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The Role of Innovation Hubs in Accelerating Circular Economies: Business Model Innovation and Cross-Sector Collaboration (A Systematic Review)

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ABSTRACT

Purpose: The study aims to explore the systematic review the critical role of innovation hubs in accelerating the transition to circular economies (CE) by fostering innovation, collaboration, and the development of sustainable business models in which to understand the mechanisms through the innovation hubs fostere circular thinking and to identify the conditions under which they most effectively drive systemic change toward a more regenerative economic framework. **Methodology:** By analysing 11 peer-reviewed studies, this review identifies several key themes, including business model innovation for the circular economy (BMI4CE), the adoption of Industry 4.0 technologies, and the importance of cross-sector collaboration. Innovation hubs facilitate the integration of circular principles by supporting startups and established businesses in experimenting with circular models, implementing advanced technologies such as blockchain and IoT, and encouraging collaboration across industries. However, significant challenges remain, including regulatory and financial barriers, constraints in technological adoption, and the need for greater consumer engagement. **Findings:** The review highlights that while innovation hubs provide essential platforms for knowledge sharing and partnership, addressing these barriers is crucial for scaling circular economy practices. Policy implications are discussed, emphasizing the need for cohesive regulatory frameworks, financial support mechanisms for circular startups, and initiatives to increase consumer awareness and participation. **Originality:** The current research makes a significant contribution to current literature and also contributes to a deeper understanding of how innovation hubs can accelerate circular economy initiatives, offering insights for policymakers, businesses, and academics.

Keywords: *Circular economy; Innovation hubs; Digital technologies; Circular business models; Sustainable development*

INTRODUCTION:

Circular Economy (CE) implies shifting from the conventional linear economy on the take-make-dispose model to a closed-loop tailored on resource renewal. This is defined as a system in which products, ware, and materials are cycled through the economy for as long as possible, in turn extracting the maximum value from those resources before they are recycling or repurposed. This concept is on the rise as one of the drivers for sustainable development as it targets core problems of the world and corporations, such as the lack of resources and pollution of the environment, as well as the need to adopt more sustainable practices (Pagoropoulos et al., 2017).

CE strategies are realized through the process of “closing”, “slowing” and “narrowing” resource loops, which refers to recycling, increasing product life cycles, and enhancing resource utilization, respectively

(Bocken et al., 2016). This approach is beneficial to the environment by slowing down the industrial activities that have a negative impact on the environment, and for the the economy, it opens up new business opportunities thereby decreasing the reliance on the limited resources (Blomsma & Brennan, 2017). As CE is gradually being implemented by organizations and governments worldwide, the role of innovation to this process has become an important issue.

Innovation hubs have been remarkable in driving innovation and entrepreneurship across numerous industries. They are centers of economic and technological advancements which gather key actors, such as entrepreneurs, scientists, and politicians, to work together on the creation of new technologies, goods and services. In the context of circular economy, innovation hubs act as facilitators of sustainable business models as they offer the platform, tools, and contacts required to advance and implement circular economy solutions (Ort et al., 2023).

The interlink between innovation hubs and circular economy principles is particularly significant. innovation hub indeed provides hubs provide the environment for intersectoral collaboration to create circular business models, which make sustainability the value proposition of economic activities. This is important because the transition to a circular economy involves redesigning supply chains, generating new recycling technologies and establishing markets for secondary materials (Pagoropoulos et al., 2017). Innovation hubs help to hasten the adoption of circular practices and can help foster a sustainable and resilient economy by offering a place to experiment and share knowledge.

RATIONALE FOR THE STUDY

While the concept and the practice of CE have grown rapidly in recent times, there is still dirt of knowledge about how innovation hubs can accelerate and enhance the transition to CE. Although there are numerous studies regarding circular business models, and the use of digital technologies in supporting these models, the role of innovation hubs has not been investigated extensively. According to Pagoropoulos et. Al (2017) many works are usually restricted to investigate specific elements of circular economy practices like waste management or resource efficiency without paying attention to the environments in which they are implemented.

Furthermore, a few studies done in the circular economy and innovation hubs areas are done with respect to certain geographical locations or sectors, which gives general literature a fragmented understanding of how these hubs work. This lack of a systematic and integrated view of innovation hubs hampers the ability to generalize the results and understand the impact of hubs in the promotion of circular economy practices. (Ort et al., 2023).

This systematic review therefore tries to fill these gaps by offering a broad literature review on innovation hubs and their contribution to the advancement of circular economies. Through a systematic review of a vast number of studies, this review will provide insights into the most significant determinants that facilitate the achievement of innovation hubs' objectives when it comes to circular practices. Furthermore, it will outline the gaps that require further investigation to improve the approach to using innovation hubs for circular economy transition.

METHODOLOGY

This study adopts the PRISMA 2020 Systematic review approach. PRISMA offers guidelines to make the process more transparent, replicable, and comprehensive in terms of the synthesized literature. This paper sought to provide a review of the literature on the innovation hubs in the development of circular economies, including their initiatives, issues, and performance indicators. The multi-phase review process involved several key steps: systematic literature search, eligibility criteria for studies, data extraction process, quality assessment of the included studies and data synthesis, all of which were conducted to minimize bias and include only the highest quality and most relevant studies.
The search was conducted systematically through the academic databases including Scopus, Web of science, PubMed, and Google scholar. To guarantee a proper search, Boolean operators were used to

connect the keywords, including circular economy, innovation hubs, and sustainable development. The specific boolen operator used is stated below.
("Circular economy" OR "Circular business models" OR "Circular economic practices") AND ("Innovation hubs" OR "Innovation centers" OR "Innovation ecosystems" OR "Collaborative platforms OR Accelerators"OR "Business incubators" OR "Startup")
There was no time limit set, but most of the sources were published in the last ten years due to the increase in interest in circular economy and innovation centers. To avoid any bias in the studies selected, only those that were published in English and peer-reviewed were used.
To make a more selective choice, inclusion and exclusion criteria were used. Literature that focused on the subject of innovation hubs and circular economy practices was given preference and the type of research; either quantitative or qualitative was taken into consideration. Only articles published in indexed peer-reviewed journals were included, excluding articles that were opinion pieces, editorials, and studies with major methodological limitations. EndNote and Rayyan were used to organize references and to filter and delete duplications in the process. Quality assessment was based on the criteria developed by the Critical Appraisal Skills Programme (CASP) to select only the best quality studies for the final analysis.

Data extraction was done using a format that included the study objectives, methods, findings, and limitations, to reduce variability in the extraction process. The review integrated qualitative findings by performing thematic analysis, and eventually, the study presented a list of common practices, issues, and best practices of innovation hubs. Due to the variability of the studies, meta-analysis was not performed. However, since the aim was to gain a more flexible and complex view of how IHs can support CE transitions, a narrative synthesis approach was employed. This methodology was effective in that the review offered an overall and close-up view of the topic of discussion.

RESULTS

The study selection process began with an initial identification of 134 records from the Scopus database. After the initial screening, three records were excluded due to language barriers, leaving 131 records to be assessed for relevance. During the screening phase, 108 records were deemed irrelevant based on predefined inclusion criteria and were subsequently excluded. This resulted in 23 reports being sought for retrieval. All reports were successfully retrieved, and the eligibility assessment was conducted. During this phase, two reports were excluded because they did not align with the scope of the study. Ultimately, 21 studies met the eligibility criteria and were included in the systematic review for further analysis.

Fig 1: PRISMA Flow Diagram:

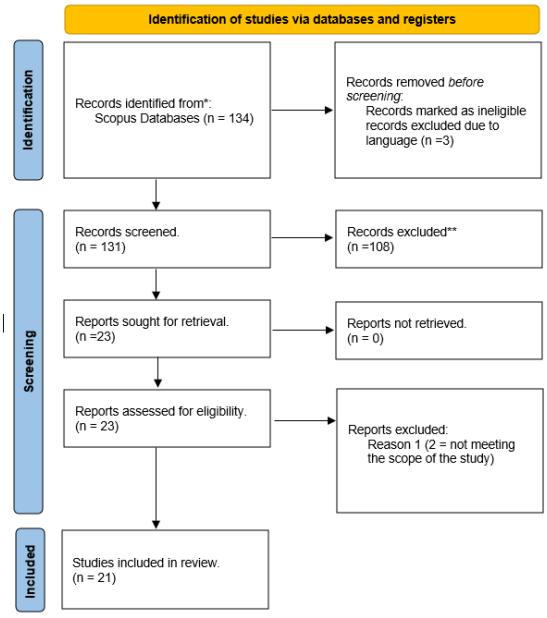


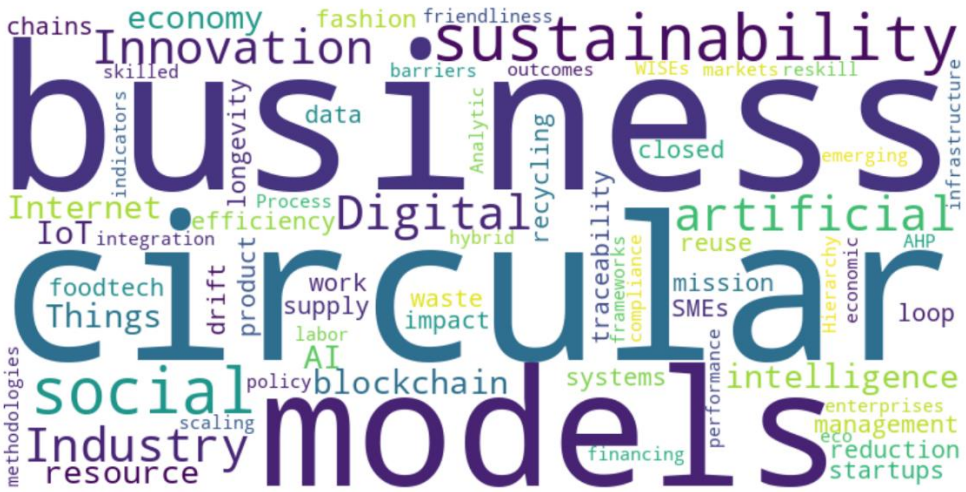
Table 1 Details of Included Study

S/N	Authors	Year	Methodology	Location	Key Findings	Themes
1	Bocken et al.	2014	Literature review		Development of sustainable business model archetypes.	Sustainable business models
2	Geissdoerfer M et al.	2017	Conceptual review		The circular economy promotes sustainability by creating closed-loop systems. It challenges linear models of resource consumption, promoting restorative and regenerative processes.	Circular Economy Principles, Sustainability, Closed-Loop Systems
3	Veleva and Bodkin	2018	Case study of 12 companies employing circular economy practices	USA	Identifies corporate-entrepreneur partnerships in advancing circular economy strategies in the absence of federal mandates.	Corporate-entrepreneur collaboration, circular business models, zero waste
4	Blomsma et al.	2019	Case studies	Manufacturing firms in the EU	Developed a circular strategies framework.	Circular strategies in manufacturing
5	Millette et al.	2020	Conceptual Framework	Global	Explores the potential of innovation hubs in supporting industrial symbiosis and promoting CE through incubators.	Industrial symbiosis, innovation hubs, sustainability networks
6	Colucci M and Vecchi A	2020	Case study of Italian fashion companies	Italy	Italian fashion companies implement circular practices, but challenges remain in supply chain integration. Circularity improves product longevity and reduces waste.	Circular supply chains, Product Longevity
7	Henry M et al.	2020	Survey of 128 circular startups	Global	Circular startups focus on material recycling, reuse, and waste reduction. However, challenges in scaling circular strategies are prevalent.	Material Efficiency, Recycling, Waste Reduction
8	Ostermann et al.	2021	Case study analysis on fashion industry startups	Global (focused on fashion)	Fashion startups use circular supply chains and digital technology to close material loops, reduce waste, and foster reuse.	Circular Business Models, Digital Innovation
9	Bag et al.	2021	Qualitative analysis	Global	Industry 4.0 and the adoption of 10R strategies for sustainability.	Industry 4.0 integration
10	Mies & Gold	2021	Mapping analysis	Global	Mapped social dimensions of circular economy.	Social impact in CE
11	Ostermann CM, Nascimento LS, and Zen AC	2021	Multiple case study	Europe, North America, Asia	Startups in the fashion industry have developed business models prioritizing environmental and economic sustainability. Digital technologies like blockchain and AI facilitate business model innovation for circular economy (BMI4CE).	Business Model Innovation for Circular Economy, Sustainable Fashion, Digital Technologies

12	Re and Magnani	2022	Interviews with actors in circular economy collaborations	Italy	Demonstrates successful co-creation processes in packaging and textile sectors, focusing on partnerships and sustainability missions.	Co-creation, packaging innovation, textile recycling
13	Tiago H. H. Silva & Simone Sehnem	2022	Systematic literature review and empirical validation with 45 startups	Brazil	Industry 4.0 technologies support CE, especially in foodtech; partnerships crucial for creating ecosystems.	Industry 4.0, Digital Innovation
14	Bassi et al.	2022	Survey-based analysis	European SMEs	Varied adoption of circular economy practices across EU countries.	Resource efficiency
15	Bocken et al.	2022	Conceptual paper		Designing circular business models for sustainability.	Circular business model design
16	Uvarova et al.	2023	Literature review and bibliometric analysis	International (various)	Analyzes emerging trends in CE principles and their application in industrial symbiosis and supply chains.	Circular economy principles, industrial symbiosis, supply chain integration
17	Van Opstal et al.	2023	Semi-structured interviews with startups and WISEs	Flanders, Belgium	Work integration ambitions can complement circular startups, especially for reskilling the workforce.	Social Impact, Work Integration
18	von Kolpinski et al.	2024	Empirical analysis of European start-ups using a sustainability assessment scheme	Europe (Central and Southern Europe, Scandinavia)	Highlights the business model dynamics and mission drift risks for circular-social hybrid start-ups.	Sustainability performance, business model innovation, mission drift
19	Roshan et al.	2024	fsQCA methodology and configurational analysis	29 countries (global)	Digital entrepreneurial ecosystems are crucial in CE startup success; digital access and protection are primary drivers of circular startup formation.	Digital Access, Entrepreneurial Ecosystems
20	Kolpinski et al.	2024	Semi-structured interviews and literature analysis	Europe	Circular-social hybrid startups blend environmental and social goals, with sustainability performance measured across three dimensions.	Hybrid Business Models
21	Manganda et al.	2024	Mixed methods: Interviews and case studies	Southern Africa	The transition to CE in Southern Africa relies heavily on innovative and disruptive production models, but barriers include financing and lack of skilled labor.	Disruptive Innovation, Regional Barriers

Thematic Analysis

Fig 1: Word Cloud



Several themes are identified from the reviewed literature. One prominent theme is the role of Industry 4.0 and Digital Innovation, highlighting technologies such as artificial intelligence (AI), Internet of Things (IoT), and blockchain. These technologies are critical in enhancing resource efficiency, traceability, and data management, which facilitate optimized resource use, waste reduction, and improved circular business models. Startups in sectors like food-tech and fashion leverage these technologies to drive circular supply chains and extend product longevity (Silva & Sehnem, 2022; Ostermann et al., 2021). However, their implementation, especially in small and medium enterprises (SMEs), remains limited due to cost and scalability challenges (Bag et al., 2021).

The next significant theme centers on Circular Business Models and Supply Chains. In industries like fashion, reuse, recycling, and waste reduction are critical components of circular business models, which rely on closed-loop systems to promote material recovery and product longevity (Ostermann et al., 2021; Colucci & Vecchi, 2020). These models, while promising in terms of sustainability, face challenges in supply chain integration and scaling to mainstream industries, limiting their broader applicability (Bocken et al., 2022).

Another theme is the Social and Environmental Impact of circular economy startups. Many companies are not only driven by environmental objectives but also focus on social impact, incorporating work integration social enterprises (WISEs) to reskill the workforce and address unemployment (Van Opstal et al., 2023). These hybrid business models blend economic, social, and environmental performance metrics (Kolpinski et al., 2024), though economic outcomes remain underexplored (Mies & Gold, 2021).

Furthermore, several Barriers to Circular Economy Adoption persist, particularly in emerging markets. Financing difficulties and a lack of skilled labor are prominent barriers, as seen in regions like Southern Africa (Manganda et al., 2024). Even in developed markets, regional heterogeneity and challenges in scaling circular models, particularly for SMEs, limit adoption (Bassi et al., 2022). Additionally, smaller companies often lack the infrastructure needed to fully implement circular strategies (Blomsma et al., 2019).

Lastly, studies emphasize the importance of Methodologies for Assessing Circular Economy Success. These methodologies are essential for tracking the effectiveness of circular initiatives and ensuring they balance economic, social, and environmental goals.

DISCUSSION OF FINDINGS

The findings from the literature highlight several key aspects influencing the development and success of circular economy startups. One of the most significant factors is the integration of Industry 4.0 technologies, such as artificial intelligence (AI), blockchain, and Internet of Things (IoT), which play a critical role in optimizing resource efficiency, traceability, and digital solutions. These technologies are particularly useful in enhancing circular business models by reducing waste and improving the flow of materials within closed-loop supply chains (Silva & Sehnem, 2022; Bag et al., 2021). For instance, startups in industries like foodtech and fashion have adopted digital tools to manage resource use more efficiently and foster reuse and recycling, contributing to overall sustainability performance (Roshan et al., 2024; Ostermann et al., 2021). However, the adoption of these technologies in small and medium enterprises (SMEs) remains limited, highlighting a significant gap in scalability and accessibility (Bag et al., 2021).

The creation of circular business models is another vital aspect. These models, particularly in sectors like fashion, focus on product longevity, reuse, and waste minimization (Ostermann et al., 2021; Colucci & Vecchi, 2020). By creating closed-loop systems, circular startups ensure that products and materials are continuously recycled, reducing environmental impact. Despite the promising developments in these models, there are notable challenges related to supply chain integration and scaling them beyond niche markets, especially in industries that are not traditionally focused on sustainability (Bocken et al., 2022). These challenges are compounded by the lack of empirical data on the financial impacts of circular practices on businesses, particularly in fashion (Colucci & Vecchi, 2020).

Another key finding is the growing focus on the social impact of circular economy startups. Many startups are integrating work integration social enterprises (WISEs) into their business models, aiming to reskill workers and provide new employment opportunities in the circular economy (Van Opstal et al., 2023). This approach not only addresses environmental goals but also helps reduce unemployment, especially in regions transitioning to new economic models. The blending of environmental and social objectives in circular startups, particularly those adopting hybrid business models, helps balance profitability with sustainability, though the economic outcomes of these models often remain underexplored (Kolpinski et al., 2024; Mies & Gold, 2021).

While these innovations in circular business models and digital technologies offer promising avenues for advancing the circular economy, various barriers hinder their broader adoption. In regions like Southern Africa, startups face significant challenges, including financing difficulties and a lack of skilled labor, which impede their ability to transition to circular production models (Manganda et al., 2024). Even in developed markets, regional heterogeneity presents issues, with SMEs struggling to adopt circular practices due to differences in infrastructure and resources across regions (Bassi et al., 2022). Furthermore, while circular strategies have been developed for larger firms, SMEs often lack the financial and logistical capacity to implement them effectively (Blomsma et al., 2019).

In addition to these barriers, assessing the success of circular economy startups remains a challenge. Tools like the Analytic Hierarchy Process (AHP) have been developed to evaluate the eco-friendliness and sustainability compliance of startups, particularly in the agricultural sector (Unnamed authors, 2024).Despite the progress in creating these assessment tools, further empirical validation is necessary to ensure their effectiveness across industries.

In summary, the findings suggest that while Industry 4.0 technologies and circular business models are driving significant advancements in the circular economy, scalability, financing, and regional disparities remain critical challenges. Moreover, the integration of social goals alongside environmental objectives is a growing trend, although gaps in understanding the economic outcomes of these efforts need to be addressed. The development of robust assessment methodologies is crucial for tracking the success of circular economy startups and ensuring they maintain their commitment to sustainability as they scale.

IDENTIFIED GAPS AND CHALLENGES

Despite the increasing number of circular initiatives, significant gaps remain in adopting and scaling circular models. One of the main challenges is the limited integration of Industry 4.0 technologies such as

blockchain, AI, and IoT, which are critical for enhancing transparency and efficiency in supply chains (Ostermann et al., 2021). SMEs, in particular, struggle with the high costs and technical expertise required for implementation (Bag et al., 2021). Additionally, industries like manufacturing and fashion lack tailored technological solutions, further hindering the adoption of circular practices (Henry et al., 2020). Addressing these technological gaps with more affordable solutions could foster broader adoption across sectors.

Scaling circular business models remains another significant obstacle, especially in industries with complex supply chains like fashion, where logistical and global operational challenges impede integration of circular principles (Colucci & Vecchi, 2020). While innovation hubs support the development of circular models, scaling them requires stronger frameworks and infrastructure. Regulatory barriers also compound these issues, as current policies tend to favor linear models, making compliance difficult for businesses attempting to implement circular economy practices (Bassi et al., 2022). More cohesive policy frameworks are needed to facilitate global circular solutions (Henry et al., 2020).

In addition to technological and regulatory hurdles, consumer engagement and the social dimensions of the circular economy are underexplored. Many circular models depend on active consumer participation, yet awareness and engagement remain low, especially in fast-moving industries like fashion (Ostermann et al., 2021). Moreover, much of the literature has overlooked social sustainability, including labor practices and equitable economic growth, particularly in sectors like fashion where labor exploitation is common (Colucci & Vecchi, 2020). Increased focus on social impact and cross-industry collaboration is essential for developing more inclusive and sustainable circular systems (Henry et al., 2020).

POLICY IMPLICATIONS

The findings of this study suggest several policy implications that are essential for driving the successful adoption and scaling of circular economy (CE) initiatives. These recommendations focus on addressing key challenges, such as technological integration, regulatory barriers, financial support, and consumer engagement, all of which are critical to enabling circular practices across industries.

First, policy interventions should focus on promoting the adoption of Industry 4.0 technologies, such as blockchain, IoT, and AI, which are fundamental enablers of circular business models. By offering financial incentives, subsidies, or tax credits, governments can reduce the cost burden associated with these technologies, particularly for small and medium-sized enterprises (SMEs). Providing technical training programs is also vital to overcoming the skills gap that currently limits the broader implementation of digital solutions for circular strategies. Supporting businesses in accessing these technologies would significantly enhance their ability to implement efficient resource management and closed-loop systems (Bag et al., 2021; Ostermann et al., 2021).

Furthermore, there is a need for a cohesive regulatory framework that supports circular economy practices. Existing regulations are often designed for linear economic models, and many businesses face difficulties navigating the legal landscape when implementing circular strategies. Governments should prioritize the development of policies that encourage circularity by aligning environmental, waste, and product regulations with circular principles. These policies must be harmonized across regions and industries to provide a consistent and supportive environment for businesses attempting to scale circular models. Such regulatory support is particularly important for sectors like manufacturing, where waste management and product lifecycle regulations play a critical role (Bassi et al., 2022).

In addition, policymakers should address the financial barriers that circular startups face. Circular business models, especially those requiring high upfront investments in technology and infrastructure, often struggle to secure traditional funding due to perceived risks and longer payback periods. To mitigate these financial challenges, governments can introduce green financing initiatives, impact investment funds, and public-private partnerships that specifically target circular businesses. By de-risking investments in circular startups through government-backed grants, loan guarantees, or subsidies, financial institutions will be more likely to support the growth of circular economy initiatives (Henry et al., 2020).

Moreover, fostering collaboration across industries is crucial for the success of circular economy models. Policymakers should support innovation hubs that facilitate cross-sector partnerships, as these collaborations are essential for scaling circular practices. By bringing together businesses, research institutions, and government agencies, these hubs enable knowledge sharing, co-innovation, and the development of integrated solutions. Governments can play a role in supporting these hubs by providing funding for joint research and development (R&D) projects and creating platforms for multi-stakeholder engagement (Colucci & Vecchi, 2020; Bassi et al., 2022).

Lastly, policies that focus on consumer education and awareness are vital for the widespread adoption of circular economy practices. Consumer participation is central to the success of circular models, particularly in areas like recycling programs, product take-back schemes, and product-as-a-service models. Governments should invest in public education campaigns that highlight the environmental and economic benefits of circular products and services. Additionally, eco-labeling programs and incentives for consumers to engage in circular behaviors, such as recycling or leasing products, would help drive demand for sustainable options (Ostermann et al., 2021).

CONCLUSION:

The study reveals several critical themes for advancing circular economy initiatives, including the importance of business model innovation, the role of emerging technologies, collaboration, regulatory and financial barriers, and consumer engagement. Innovation hubs are central to driving these initiatives by providing platforms for collaboration, technical support, and experimentation with circular models. However, the study identifies significant gaps that must be addressed to scale circular practices across industries, particularly in terms of technological adoption, regulatory support, and consumer behavior.

To bridge these gaps, policymakers must focus on creating a supportive ecosystem for circular businesses by providing financial incentives, developing cohesive regulatory frameworks, and promoting cross-sector partnerships. Additionally, educating consumers on the benefits of circular products and services is essential for achieving widespread adoption. Addressing these challenges will not only enhance the environmental sustainability of industries but also contribute to long-term economic viability through resource efficiency and waste reduction. By fostering a more supportive policy environment, governments can accelerate the transition to a circular economy and ensure its success across diverse sectors.

AUTHOR CONTRIBUTIONS

Conceptualization: Aderinsola Kayode
Methodology: Abraham O Adeniran
Writing: Kayode and Adeniran
Writing (review and editing): Aderinsola Kayode

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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