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Circular Economy and Resource Efficiency in Industrial Competitiveness

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ABSTRACT

The transition toward a low-carbon economy has pushed industries to adopt circular economy and resource efficiency not merely as environmental initiatives, but as strategic drivers of competitiveness. However, academic studies examining the relationship between circular economy, resource efficiency, and industrial competitiveness remain fragmented and report inconsistent findings. This study aims to systematically analyze the contribution of circular economy and resource efficiency to industrial competitiveness and to identify the key mechanisms underlying this relationship. A systematic literature review was conducted using an evidence-based industrial sustainability approach, synthesizing peer-reviewed journal articles published between 2020 and 2025 and selected through the PRISMA process. The findings indicate that circular economy enhances industrial competitiveness primarily through improvements in resource efficiency, leading to cost reduction, supply stability, productivity gains, and process innovation. Resource efficiency emerges as a critical mediating mechanism translating circular practices into measurable competitive advantages. Nevertheless, the strength of evidence varies across industrial sectors, firm sizes, and institutional contexts. This study concludes that circular economy and resource efficiency act as strategic enablers of industrial competitiveness when implemented systematically and contextually, rather than as universally applicable solutions.

Keywords: *circular economy; industrial competitiveness; resource efficiency; sustainability strategy; systematic literature review*

INTRODUCTION

The global transition toward a low-carbon economy has driven fundamental changes in how industries perceive sustainability and competitiveness. In recent decades, pressure on industry has no longer been limited to environmental compliance, but has expanded to include demands for resource efficiency, supply stability, and operational resilience within increasingly competitive global markets. In this context, the circular economy and resource efficiency have emerged as promising strategic approaches, as both offer frameworks for optimizing resource use while simultaneously enhancing sustainable industrial performance (Alhawari et al., 2021; Hossain et al., 2024). The circular economy is no longer positioned merely as an environmental agenda, but as a structural instrument with the potential to strengthen industrial competitiveness through reduced dependence on primary resources, improved cost efficiency, and enhanced supply chain resilience (Baars et al., 2020; Silvério et al., 2023).

In contemporary industrial practice, the circular economy and resource efficiency are increasingly intertwined with long-term competitiveness strategies. Industries face

dual pressures: the need to improve resource efficiency amid global material constraints, and the need to maintain competitive positions in markets characterized by price volatility, supply chain disruptions, and increasingly stringent environmental regulations. Numerous studies indicate that circular economy practices can generate competitive advantages through reduced production costs, greater stability of material supply, and value creation via product and process innovation (Dey et al., 2020; Dennison et al., 2024). However, empirical evidence regarding the extent to which circular economy and resource efficiency genuinely contribute to industrial competitiveness remains highly variable across sectors and national contexts.

From an academic perspective, the literature on circular economy and resource efficiency has expanded rapidly but remains fragmented. Many studies position the circular economy primarily as an environmental strategy focused on waste reduction and ecological impacts, without explicitly linking it to industrial competitive performance (Lamata & Martínez, 2022; Hossain et al., 2024). Conversely, research on resource efficiency often concentrates on operational efficiency and productivity, but does not always integrate these aspects within a broader circular economy framework (Rao et al., 2024; Rosário et al., 2024). This fragmentation has resulted in the absence of an academic consensus regarding the causal mechanisms through which circular economy and resource efficiency contribute to industrial competitive advantage.

From a practical standpoint, this fragmented literature poses challenges for industry actors and policymakers. Industries require an evidence-based foundation to assess whether investments in circular economy and resource efficiency genuinely enhance competitiveness, or merely serve regulatory compliance and social legitimacy pressures. Without a clear understanding of value creation mechanisms, the implementation of circular economy practices risks being perceived as a short-term cost burden rather than a value-adding business strategy (Bjørnbet et al., 2021; Martín-Díez et al., 2025). Similarly, industrial policymakers need robust scientific synthesis to design incentives and regulations that effectively encourage circular economy adoption with tangible impacts on industrial performance.

A critical review of prior studies reveals that most research still evaluates the circular economy in a partial manner. Several studies focus on environmental aspects of circular practices, such as emission or waste reduction, without directly linking them to indicators of industrial competitiveness (Baars et al., 2020; Lamata & Martínez, 2022). Other studies assess resource efficiency as a standalone operational variable, such as energy or material efficiency, without situating it within an integrated circular economy strategy (Rao et al., 2024; Rosário et al., 2024). Moreover, empirical findings on the impact of the circular economy on industrial performance and competitiveness are often inconsistent, influenced by differences in industrial sectors, firm size, and institutional and regulatory contexts (Dey et al., 2020; Silvério et al., 2023).

These limitations indicate a significant research gap. To date, there is no systematic literature review that explicitly synthesizes the relationships between circular economy, resource efficiency, and industrial competitiveness within a single integrative analytical framework. Existing SLRs tend to emphasize conceptual mapping of the circular economy or related innovations, without evaluating the strength of empirical evidence linking circular practices to industrial competitive advantage (Mhatre et al., 2021; Hossain et al., 2024). In addition, few studies differentiate evidentiary strength based on research design, industrial sector, and geographical context, making it difficult to draw generalizable conclusions.

Based on this gap, the present study offers novelty through an integrative synthesis of the relationships between circular economy, resource efficiency, and

industrial competitiveness grounded in an evidence hierarchy. The circular economy is repositioned from a normative environmental approach to a competitive industrial strategy capable of generating economic, operational, and strategic value. Using a systematic literature review approach grounded in evidence-based industrial sustainability, this study aims to systematically analyze the contributions of circular economy and resource efficiency to industrial competitiveness, and to identify the key mechanisms and strength of evidence underpinning these relationships. Through this synthesis, the study is expected to provide a theoretical contribution to the development of an integrative circular economy–resource efficiency–competitiveness model, while also offering an empirical basis for strategic industrial decision-making and evidence-based policy formulation.

METHODS

This study employs a systematic literature review approach within an evidence-based industrial sustainability framework to synthesize the relationships between circular economy, resource efficiency, and industrial competitiveness. Literature was collected from the Scopus, Web of Science, and ScienceDirect databases, covering publications from 2020 to 2025, using the keywords "circular economy," "resource efficiency," "industrial competitiveness," and "firm performance." Included articles were peer-reviewed journal publications focusing on industrial sectors or firms and explicitly discussing the contribution of circular economy and/or resource efficiency to industrial competitiveness. Non-academic publications, macro-level policy studies without direct industrial implications, and publications with unclear methodologies were excluded from the analysis. The SLR approach was selected because it enables systematic synthesis and evaluation of evidentiary strength across sectors and research designs (Snyder, 2019).

The literature selection process followed the PRISMA flow to ensure transparency and replicability. During the identification stage, 238 articles were retrieved from the three databases, after which 46 duplicates were removed, leaving 192 articles for the screening stage. Title and abstract screening eliminated 128 articles that were not relevant to industrial competitiveness, resulting in 64 articles proceeding to the eligibility stage. Full-text review at this stage excluded 24 articles because they did not explicitly address industrial competitiveness, focused on macro-level policy, or exhibited weak methodological quality. Consequently, 40 articles were included in the final synthesis. The analysis was conducted through narrative and thematic synthesis to identify the mechanisms through which circular economy and resource efficiency contribute to industrial competitiveness, as well as variations in evidentiary strength across industrial contexts.

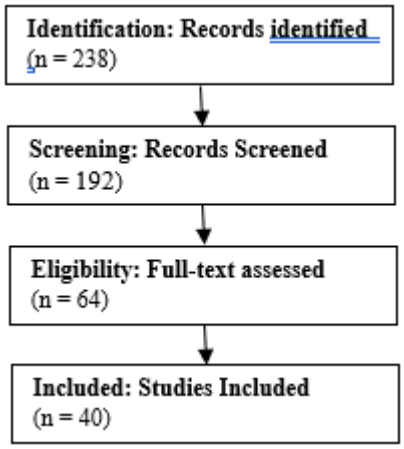

Figure 1. PRISMA Flow Diagram of the Systematic Literature Review

RESULTS AND DISCUSSION

Circular Economy as a Structural Strategy for Enhancing Industrial Efficiency and Competitiveness

The synthesis of the literature indicates that the circular economy is increasingly understood as a structural strategy that shapes how industries manage resources, design production processes, and build long-term competitive advantage. Unlike the traditional linear approach based on extraction, production, and disposal, the circular economy emphasizes the optimization of material cycles through strategies such as reuse, remanufacturing, recycling, and product life extension. Numerous studies show that the shift toward circular practices enables industries to reduce dependence on primary resources that are increasingly costly and volatile, thereby enhancing operational stability and competitiveness in global markets (Baars et al., 2020; Silvério et al., 2023).

In the context of industrial competitiveness, the circular economy contributes directly to cost efficiency and supply chain resilience. Studies in manufacturing and material-intensive industries demonstrate that optimizing material reuse and reducing waste can lower input costs while simultaneously mitigating the risks associated with disruptions in raw material supply (Bjørnbet et al., 2021; Dennison et al., 2024). These efficiencies not only generate short-term cost reductions but also strengthen the ability of industries to sustain performance amid market uncertainty and increasing environmental regulatory pressures. In this sense, the circular economy functions as a structural foundation that reinforces industrial competitiveness through systemic efficiency improvements.

The literature further highlights that the circular economy stimulates process innovation and business model innovation that are closely linked to industrial competitiveness. Several studies indicate that the adoption of circular practices encourages firms to develop modular, durable, and recyclable product designs, which in turn create opportunities for product differentiation and value creation (Coppola et al., 2023; Suchek et al., 2021). Innovation driven by the circular economy not only enhances internal efficiency but also strengthens corporate reputation and market positioning, particularly in sectors that are sensitive to sustainability issues.

However, the results of the SLR also show that the contribution of the circular economy to industrial competitiveness is neither automatic nor universal. The positive impact of circular practices is strongly influenced by the degree to which circular strategies are integrated into managerial systems and industrial operations. Manufacturing case studies indicate that the circular economy delivers more consistent competitive benefits when adopted as a long-term, integrated strategy rather than as a partial or ad hoc initiative (Dey et al., 2020; Martín-Díez et al., 2025). This finding underscores that the circular economy must be positioned as a strategic framework rather than merely a tool for environmental compliance.

In addition, the literature points to sectoral variation in the strength of the relationship between the circular economy and industrial competitiveness. Sectors with high material intensity, such as manufacturing, automotive, and textiles, tend to exhibit stronger links between circular practices and operational efficiency than service-oriented or knowledge-based industries (Mhatre et al., 2021; Silvério et al., 2023). This variation suggests that the circular economy operates within distinct structural contexts, and its implications for competitiveness must therefore be understood in a contextualized manner.

Overall, this subsection confirms that the circular economy functions as a structural strategy capable of enhancing resource efficiency, operational stability, and industrial innovation capacity. These contributions form an important foundation for improving industrial competitiveness, particularly when circular practices are systematically integrated into corporate strategy and operations. Nevertheless, the strength of these impacts depends on industrial sector characteristics, levels of adoption, and alignment with long-term business objectives, indicating that the circular economy cannot be treated as a generic solution applicable uniformly across all industrial contexts.

The Role of Resource Efficiency in Mediating the Relationship between Circular Practices and Industrial Competitiveness

The synthesis of the literature demonstrates that resource efficiency serves as the primary operational mechanism mediating the relationship between circular economy implementation and enhanced industrial competitiveness. While the circular economy is often conceptualized as a macro-level strategic framework, the findings of this SLR emphasize that its competitive effects materialize only when translated into tangible improvements in resource use efficiency at the process and operational levels. In other words, the circular economy provides strategic direction, whereas resource efficiency constitutes the main channel through which competitive value is concretely realized (Alhawari et al., 2021; Suchek et al., 2021).

A wide range of empirical studies show that improvements in resource efficiency enable industries to reduce production costs by lowering material, energy, and water consumption per unit of output. These efficiency gains directly affect firms' cost structures, thereby increasing profit margins and pricing flexibility in competitive markets (Dey et al., 2020; Rao et al., 2024). In this context, resource efficiency functions not only as an indicator of operational sustainability but also as a critical determinant of economic performance and industrial competitive positioning, particularly in resource-intensive sectors.

Beyond cost considerations, the literature also emphasizes the role of resource efficiency in enhancing productivity and operational stability. Industries with high levels of resource efficiency tend to exhibit more controlled production processes, lower waste generation, and reduced exposure to fluctuations in primary raw material prices (Baars et al., 2020; Dennison et al., 2024). Such stability becomes a key factor in strengthening long-term competitiveness, especially in the context of global supply chain disruptions and geopolitical uncertainty affecting resource availability.

Resource efficiency also acts as a catalyst for process and technological innovation aligned with circular economy objectives. Several studies indicate that efforts to improve material and energy efficiency drive the adoption of new technologies, process redesign, and the integration of digital systems for monitoring and optimizing resource use (Liu et al., 2023; Oladapo et al., 2024). These innovations not only enhance environmental performance but also strengthen firms' dynamic capabilities to respond to market and regulatory changes, thereby reinforcing industrial competitiveness.

Nevertheless, the SLR findings indicate that the mediating role of resource efficiency is context-dependent and influenced by industry characteristics and organizational capacity. In large firms with sufficient financial and technological resources, improvements in resource efficiency are often an integral component of a structured circular economy strategy, resulting in relatively consistent competitive outcomes (Bjørnbet et al., 2021; Silvério et al., 2023). In contrast, small and medium-sized enterprises may face limitations related to upfront investment and technical

capabilities, which constrain their ability to translate circular practices into significant resource efficiency gains and lead to more variable competitive impacts (Dey et al., 2020; Martín-Díez et al., 2025).

The synthesis of the mediating role of resource efficiency between circular practices and industrial competitiveness is summarized in Table 1 to clarify the key mechanisms identified in the literature.

Tabel 1. The Mediating Role of Resource Efficiency between Circular Economy Practices and Industrial Competitiveness.

Circular Economy Practice	**Resource Efficiency Mechanism**	**Competitiveness Outcome**
Material reuse and recycling	Reduced raw material input per unit output	Lower production costs and price competitiveness
Energy-efficient processes	Decreased energy intensity	Improved productivity and operational resilience
Waste minimization	Reduced waste treatment and disposal costs	Enhanced cost efficiency and regulatory compliance
Process innovation	Optimized material and energy flows	Increased flexibility and adaptive capability
Supply chain circularity	Reduced dependency on primary resources	Improved supply stability and long-term competitiveness

The table shows that resource efficiency functions as an operational linkage that translates the circular economy from a strategic concept into measurable competitive performance. Without improvements in resource efficiency, circular practices tend to lose their leverage on industrial competitiveness and risk being perceived merely as environmental initiatives.

Overall, this subsection confirms that resource efficiency is a key mediator in the relationship between the circular economy and industrial competitiveness. The positive impact of the circular economy on industrial competitiveness becomes most consistent when circular practices systematically generate tangible and sustainable improvements in resource efficiency. This finding strengthens the argument that investment in the circular economy should be focused on reinforcing operational efficiency mechanisms so that it truly functions as an industrial competitiveness strategy rather than merely a normative response to environmental pressures.

Variation in the Strength of Evidence and Implementation Challenges of the Circular Economy in Industrial Contexts

The synthesis of the literature indicates that the strength of evidence regarding the contribution of the circular economy to industrial competitiveness varies significantly across industrial sectors, firm sizes, and institutional contexts. This variation suggests that the circular economy cannot be treated as a generic solution that produces uniform competitive impacts in all settings. Hossain et al. (2024) show that while some studies report a consistent positive relationship between circular practices and industrial performance, others find weaker or indirect effects depending on the structural characteristics of the sectors examined.

Differences across industrial sectors represent a major factor influencing the strength of evidence. Studies in sectors with high material and energy intensity, such as manufacturing, automotive, and textiles, tend to demonstrate stronger evidence of the competitive benefits of the circular economy. Bjørnbet et al. (2021) show that in the

manufacturing sector, the adoption of circular practices produces tangible effects on cost efficiency and supply stability. In contrast, in sectors with lower material intensity, the contribution of the circular economy to competitiveness is often more indirect and difficult to quantify. Silvério et al. (2023) emphasize that differences in production structures and value chains across sectors shape the causal pathways between circular practices and competitive performance.

Firm size also influences the extent to which the circular economy can be effectively implemented and translated into competitiveness. Large firms generally possess greater financial, technological, and managerial capacities to adopt circular practices in an integrated manner. Dennison et al. (2024) show that large firms are better able to absorb the upfront costs of circular economy implementation and exploit economies of scale to enhance resource efficiency. Conversely, small and medium-sized enterprises often face investment constraints and limited access to technology, resulting in partial implementation of circular practices and more limited competitive impacts. Dey et al. (2020) highlight that in SME contexts, the competitive benefits of the circular economy tend to emerge only in the medium to long term.

Institutional and regulatory contexts also play a critical role in shaping the strength of evidence. Cross-country studies indicate that supportive policy environments, such as fiscal incentives, clear environmental standards, and innovation support mechanisms, strengthen the relationship between the circular economy and industrial competitiveness. Mhatre et al. (2021) show that in regions with well-developed circular economy policy frameworks, industries are more successful in converting circular practices into competitive advantages. Conversely, regulatory uncertainty and weak policy enforcement can reduce incentives for industries to invest seriously in circular practices. Martín-Díez et al. (2025) emphasize that policy uncertainty often constitutes a major barrier to the adoption of circular economy practices that positively affect industrial performance.

Beyond variations in evidence strength, the literature also identifies several implementation challenges that may constrain the contribution of the circular economy to industrial competitiveness. One of the most frequently reported challenges is the high level of initial investment costs. Baars et al. (2020) show that developing circular infrastructure, such as recycling systems and product redesign, requires significant capital investment that cannot always be immediately offset by operational cost savings. This condition leads some firms to perceive the circular economy as a short-term burden rather than a competitive strategy.

Supply chain complexity also represents a structural challenge in circular economy implementation. Rao et al. (2024) indicate that adopting circular practices often requires coordination among multiple value chain actors, including suppliers, distributors, and consumers. The lack of readiness among other actors in the supply chain can hinder the full realization of circular economy benefits. This challenge becomes even more pronounced in global supply chains characterized by differing standards and regulations across countries.

Dependence on technology and organizational capabilities further influences the success of circular economy implementation. Oladapo et al. (2024) show that the integration of digital technologies and information systems is a critical prerequisite for monitoring and optimizing resource flows. However, not all firms possess sufficient technological capabilities and human resources to support such transformations. As a result, the circular economy may exacerbate competitiveness gaps between firms with advanced capabilities and those that are technologically lagging.

Overall, this subsection demonstrates that while the circular economy and resource efficiency hold strategic potential for enhancing industrial competitiveness, the strength of evidence and effectiveness of implementation are highly contingent on sectoral characteristics, firm size, and institutional environments. Challenges related to investment costs, supply chain complexity, and regulatory uncertainty underscore that the circular economy is not a universal solution that can be applied uniformly. These findings reinforce the argument that the circular economy must be positioned as a contextual strategy requiring structural adaptation and policy support in order to generate sustainable competitive advantages for industry.

CONCLUSIONS

Based on the synthesis of this systematic literature review, it can be concluded that the circular economy and resource efficiency play strategic roles in enhancing industrial competitiveness, although their contributions are highly contextual and dependent on implementation mechanisms. The findings indicate that the circular economy functions as a structural framework that guides industries toward optimizing material cycles, reducing dependence on primary resources, and improving operational resilience. The competitive impacts of the circular economy become most evident when circular practices are systematically integrated into corporate strategy and operations, resulting in cost efficiency, supply stability, and innovation capacity relevant to long-term industrial competition.

The study also confirms that resource efficiency serves as the primary mediating mechanism linking circular practices to industrial competitive performance. Improvements in the efficiency of material, energy, and resource use enable industries to translate circular economy principles into measurable operational advantages, such as higher productivity and cost flexibility. However, the strength of evidence regarding these relationships varies significantly depending on industrial sector, firm size, and institutional context. Material-intensive sectors and firms with strong technological and managerial capabilities tend to demonstrate more consistent competitive benefits, while small and medium-sized enterprises face structural challenges that limit the impact of the circular economy on competitiveness.

In addition to variations in evidence strength, this study identifies several key challenges in circular economy implementation, including high upfront investment costs, supply chain coordination complexity, technological dependency, and regulatory uncertainty. These challenges highlight that the circular economy cannot be treated as a generic or uniform solution across all industrial contexts. Therefore, from a theoretical perspective, there is a need to develop integrative models linking the circular economy, resource efficiency, and industrial competitiveness while accounting for sectoral and institutional characteristics. From a practical perspective, industries are encouraged to position the circular economy as a long-term competitive strategy focused on strengthening resource efficiency rather than merely responding to environmental regulatory pressures. Future research should include cross-country and cross-sector empirical studies to test the generalizability of these SLR findings and to further explore the dynamics of circular economy implementation across diverse industrial contexts.

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