Letter

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A Perspective on Circular Innovation: Dynamics, Strategies, and Implications

Ruth Cherrington[1], Eduardo A Llano[2], Rosen Dimov[3], and Ananya Bhattacharya[4]

[1]University of Exeter, Business School, Department of Management, Sustainable Futures, United Kingdom, TR10 9FE | *R.Cherrington@exeter.ac.uk*
[2]Department of Marketing, Management and International Business, Oulu Business School, University of Oulu, Finland | *Eduardo.AcostaLlano@oulu.fi*
[3]Soós Ernő Research and Development Center, Renewable Energy Research Group, University of Pannonia, Hungary | *dimov.rosen@pen.uni-pannon.hu*
[4]Department of Management, Monash University, Australia | *ananya.bhattacharya@monash.edu*

Abstract

This Letter considers the multifaceted realm of circular innovation, shedding light on its dynamics, strategic implications, and broader significance for sustainable development. By evaluating existing research and exploring examples across sectors, this work contributes to a deeper understanding of the role of circular innovation in transforming industries, economies, and societies. Although the topic has received increased interest in recent years, we find that there are notable gaps. While significant attention has been given to initial adoption and expansion, there is a lack of understanding regarding the enduring impacts on businesses and society. Further research addressing these gaps can enrich our understanding of the challenges and opportunities in this evolving field.

Keywords: Circular economy, Innovation, Business, Policy, Society.

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1 Introduction

Circular innovation represents the convergence of two distinct but interconnected fields of study. It brings together the principles of sustainable resource management from the Circular Economy (CE) with the dynamic processes of creative change and advancement inherent in innovation. The CE is a regenerative economic system that aims to maximize the use of resources, minimize waste, and create value through the continuous circulation of products, materials, and resources (Stahel, 2016). It seeks to shift away from the traditional linear 'take-make-dispose' model to a circular model that emphasizes longevity, reuse, remanufacturing, and recycling (Hopkinson, Zils, Hawkins, & Roper, 2018). CE principles address resource scarcity, environmental degradation, and the unsustainability of traditional consumption and production patterns. Innovation encompasses the generation, development, and implementation of novel ideas, processes, products, or services that create value and drive positive change (Bahrami, Atkin, & Landin, 2019). It is often associated with technology and product development, but it extends to organizational, social, and systemic changes (Zaffiro & Mourgis, 2018). Innovation involves creativity, risk-taking, experimentation, and adaptation to evolving contexts. It is a driving force behind economic growth, competitiveness, and societal progress (Vollenbroek, 2002). Bridging these two fields of study comes the concept

of circular innovation that embeds the principles of the CE into the processes and outcomes of innovation. It leverages innovation to design, develop, and implement solutions that align with CE principles.

Circular innovation is not a monolithic concept but rather a complex, multifunctional, and dynamic phenomenon. It spans various stages, from ideation and design to implementation and diffusion, involving diverse stakeholders, industries, and domains. The life cycle and evolution of circular innovation are characterized by intricate interplays between technological, organizational, and societal dynamics. Collaboration, co-creation, and stakeholder engagement emerge as critical drivers of circular innovation success, underscoring the need for cross-sectoral partnerships and participatory approaches (Eisenreich, Füller, & Stuchtey, 2021).

Considering these intricate dynamics, a central question emerges: What strategies and mechanisms can harness the integrated principles of circular innovation to foster the emergence of highly impactful and sustainable paradigms in business models, technological advancements, and policy frameworks? To address this, we need to understand the complex interplay of elements within circular innovation dynamics and seeks to unveil their collective potential in instigating profound and transformative shifts across a spectrum of industries. In response to this, we begin by considering the background literature on circular innovation. First it explores the life cycle and evolution of circular innovation, tracing its trajectory from ideation to implementation and diffusion. It continues by examining various strategies adopted by organizations to embrace circular innovation and then delves into the broader impacts of circular innovation, both on socioeconomic and environmental dimensions. It concludes by highlighting gaps in literature and avenues for further research.

2 Background Literature

2.1 Dynamics of Innovation

Traditionally, circular innovation has been conceptualised as a dynamic, iterative process evolving through various stages, from ideation to implementation and diffusion (Bocken, Pauw, Bakker, & Grinten, 2016; Geissdoerfer, Savaget, Bocken, & Hultink, 2017). The transition from linear to circular models has been understood to involve not just technological changes but also shifts in business models and consumer behaviour (Lieder & Rashid, 2016). Understanding how innovations enter and alter organisations can reveal several techniques for embracing innovation as a creative force for incorporating circular principles (de Jesus, Antunes, Santos, & Mendonça, 2018).

The journey of circular innovation commences with ideation, the conceptualization of novel approaches to address resource constraints and sustainability challenges (de Jesus et al., 2018). It then progresses through design, experimentation, and prototyping, where circular principles are infused into products, services, or processes (Geissdoerfer, Vladimirova, & Evans, 2018). Subsequently, successful ideas enter the implementation phase, marked by piloting and scaling to demonstrate their viability and impact (Guzzo, Trevisan, Echeveste, & Costa, 2019). As innovations gain traction, they move into the diffusion stage, reaching broader markets and sectors. This life cycle is often iterative, as feedback loops prompt refinements, adjustments, and the emergence of advanced iterations, leading to a continuous cycle of innovation (Konietzko, Bocken, & Hultink, 2020).

Recent global shifts have prompted businesses to reassess their traditional models. The rise of digital technologies, changes in consumer behaviors and preferences, environmental concerns, geopolitical transformations, and economic fluctuations are among the key factors. These changes have significantly impacted how businesses function, sell products, interact with customers,

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and manage resources. Recovery and resilience have been in the research focus (Kennedy & Linnenluecke, 2022), justifying and evaluating the benefits of circular innovation for businesses using existing performance measurement tools. This has led to a pressing need for new evaluative frameworks that can effectively capture the complexities of a post-pandemic world. New models that incorporate non-market-based environmental goods valuation methods (Nandi, Hervani, Helms, & Sarkis, 2023) have recently been proposed that allow for simultaneous, real-time observation and enhancement of the supply value chain.

Collaboration emerges as a cornerstone of circular innovation dynamics. Circular initiatives frequently involve a multitude of stakeholders, ranging from businesses and governments to civil society and academia. Collaboration transcends traditional boundaries, allowing diverse actors to pool their expertise, resources, and perspectives (Geissdoerfer, Bocken, & Hultink, 2016). Co-creation, the joint development of solutions among stakeholders, is pivotal. Virtual or embedded networks and communities of practice (Cherrington et al., 2023) harness collective intelligence, fostering the generation of innovative ideas, cross-fertilization of knowledge, and the convergence of various disciplines. Effective collaborations necessitate transparent and ongoing communication (Santa-Maria, Vermeulen, & Baumgartner, 2022), facilitating the continuous exchange of information concerning material locations, conditions, components, and the presence of hazardous substances. Such information exchange contributes to identifying the most efficient methods for material use. Companies should possess the capacity to evaluate whether a circular approach is superior to conventional solutions. Moreover, a comprehensive understanding of the boundaries of our production model is essential. It is a fundamental misunderstanding to assume that human activities are dis-embedded and do not have an environmental impact. We engage in essential activities for the maintenance of life and for sustaining individual health and well-being like eating, transportation, clothing, accessing healthcare, education, and obtaining water and food. However, we must gain a precise understanding of the extent to which we are depleting Earth's resources and how we can regenerate them before they run out.

The dynamics of circular innovation are further influenced by a complex interplay of technological, organisational, and societal factors. Technological advancements have been gaining force to become a key enabler in circular systems (Korhonen, Nuur, Feldmann, & Birkie, 2018). Organisational factors, including leadership and corporate culture, also play a significant role (Chowdhury et al., 2022). In the societal domain, consumer awareness and regulatory frameworks are major drivers (Ghisellini, Cialani, & Ulgiati, 2016). The convergence of these dynamics often shapes the pathways for circular innovation, making it a multi-dimensional construct (Prieto-Sandoval, Jaca, & Ormazabal, 2018). Considering these dynamics, organizations can leverage interconnected strategies to catalyze circular innovation, we explore this in the next section.

Open innovation platforms and innovation ecosystems cultivate spaces where actors with complementary skills and insights collaborate, accelerating the translation of circular ideas into tangible innovations (Lähteenmäki & Töyli, 2023). For many people, online platforms have become indispensable to enable engagement in a new 'hybrid world' (Cherrington et al., 2023). They help to manage data streams, economic connections, and social interactions among users. These online platforms have been highlighted as a key enabler for a CE (Lewandowski, 2016). Engaging stakeholders at various stages of the innovation process ensures that solutions align with real-world needs, preferences, and contextual complexities (Watson, Wilson, Smart, & Macdonald, 2018). Inclusive engagement invites input from end-users, suppliers, policymakers, non-governmental organizations, and local communities, facilitating the integration of diverse perspectives. This inclusive approach not only enhances the quality and relevance of circular innovations but also

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fosters a sense of ownership and commitment among stakeholders, contributing to the sustainable adoption and diffusion of circular practices.

2.2 Strategies for Circular Innovation

According to Konietzko et al., (2020) there are five interconnected strategies that organizations can use to catalyze circular innovation. These strategies may require a product, business model, or ecosystem approach. Initially, three were suggested by Bocken et al., (2016). The first strategy proposes that businesses simply use less and 'narrow' their usage of goods, components, materials, and energy during design and manufacturing (Baumann, Boons, & Bragd, 2002). This strategy also includes the stages of delivery, usage, and recovery. The second strategy proposes that organisations can 'slow' the usage of goods, components, and materials to keep them in the economy for a longer time (Bocken et al., 2016). Design for physical durability is an approach which retains performance over time (den Hollander, Bakker, & Hultink, 2017). The third strategy proposes that organisations may 'close' loops by reintroducing post-consumer waste into the economic cycle (Bocken et al., 2016). A closing product approach is to create using materials that are suitable for primary recycling.

Subsequently, Konietzko et al., (2020) added two further strategies to the field. The strategy 'regenerate' was developed to account for two additional features that were significant in the early development of the CE (McDonough & Braungart, 2010). This emphasises the use of non-toxic chemicals (Cardoso et al., 2009), while considering the need to increase the use of renewable resources and energy in a CE (Stahel, 2008). Regenerating is an economic activity that maintains and supports natural ecosystem services. This approach primarily addresses the CE's biological cycle, but it also includes parts important to the technological cycle, particularly with relation to the use of renewable energy (Konietzko et al., 2020). Finally, the support strategy 'inform' was introduced because various researchers and practitioners have emphasised the importance of data in enabling a CE.

The use of artificial intelligence (The Ellen MacArthur Foundation, 2019), the internet of things (Bocken, Ingemarsdotter, & Gonzalez, 2019), big data (Xu, Cai, & Liang, 2015), or online platforms (Konietzko, Bocken, & Hultink, 2019) have all been highlighted. While using data might help to increase environmental sustainability, it may also have negative consequences (Nobre & Tavares, 2017), such as the greater energy needs of digital infrastructure (Bocken et al., 2019). It is also critical to emphasise that data should be considered as a technique to accomplish an end goal rather than the final goal itself.

Circular design lies at the heart of these strategies, aligning product creation with the principles of the CE (Piller, 2023). By focusing on modular components, recyclable materials, and repair-friendly designs, circular design enables products to be easily disassembled, refurbished, and reintroduced into the value chain, minimizing waste and resource depletion (Atta, Bakhoum, & Marzouk, 2021). Product stewardship extends this commitment beyond design, emphasizing the role of manufacturers in supporting repair, reuse, and recycling efforts (Degenstein, McQueen, Krogman, & McNeill, 2023). It embodies the transition from linear consumption to a circular model, where products are valued for their durability and potential for continuous use (den Hollander et al., 2017). Remanufacturing emerges as a tangible embodiment of circular innovation, presenting economic and environmental advantages (Sundin, 2018). By reconditioning used products, remanufacturing not only conserves resources but also reduces the need for raw materials and energy-intensive production processes (Han, Heshmati, & Rashidghalam, 2020). Resource optimization complements these strategies, focusing on reducing waste, enhancing efficiency, and minimizing the environmental footprint of production processes (Zhang, Du, & Wang, 2018). It

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involves approaches such as lean manufacturing, sustainable sourcing, and eco-efficient production techniques (Tukker, 2015).

These strategies not only drive circular business models but also lead to various positive implications. They can enhance resource efficiency, reduce environmental impact, foster customer loyalty, and boost revenue through novel service offerings (Oghazi & Mostaghel, 2018). Additionally, embracing circular innovation strategies contributes to organizations' resilience by mitigating the risks associated with resource scarcity and regulatory changes (Gomes, Castillo-Ospina, Facin, Ferreira, & Ometto, 2023).

2.3 Socioeconomic and Environmental Implications

Circular Economy (CE) not only promises superior quality and safer products for consumers (Beske, Land, & Seuring, 2014), but it also fosters a community-centric approach to waste reduction (Govindan & Hasanagic, 2018). This community focus not only enhances the quality of life but also promotes inclusivity and social cohesion (Newman & Dale, 2020). By prioritizing waste reduction and sustainable practices, CE contributes to creating more resilient and connected communities, aligning with social sustainability goals (Smith & Sharicz, 2011).

CE's impact on social sustainability extends further. The adoption of circular principles in industries like food and agriculture encourages regenerative food production and reduction of food waste (Bocken et al., 2016; Charonis, 2012). This shift not only addresses environmental concerns but also plays a crucial role in ensuring food security and reducing disparities in access to nutritious food (Mazur & Curtis, 2008). Communities benefit from improved access to healthier and more sustainably produced food, promoting better public health outcomes and fostering equitable development (Monsivais et al., 2021). By incorporating CE practices, businesses can create employment opportunities and empower local communities. For instance, the integration of circular models often demands new skills and workforce training, potentially leading to increased employment rates (European Commission, 2018). Moreover, CE's emphasis on localized production and consumption can bolster local economies by supporting small and medium-sized enterprises (SMEs) and fostering entrepreneurship within communities (Ranta et al., 2021).

While circular innovation delivers many social benefits, it equally champions long-term economic value for businesses. By adapting operations, businesses enhance eco-efficiency, paving the way for sustained cost reductions (Klewitz & Hansen, 2014) and holistic, sustainable growth (Brown, Bocken, & Balkenende, 2019). Empirical studies underscore the positive correlation between circular innovation and potential improvements in economic sustainable performance (Dey et al., 2020; Rodríguez-Espíndola et al., 2022). For instance, it could generate opportunities for new skills, projecting a net increase of 6 million jobs by 2030 (International Labour Organization, 2018), and unlock a $4.5 trillion economic opportunity by the same year (Accenture, 2015).

When effectively implemented, circular innovation becomes a cornerstone for businesses and nations to meet multiple sustainability agendas and attain the United Nations Sustainable Development Goals (SDGs). Circular Economy efficiently utilizes resources by minimizing inputs and eradicating waste and emissions, directly contributing to sustainable production and consumption (SDG12) and indirectly supporting other SDGs like SDG1 (no poverty) and SDG2 (zero hunger). Therefore, despite the initial costs of transitioning from traditional business models to circular ones, circular innovation promises to deliver global sustainability goals and enduring value through multi-industry collaboration.

Yet, our perspective on emissions and pollution demands a reevaluation. Not all contamination proves inherently detrimental; the key lies in gauging specific activities' impact against the Earth's capacity to absorb them (Ford et al., 2022). It's crucial to strategize the gradual

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replacement of less sustainable practices with better alternatives. Even if we integrate the most eco-friendly materials and adopt circular production methods, some environmental impact remains unavoidable. Aspirations for zero emissions, zero waste, and a zero-carbon footprint might mislead, fostering the illusion of eliminating our negative impact. Instead, prioritizing education and further understanding natural ecosystems' functioning can guide us toward harmonious coexistence rather than an unattainable ideal. It seems we've been dangling an unending carrot in front of ourselves, contributing to missing targets like those set in the Kyoto Protocol over two decades ago, while compromising on the 2030 Agenda with less than seven years to fulfill it.

3 Avenues for research, policy and practice

3.1 Challenges and Barriers

While the concept of the CE has garnered significant attention from various stakeholders, including practitioners, scholars, and politicians, achieving comprehensive integration remains an uphill battle. According to the Circularity Gap Report for 2023, the global economy currently operates at a circularity level of only 7.2% (Fraser, 2023). This represents a declining trend from 9.1% in 2018 and 8.6% in 2020, emphasizing the substantial gap that exists between our current state and the zero-waste goal at the heart of the CE (Fraser, 2023). Despite the numerous potential benefits it holds for businesses, ecology, and society as a whole, realizing these advantages is becoming increasingly challenging.

Numerous barriers to the growth of circular innovations have been identified within the scientific community (illustrated in Figure 1) (De Jesus & Mendonça, 2018). These hurdles encompass increased costs, intricate supply networks, inadequate collaboration, limited information sharing, a dearth of specialized skills, constraints on product quality, and a significant absence of disassembly and recovery processes (Jaeger & Upadhyay, 2020). Obtaining circular materials has become a more costly choice for many stakeholders compared to readily available virgin materials (Corvellec, Stowell, & Johansson, 2021). This trend is observed across diverse industries, including textiles (Piller, 2023), building materials (Guerra & Leite, 2021), medical devices (MacNeill et al., 2020), and minerals (Rankin, 2011). Regrettably, the CE is progressively being adopted as a mere slogan by various stakeholders, often symbolizing positive intentions rather than comprehensive implementation. While the CE's foundational principles of recycling, reusing, and reducing are central, the focus often remains primarily on the first two (Reike, Vermeulen, & Witjes, 2018). For example, plastic manufacturers promote the use of recycled materials, but it's crucial to acknowledge that plastic's recyclability is not limitless, and in some cases, recycling can have a more detrimental environmental impact (Alsabri & Al-Ghamdi, 2020). Consequently, this trend results in an increased production of plastics, emphasizing reusing and recycling while sidelining the principle of reduction (Organisation for Economic Cooperation and Development, 2022).

Although collaboration has been highlighted as a cornerstone of circular innovation dynamics, in practice, a lack of collaboration among key parties appears to be a common factor in the failure of many circular innovation efforts (Eisenreich et al., 2021). For instance, the complex structure of electronics necessitates collaboration between producers, recyclers, and regulatory organizations in electronic waste (e-waste) recycling. Without this collaboration, recycling projects falter, leading to insufficient collection infrastructure, improper disposal, and a lack of standardized recycling procedures. The fashion and textile industries have encountered similar challenges in pursuing circular innovation through textile recycling (Piller, 2023). Efficient collaboration among fashion labels, textile manufacturers, and recycling facilities is vital due to the diverse materials involved. Without such collaboration, the development of a streamlined infrastructure for sorting,

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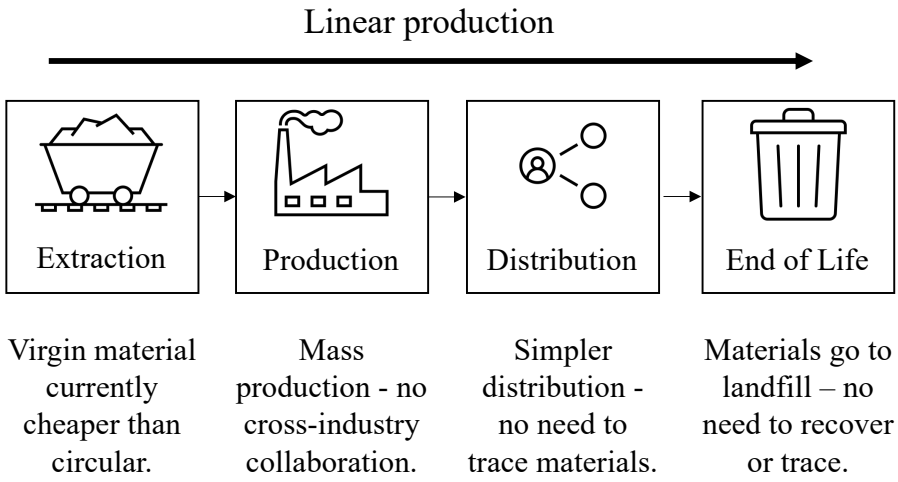

Figure 1. Challenges actors face adopting circular practices over linear production

processing, and reintegrating recycled fabrics into new fashion products is hindered (Riemens, Lemieux, Lamouri, & Garnier, 2021). Across industries, a lack of coordination among producers, recycling facilities, and governments has impeded circular innovation (Johansen, Christensen, Ramos, & Syberg, 2022). Inconsistent labeling standards and recycling practices have confused consumers and complicated recycling efforts (Scott, 2023)(Manolchev, 2022). Additionally, without collaborative product design for recyclability (Bocken et al., 2016), the recycling process becomes more intricate, diminishing the potential for a closed-loop plastic recycling system. Collaboration is equally crucial in addressing food waste reduction within supply chains, involving producers, distributors, retailers, and consumers. Without effective teamwork, managing waste from surplus food remains a significant challenge, with suboptimal redistribution efforts and underutilization of excess food. Even in the concept of circular cities, where various urban sectors collaborate to create self-sustaining ecosystems, synergies are essential (Ellen MacArthur Foundation, 2019). Inadequate coordination among urban planners, waste management agencies, energy providers, and other stakeholders can result in inefficient waste management, poor energy recovery, and the underutilization of municipal resources.

To address these challenges and capitalize on missed opportunities, strategic policymaking and effective public governance are imperative. In the next section, we will explore how well-crafted policy frameworks and public governance processes can facilitate and accelerate the transition to a truly CE, paving the way for comprehensive realization of circular technologies and their wide-ranging benefits by resolving legislative loopholes and harmonizing stakeholders' interests (Morseletto, 2020).

3.2 Policy and Governance

The core of the CE, as highlighted earlier, hinges on collective cooperation, involving individuals, businesses, institutions, and governments (Ellen MacArthur Foundation, 2023b). However, a notable challenge emerges from the global disparity in regulations and policy frameworks, which vary in scope and strictness. Differences among countries in waste management regulations result in an uneven playing field for producers and companies aiming to adopt CE principles. In regions with more lenient regulations, material recovery is less constrained, leading to cost-effective and streamlined manufacturing processes (Salmenperä, Pitkänen, Kautto, & Saikku, 2021). This

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puts pressure on firms in areas with stricter regulations, often pushing them toward conventional practices instead of the circular approach.

The lack of consistent rules and conditions in waste management not only makes competition unfair but also hampers new policy ideas. This leads to a paradox: governments trying to control waste strictly are unintentionally slowing down the adoption of CE practices. As a result, the benefits of the CE aren't clear. This raises some key questions: How can governments continue to support circular initiatives when people can't see the benefits for society, the environment, and the economy? How can governments encourage both businesses and individuals to embrace CE practices? How can policymakers access reliable information that's the same across different regions?

In various countries, including Germany, Sweden, the Netherlands, and the UK, notable projects support the CE. Extended Producer Responsibility (EPR) programs, like those in Germany, place the onus on manufacturers to manage their products through their entire lifecycle, including collection, recycling, and safe disposal, notably reducing waste, especially in packaging materials. Waste-to-energy initiatives, successfully implemented in countries such as Sweden, transform waste into a valuable resource, reducing landfill waste and generating renewable energy. Circular procurement, exemplified by governments in the Netherlands and Belgium, prioritizes eco-friendly products and services, driving demand for sustainable alternatives and promoting circular supply chains. Tax incentives, as seen in the UK, provide benefits to companies investing in recycling technologies, encouraging environmentally responsible choices, and reducing corporate ecological impact. These examples showcase innovative government programs at the local level. However, they currently operate in relative isolation (Grafström & Aasma, 2021) highlighting the ongoing need for enhanced global cooperation to optimize resource utilization on a global scale, fostering interconnectedness and equitable conditions for all countries and regions.

In these developed countries, policies often focus on fostering innovation, advancing technology, and implementing strict regulations to promote circular practices. These nations usually have well-established infrastructure and resources for waste management, recycling facilities, and sustainable production methods. However, developing countries often lack the infrastructure and financial resources necessary to implement comprehensive CE policies (Henrysson & Nuur, 2021). They tend to focus on capacity building, technological transfer, and collaboration with international partners. They may prioritize strategies like waste management improvements, promoting eco-friendly practices in industries, and enhancing resource efficiency in manufacturing processes (Wilson et al., 2015). The emphasis is often on balancing economic growth with sustainable practices to meet both developmental and environmental goals. Further understanding of the different policy requirements is crucial for a global transition toward a more circular and sustainable economy.

4 Conclusions and Future Work

Recent research has highlighted valuable insights into the emerging field of circular innovation. Nevertheless, certain gaps and avenues for further inquiry have surfaced within the literature. While a substantial body of literature has centered on the initial stages of adoption and expansion, there is a noticeable lack of research into the enduring impacts of these innovations on businesses, industries, and the broader economy. Of notable significance are the human and cultural dimensions associated with the adoption and advancement of circular innovations, which have been somewhat overlooked. To cultivate a deeper understanding, it becomes imperative to explore the behavioral drivers and barriers underpinning circular practices within organizational and societal contexts. Although glimpses of policy influences on circular innovation are present in select articles, the field

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presents an avenue for comprehensive exploration. This includes an in-depth assessment of policy efficacy, implementation challenges, and the intricate interplay between different policy strategies. Rather than focusing solely on specific sectors or industries, a comprehensive cross-sectoral analysis has the potential to uncover both commonalities and divergences in circular innovation strategies and challenges across a spectrum of sectors. The socioeconomic implications of circular innovation also warrant further exploration, encompassing aspects such as job creation, equitable benefit distribution, and the concurrent resolution of social and environmental predicaments. To holistically evaluate the impact of initiatives, a call for standardized system-level metrics and measurement frameworks arises. Such frameworks should comprehensively assess the environmental, social, and economic outcomes of circular innovations. In summary, addressing these gaps through dedicated research holds the potential to enrich understanding of the challenges and opportunities inherent in this developing topic.

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Biographies

Ruth Cherrington. Ruth Cherrington, PhD is a Lecturer in Sustainable Futures at the University of Exeter Business School. She is an affiliate member of the Exeter Centre for Circular Economy and the Centre for Entrepreneurship and her research sits within these overlapping themes to consider the future of business. She has experience of a wide portfolio of research projects that collectively strive to address environmental sustainability, industry innovation, and societal impact, employing multidisciplinary approaches and collaborations between academia, industry, and local communities to drive the transition toward circularity. Her papers are published in multidisciplinary scholarly journals such as Resources, Conservation and Recycling, Management Learning and Sustainable Production and Consumption.
ORCID: https://orcid.org/0000-0003-1108-7132
CRediT Statement: Conceptualization, Writing - original draft, Writing - review and editing.

Eduardo A Llano. Eduardo Acosta Llano is a PhD student at Oulu Business School's department of marketing, management, and international business. He is passionate about finding new ways to redesign business models towards more sustainable ones, optimizing resources, and tackling global issues like climate change, waste, pollution, and biodiversity loss with the help of state-of-art technology. In the last years, he has been working in the Nordic countries of Sweden and Finland in sustainable entrepreneurship from an academic perspective creating valuable collaborations and synergy with policymakers and entrepreneurs in various industries.
ORCID: https://orcid.org/0009-0003-3140-2862
CRediT Statement: Conceptualization, Writing - original draft, Writing - review and editing.

Rosen Dimov. Rosen Dimov PhD is an Associate Professor at Soós Ernő Research and Development Center, Renewable Energy Research Group, University of Pannonia, Hungary, and Innovation Manager at emotion3D in Vienna. He has obtained a transdisciplinary background in his earlier education that has led him to a Marie Curie PhD and early-stage research in innovation management. During his studies he gained experience in policy making and governance by working at the European Parliament, the European Commission, and the World Bank Institute. In the consultancy field he has supported the interest representation and international cooperation of innovative small businesses in Europe and Turkey. While he was living in Istanbul for nearly 5 years, he managed projects about the economic integration of Turkey into the EU market, facilitating and furthering the exchange of best practices and networking among innovation stakeholders from both sides.
ORCID: https://orcid.org/0000-0002-5538-5599
CRediT Statement: Writing - original draft

Ananya Bhattacharya. Ananya Bhattacharya, PhD is a Senior Lecturer in the Department of Management at Monash University. Currently she is involved in research on supply chains, food waste and circular economy. As a part of the team, she has received funding from the Sustainability Victoria to complete research on 'Manufacturing Sector Circular Economy Capabilities: Identifying Enablers, Barriers, and Enhancements'. She collaborated on a research project with the local council and small/medium sized businesses to understand their circular economy challenges and practices. She has also received internal grant to explore waste in food service businesses and conducted research on food waste in the hospitality industry. Her sustainability-related papers are published in several scholarly journals such as Journal of Cleaner Production, Industrial Marketing Management, International Journal of Production Economics, International Journal of Production Management, Australasian Journal of Environment Management, Journal of Business Research and International Journal of Hospitality Management.
ORCID: https://orcid.org/0000-0002-9406-7630
CRediT Statement: Writing - original draft, Writing - review and editing.

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