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Breaking Barriers: Accelerating the Transition to a Circular Economy




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Abstract: Global resource consumption is continuously increasing, accelerating the transgression of planetary boundaries. Solving the related environmental problems requires targeted action and a systemic transition from the prevailing linear economic model to a circular one. This paper adopts a systemic approach to identify the transition barriers across relevant levels, including product, business, ecosystem, industry, and society/regulation systems. It contributes to research by structuring and mapping the barriers based on eight underlying mechanisms. These mechanisms help explain how the barriers function and why they hinder the transition of socio-technical regimes from linear to circular ones. For example, the Prisoner's Dilemma describes how short-term self-interests often overrule collective benefits and leads to suboptimal outcomes. The mechanisms also provide insights into potential solutions for addressing the barriers and accelerating the implementation of a circular economy. Illustrative examples from practice are introduced to demonstrate that "breaking barriers" is both possible and necessary—primarily through various forms of collaboration.

Keywords: Circular Economy, Systemic barriers, Systemic change, Socio-technical regimes, Collaboration

Barrieren überwinden: Den Wandel zur Kreislaufwirtschaft beschleunigen

Zusammenfassung: Der globale Ressourcenverbrauch nimmt kontinuierlich zu und beschleunigt damit die Überschreitung planetarer Grenzen. Die Lösung der damit verbundenen Umweltprobleme erfordert gezielte Massnahmen und einen systemischen Wandel vom vorherrschenden linearen Wirtschaftsmodell hin zu einem zirkulären. Dieser Artikel verfolgt einen systemischen Ansatz, um die Transformationsbarrieren auf verschiedenen relevanten Ebenen zu identifizieren – darunter Produkt-, Unternehmens-, Ökosystem-, Industrie- sowie gesellschaftliche und regulatorische Systeme. Er leistet einen Beitrag zur Forschung, indem er die Barrieren anhand von acht zugrunde liegenden Mechanismen strukturiert und darstellt. Diese Mechanismen erklären, wie die Barrieren funktionieren und weshalb sie den Wandel von linearen zu zirkulären sozio-technischen Regimen

behindern. So beschreibt etwa das Gefangenendilemma, wie kurzfristige Eigeninteressen häufig kollektive Vorteile überlagern und dadurch zu suboptimalen Ergebnissen führen. Gleichzeitig geben diese Mechanismen Hinweise auf potenzielle Lösungsansätze, um die Barrieren zu überwinden und die Umsetzung einer zirkulären Wirtschaft zu beschleunigen. Anhand praxisnaher Beispiele wird veranschaulicht, dass das „Durchbrechen von Barrieren“ sowohl möglich als auch notwendig ist – insbesondere durch verschiedene Formen der Zusammenarbeit.

Stichwörter: Kreislaufwirtschaft, Systemische Barrieren, Systemwandel, Sozio-technisches Regime, Zusammenarbeit

1. Introduction: Relevance of a Circular Economy

A circular economy (CE) is regarded as a promising alternative economic system that entails fundamentally different configurations of the *socio-technical regime* (Geels, 2022; Markard et al., 2012a), offering pathways to reduce pressures on already critically exceeded planetary boundaries (Desing et al., 2020; Geissdoerfer et al., 2017; Merli et al., 2018; Richardson et al., 2023; Rockström et al., 2009). The idea is to reshape resource flows within today's production and consumption systems in more environmentally sustainable ways through *circular strategies*, also called R-strategies (Potting et al., 2017)—regenerate, reduce, reuse, repair, remanufacturing, and recycle. These strategies fundamentally affect mechanisms of value creation and value capture within companies and across the broader economic system, enabling an alignment with the principles of a CE (Bocken et al., 2018; Frankenberger et al., 2021; Urbinati et al., 2017). The aim is to narrow, slow down, and close resource flows (Bocken et al., 2016; Geissdoerfer et al., 2018), thereby eliminating waste, reducing primary resource extraction, and increasing resource productivity (Ellen MacArthur Foundation, 2013), as well as regenerating nature (Morseletto, 2020).

In contrast to the prevailing socio-technical regime of the linear economy, establishing a CE is deemed as a sustainability transition (Markard et al., 2012a). This transition remains deeply challenging, as it requires transforming the current configurations of the regime organized around linear resource flows into circular ones (Geissdoerfer et al., 2023; Govindan & Hasanagic, 2018a; Grafström & Aasma, 2021; Guldmann & Huulgaard, 2020; Kirchherr et al., 2018). Although the environmental rationale and need for this transition is well established, the extent of its actual implementation remains limited (only about 7 % of the global economy currently operates as a CE) (Circle Economy, 2025). Indeed, global resource use has more than tripled over the past 50 years and continues to grow at a rate of 2.3 % annually (International Resource Panel, 2024).

Research has offered clear insights into the key structures and rules that define a socio-technical regime aligned with the principles of a CE, including circular business models (Geissdoerfer et al., 2020; Hofmann, 2019; Ünal et al., 2018; Urbinati et al., 2017), ecosystems (Hofmann Trevisan et al., 2023; Kanda et al., 2021; Konietzko et al., 2020a, 2020b; Takacs et al., 2020), and industry standards (Bressanelli et al., 2020; Elia et al., 2020; Fischer & Pascucci, 2017; Parida et al., 2019). Notably, the transition to a CE has been slower than anticipated, even in the face of clear signals from policymakers, such as those in the European Union, and growing concerns over resource scarcity (European Commission, 2020; WBCD, 2020).

To elucidate the persistent inertia in the CE transition, we pose the following research question: *What underlying mechanisms impede the transition to a CE, and how do they shape and reinforce existing barriers?* Research on CE barriers has established the key challenges obstructing the transition (Geissdoerfer et al., 2023; Govindan & Hasanagic, 2018b; Grafström & Aasma, 2021; Takacs et al., 2022) but has not explored the deeper mechanisms through which these barriers emerge and persist. In addition, research has only partially been conducted from a systemic economic, social, and technical perspective, for example, by integrating the concept of social-technical regimes and taking a comprehensive multi-level lens (Geels, 2002, 2010). Understanding these mechanisms may aid in overcoming the current slow pace of adopting circular strategies. To address this gap, we systemically identify the most prominent barriers from the literature and analyze the underlying mechanisms influencing their impact.

This paper serves as the lead article in the special issue "Exploring the Circular Economy – Pathways to a Sustainable System within Planetary Boundaries" in the *Swiss Journal of Business*. It provides a foundation for the other papers of this special issue through an in-depth discussion of the CE transition. This paper makes three contributions. First, we present an overview of the barriers that hinder the transition toward circular socio-technical regimes across five relevant levels—product, business, ecosystem, industry, and society/regulation. This overview offers a comprehensive, literature-based mapping of relevant barriers. Second, we identify and discuss the underlying mechanisms that give rise to these barriers. We present eight mechanisms that help explain how these barriers function, thereby elucidating the systemic challenges involved. Third, building on this foundation, we derive and discuss practical interventions that help overcome the identified mechanisms and thereby advance CE transition.

2. Background: Understanding the Underlying Mechanisms of Circular Economy Barriers

A socio-economic regime (c.f., Geels, 2002, 2022; Geels & Schot, 2007) refers to the dominant configurations of system-relevant elements (e.g., technologies, institutions, practices, networks, cultural norms, and companies) that shape how societal functions (e.g., energy, transport, and food) are fulfilled. These configurations, characterized by *dynamic stability* (Geels, 2010), collectively shape the trajectory of possible change along established pathways, thereby influencing the ease or difficulty of transformation (Markard et al., 2012a). Actors embedded in these elements tend to align their behavior with dominant cognitive frames (Geels, 2002). They follow prevailing regulatory structures (Geels & Schot, 2007), adhere to established value creation logics (Geels, 2006), and maintain conventional engineering practices (Rip & Kemp, 1998). Prior investments in business models, ecosystems, infrastructure, and assets further entrench these trajectories, as mechanisms of value capture become institutionalized and difficult to displace (Markard & Truffer, 2006; Unruh, 2000a). Research adopting the multi-level perspective (MLP) (Geels, 2002) has established that these socio-technical regimes—particularly when in a stable state (e.g., the current linear economy)—exhibit inherent resistance to structural adaptation and system innovation owing to their deeply embedded configurations and reinforcing dynamics (Coenen et al., 2012).

Flow of Resources

Inspired by the concept of industrial metabolism introduced by Ayres (1997), we argue that the degree of circularity in a socio-technical regime depends on the operationalized logic of the flow of resources (Bocken et al., 2016) and the extent of the capacity for natural regeneration (Morseletto, 2020). These factors determine the socio-technical regime's overall compatibility with planetary boundaries (Desing et al., 2020). The emerging dichotomy allows for the positioning of socio-technical regimes along a nuanced yet fuzzy continuum between linear and circular (Morseletto, 2023). Within these regimes, embedded actors perform (coordinated) activities that shape value-creation pathways across resource extraction, processing, consumption, discarding, and recovery levels (Geels & Schot, 2007; Unruh, 2000a).

In this context, *linearity* is characterized by a "take–make–use–dispose" logic (Ellen MacArthur Foundation, 2013), which is open (i.e., generating waste, leftovers) and inherently generates negative environmental externalities (Esposito et al., 2018; Hummen & Desing, 2021). Among its practical consequences, linearity lacks provisions for product longevity, price internalization for negative external effects, effective resource utilization, and take-back mechanisms. Linearity fails to recognize the value of natural capital and residual value of products and resources, as well as lacks incentives for production and consumption reduction (Desing et al., 2021; Geissdoerfer et al., 2017; Morseletto, 2023; Tukker, 2015), resulting in environmental overshoot (Desing et al., 2020; Whiteman et al., 2013). Despite these drawbacks, linear systems have been optimized over the decades and thus perform with high efficiency (Morseletto, 2023; Pavel, 2018).

In contrast, *circularity* fundamentally redefines the flow of resources within socio-technical regimes by introducing novel approaches to value creation and value capture. It incorporates thinking of multiple lifecycles through different circular strategies (e.g., regenerate, reduce, reuse, repair, remanufacturing, and recycle) with the goal of minimizing environmental impact, resource devaluation, and waste (Bocken et al., 2016; Ünal et al., 2018; Urbinati et al., 2017). Circularity represents a paradigm shift. Ideally, all technical materials (technocycle) should be restored, and all biological materials (biocycle) should be regenerated (Ellen MacArthur Foundation, 2013). Hence, it aims to restore and regenerate natural capital (Morseletto, 2020) while promoting a holistic and society-wide perspective of well-being within planetary boundaries (Desing et al., 2020).

Barriers to the Circular Economy Transition

Various barriers hinder the transition from a purely linear to a fully circular socio-technical regime (Geissdoerfer et al., 2023; Kirchherr et al., 2018; Takacs et al., 2022). A CE transition—a sustainable transition—is a long-term, multidimensional, and fundamental transformation of socio-technical regimes (Coenen et al., 2012; Geels & Schot, 2007; Markard et al., 2012b). It is actively driven by a subset of actors across public and private sectors who seek to establish an alternative socio-technical regime with novel configurations that allow for production and consumption within environmental boundaries (Collste et al., 2021; Desing et al., 2020). The underlying mechanisms and factors that hinder this transition can be elucidated by combining the research on CE barriers (c.f., Kirchherr et al., 2018; Takacs et al., 2022) with the MLP and its conceptualization of transition in socio-technical regimes (c.f., Geels, 2002; Geels & Schot, 2007; Rip & Kemp, 1998). Drawing on these two research streams, we classify the barriers into five levels:

- *product* (including *technology*) (Bakker et al., 2014; Bocken et al., 2016; Nag et al., 2022),
- *business* (Geissdoerfer et al., 2020; Hofmann, 2019),
- *ecosystem* (i.e., inter-organizational networks and partnerships) (Kanda et al., 2021; Konietzko et al., 2020b),
- *industry* (Awan et al., 2021; Fischer & Pascucci, 2017; Flynn & Hacking, 2019), and
- *society* (Michaud & Llerena, 2011; Pepper et al., 2009) and *regulation* (Agamuthu & Visvanathan, 2014; Desing et al., 2021; Zhu & Geng, 2013).

Although previous research has effectively identified key barriers (c.f., Geissdoerfer et al., 2023; Govindan and Hasanagic, 2018; Grafström and Aasma, 2021; Ritzén and Sandström, 2017), it has not provided sufficient theoretical and practical grounding to explain how these barriers operate and why, as a result, the transition to a CE remains so challenging. This lack of a systemic understanding of the fundamental underlying mechanisms represents a key shortcoming. Effectively addressing the barriers—to deploy solutions that actually tackle the root causes—requires a deep understanding of the underlying mode of action of these underlying, interlinked, and reciprocally interacting mechanisms across levels. Addressing individual barriers may only result in (small) short-term improvements or benefit isolated levels (e.g., product improvement only), without fostering systemic change throughout whole socio-economic regimes. To advance research on CE barriers and accelerate the CE transition, we propose a shift in focus toward the root causes of barriers and introduce a new conceptual framework that expands the existing literature by incorporating a systemic perspective.

Underlying Mechanisms

Our research identifies eight underlying mechanisms behind the barriers to a CE transition, identified in existing literature and managerial practice. After briefly introducing the theoretical foundations, we illustrate how the mechanisms and respective barriers work across levels (see Section 3), before discussing potential solutions to break them (see Section 4).

The first mechanism constitutes ***lock-in***, which is closely associated with path dependency. Geels (2006) highlighted that socio-technical regimes, given the nature of their configurations, cause lock-ins as they (explicitly and implicitly) attempt to stabilize the predominant value creation and capture logic—in our study, the linear flow of resources (Sopjani et al., 2020). Lock-ins increase the switching costs fueled by past expansions of actors involved (owing to network effects), their relations and structural embedding (David, 1985), and the vested interests of already made investments (Geels, 2006). Technologies and infrastructure in the prevailing socio-technical regime—created and designed to remain stable and functional over time (Berkhout, 2002)—lock up the actors in a dominant linear value creation and capture logic (Henrysson & Nuur, 2021; Turnheim et al., 2015).

The second mechanism constitutes ***institutional inertia*** and arises from prevailing institutions that shape behavior, expectations, and organizations through formal and informal rules and norms, thereby stabilizing the socio-technical regime; individuals align with these frameworks over time (North, 1990). The “stickiness” of institutions arises from their design, which provides stability and predictability but simultaneously impedes transitions toward sustainable alternatives (Hannan & Freeman, 1984; Rosenschöld et al., 2014; Sydow et al., 2009). Furthermore, expected returns embedded in established value-capturing mechanisms keep the previously chosen path the dominant option, as it becomes more advantageous the longer it is followed (Pierson, 2000).

A further mechanism builds ***information asymmetry***, leading to market failures. When one actor holds better information than another, adverse selection and inefficient resource allocation can ensue (Akerlof, 1970; Löfgren et al., 2002). Principal–agent theory explains how asymmetric information can result in incentive misalignment (Ross, 1973) and conflicts of interest between the instructing principal and the executing agent. This leads to opportunistic behavior that does not support a sustainable design of resource flows (Lahti et al., 2018; Rizzati & Landoni, 2024).

Asymmetric incentives are also central to the ***prisoner’s dilemma***, a game-theoretical construct that describes the situation in which actors in socio-technical regimes could achieve better outcomes through cooperation yet are often driven toward suboptimal (collective) results owing to (short-term) self-interests (Axelrod, 1980; Nash, 1950). This dilemma illustrates the tension between responsibility for collectively shared resources and ecological integrity, as well as the self-interests of corporate and national actors that neglect this responsibility (Robèrt & Broman, 2017). Trapped in this dilemma, firms are pressured into unsustainable behavior, as individual deviation is rewarded (e.g., by short-term profits). Meanwhile, pursuing the sustainable path often entails disadvantages (e.g., market losses or cost increases), even though it would be collectively better over time (Pacheco, Dean, et al., 2010).

The ***innovator’s dilemma*** describes the tendency of actors to prioritize incremental (i.e., exploitation) over disruptive (i.e., exploration) innovation (Christensen, 1997; Frankenberger et al., 2020). Various factors lead to the fixation on incremental advancements, including entrepreneurial resource allocation, where resources are directed toward optimizing existing capabilities rather than exploring transformative opportunities (Corso & Pellegrini, 2007; Sharma, 1999). Short-term time preferences lead to prioritization of immediate returns over long-term innovation (Lumpkin & Brigham, 2011; O’Reilly & Tushman, 2008). This situation is evident in companies that have long focused on linear business models, optimizing them for efficiency. As such, circular solutions initially perform worse by direct comparison (Morseletto, 2023; Pavel, 2018).

A further mechanism pertains to the so-called ***environmental externalities*** (Ostrom, 1990), whereby environmental consequences (e.g., damage, pollution) of economic value creation processes (e.g., usage and disposal) are not internalized in market prices (Chava, 2014; Delucchi, 2000). This effect is reinforced by the fact that the economic value of so-called natural ecosystem services and natural functionality is not assigned a measurable value or price. Hence, the cost of exploitation of natural resources and the value of ecosystem services are excluded from economic calculations (Costanza et al., 1997). This lack of price internalization leads to market failures, misuse and overuse of resources (e.g., fossil fuels) and common goods (e.g., clean air), as well as free riding behaviors. As prices do not reflect the totality of costs generated (i.e., internalization leads to higher prices and reduced (over)consumption), systemically inefficient resource allocation is observed (Chander, 1997; Meade, 1973), as in today’s linearly functioning socio-technical regimes.

Social norms constitute the explicit and implicit standards and rules that govern the behavior of actors. From a functionalist systems theory perspective, actors within a socio-technical regime operate in alignment with and in fulfillment of systemic needs and goals, which then shape their functions, tasks, and roles (Geels, 2010). These normative rules become relevant as actors do not operate in isolation but rather within social networks, effectively defining the "rules of the game" (Geels & Schot, 2007). Subsequently, social norms influence the individual and aggregated perceptions and emotions of producers and consumers (e.g., regarding product design and functionality) and thus actively shape market demand (Godinho Filho et al., 2024; Moreau et al., 2017). Thus, firms strongly align their value creation processes with prevailing social norms, as well as dominant consumer behaviors and demands, which are predominantly structured in a linear manner (Ahmadov et al., 2023).

At the heart of these norms lies the ***growth paradigm***. It describes the dominant narrative deeply embedded within the actors and institutions in the socio-technical regimes asserting that economic growth (i.e., mostly measured in society as increases in the gross domestic product [GDP] and in companies as revenue growth) is both desirable and necessary for the prosperity of societies and businesses (Jackson, 2016; Raworth, 2017). A core element of this narrative is its linkage to societal progress (Ayres, 1996). This assumption implicitly carries the belief that growth is both indefinitely possible and allows for a decoupling of economic expansion from environmental degradation. Notably, these assertions have been conceptually and empirically contested (Hickel & Kallis, 2020; Parrique et al., 2019). This paradigm manifests in the expectations of actors, shaping and guiding their activities, and is structurally embedded in the measurement systems and targets of the socio-technical regimes, defining what prosperity is and how it is achieved. It is closely linked to the imperative to expand monetary value creation processes to deliver more products and services, which further reinforces the linear flow of resources (Desing, Brunner, et al., 2020; Martínez-Alier et al., 2010; Schmelzer, 2015).

3. Findings: Linking Barriers to Underlying Mechanisms

We identified the most relevant barriers in the CE literature and assigned them to one of the five levels—product, business, ecosystems, industry, and society/regulation—based on their level of impact and respective relevance for practitioners (see Figure 1). We then conducted a categorization of the key barriers through a comprehensive morphological analysis (i.e., Frow et al., 2015; Lüdeke-Freund et al., 2018). Table 1 (in the appendix) provides an overview of the 27 most relevant barriers as well as the identification of the most dominant underlying mechanism for each barrier. Next, we conducted a series of five workshops over the course of one year (from late 2023 to late 2024) with more than 150 executives, to challenge the categorization and discuss the underlying mechanisms in the context of managerial practice, thereby moving beyond the static perspective on barriers typically found in CE research. The barrier overview (Figure 1) is based on an extensive literature review and insights from Takacs et al. (2022). On each level, a few underlying mechanisms, as previously explained, influence the functioning of the barriers.

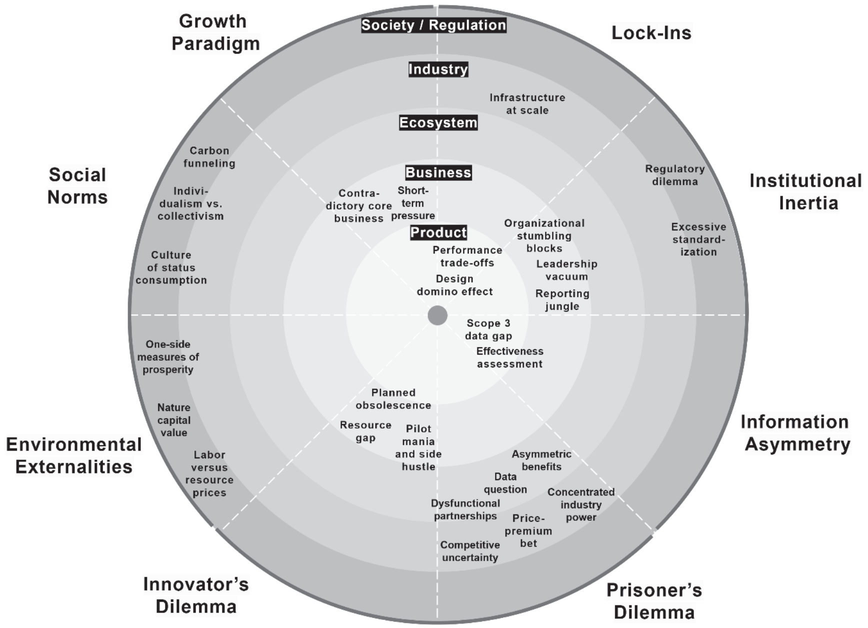

Figure 1 Identified barriers and their underlying mechanisms

Product Level

Two underlying mechanisms hinder the development of circular products and services. First, **lock-ins** create path dependencies on previous linear processes and design specifications. This leads to a *design domino effect* where fragmented design decisions across the value chain hinder product development teams from adjusting their conventional ways of designing products and implement design changes to support circular strategies (Cantú et al., 2021; Guldmann & Huulgaard, 2020; Hansen & Schmitt, 2021; Kumar et al., 2019). For example, the design of a car is typically planned multiple years before start of production and is optimized for production platforms that serve multiple vehicle generations. Customers' (product) performance expectations regarding quality, aesthetics, and designs intensify lock-ins. Customers develop expectations based on previous product offerings and may apply these to circular alternatives. Depending on the type of circular products, the functionalities, quality, and appearance may differ from those of linear options. These *performance trade-offs* may create consumer skepticism, ultimately resulting in limited demand (Cantú et al., 2021; Hina et al., 2022; Luchs et al., 2010, 2012). For instance, a remanufactured phone may offer the same performance and warranty as a brand-new device, yet minor imperfections can make it less appealing to consumers who equate appearance with value.

The second dominant underlying mechanism is **information asymmetry**, which exists between value chain actors and complicates decision-making in favor of existing linear design standards. Although producers have insights into general data, they often lack granular details from upstream players (i.e., *scope 3 data gap*), which complicates the implementation of circularity, as seen in the design of toxic-free product components (upstream) or operationalization of take-back processes (downstream) (Hansen & Schmitt, 2021; Jaeger & Upadhyay, 2020a; Jäger-Roschko & Petersen, 2022; Wijewickrama et al., 2021). Information asymmetries impede *effectiveness assessments* of circular strategies (e.g., limited lifecycle assessments, lack of standardizations). Consequently, decisions on the most environmentally friendly end-of-life design implications and circular strategies, such as repair, are often hindered by a lack of insights into a given product's material composition, origins, resource values, and after-usage handling. In such cases, stakeholders face uncertainty, from an energy efficiency perspective, about whether it is more beneficial to repair and thereby extend the product's lifespan or prefer a replacement. Such asymmetries drive the difficulty in appropriately evaluating and deciding suitable circular strategies and alternative material choices and may erode trust between consumers and sellers (Guldmann & Huulgaard, 2020; Hina et al., 2022; Jaeger & Upadhyay, 2020a; Kirchherr et al., 2018).

Business Level

Three underlying mechanisms drive the barriers that hinder the innovation of circular business models (Bocken et al., 2018; Geissdoerfer et al., 2020; Ünal et al., 2018). First, **institutional inertia** creates rigid structures, siloed thinking, and legacy processes that hinder cross-functional collaboration within companies and prohibit the introduction of novel business models, organizational designs, and processes that would support scaling circular strategies at the organizational level (i.e., *organizational stumbling blocks*) (Arranz et al., 2024; Hansen & Schmitt, 2021; Hofmann & Jaeger-Erben, 2020; Santa-Maria et al., 2021; Sarja et al., 2021). Institutional inertia also drives insufficient senior sponsorship for CE, a lack of psychological safety, and a limited openness toward sustainability, often owing to an unwillingness to leave the comfort zone of daily business and manifesting in a *leadership vacuum* (Govindan & Hasanagic, 2018b; Ritzén & Sandström, 2017; Rizos et al., 2015). The barrier *reporting jungle* further exacerbates this situation through inaction. In current business practice, numerous new regulations, laws, and reporting obligations are being introduced within the European Union (e.g., Corporate Sustainability Reporting Directive, EU Taxonomy regulation) to solve environmental problems through transparency and reporting practices. However, these new settings also impose additional administrative burdens and high costs, which reinforce institutional inertia. Consequently, companies are diverted from innovation-driven approaches toward bureaucratic compliance, pressured to adopt reactive sustainability strategies instead of taking time to proactively innovate circular business models (George et al., 2021; Hummel & Jobst, 2024; Rizos et al., 2015).

The second underlying mechanism reinforcing business-level barriers is the **innovator's dilemma**. It pertains to a situation where constantly adding new features or functionalities to products—to signal technological progress (i.e., *planned obsolescence*), even though performance is improved only slightly—becomes the new normal. Such additional features jeopardize circular design, which focuses on simplicity, modularity, and accessibility, and complicate end-of-life handling (Barros & Dimla, 2021; Ellen MacArthur Foundation & IDEO, 2020; Jain, 2019; Özkan & Karataş Yücel, 2020). Furthermore, past investments (e.g., in machinery or technology) and the ongoing operation of such investments tie up significant resources (e.g., human or financial resources), creating a *resource gap* for the build-up of new resources and skills for CE, especially in small- and medium-sized companies (Hart et al., 2019; Hina et al., 2022; Rizos et al., 2015; Takacs et al., 2022). The innovator's dilemma also stimulates the tendency of companies to treat their CE strategies as a *side hustle* instead of aligning it with their core business. Pilot projects improving circular strategies often do not receive the same attention and resources as other existing products or business models, which leads to unsuccessful or slow pilot project outcomes (i.e., *pilot mania*) (Cantú et al., 2021; Guldmann & Huulgaard, 2020; Lauten-Weiss et al., 2024; Salmenperä et al., 2021).

Finally, the third underlying mechanism—the **growth paradigm**—prevents companies whose value propositions are fundamentally incompatible with ecological or circular principles (e.g., firms producing non-recyclable, fossil-based products) from preparing for their own phase-out or voluntarily renunciation of harmful economic practices for the greater good (i.e., *contradictory core business*). As a result, harmful products or suboptimal alternatives are maintained, or only incremental changes are pursued, rather than actively working toward strategic liquidation or market exit, driven in part by the interests of owners, employees, or customers. Also, *short-term pressure* (e.g., given through the requirements of delivering shareholder value) fosters a culture of short-termism among company leadership, where immediate revenue gains are prioritized at the expense of long-term sustainability and organizational resilience. This puts circular strategies at a disadvantage compared to existing linear business models, as their profitability might take longer to achieve (de Jesus & Mendonça, 2018; Hina et al., 2022; Takacs et al., 2022; Van Eijk, 2015a).

Ecosystem Level

At the ecosystem level, the **prisoner's dilemma** is the dominant underlying mechanism. It is derived from misalignments between value chain actors and from challenges faced by individual organizations in ecosystems, often owing to the limited involvement of stakeholders committed to the CE. Collaboration would be mutually beneficial, but is hindered by short-term interests and the uncertainty of involved actors. A lack of trust in the fair distribution and capture of value prevents joint action. Barriers such as complex collaborative set-ups, difficulties in building trust among actors, and a lack of transparency are significant challenges that slow down the formation of CEs (Cantú et al., 2021; Hina et al., 2022; Kanda et al., 2021; Konietzko et al., 2020b; Takacs et al., 2020).

Within this context, *asymmetric benefits* comprise a key barrier. Imbalances in value distribution within circular ecosystems, such as between an original equipment manufacturer (OEM) and a supplier, often create a disconnect between those who generate value and those who ultimately capture it. This misalignment leads to adverse incentives and mistrust, reducing motivation for collaboration despite the fundamental role of transparency and trust in enabling a CE (Berardi & de Brito, 2021; Brown et al., 2020; Evertsen & Knotten, 2024). Closely related to this challenge is the *data question*. The ability to share data across value chains and among actors delivering circular value propositions is necessary for successfully realizing CE initiatives. However, this often proves difficult owing to a lack of mutual benefits and security concerns. A lack of trust prevents open data sharing and access, as stakeholders fear that disclosing information could place them at a competitive disadvantage, again reflecting a prisoner's dilemma situation (Gupta et al., 2019; Jäger-Roschko & Petersen, 2022; Khan & Abonyi, 2022; Serna-Guerrero et al., 2022). A further barrier is represented by unproductive partnerships (i.e., *dysfunctional partnerships*), emerging from similar prisoner's dilemma conditions. In many cases, partnerships progress only to the extent of the lowest common denominator between actors, lacking a clear vision and structured plans for mutual benefit (Berardi & de Brito, 2021; Hina et al., 2022; Köhler et al., 2022; Santa-Maria et al., 2021).

Industry Level

Prevailing market structures, technology adoption, and value chain configurations present significant barriers to CE transition (Cantú et al., 2021; Geels, 2002; Hansen & Schmitt, 2021; Loorbach et al., 2017; Magnusson & Werner, 2023). Past investments in conventional, linear infrastructure (e.g., incineration plants) constitute a major industry-level barrier, again driven by **lock-ins** as the underlying mechanisms. Deviation from investments in linear infrastructure, established and optimized over decades (e.g., incineration plants or one-way shipping), is a significant challenge. As such, *infrastructure at scale* to support circular strategies (e.g., collection and recycling systems for plastics) remains lacking, exacerbated by a limited availability of partners (de Jesus & Mendonça, 2018; Markard et al., 2012b; Seto et al., 2016; Unruh, 2000b).

The **prisoner's dilemma** also drives barriers at the industry level. First, *competitive uncertainty* hinders the transition as actors are often reluctant to shift toward circular products or business models over concerns that doing so might place them at an immediate industry-wide competitive disadvantage. Many firms in highly competitive industries adopt a "wait and see" approach, delaying necessary transitions and reinforcing the status quo (Cantú et al., 2021; Jaeger & Upadhyay, 2020b; Paha, 2023; Quairel-Lanoizelée, 2011; Van De Ven & Jeurissen, 2005). Second, the prisoner's dilemma creates a *price-premium bet* barrier, in which circular alternatives are often more expensive than their linear, unsustainable counterparts, owing to unpriced externalities, such as the costs of chemical pollution for conventional fruits and vegetables. Assuming the consumers' limited willingness to pay, businesses face difficulties in justifying the price premiums of circular products. Companies that deviate and opt for the more expensive circular value creation are potentially penalized by a decline in demand. Indeed, they may have to perform within niches (Boyer et al., 2021; Hamzaoui Essoussi & Linton, 2010; Pretner et al., 2021). Third, *concentrated industry power* hinders the CE transition. Industry incumbents frequently dominate market agendas, often to the disadvantage of more sustainable businesses. This situation is also rooted in the prisoner's dilemma, where established firms, hesitant to deviate from their past successes, dictate the trajectory of market development (e.g., lobbying for a specific policy agenda). Their reluctance to explore circular alternatives makes it more challenging for emerging, sustainable substitutes to gain traction, ultimately slowing down the CE transition at an industry-wide level (Geels, 2002, 2022; Loorbach et al., 2017; Magnusson & Werner, 2023).

Society and Regulation Level

The barriers at the society and regulatory levels are driven by the mechanisms of social norms, institutional inertia, and environmental externalities. First, **social norms** play a crucial role in fostering a *culture of status consumption*, which conflicts with CE principles on the consumer side. Often, consumption is motivated by the desire to signal wealth, engage in social comparisons, or access desirable networks (Eastman et al., 1999; Goldsmith & Clark, 2012). Consequently, consumers tend to prioritize consumption volume—manifesting as overconsumption beyond essential needs—and continue to follow traditional ownership models, rather than adopting alternatives like product–service systems (Bocken & Konietzko, 2022; Camacho-Otero et al., 2018; Eastman et al., 1999; Goldsmith & Clark, 2012). Moreover, scholars have identified the *individualism versus collectivism* barrier. This barrier pertains to an ongoing societal and regulatory debate on whether the ecological challenges addressed by the CE should be tackled through the aggregation of individual behavioral and preference changes (i.e., bottom-up approaches such as reducing individual overconsumption) or through collective, top-down measures (e.g., carbon taxes or market interventions that increase the cost of consumption) (Cho et al., 2013; Ianole-Călin et al., 2020; Saracevic et al., 2022). Social norms also drive *carbon funneling*, describing the tendency to overly prioritize efforts and resources aimed at reducing carbon emissions (i.e., planetary boundary of climate change), neglecting other critical environmental issues (e.g., biodiversity loss, land system change) and creating an imbalance in how firms respond to sustainability challenges (Gallego-Schmid et al., 2020; Richardson et al., 2023b).

Institutional inertia serves as another mechanism underlying barriers across regulatory and administrative frameworks. Regulatory frameworks must balance economic activity with environmental protection while avoiding excessive bureaucracy (i.e., *regulatory dilemma*) (Kitching et al., 2015; Peng & Shen, 2024; Pickman, 1999). Similarly, standardization efforts (i.e., *excessive standardization*) must prevent administrative burdens while ensuring comparability of circularity data at the material, product, and process levels (Flynn & Hacking, 2019; Grillo et al., 2024).

Finally, scaling circular strategies is strongly reliant on profitable business models. However, achieving this requires a shift in market boundary conditions, which is strongly prevented through unpriced **environmental externalities**. An important barrier—driven by the mechanism of environmental externalities—that hinders the CE transition is the imbalance between low resource prices and high labor costs (i.e., *labor versus resource prices*). This cost structure discourages circular strategies, such as repair and refurbishment, which are labor-intensive but receive little economic incentive compared with resource extraction and virgin production. These circular strategies tend to be labor-intensive in implementation, as the given problems are poorly structured, difficult to process through automation, and thus hard to scale through technology. For example, repairing a pair of jeans involves significantly more complexity and manual effort compared with highly standardized waste incineration processes and (re)production of new products (de Jesus & Mendonça, 2018; Guldmann & Huulgaard, 2020; Kissling et al., 2013; Llorente-González & Vence, 2020; Stahel, 2013; Vence & López Pérez, 2021). Additionally, the failure to account for *nature capital value* in economic activities leads to severely underpriced market values, discouraging sustainable practices, such as circular strategies (Bateman & Mace, 2020; Baumol & Oates, 1988; Fenichel & Abbott, 2014; Rizos et al., 2016). The current socio-technical regime is significantly driven by linear, resource-extractive practices, as can be seen by the amount of subsidies (7 % of global GDP) supporting fossil fuels (IMF, 2025). Further intensifying both of these challenges is the current focus on *one-sided measures of prosperity*, particularly GDP, which prioritizes financial, economic output (driven by material throughput and resource extraction) over other social or environmental benefits, such as health or economic resilience. The situation is comparable to the dominance of growth-oriented performance indicators in companies (Costanza et al., 2009; Jackson, 2009; Kallis, 2017; Stockhammer et al., 1997).

4. Discussion: Breaking Barriers

A wide range of potential interventions exists to effectively address the identified barriers. We present a selection of those we consider particularly relevant—cross-level and interdependent—and link them to the underlying mechanisms that shape these barriers.

The CE transition can be enabled by interventions that break the quasi-irreversibility and path dependency created by ***lock-ins*** within dominant linear regimes. This possibility is illustrated by other historically fundamental transitions, such as the one from the carriage to the automobile (Berkhout, 2002). Geels (2002) recommended opening a "window of opportunity" for innovation, therefore actively bringing CE innovation out of its niche. This release can gradually destabilize existing regime configurations (in business, industry, society), potentially triggering further reinforcing changes, known as "circular causality" (Geels, 2006). On the one hand, regulatory bodies can perform "shielding" interventions—known from strategic niche management (Kemp et al., 1998)—that protect the upcoming innovation within its niche to prevent it from being crushed before scaling and usher it into the socio-technical regime (Turnheim et al., 2015). To illustrate, new material innovations (e.g., seaweed-based packaging) are often driven by start-ups or research institutes rather than established organizations (e.g., plastics packaging companies). Many circular business model innovations, such as circular as-a-service models, require development in a protected organizational space to avoid potential early conflicts with the incumbent solution (e.g., BlueMovement is an entrepreneurial spin-off of Bosch-Siemens Hausgeräte). On the other hand, firms and regulators must enable a gradual reconfiguration—simultaneously across multiple levels, ideally—to limit resistance within existing regimes (Geels, 2002). According to Geels (2006), two particularly useful interventions can be applied to the CE context. First, add-on interventions (e.g., adding equipment-as-a-service alongside traditional machine sales) can target new customer segments. Second, retrofitting and component substitution within existing infrastructure, as demonstrated by firms like Lorenz Water Meters and Renault's The Refactory, can generate cost advantages.

In its scope and magnitude, the transition from combustion engines in the car industry toward lower-carbon mobility technologies (e.g., battery electric vehicles, BEVs) serves as a good example of the break from predominant, locked-in regimes. Technology adoption typically follows an S-curve, scaling exponentially once a tipping point is reached. Enabling solutions to reach such tipping points—often signaled by cost parity, user attractiveness, and accessibility—is therefore critical (Systemiq & University of Exeter, 2023). In this case, at the product, business, and ecosystem levels, companies can work toward making BEVs cheaper than combustion engines (e.g., through cost optimization, ecosystems for process innovation, economies of scale). Several Chinese original equipment manufacturers have achieved major progress in this regard. At the ecosystem level, companies can make BEVs more fun to drive (i.e., increasing relative attractiveness) and establish an accessible network of charging stations (i.e., possible through an add-on approach, without disrupting existing fossil-based petrol station infrastructure), such as that implemented by Tesla. At the industry level, gradual infrastructure adaptation can help break lock-ins, as exemplified by Norway, which established free parking opportunities and road toll discounts to make EVs cost-competitive and more attractive in usage. Norway has also implemented society- and regulatory-level adjustments to vehicle taxation by modifying VAT and import duties for EVs.

Institutional inertia is characterized by a stickiness of established formal and informal rules and norms in business, society, and at the regulatory level, hindering CE transition. A common intervention is institutional entrepreneurship, which aims to help circular solutions move from niche into the socio-technical regime (Dorado, 2005; Hardy & Maguire, 2008; Pacheco, York, et al., 2010). According to Rosenschöld et al. (2014), who examined institutional entrepreneurship in the context of climate change, companies and their representatives must engage in power brokerage among different actors willing to drive regime change (i.e., through coalition building) and craft incentives for lowering transaction costs (i.e., making communication and negotiation more efficient). For example, the Business Coalition for a Global Plastics Treaty, convened by the Ellen MacArthur Foundation and WWF, brought together businesses and financial institutions to support the challenging global treaty negotiation process and unite businesses through a coalition of the willing. Institutional inertia in business and within government institutions can also be overcome through actively (re)shaping the public framing (Dorado, 2005). Political and societal interventions (i.e., more signals toward CE) can make it easier to mobilize resources across and within companies. For example, Zurich's public vote on a CE initiative, which was driven by different parties and companies and approved by the public, now significantly drives the actions of local authorities—both financially and ideologically. Another example is the Circular Economy Action Plan launched by the European Commission in 2015 and renewed in 2020.

Information asymmetries underlying various barriers potentially lead to market failures (i.e., insufficient allocation of resources) and hinder circular solutions owing to adverse selection and moral hazards (Goering, 1997; Rizzati & Landoni, 2024). These asymmetries can be mitigated through various interventions based on signaling, screening, contractual incentives, and the establishment of repeated interactions (Löfgren et al., 2002; Ross, 1973; Spence, 1973; Stiglitz, 1975). All these measures aim to improve market allocation in the sense of a CE—immediate and over time—by fostering information transparency and aligning the knowledge base of involved actors. Promising efforts regarding these interventions have been applied. First, to send credible signals, companies are increasingly relying on recognized certificates and standards. Emerging circular standards include DIN, ISO norms (e.g., 59004), and the Cradle-to-Cradle certificate (McDonough & Braungart, 2002). These initiatives primarily operate at the product and business levels. Meanwhile, early developments at the ecosystem and industry levels are also taking shape. For instance, consortia of companies are developing industry-wide digital product passports, as seen in the case of the battery passport (mandated by the EU Battery regulation as of 2027), to ensure transparent information and sustainable material flows. This type of intervention is implemented by Catena-X, the first European open data ecosystem designed for the automative industry. Such collaborative approaches play an important role in creating the trusted infrastructure to share information. Indeed, platforms play an increasingly important role in strengthening companies' screening capabilities. For example, Excess Material Exchange aims to facilitate the reuse of materials across companies and industries. The platform Materiom also inspires and connects circular material innovators.

To break the ***prisoner's dilemma*** and thereby address the associated barriers, the authorities require solutions that either discourage companies from persisting with linear practices (e.g., owing to short-term cost advantages or reputational concerns) or create incentives for collaboratively adhering to higher circular strategies and standards. That is, interventions that make unilateral deviation less attractive must be formulated. The prisoner's dilemma arises when competitive incentives lead to a collectively suboptimal outcome. Circular-oriented companies face disadvantages for implementing more costly yet sustainable alternatives (e.g., monomaterial, recyclable design), as these costs are not internalized by competitors who opt out of such practices for reasons of short-term self-interest (Ostrom, 1990; Pacheco, Dean, et al., 2010). Avoiding this requires institutional entrepreneurship, aimed at changing existing, linear-dominated institutions—such as the rules of the market—so that minimum standards are established, and collaboration becomes worthwhile. This, however, depends on targeted lobbying efforts explicitly oriented toward enabling the CE transition (Pacheco, Dean, et al., 2010; Pacheco, York, et al., 2010). The packaging industry serves as a good example for interventions to overcome this dilemma, requiring policy makers to introduce clear rules, such as the Packaging and Packaging Waste directive (PPWRD), to set minimum standards (e.g., recycled content quotas) that create a level playing field for innovation. Another intervention is driven by the creation of secure and interoperable data and information flows that break misaligned incentives (see SINE Foundation). In practice, this requires privacy-preserving, cross-industry standards for data exchange and analysis that account for specific values (e.g., security, reciprocity, openness) and actively fosters collaboration, such as the Partnership for Carbon Transparency (PACT) initiative by the WBCSD, which aims to develop a methodology for calculating and exchanging product-level Scope 3 data across value chains, together with leading stakeholders from industrial practice (WBCSD, 2025).

The ***innovator's dilemma***, which underlies various barriers, can be addressed if companies develop a tolerance for ambiguity between their existing linear business model and a potential new circular one—the former is typically aligned with an exploitation path, whereas the latter is understood as an exploratory innovation path (Frankenberger et al., 2020; Morseletto, 2023). Such tolerance enables them to learn to perform across both trajectories (Corso & Pellegrini, 2007). Christensen (1997) emphasized the importance of creating room and ring-fence innovation, such as by enabling new business units or entrepreneurial ventures to drive innovation, or by integrating long-term value creation metrics (e.g., Hilti's Circelligence method or the Environmental Profit & Loss accounting by Kering) to actively manage dual strategies (sustain vs. disrupt). To establish the exploration path in the context of the CE, the chemical company BASF designed a circular intrapreneurship program that allowed project leaders to apply for circular initiatives with minimal bureaucracy. These projects were funded equally by corporate and the divisions and guided through a multi-step project funnel from initial idea to market launch.

Other interventions to bridge the dilemma are partnerships and ecosystem innovation—coalitions or alliances drive circular solutions. For example, integrated value chain partnerships, such as Project STOP against ocean plastics, the Circular Electronics Partnership, and SENS for electronic recycling in Switzerland, are types of interventions that establish novel configurations in the socio-technical regime. Similarly, partnering with entrepreneurial innovators or venture builders (e.g., Antler or Carbon-13), or engaging in corporate venture capital investing, can enable access to innovation that is still in the niche. Moreover, an increasing number of circular innovation networks are aiming to bring companies together and enable ecosystem innovation partnerships. For example, the Ellen MacArthur Foundation has played a key role as a field builder for CEs in the past 15 years, facilitating a solution-focused international network. Similarly, Circular Republic, a Munich-based regional network, is following a programmatic approach to facilitate circular innovation (e.g., to close the loop on EV batteries) by uniting OEMs, suppliers, recyclers, and start-ups to develop scalable solutions for EV battery reuse and recycling.

To address the underlying mechanism of ***environmental externalities***, governments must push interventions that help internalize the full cost of all currently unpriced effects and environmental costs, both negatively (e.g., cost of pollution) and positively (e.g., value of ecosystem services) (Chava, 2014; Delucchi, 2000). Circular strategies may have a structural disadvantage if their benefit or the true cost of the linear alternative is mispriced. Practical examples are market-based instruments, such as CO_2 pricing, either through carbon markets or emission trading schemes. These are impactful regulatory interventions, as shown by the EU Emissions Trading Scheme, which applies to the electricity, aviation, and industrial manufacturing sectors. This scheme requires polluters to pay for CO_2 emissions, setting a cap that is reduced annually according to the EU's climate targets. Another example for regulatory measures that aim to support CE transition are Extended Producer Responsibility schemes, which are becoming increasingly applied (e.g., for packaging, textiles, tires) by countries to make producers responsible for products across the entire lifecycle, while creating incentives for sustainable product design choices (e.g., reduced fee for products with higher recycled content). Similarly, subsidies on clean energy for the sustainability transition are essential to counteract the high subsidies for fossil fuels. Novel approaches call for interventions that support a proper natural capital accounting, to "put nature on the balance sheet" (e.g., the case of the LandBanking Group), and establish natural capital as an asset class. In this way, ecosystem services are actually valued and can become an investable asset.

Social norms and the ***growth paradigm*** serve as fundamental frameworks that guide behavior within organizations, shape society, and influence regulations. While the former refers to broader socio-cultural expectations, the latter specifically concerns the anticipation of continuous growth within economic value creation. Social norms typically manifest in concrete ways. For example, the continuous renewal of trends fosters fast consumption patterns, as seen in ultra-fast fashion, simultaneously driven by corporate growth ambitions, which are pursued through strategies such as (influencer) marketing, planned obsolescence, and the expansion of production volumes. The deeply ingrained desire for ownership fuels new purchasing decisions, even for products that are typically underutilized, such as cars. Moreover, even when products are shared, individualistic—as opposed to collectivist—behavior can pose challenges for circular business models, as illustrated by the mindset of "don't be gentle, it's a rental." As for the growth paradigm, it is specifically attributed by Geels (2002) to the so-called landscape within the MLP framework. It represents an overarching structure that is highly resistant to change and can only be influenced through the fundamental transformation of socio-technical regime configurations. Together, social norms and the growth paradigm shape the "rules of the game" (Geels & Schot, 2007) through implicit views, preferences, and expectations—rules that must be reoriented in the light of a CE.

Interventions to address these mechanisms include social activism (e.g., environmental movements, demonstrations) as well as educational awareness campaigns (e.g., documentaries, influencers) (Akemu et al., 2016; Ho et al., 2022). Policymakers have a critical role to support the structural shift against accelerated consumption. Scaling reuse (e.g., adapted VAT for second-hand products in Sweden) and longer product life (e.g., repair bonus in Austria) may lead to achieving the same benefits for society with less production. At the societal level, the International Resource Panel (2024) suggested that greater focus must be placed on *provisioning systems* (i.e., nutrition, mobility, built environment) to identify less resource-intensive ways of meeting human needs while advancing shared sustainability objectives.

To address the growth paradigm, governments and businesses need to think about alternative measures of prosperity at the business and society levels. At the company level, alternative key performance indicators that account not only for sales volumes but also circular strategies can help redirect managerial attention away from pure volume growth toward more sustainable value creation and capture. At the societal level, alternative metrics can be used to assess well-being, such as the Genuine Progress Indicator (GPI). Unlike GDP, the GPI incorporates economic, social, and environmental dimensions, offering a more comprehensive reflection of a country's overall progress. Other examples of relevant global movements are the Economy of the Common Good or the "Enkelfähig" community (i.e., pushing for generating value for generations). More fundamentally, the *sufficiency* movement promotes reduced consumption through moderation and simplicity, enabling CEs by ensuring that resource loops are not only closed but also slowed and scaled down.

"Moving away from our current inefficient, linear logic, which creates waste, risks, and pollution, and toward a circular, resource-efficient world economy that operates within the finite and absolute budgets provided by the planetary boundaries" requires "systematic deep innovation and transformation," as emphasized by leading climate scientist Johan Rockström (2024). For transitioning to socio-technical regimes in favor of a CE and compatible with planetary boundaries, we must break several of the key barriers illustrated in this article. Numerous practical interventions can tackle the underlying mechanisms of the barriers and overcome siloed interventions and incremental improvements. A cross-level, collective approach to building ecosystems, pioneering leadership, and supportive regulatory conditions may help speed and scale up the much-needed CE transition.

Table 1. Most relevant circular economy (CE) barriers and their most dominant underlying mechanisms

	Underlying mechanisms							
CE Barrier	Lock-ins	Institutional inertia	Information asymmetry	Prisoner's dilemma	Innovator's dilemma	Environmental externalities	Social norms	Growth paradigm
Product								
Design domino effect: Previous design decisions (across the value chain) create a linear path dependency, hindering the implementation of the design changes needed to support circular strategies (e.g., modularity) (Cantú et al., 2021; Guldmann & Huulgaard, 2020; Hansen & Schmitt, 2021; Kumar et al., 2019).	X							
Performance trade-offs: Circularity-driven choices (e.g., material, design, feature) compromise the primary product performance (e.g., regarding functionality or aesthetics), leading to consumer dissonance manifesting in limited consumer interest or demand (Cantú et al., 2021; Hina et al., 2022; Luchs et al., 2010, 2012).	X							
Scope 3 data gap: A lack of transparency about upstream and downstream product data (e.g., material composition) complicates the innovation of novel products, their designs, and tack-backs (Cantú et al., 2021; Hansen & Schmitt, 2021; Jaeger & Upadhyay, 2020a; Jäger-Roschko & Petersen, 2022; Wijewickrama et al., 2021).			X					
Effectiveness assessment: Challenging evaluations of the effectiveness of potential circular strategies (e.g., unclear reuse cycles) and material composition (e.g., recycling content), given limited lifecycle assessment insights, a lack of standardizations, and baseline measurements, can erode trust between consumers and sellers (Guldmann & Huulgaard, 2020; Hina et al., 2022; Jaeger & Upadhyay, 2020a; Kirchherr et al., 2018).			X					

CE Barrier	Underlying mechanisms							
	Lock-ins	Institutional inertia	Information asymmetry	Prisoner's dilemma	Innovator's dilemma	Environmental externalities	Social norms	Growth paradigm
Business								
Organizational stumbling blocks: Existing (rigid) structures, siloed thinking, and legacy processes hinder CE investment and cross-functional collaboration. CE remains isolated (e.g., in projects) rather than integrated across divisions (Arranz et al., 2024; Hansen & Schmitt, 2021; Hofmann & Jaeger-Erben, 2020; Santa-Maria et al., 2021; Sarja et al., 2021).		X						
Leadership vacuum: Weak leadership support (e.g., lack of senior sponsorship), psychological safety (e.g., tolerance for mistakes), openness toward sustainability, and operational decision-making hinder the development of circular strategies (Govindan & Hasanagic, 2018b; Ritzén & Sandström, 2017; Rizos et al., 2016).		X						
Reporting jungle: Organizations are occupied with measuring, aggregating, and processing data, leading to increased administrative costs attributable to compliance-driven reporting requirements. Thus, they have less time to formulate a cohesive sustainability strategy. Consequently, they foster a reactive approach to a CE (e.g., focus on communicable goals instead of actual internalization), instead of a proactive and innovation-driven one (George et al., 2021; Hummel & Jobst, 2024; Rizos et al., 2016).		X						
Planned obsolescence: This pertains to the tendency to incorporate unnecessary functionalities and features (c.f., feature creep) in products and services, as companies aim to signal (technological) progress to their stakeholders (e.g., customers). This drives planned obsolescence, including the prioritization of sales stimuli over eco-friendly products and business model innovation (Barros & Dimla, 2021; Ellen MacArthur Foundation & IDEO, 2020; Jain, 2019; Özkan & Karataş Yücel, 2020).					X			

CE Barrier	Underlying mechanisms							
	Lock-ins	Institutional inertia	Information asymmetry	Prisoner's dilemma	Innovator's dilemma	Environmental externalities	Social norms	Growth paradigm
Resource gap: Lack of funding, knowledge, time, and labor slows CE implementation. Daily demands limit capacity for further development. Progress requires skilled human resources (Hart et al., 2019; Hina et al., 2022; Rizos et al., 2015; Takacs et al., 2022).					X			
Pilot mania and side hustle: Circular practices are peripheral to and misaligned with a company's core mission and strategy, focusing on incremental innovation that leads to weak sustainability changes. Without strategic focus or immediate monetization, efforts stall at the pilot phase. This results in fragmented efforts, limited commitment, and insufficient resources (Cantú et al., 2021; Guldmann & Huulgaard, 2020; Lauten-Weiss et al., 2024; Salmenperä et al., 2021).					X			
Contradictory core business: Companies' core value propositions are incompatible with environmental sustainability (e.g., oil processing, fossil-based products). While business liquidation may align with ecological goals, it conflicts with economic survival (e.g., driven through the will to survive of owners, employees, or customers), leading companies to avoid environmentally superior options (i.e., different, fewer, or no products at all) and rather prioritize harmful products, overlooking the ecological necessity of (parts of) their existence.								X
Short-term pressure: Short-term focus arises in response to pressures from shareholders (e.g., capital markets, owners) and financial institutions. Quarterly earnings, annual targets, and sales incentives lead to a prioritization of immediate sales over long-term strategy, sustainability, and resilience (de Jesus & Mendonça, 2018; Hina et al., 2022; Takacs et al., 2022; Van Eijk, 2015b).								X

CE Barrier	Underlying mechanisms								
	Lock-ins	Institutional inertia	Information asymmetry	Prisoner's dilemma	Innovator's dilemma	Environmental externalities	Social norms	Growth paradigm
Ecosystem								
Asymmetric benefits: Imbalanced value distribution in CEs create a disconnect between value creation and capture. Asynchronous benefits, mistrust, and adverse incentives reduce motivation to collaborate (Berardi & Peregrino de Brito, 2021; Brown et al., 2020; Evertsen & Knotten, 2024).				X				
Data question: This challenge highlights issues with data availability, security, and openness in CEs. Limited access, lack of mutual benefits, and security concerns hinder collaboration and data-driven decision-making (Gupta et al., 2019; Jäger-Roschko & Petersen, 2022; Khan & Abonyi, 2022; Serna-Guerrero et al., 2022).				X				
Dysfunctional partnerships: Partnerships lack momentum and clear guidance, delaying CE implementation. Progress is often stalled by the lowest common standard among participants (Berardi & de Brito, 2021; Hina et al., 2022; Köhler et al., 2022; Santa-Maria et al., 2021).				X				
Industry								
Infrastructure at scale: The infrastructure for circular strategies is insufficiently established in industries, with limited partners (e.g., for reverse logistics). Issues with material recovery (e.g., non-existence of secondary material markets) hinder recycled material availability and demand fulfillment. Past investments lead to dependence on existing technologies and hinder the adoption of circular alternatives, reducing the willingness to change. Prospective path dependencies arise from future anticipations, limiting flexibility and innovation (de Jesus & Mendonça, 2018; Hansen & Schmitt, 2021; Markard et al., 2012a; Unruh, 2000a).	X							
Competitive uncertainty: Fears of disadvantages in highly competitive industries lead to a "wait-and-see" approach. Companies hesitate to change over concerns about first-mover risks. Low margins do not allow any scope for deviations from present strategies (Cantú et al., 2021; Jaeger & Upadhyay, 2020b; Paha, 2023; Quairel-Lanoizelée, 2011; Van De Ven & Jeurissen, 2005).				X				

CE Barrier	Underlying mechanisms							
	Lock-ins	Institutional inertia	Information asymmetry	Prisoner's dilemma	Innovator's dilemma	Environmental externalities	Social norms	Growth paradigm
Price-premium bet: This pertains to the practice of expecting that circular solutions will be financed directly by customers willing to pay a premium for sustainability. If this willingness to pay does not materialize (e.g., recycled products are seen as not clean), the solution fails to achieve market penetration. This reliance on a premium segment ultimately prevents broader adoption (Boyer et al., 2021; Hamzaoui Essoussi & Linton, 2010; Pretner et al., 2021).				X				
Concentrated industry power: Incumbents dominate industry agenda, often disadvantaging sustainable companies. This power concentration discourages deviation from established success, slowing progress toward CE practices (Geels, 2002; Loorbach et al., 2017; Magnusson & Werner, 2023).				X				
Society/Regulation								
Culture of status consumption: Social status drives consumption by influencing individuals' desire to signal wealth, engage in comparison, and turn consumption into an end in itself. In a CE, consumers reuse products, shift away from a disposable mindset, and foster sustainability awareness. However, some consumers perceive circular products as of a lower quality or prefer traditional purchasing methods over as-a-service models (Bocken & Konietzko, 2022; Camacho-Otero et al., 2018; Eastman et al., 1999; Goldsmith & Clark, 2012).							X	
Individualism versus collectivism: The tension between individualism and collectivism shapes societal views on responsibility in the socioeconomic system. Individualism emphasizes autonomy and personal accountability, whereas collectivism prioritizes shared responsibility and cooperation (Cho et al., 2013; Ianole-Călin et al., 2020; Saracevic et al., 2022).							X	

CE Barrier	Underlying mechanisms							
	Lock-ins	Institutional inertia	Information asymmetry	Prisoner's dilemma	Innovator's dilemma	Environmental externalities	Social norms	Growth paradigm
Carbon funneling: This refers to the tendency to overly prioritize efforts and resources toward mitigating carbon emissions and addressing climate change, while neglecting other planetary boundaries that have been surpassed or are at risk of being exceeded. This narrow focus on carbon can lead to an imbalance in addressing broader environmental issues, such as biodiversity loss and land degradation (Gallego-Schmid et al., 2020; Richardson et al., 2023b).							X	
Regulatory dilemma: Regulations must balance economic activity and planetary boundaries. Overregulation stifles innovation; weak regulations cause environmental harm, social injustice, and market failure (Kitching et al., 2015; Peng & Shen, 2024; Pickman, 1999).		X						
Excessive standardization: Standards can set a uniform understanding of CEs across material, product, and process levels, ensure quality standards, and allow for data exchange. However, standardization also creates a heavy administrative burden, bureaucracy, and unanticipated behavioral rebound effects, like changes in consumer perceptions (Flynn & Hacking, 2019; Grillo et al., 2024).		X						
Labor versus resource prices: Low resource costs incentivize production-focused (e.g., pressure for virgin materials) methods over circular strategies. This favors incineration and recycling over labor-intensive practices like repair or refurbishment. High labor taxation amplifies this. However, the execution of work by humans is generally more ecological than the use of machines and raw materials (de Jesus & Mendonça, 2018; Guldmann & Huulgaard, 2020; Kissling et al., 2013; Llorente-González & Vence, 2020; Stahel, 2013; Vence & López Pérez, 2021).						X		

CE Barrier	Underlying mechanisms							
	Lock-ins	Institutional inertia	Information asymmetry	Prisoner's dilemma	Innovator's dilemma	Environmental externalities	Social norms	Growth paradigm
Nature capital value: The true environmental costs of economic activities are not incorporated in market prices. Negative externalities (e.g., pollution) are not factored into the cost of goods and services, leading to underpricing and a misallocation of resources. Ecosystem services (e.g., pollination) are undervalued. This discourages the adoption of sustainable practices (Bateman & Mace, 2020; Baumol & Oates, 1988; Fenichel & Abbott, 2014; Rizos et al., 2016).						X		
One-sided measures of prosperity: Established metrics prioritize economic output over broader well-being, limiting incentives for circular strategies. GDP, for instance, overlooks societal and environmental benefits, reinforcing a focus on monetary transactions and economic growth (Costanza et al., 2009; Jackson, 2009; Kallis, 2017; Stockhammer et al., 1997).						X		

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