WHAT HOLDS BACK CIRCULAR TRANSITIONS? A SYSTEMS APPROACH TO STRATEGIES AND BARRIERS

1 INTRODUCTION

The circular economy (CE) has gained global prominence as a response to the unsustainable patterns of production and consumption that characterize the linear model of extract-produce-consume-dispose (Geissdoerfer et al., 2017). CE seeks to create restorative and regenerative systems in which resources are kept in productive use, waste is eliminated at the design stage, and natural systems are regenerated (Kirchherr et al., 2023).

The transition to CE faces significant challenges. Industrial and service sectors are central to competitiveness and sustainable development, yet the adoption of circular strategies remains limited (Sgambaro et al., 2025). Firms encounter technological and financial barriers, sectors struggle with fragmented supply chains and low cooperation, and policy frameworks remain complex and weakly enforced (Govindan & Hasanagic, 2018).

Although CE research has advanced considerably, it remains fragmented across different levels of analysis. Studies often examine product design strategies at the firm level, sectoral dynamics within supply chains, or national policy frameworks, but rarely integrate these perspectives. This lack of articulation creates a significant problem: without a systemic view of CE, decision-makers struggle to design coherent strategies that align organizational practices, sectoral initiatives, and public policies.

This paper addresses this gap by adopting a systemic perspective that distinguishes three levels of analysis: micro (products, firms, and organizational practices), meso (sectors, supply chains, and networks), and macro (policies, institutions, and society). Thus, the research question that guided this study is: How can a multi-level perspective help decision-makers overcome barriers and leverage strategies for advancing the CE?

Accordingly, the specific objectives are:

- To map CE strategies and barriers reported in the literature and propose a conceptual framework that links them at micro, meso, and macro perspectives;
- To discuss the implications of this systemic framework for decision-makers, including managers, organizations, and policymakers, in advancing CE transition.

By pursuing these objectives, the study contributes conceptually to CE research and provides a practical tool for decision-makers engaged in advancing circular transitions.

2 THEORETICAL BACKGROUND

CE is widely defined as an economic model that is restorative and regenerative by design, aiming to eliminate waste, extend product lifecycles, and regenerate natural systems (Kirchherr et al., 2023). To analyze how CE unfolds in practice, the analysis can be structured into three levels: micro, meso, and macro. This classification provides a lens to understand how strategies and barriers manifest at different scales and how they interact.

At the microlevel, CE is closely linked to decisions made during the design and development of products. Product development processes determine material selection, production technologies, and business models that can either enable or constrain circular practices (Schöggl et al., 2024). Strategies such as design for disassembly, remanufacturing, recycling, and product life extension exemplify how firms can close material loops and reduce environmental impacts over the lifecycle (Sgambaro et al., 2025).

However, several barriers also emerge at this level. Firms often face technological complexity, financial limitations, and internal cultural resistance when attempting to embed CE principles in daily operations. Industrial organizations struggle to align engineering decisions, material choices, and process innovations with circular objectives while simultaneously responding to competitive and regulatory pressures (Petrudi & Arabi, 2025).

The mesolevel emphasizes the collective dynamics of sectors and value chains (Eslamipoor & Sepehriar, 2024). Circularity depends on coordination among actors, integration of supply chains, and diffusion of practices across industries such as automotive, textile, electronics, construction, transportation, health, and finance (Govindan & Hasanagic, 2018).

Barriers at this level are often structural and relational. Limited cooperation among firms, lack of trust, low integration of value chains, and sector-specific regulatory challenges all constrain the diffusion of CE practices (Schöggl et al., 2024). In services, barriers include insufficient investment in organizational innovation, and difficulties in scaling sharing or access-based models (Geissdoerfer et al., 2017). In manufacturing, barriers include technological bottlenecks, rigid production systems, and inertia in established supply chains. These mesolevel barriers illustrate how even when firms adopt CE strategies internally, systemic coordination failures can impede broader circular transitions.

At the macrolevel, the CE transition depends on the enabling environment created by governments, regulatory institutions, and international agreements (Petrudi & Arabi, 2025). National policies can stimulate or obstruct circularity through regulatory frameworks, fiscal incentives, and investments in R&D. The policy context remains fragmented, with insufficient articulation across ministries and limited alignment between industrial, environmental, and innovation agendas (Govindan & Hasanagic, 2018). Barriers at the macrolevel also include regulatory complexity, insufficient enforcement of existing environmental laws, and gaps between national commitments and sectoral realities (Schöggl et al., 2024).

3 METHODOLOGY

This study adopts a conceptual research design based on a narrative literature review. A narrative review provides flexibility for synthesizing and critically analyzing contributions from the literature in order to develop new theoretical insights. This approach is particularly appropriate for the present study, which seeks to propose a conceptual framework that organizes strategies and barriers into a systemic perspective.

The review was conducted based on peer-reviewed papers published in journals indexed in Web of Science and Scopus. Priority was given to studies that explicitly addressed CE strategies or barriers in contexts relevant to product development, manufacturing, and services.

After the initial search, studies were selected based on their contributions to the understanding of CE practices and challenges. A process of iterative reading and thematic categorization was applied to synthesize insights across the literature. To structure this synthesis, the study adopted qualitative inductive content analysis (Elo & Kyngäs, 2008), which supports the identification of patterns and themes that cut across diverse contributions.

The outcome of this process is a synthesis that maps CE strategies and barriers from the literature and organizes them into the three systemic levels of analysis (micro, meso, and macro) as discussed in the following section.

4 RESULTS AND DISCUSSION

4.1 MICROLEVEL: FIRMS, PRODUCTS AND ORGANIZATIONAL PRACTICES

At the microlevel, CE depends on firm-level decisions in areas such as product design, material selection, process innovation, and business models. The main strategies (S) and barriers (B) identified at the microlevel are summarized in Table 1.

Table 1 - CE strategies and barriers at the microlevel.

Microlevel S / B	Key elements	Example
(Micro-S1) Design for circularity	Designing products for circular outcomes (disassembly, durability, reparability)	Modular smartphones designed for easy repair and part replacement
(Micro-S2) Remanufacturing	Restoring used products to like-new condition through industrial processes	Heavy machinery components remanufactured for extended use
(Micro-S3) Component harvesting	Recovering functional parts from discarded products for reintegration	Spare parts from end-of-life vehicles reused in new products
(Micro-B1) Technology limitations	Material science challenges, lack of scalable recycling processes, poor traceability	Composite materials in aircraft difficult to recycle
(Micro-B2) Capability gaps	Lack of skills, knowledge, and training in circular design	Engineers unfamiliar with eco-design tools
(Micro-B3) Financial constraints	High upfront investment and uncertain financial returns	Expensive R&D for recyclable packaging with unclear payback

Fonte: Elaborado com base em Govindan and Hasanagic (2018), Schöggl et al. (2024) and Wandji et al. (2025).

Strategies at this level include practices such as design for disassembly, reuse, remanufacturing, recycling, and product life extension. These initiatives can reduce environmental impacts while creating new opportunities for circular business models.

However, several barriers constrain firms in adopting CE principles. These include technological complexity in production systems, financial limitations related to redesign and innovation costs, and internal cultural resistance to organizational change (Schöggl et al., 2024). These barriers highlight the limits of firm-level action when not supported by sectoral and policy frameworks.

4.2 MESOLEVEL: SECTORS, SUPPLY CHAINS AND NETWORKS

At the mesolevel, CE transitions rely on cooperation among firms, sectoral coordination, and integration of supply chains. The main strategies (S) and barriers (B) identified at the mesolevel are summarized in Table 2.

Table 2 - CE strategies and barriers at the mesolevel.

Mesolevel S / B	Key elements	Example
(Meso-S1) Industrial symbiosis	Sharing physical resources such as waste, energy, and water among firms	Waste heat from one facility used in nearby operations
(Meso-S2) Shared infrastructure and services	Co-investments in logistics, repair hubs, and recycling facilities	Collective e-waste collection and treatment systems
(Meso-S3) Standardization and open innovation	Modular design and cross-industry collaboration through common standards	Standardized chargers reducing electronic waste
(Meso-B1) Data and transparency gaps	Poor traceability across value chains	Difficulty in tracking recycled textiles in the fashion sector
(Meso-B2) Infrastructure and institutional voids	Absence of repair/recycling facilities and intermediaries connecting actors	Limited availability of e-waste recycling plants
(Meso-B3) Competitive tensions and low trust	Reluctance to cooperate due to fear of losing competitive advantage	Producers resisting participation in collective recycling schemes

Fonte: Elaborado com base em Govindan and Hasanagic (2018), Schöggl et al. (2024) and Wandji et al. (2025).

Strategies identified in the literature include collaborative logistics, sectoral cooperation for the use of secondary materials, sharing and access-based models (Wandji et al., 2025). Regarding the barriers, these include lack of integration across supply chains, weak cooperation and trust among firms, sector-specific regulatory complexity, and insufficient investment in innovation. Such obstacles demonstrate the challenges of scaling circular practices beyond the firm level and emphasize the importance of collective action (Govindan & Hasanagic, 2018).

4.3 MACROLEVEL: POLICIES, INSTITUTIONS AND SOCIETAL FRAMEWORKS

At the macrolevel, CE depends on the enabling environment created by governments and institutions. The main strategies (S) and barriers (B) identified at the macrolevel are summarized in Table 3.

Table 3 - CE strategies and barriers at the macrolevel.

Macrolevel S / B	Key elements	Example
(Macro-S1) Shared producer–consumer responsibility	Extending responsibility beyond producers to include consumer incentives	Policies granting consumers the right to repair products
(Macro-S2) Public procurement	Using procurement to stimulate circular supply chains, not only single products	Public tenders requiring circular criteria in furniture acquisition
(Macro-S3) Incentives and disincentives	Subsidies for circular practices and taxes on linear ones	Reduced tax on repair services or taxes on virgin plastics
(Macro-B1) Policy misalignment	Contradictions between industrial, environmental, and fiscal policies	Recycling coexisting with subsidies for virgin materials
(Macro-B2) Institutional weakness	Limited enforcement, corruption, and lack of resources in public agencies	Weak monitoring of extended producer responsibility schemes
(Macro-B3) Consumer behavior inertia	Strong social norms favoring disposability and ownership	Low acceptance of rental and sharing models in markets

Fonte: Elaborado com base em Govindan and Hasanagic (2018), Schöggl et al. (2024) and Wandji et al. (2025).

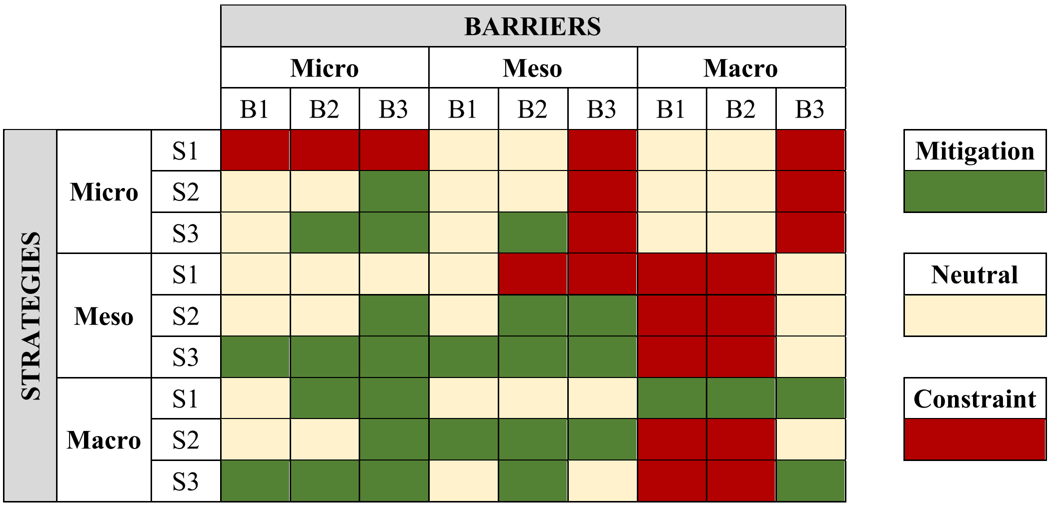
Strategies emphasized in the literature include extended producer responsibility, sustainable public procurement, and public investment in circular innovation and research (Wandji et al., 2025). These measures can strengthen national competitiveness and align development trajectories with sustainability goals. Still, barriers remain significant. Fragmented and complex regulations, weak enforcement of existing laws, and insufficient alignment between industrial, environmental, and innovation policies limit the effectiveness of macrolevel strategies (Govindan & Hasanagic, 2018).

4.4 SYSTEMS VIEW OF CIRCULAR ECONOMY

The heatmap matrix (Figure 1) provides a systemic overview of how CE strategies and barriers interact across micro, meso, and macro levels. By visualizing whether strategies mitigate (green), are constrained by (red), or remain neutral (yellow) in relation to barriers, the framework reveals important patterns that are not evident when levels are considered in isolation.

At the microlevel, strategies such as design for circularity and remanufacturing are consistently constrained by technological limitations, financial costs, and capability gaps. The diagram highlights that while remanufacturing and component harvesting can partially mitigate financial barriers by lowering production costs, their effectiveness remains undermined by technological and cultural constraints. This suggests that firm-level innovation cannot be expected to succeed without complementary actions at higher systemic levels.

Figure 1 – Matrix of relations between strategies and barriers.



Fonte: Elaborado pelos autores.

At the mesolevel, strategies such as industrial symbiosis and shared infrastructure are heavily dependent on overcoming infrastructure voids and competitive tensions. The heatmap illustrates how shared infrastructure and standardization act as critical enablers, mitigating both financial barriers at the microlevel and data gaps across supply chains. However, these strategies are highly vulnerable to macrolevel barriers: policy misalignment and institutional weakness appear as structural bottlenecks that limit the scaling of mesolevel initiatives.

At the macrolevel, incentives, disincentives, and shared producer–consumer responsibility show the greatest capacity to mitigate barriers across levels. Incentives can directly reduce financial constraints at the firm level, stimulate infrastructure investment at the sectoral level, and reshape consumer behavior at the societal level. Yet the heatmap also demonstrates that these strategies lose effectiveness when confronted with policy misalignment or institutional weakness. Public procurement emerges as another leverage point, with potential to cascade benefits to meso- and microlevels by creating demand for standardization, infrastructure, and transparency.

Taken together, the heatmap reinforces the need for alignment across systemic levels. Strategies located at one level often depend on barrier removal at another. For example, design for circularity (micro) requires sectoral standardization (meso) and supportive regulation (macro). Conversely, consumer inertia (macro) can undermine the success of remanufacturing or component harvesting (micro), even when sectoral infrastructure is in place. The analysis underscores that piecemeal interventions are insufficient. Only coordinated, multi-level actions can address the reinforcing nature of barriers and unlock the full potential of CE strategies.

5 FINAL CONSIDERATIONS

This study proposed a systemic framework that maps strategies and barriers for the CE across micro, meso, and macro levels. By visualizing their interactions in a heatmap, the analysis revealed how strategies often mitigate or are constrained by barriers within and across levels. The results demonstrate that isolated initiatives are insufficient. Effective circular transitions require coordinated actions that align product, sectoral, and policy frameworks.

The study advances the literature by integrating fragmented insights into a multi-level perspective and contributes to practice by offering decision-makers a tool to identify leverage points and systemic bottlenecks. Its main limitation lies in the conceptual nature of the analysis, based solely on a narrative review of peer-reviewed studies, without empirical testing.

Future research should empirically validate and refine the framework in different sectors and national contexts, examining how strategies and barriers evolve over time and how coordination across levels can be fostered. Such studies could provide actionable evidence for managers, organizations, and policymakers seeking to accelerate the transition to a CE.

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