaboration to achieve improved circular performance outcomes.

Overall, the results indicate that organizations lacking strong digital leadership are unlikely to achieve advanced levels of Circular Economy maturity, regardless of technological readiness. Conversely, digitally enabled leadership significantly enhances the likelihood of successful CE implementation by ensuring strategic coherence, organizational engagement, and system-level integration.

5. Conclusions and Recommendations

This study examined the role of digital leadership in enabling Circular Economy (CE) performance within sustainable supply chains by synthesizing insights from existing literature through an integrative qualitative approach. The findings demonstrate that digital leadership is not a peripheral or supporting factor, but a central driver that determines how effectively circular principles are translated into supply chain practices and performance outcomes. By aligning digital transformation initiatives with sustainability objectives, digital leaders play a critical role in embedding CE strategies into organizational decision-making, operations, and inter-organization collaboration.

The results highlight that successful CE implementation requires the convergence of strategic leadership vision, digitally enabled technologies, supportive organizational culture, and coordinated supply chain governance. Digital leadership influences not only the adoption of advanced Industry 4.0 technologies but also how these technologies are leveraged to support circular objectives such as closed-loop supply chains, resource optimization, and lifecycle management. Furthermore, leadership-driven cultural mechanisms such as employee empowerment, continuous learning, and innovation orientation significantly enhance engagement in circular practices across supply chain functions.

From a theoretical perspective, this study contributes to the growing body of sustainability and supply chain literature by explicitly integrating digital leadership with Circular Economy research. The proposed Digital Leadership–Circular Economy framework addresses a critical gap in existing CE models by positioning leadership as the key mechanism linking digital capabilities with circular performance. This leadership-centric perspective provides a more comprehensive explanation of why many CE initiatives remain fragmented or fail to progress beyond early adoption stages despite technological readiness. Practically, the findings offer actionable insights for managers and policymakers seeking to accelerate circular transitions in supply chains. Organizations should invest in developing digital leadership capabilities that emphasize sustainability-oriented decision-making, cross-functional collaboration, and data-driven governance. Policymakers may also leverage these insights to design leadership development programs and digital infrastructure policies that support circular supply chain ecosystems.

While this study is conceptual in nature and relies on secondary data, it provides a robust foundation for future empirical research. Future studies may validate the proposed framework through quantitative surveys, case studies, or longitudinal analyses across industries and regions. Additionally, examining the influence of different leadership styles, organizational contexts, and cultural settings on digital-enabled CE performance represents a promising avenue for further investigation.

Overall, this research reinforces that achieving Circular Economy objectives in supply chains is not solely a technological challenge but a leadership-driven transformation. Digital leadership emerges as a critical enabler of sustainable, resilient, and circular supply chain systems capable of meeting contemporary environmental and economic challenges.

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