



Network and Thematic Trend Analysis of Entrepreneurship in Circular Economy

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Abstract

This study investigates the intersection of entrepreneurship and the circular economy (CE) through an integrative bibliometric and Delphi-based approach, emphasizing the knowledge dynamics that underpin this evolving field. The quantitative bibliometric analysis reveals a surge in scholarly outputs post-2015, reflecting the rapid diffusion of CE-related knowledge, particularly around recycling, sustainability, digital circularity, and innovative business models. Network analysis highlights the pivotal role of knowledge creation and dissemination through academic collaborations, institutional leadership, and SME-driven innovations. The subsequent qualitative validation by domain experts reinforces the emergence of six core thematic knowledge clusters—including digital transformation, advanced recycling technologies, and governance frameworks—underscoring how entrepreneurial ecosystems generate and apply knowledge to enable CE transitions. Situated at the confluence of environmental innovation and economic productivity, this study contributes to the knowledge-based economy by mapping how CE entrepreneurship fosters systemic transformation (macro), organizational learning (meso), and individual entrepreneurial action (micro), drawing on insights from the knowledge-based view. The findings offer actionable insights for scholars, practitioners, and policymakers aiming to leverage knowledge creation and application for sustainable economic development.

Keywords Circular economy · Entrepreneurship · Social network analysis · Thematic trends · Small and medium-sized enterprises

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Introduction

The circular economy (CE) has emerged as a transformative economic model aimed at minimizing waste and optimizing resource efficiency by closing material loops and extending product lifecycles (Domenech & Borrión, 2022; Sánchez-García et al., 2024). Unlike traditional linear economic systems characterized by a “take-make-dispose” approach, CE emphasizes reuse, recycling, and regeneration, thus aligning economic growth with long-term environmental sustainability goals (Geissdoerfer et al., 2020; Maghsoudi et al., 2025). Recent scholarly attention highlights the necessity of integrating CE principles not only at macro-policy levels but also within entrepreneurial ventures, particularly small and medium-sized enterprises (SMEs), which are increasingly recognized as critical agents for sustainable innovation (Baiocco & Paniccia, 2023; Ferreira et al., 2024). This transition is also embedded within the broader context of the knowledge-based economy, where economic progress increasingly depends on the generation, sharing, and application of knowledge (Pu et al., 2023). In this setting, circular economy entrepreneurship is not only an environmentally oriented practice but also a process through which knowledge assets such as technological skills, organizational learning, and institutional experience are mobilized to produce both economic and sustainability outcomes (Basit et al., 2024; Sabet & Soghi, 2025).

Entrepreneurship plays a pivotal role in implementing CE practices, driving innovations in business models, products, and processes that mitigate environmental impacts while creating economic value (Wells & Skeete, 2023). Entrepreneurs, particularly SMEs, function as agile actors capable of rapidly adopting and diffusing circular innovations across various industry sectors (Dantas et al., 2022). Nevertheless, despite the acknowledged importance of entrepreneurial activities in advancing CE transitions, significant barriers persist, including financial constraints, inadequate regulatory frameworks, limited technological capabilities, and consumer resistance to circular products and services (Mehrotra & Jaladi, 2022; Zaccone et al., 2022).

While extensive literature exists on the broader concept of CE, the intersection between entrepreneurship and CE remains fragmented and insufficiently explored. Prior systematic literature reviews (SLRs), including the recent work by Suchek et al. (2022), offer valuable summaries of entrepreneurial activities within CE but often lack comprehensive analyses of global academic collaboration networks, thematic evolutions, and emerging trends. Additionally, existing reviews rarely integrate quantitative bibliometric techniques with qualitative expert insights, leaving critical gaps in understanding the structural dynamics and future trajectories of CE entrepreneurship research. In addition, the study offers insights into how knowledge is created, structured, and transmitted among scholars, institutions, and practitioners working in this domain, thereby contributing to a deeper understanding of knowledge flows within the circular economy.

To address these gaps, the present study employs rigorous bibliometric methods, complemented by qualitative validation through expert evaluation, to systematically examine the academic landscape of entrepreneurship within the CE

field. Specifically, our objectives include identifying key authors, institutions, and countries contributing to CE entrepreneurship research; mapping academic collaboration networks; analyzing thematic evolutions across distinct temporal periods; and qualitatively validating the identified thematic clusters to derive prospective insights for future research and practice.

This paper makes several novel contributions. First, unlike previous systematic reviews (e.g., Suchek et al., 2022), our bibliometric approach enables a quantitative assessment of collaboration patterns and thematic structures within the academic field. Second, integrating qualitative validation by a panel of experts ensures robust interpretation of the bibliometric clusters, enhancing practical relevance and reliability. Finally, by explicitly addressing technology-intensive themes such as digital circularity and emerging business models, this study provides forward-looking insights and actionable implications for entrepreneurs and policymakers. While several bibliometric studies have explored the evolution of circular economy research (e.g., Goyal et al. (2021); Khitous et al. (2020)), they typically focus on macro-level trends or citation mapping in isolation. Our unique contribution is methodological and substantive. Methodologically, we integrate bibliometric mapping with Delphi-based expert validation to move from descriptive structures to validated knowledge dynamics. Substantively, we surface investable and policy-relevant themes—digital circularity, circular finance, and SME-centric business models—and map how these themes translate into competitive advantage and capability building. Our focus on knowledge creation and SME-led innovation within CE entrepreneurship—validated by domain experts—sets this research apart from earlier literature reviews that did not combine structural network insights with thematic validation.

The remainder of this paper is structured as follows. Section 2 synthesizes existing literature, clearly articulating gaps that motivate our study. Section 3 outlines the detailed methodology, including data collection, bibliometric analysis, and qualitative validation procedure. Section 4 presents quantitative and qualitative results, including network analyses and expert-validated thematic clusters. Section 5 discusses these findings within broader theoretical and practical contexts, explicitly highlighting implications for research, entrepreneurship practice, and public policy. Section 6 summarizes key contributions, acknowledges limitations, and outlines future research directions.

Literature Review

Circular Economy and Entrepreneurship: Key Concepts

The circular economy (CE) has gained widespread attention as an alternative economic paradigm addressing global environmental challenges such as resource depletion, climate change, and waste generation (Govindan & Hasanagic, 2018; Roleders et al., 2022). Core CE principles—reuse, recycle, regenerate—have been extensively explored in various contexts, particularly through concepts such as industrial symbiosis, remanufacturing, and sustainable supply chains (Ferreira et al., 2024; Rizos et al., 2016). However, the operationalization of these principles critically

depends on innovative entrepreneurship that introduces viable business models capable of aligning economic incentives with sustainability goals (Hartini et al., 2022; Schützenhofer et al., 2022). Entrepreneurial initiatives in CE manifest predominantly through business model innovations such as product-as-a-service, sharing economy platforms, and digitally-enabled circular solutions (Atstaja et al., 2022; Lüdeke-Freund et al., 2019). SMEs, due to their inherent agility and responsiveness to local market dynamics, have emerged as central actors driving these innovations (Voukkali et al., 2023). These firms also serve as key agents of knowledge creation and diffusion in the circular economy (Maher et al., 2023). Nevertheless, entrepreneurs operating within CE frameworks often confront significant systemic barriers, including limited financial resources, technological challenges in achieving closed-loop systems, regulatory obstacles designed around linear economic paradigms, and consumer reluctance to adopt circular products and services (Ambaye et al., 2023; Mehrotra & Jaladi, 2022).

The Knowledge-Based View as Theoretical Lens

To provide a robust theoretical foundation for analyzing the evolving landscape of entrepreneurship within CE, this study adopts the knowledge-based view (KBV). The KBV asserts that an organization's most critical resource is its knowledge both explicit and tacit, which serves as a primary driver of sustainable competitive advantage (Grant, 1996). This perspective is particularly pertinent to CE, as the transition to circular models is inherently knowledge intensive, demanding new scientific, technological, and managerial expertise in areas such as material flows, waste valorization, and innovative business models (Mohammadi et al., 2025; Vu et al., 2023). Similarly, entrepreneurs in the CE sphere act as agents of change, leveraging existing knowledge or creating new insights to identify and exploit opportunities, with their success often contingent on their effective utilization of specialized knowledge assets (Audretsch & Fiedler, 2024). Therefore, by applying the KBV, this study interprets its quantitative bibliometric findings and qualitative expert validations through the lens of knowledge dynamics. Our analysis of academic collaboration networks will illuminate how knowledge is co-created and diffused across the field, while the identified thematic clusters will reveal the key emerging and maturing knowledge domains crucial for CE entrepreneurship. This theoretical grounding enables us to articulate how knowledge creation, structuring, and transmission contribute to a deeper understanding of knowledge flows, ultimately fostering systemic transformation macro, organizational learning meso, and individual entrepreneurial action micro within the circular economy.

Thematic Evolution and Emerging Research Trends

Research trends also reflect how knowledge is developed and applied across economic levels to support CE innovation (Alka et al., 2024). Early CE entrepreneurship research primarily addressed foundational issues such as recycling and life-cycle assessments (Guide et al., 2003; Moreno et al., 2016). Recent scholarship,

however, reflects a notable thematic diversification, increasingly focusing on specialized areas such as digital circularity, blockchain-enabled supply chain transparency, and AI-driven resource optimization (De Angelis et al., 2018; Onyeaka et al., 2023). Furthermore, contemporary studies emphasize the socio-economic impacts of CE transitions, recognizing the importance of equitable distribution of circular economy benefits (Ferasso et al., 2020; Zaccone et al., 2022). Despite this thematic diversification, existing literature remains fragmented, lacking systematic analyses that integrate thematic evolution with global academic collaboration networks. Previous bibliometric analyses such as Goyal et al. (2021) and Homrich et al. (2018) highlight thematic structures but fail to elucidate how interdisciplinary collaborations and international networks facilitate thematic progressions. Additionally, the specific role of SMEs and technology-intensive circular ventures remains underrepresented, leaving critical questions unanswered regarding their impacts and scalability within diverse geographical contexts.

Related Works and Gap Analysis

While significant reviews exist—such as the comprehensive systematic literature review by Suchek et al. (2022)—these studies primarily adopt qualitative methodologies, overlooking quantitative analyses of academic collaborations and thematic evolutions. Table 1 provides a detailed overview of related works, clarifying the limitations of existing studies, particularly highlighting gaps in quantitative network analysis, thematic integration, qualitative validation, and emerging technology themes. Specifically, Goyal et al. (2021) conducted an extensive bibliometric analysis, but their scope was limited to macro-level CE trends without addressing the entrepreneurial dimension or validating emergent themes through expert-driven methods. Our study uniquely bridges this gap by integrating quantitative network mapping with qualitative insights to unpack how entrepreneurship dynamically drives CE knowledge diffusion.

While Table 1 outlines the methodologies and findings of prior studies, a systematic comparison underscores the unique contributions of this research. For example, unlike Goyal et al. (2021), who relied exclusively on bibliometric mapping without qualitative triangulation, our study incorporates Delphi-based expert validation to ensure interpretive rigor and practical relevance. Compared to Suchek et al. (2022), which offered a qualitative review of entrepreneurship in the circular economy, our work integrates quantitative bibliometric techniques to map collaboration networks and thematic evolutions. Rovanto and Finne (2023) adopt a case-based approach grounded in self-determination theory, whereas our study provides field-wide generalizability by drawing on a comprehensive dataset of over one thousand documents. Similarly, while Khitous et al. (2020) and Razmjooei et al. (2024) focused on thematic evolutions in specific domains (general CE and maritime CE, respectively), they did not examine entrepreneurship as a distinct lens. Our study fills this gap by explicitly focusing on SMEs and emerging technologies such as blockchain and AI, thereby connecting the structural dynamics of knowledge with practical entrepreneurial and policy implications.

Table 1 Related works								
Authors	Research methods	Study focus	Database(s) used	Keywords	Period	Sample size	Key findings	How this study differs
Homrich et al. (2018)	Bibliometrics, network analysis, content analysis	Trends, gaps, and convergence pathways in circular economy literature	Web of Science and Scopus	Circular economy, sustainable development, recycling, industrial symbiosis, closed loop, eco-efficiency, supply chain, waste management	2001–2016	327 articles	Identifies trends and gaps in CE research, highlights regional differences, and calls for more integrated research across fields	Our study integrates entrepreneurship explicitly and validates themes through Delphi experts, linking knowledge clusters to practical entrepreneurial implications
Okorie et al. (2018)	Systematic literature review (SLR)	Developing a synergistic framework combining CE and digital technologies	Scopus	Industry 4.0, digital technologies, digital intelligence, manufacturing data, circular economy, 9Rs (Reduce, Reuse, Recycle, Recover, Refurbish, Repair, Remanufacture, Rethink, Refuse, Repurpose)	2000–2018	174 articles	Proposes a framework integrating CE and Industry 4.0 technologies, identifies gaps in digital technology integration in CE practices	We combine bibliometric analysis with qualitative validation, and extend to entrepreneurship and SMEs while incorporating emerging technologies like blockchain and AI

Table 1 (continued)

Authors	Research methods	Study focus	Database(s) used	Keywords	Period	Sample size	Key findings	How this study differs
Goyal et al. (2021)	Bibliometric analysis, citation mapping, content analysis	Evolution and trends in Circular Economy research from 2000 to 2019	Web of Science	Circular Economy, Circular Value Chain, Shared Economy, Zero Waste	2000–2019	2279 articles	Highlights 10 CE themes, proposes an integrated conceptual framework linking CE drivers, practices, and performance measures	Our study specifically investigates CE entrepreneurship, and uniquely applies Delphi validation to strengthen interpretive rigor
Khitous et al. (2020)	Systematic literature network analysis (SLNA), citation and keyword co-occurrence network analysis	Exploring themes and emerging research trends in circular economy through systematic network analysis	Scopus	“Circular economy” and related terms	2004–2018	1558 articles	Identifies eight major research trends in CE and emphasizes the need for a more integrated approach across various domains	We build on SLNA but extend analysis to entrepreneurship in CE, mapping SMEs and innovation ecosystems and validating with experts

Table 1 (continued)

Authors	Research methods	Study focus	Database(s) used	Keywords	Period	Sample size	Key findings	How this study differs
Razmjooei et al. (2024)	Bibliometric analysis, citation analysis, co-occurrence analysis, keyword frequency analysis	Examining the evolution, research trends, and gaps in circular economy, key-word frequency and sustainability within the maritime industry	Web of Science	Seaport, port, shipping, container terminal, marine transport, circular economy, recycle, reuse, recover, waste management, SDGs	1970–2021	938 articles	Highlights key trends in maritime CE adoption, emphasizes the need for more research on underexplored “R-imperatives.”	Our study provides cross-sectoral insights with a focus on SMEs and entrepreneurship, making findings broadly applicable to CE-driven business ecosystems
Rovanto and Finne (2023)	Self-determination theory (SDT), comparative case study	Understanding entrepreneurial motivations for circular economy practices and how sociocultural contexts in Finland and Japan shape these approaches	Interviews; supplemented by company websites, reports, and external literature	Circular economy, sustainability, motivation, sociocultural context, self-determination theory	Not explicitly specified	27 interviews	Shows that sociocultural factors play a key role in shaping entrepreneurial approaches to CE, with intrinsic motivations driving meaningful progress	Unlike this narrow, qualitative focus, our study leverages large-scale bibliometric data and expert validation to provide generalizable insights on CE entrepreneurship

Table 1 (continued)

Authors	Research meth-ods	Study focus	Database(s) used	Keywords	Period	Sample size	Key findings	How this study differs
Suchek et al. (2022)	Systematic litera-ture review of 102 articles	Mapping the intersection of entrepreneurship and circular economy to identify research themes, trends, and future directions	Web of Science and Scopus	“Circular economy,” “circularity,” “closed-loop,” “entrepreneur,” “start-up,” “startup,” “small business,” “SME,” “new venture,” “new business”	2016–2021	102 articles	Identifies thematic areas like growing circular SMEs and calls for more focus on born-circular firms and social evolution.	We extend their contribution by applying bibliometrics to map collaboration networks and thematic evolution, and validating clusters through Delphi experts

Our research differentiates itself by explicitly addressing these gaps through a combination of bibliometric methodologies and qualitative validation techniques. Specifically, our study quantitatively maps the academic landscape, identifies key collaboration networks and thematic clusters, and qualitatively validates these findings through expert insights. Furthermore, our explicit focus on SMEs and emerging technologies such as blockchain and AI provides forward-looking contributions, responding to urgent calls for more integrative and actionable research in CE entrepreneurship. In sum, this study aims to address identified gaps by providing a comprehensive, integrative, and validated understanding of the field, thus significantly advancing scholarly discourse on entrepreneurship within the circular economy and providing clear implications for practice and policy. This integrative perspective aligns with the knowledge-based economy by highlighting how knowledge flows shape CE entrepreneurship across individual, organizational, and systemic levels.

Methodology

This study was designed to transform static bibliometric patterns into decision-ready insights by subjecting clusters and trajectories to Delphi scrutiny, ensuring that trends reflect shifts in markets, policy, and entrepreneurial practice rather than transient academic attention.

Research Design and Approach

This study adopted a comprehensive mixed-method approach, integrating quantitative bibliometric analyses and qualitative expert validation to systematically examine the research landscape of entrepreneurship within the circular economy (CE). The research design was structured in two primary phases: (1) quantitative bibliometric analysis and (2) qualitative expert validation. The bibliometric analysis provided a structured and objective mapping of scholarly contributions, thematic evolutions, and collaborative networks, while the qualitative validation phase ensured the robustness, practical relevance, and interpretability of the bibliometric clusters identified. Figure 1 illustrates the structured research process followed in this study:

Data Collection

The bibliometric data were collected using the Scopus database, widely recognized for its comprehensive coverage in business, management, and environmental sciences (Aria & Cuccurullo, 2017). We selected Scopus due to its extensive indexing of peer-reviewed articles, reviews, and conference papers, ensuring the breadth and depth required for a comprehensive bibliometric analysis. The decision to use Scopus was based on prior literature highlighting its suitability and extensive coverage of relevant disciplines (Goyal et al., 2021; Suchek et al., 2022). The search strategy was meticulously designed based on previous review studies such as “A review of entrepreneurship and circular economy research:

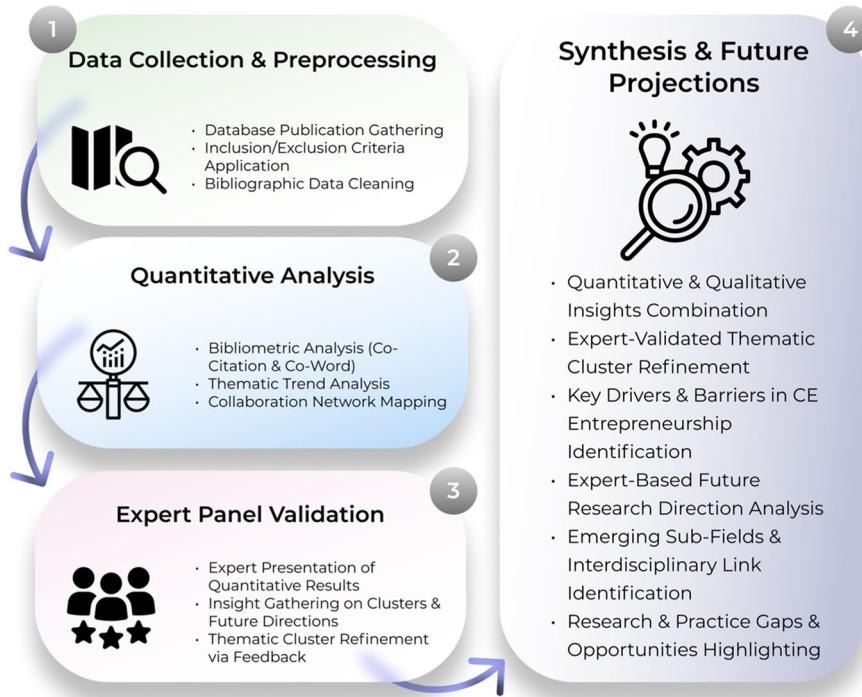


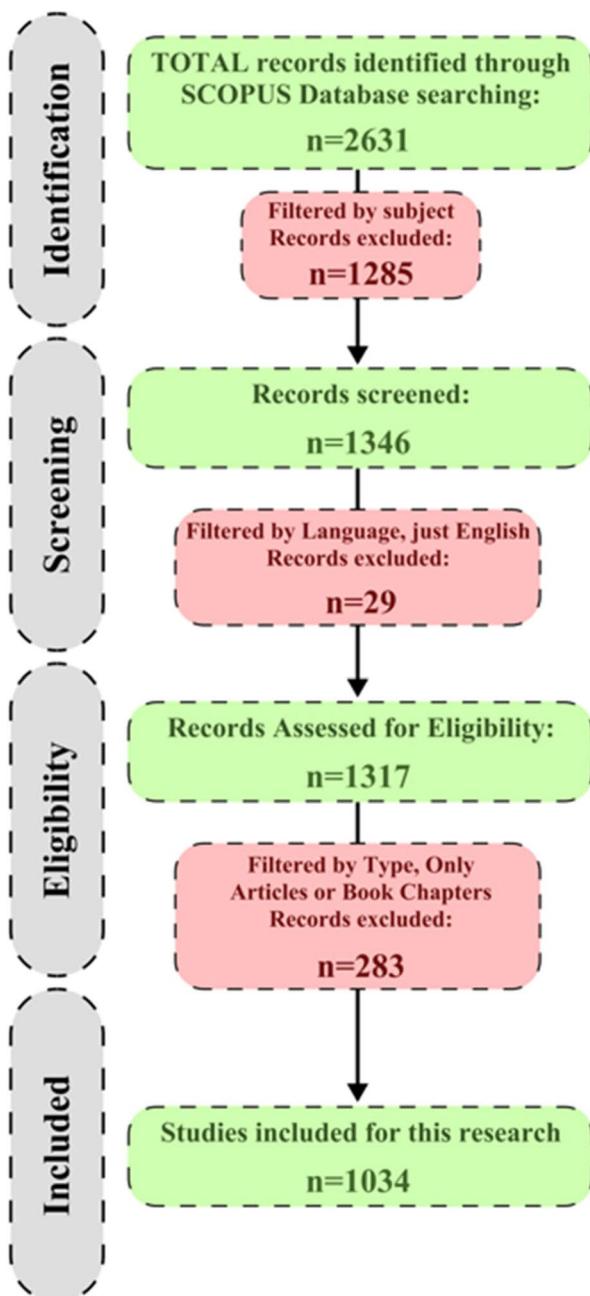
Fig. 1 Visualized research process

State of the art and future directions" (Suchek et al., 2022), incorporating diverse and comprehensive keyword combinations that reflect both the domains of entrepreneurship and CE. The final search query executed in Scopus was as follows:

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TITLE-ABS-KEY ("circular economy" OR "circularity" OR "closed-loop") AND
("entrepreneur*" OR "start-up" OR "startup" OR "new venture" OR "new enterprise" OR "small
enterprise" OR "small business" OR "SME")
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This keyword combination was deliberately broad to capture relevant studies across multiple dimensions of entrepreneurship and CE, aligned with previous bibliometric and systematic literature reviews (Goyal et al., 2021; Homrich et al., 2018; Suchek et al., 2022). The search was conducted on July 9, 2024, resulting initially in 2631 documents. Application of Scopus filters, including subject areas (business, management and accounting; environmental science), English language, and document types (articles, reviews, and conference papers), resulted in a refined dataset of 1034 documents. Figure 2 illustrates the PRISMA flow diagram for this process.

Fig. 2 PRISMA flow diagram for the present research



Bibliometric Analysis

The bibliometric analysis was performed using the RStudio software equipped with the “Biblioshiny for Bibliometrix” package, a widely recognized tool for science mapping and bibliometric analyses (Aria & Cuccurullo, 2017). This approach enabled comprehensive analyses, including descriptive bibliometric indicators, social network analysis (SNA), thematic mapping, bibliometric coupling, and keyword evolution. Then, the social network analysis (SNA) was specifically utilized to map collaborative relationships among authors, institutions, and countries. This technique identifies influential researchers, prominent institutions, and global collaboration patterns through metrics such as co-authorship networks, betweenness centrality, and clustering coefficients, thus illuminating the structural configuration of academic collaborations in CE entrepreneurship research. Finally, thematic map analysis was conducted based on co-word analysis, identifying clusters of keywords according to their density (internal coherence) and centrality (importance within the broader research landscape). As outlined by prior literature (Curado et al., 2022; Maghsoudi et al., 2023), thematic maps categorize research topics into four quadrants: motor themes, niche themes, emerging or declining themes, and basic themes (Fig. 3).

1. Motor Themes (Red—Upper-Right Quadrant):

These themes are well-developed and play a crucial role in advancing the research field. They have high centrality, indicating a strong connection with other topics, and high density, showing their internal cohesiveness and maturity.

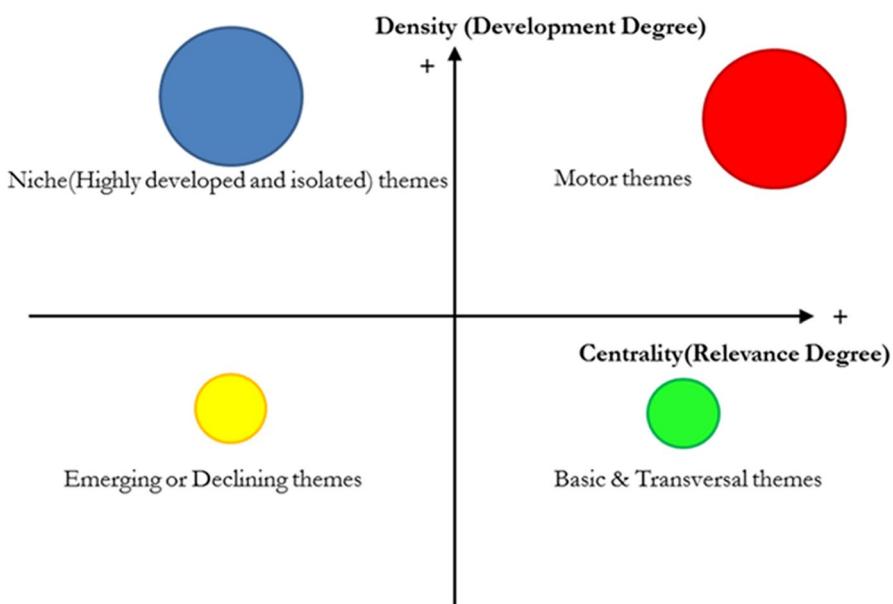


Fig. 3 Various themes based on density and centrality

- Motor themes often represent cutting-edge or “hot” topics in the field that drive innovation and scholarly discussion.
2. Niche Themes (Blue—Upper-Left Quadrant):
Niche themes are highly specialized and internally robust but exhibit low centrality, meaning their connection to the broader research field is limited. These themes typically focus on specific, in-depth issues that are important within their niche but may not yet have broader implications or widespread integration in the field.
 3. Emerging or Declining Themes (Yellow—Lower-Left Quadrant):
Themes in this quadrant are characterized by low density and low centrality, suggesting that they are either underdeveloped or losing relevance. Emerging themes may represent nascent areas of research with potential for growth, while declining themes might reflect topics that are no longer at the forefront of academic or practical interest.
 4. Basic and Transversal Themes (Green—Lower-Right Quadrant):
These themes are foundational to the field and exhibit high centrality but low density. They are crucial for the development of the discipline as they address fundamental or overarching issues. However, their internal development is often limited, indicating a need for further exploration and refinement to strengthen their contribution to the field.

Beyond identifying clusters of research activity, bibliometric techniques also illuminate the dynamics of knowledge within the field. Co-word and thematic evolution analyses enable us to trace how concepts migrate across categories (from emerging to motor themes, or from niche to basic themes), revealing patterns of maturation, convergence, or decline. In this sense, bibliometrics does not merely describe static structures of scholarship but captures the underlying knowledge dynamics—the processes through which ideas gain traction, consolidate into dominant paradigms, or fade in relevance. These knowledge dynamics are central to understanding how academic research shapes, and is shaped by, broader socio-economic and technological transformations in the circular economy entrepreneurship domain.

Qualitative Expert Validation

The Delphi procedure functions as an interpretive layer over the co-word/thematic maps to test economic salience (investment, policy, and SME strategy) of the bibliometrically identified dynamics. To enhance the robustness, interpretability, and practical relevance of the bibliometric findings, a rigorous qualitative validation process was conducted following the bibliometric analysis. The rationale for this phase was to address inherent limitations of purely quantitative bibliometric methods, including potential ambiguities in thematic cluster interpretation and the limited ability to derive actionable insights solely from quantitative data. The qualitative validation aimed to integrate domain-specific expert insights, thereby providing a deeper and more nuanced understanding of the thematic clusters identified from the bibliometric analysis.

The qualitative validation involved assembling an expert panel of 10 renowned specialists who were selected based on their substantial academic credentials, professional expertise, and recognized contributions to the fields of circular economy and entrepreneurship. Experts were chosen using clearly defined selection criteria, ensuring diversity in expertise, geographical representation, and sectoral coverage. The selected experts included individuals holding advanced academic qualifications (such as Ph.D. or Master's degrees) and extensive experience ranging from 12 to 20 years in relevant areas. Specifically, their expertise encompassed environmental economics, industrial engineering, environmental management, sustainable entrepreneurship, public policy, environmental law, digital transformation, life cycle assessment, operations management, social innovation, and circular supply chains. In summary, this qualitative expert validation phase significantly augmented the methodological rigor of the study, addressing limitations inherent in purely quantitative bibliometric approaches. By incorporating expert insights, the study ensures more robust, accurate, and practically relevant thematic interpretations, thus contributing meaningfully to both scholarly discourse and practical implementation of circular economy entrepreneurship.

Unlike prior works such as Goyal et al. (2021), which relied solely on bibliometric citation mapping using HistCite, our study extends methodological boundaries by incorporating Delphi-based expert validation. This triangulated approach not only captures co-authorship and thematic structures but also ensures interpretive rigor through practitioner and academic expert feedback. Such methodological integration has not been addressed in earlier bibliometric reviews of CE.

The Delphi-based expert validation adds interpretive depth to these dynamics by assessing whether bibliometrically identified trends correspond to meaningful shifts in practice and policy. Experts help distinguish between themes that represent transient academic interests and those that reflect substantive transformations in entrepreneurial ecosystems and market structures. In this way, expert validation not only confirms the robustness of thematic clusters but also clarifies their economic salience, identifying which knowledge dynamics are likely to drive innovation, investment, and long-term competitiveness in the circular economy.

Analyzing Knowledge Structures and Economic Implications

This section formalizes how we read the maps. A critical dimension of the present methodological design lies in its ability to interpret how knowledge is structured and to consider the economic implications of these structures. The bibliometric mapping, combined with expert validation, enables a dual analysis: On the one hand, it delineates the architecture of academic knowledge, and on the other, it situates these patterns within broader economic and entrepreneurial contexts.

From a knowledge-structural perspective, the four thematic categories identified through bibliometric mapping—motor, basic, niche, and emerging themes—can be seen as distinct layers in the evolution of scholarly discourse. Motor themes reflect established and influential research streams that are well-integrated into the field's intellectual core; basic themes function as foundational

knowledge, providing the conceptual scaffolding upon which the field rests; niche themes represent specialized insights that deepen understanding in targeted subdomains; while emerging or declining themes illustrate the temporal dynamics of knowledge, highlighting nascent areas with disruptive potential or topics in decline. Taken together, these categories provide a framework for analyzing how knowledge is organized, circulated, and reconfigured across time.

The economic implications of this structuring are particularly salient in the context of entrepreneurship and the circular economy. Motor themes often align with mature knowledge domains that shape policy agendas, direct funding priorities, and guide entrepreneurial strategies toward mainstream adoption of circular practices. Basic themes, though less developed, are crucial for sustaining the long-term viability of circular entrepreneurship, as they define the conceptual and methodological foundations upon which future innovations can be built. Niche themes, despite their limited centrality, can have strong economic relevance in specialized markets, where highly targeted solutions may lead to competitive advantages or unique entrepreneurial opportunities. Emerging themes, finally, are of particular importance to practitioners and policymakers, as they signal potential growth areas where early investment, experimentation, or institutional support may yield high returns.

By integrating bibliometric mapping with expert validation, this study operationalizes the analysis of knowledge dynamics as both a structural and an economic phenomenon. The structural view provides insight into how knowledge is generated, connected, and transformed across domains, while the economic perspective highlights the material and entrepreneurial implications of these dynamics. This dual lens not only enriches the methodological rigor of the study but also ensures that the findings are directly relevant to stakeholders concerned with innovation, competitiveness, and sustainable economic transformation in the circular economy.

Methodological Rigor and Limitations

Throughout the methodological design, rigorous adherence to established bibliometric procedures and transparency standards, such as the PRISMA protocol, ensured reliability and replicability of findings. However, as with all bibliometric studies, certain limitations are acknowledged. The exclusive reliance on the Scopus database may introduce potential linguistic bias, predominantly capturing English-language studies and potentially excluding valuable research contributions from non-English-speaking regions. Additionally, while bibliometric analysis provides objective quantification, it inherently lacks qualitative nuance, a limitation addressed explicitly through the expert validation phase. To further clarify, while the PRISMA diagram terms “records screened” and “records assessed for eligibility” reflect systematic refinement through Scopus filters, they do not imply formal quality assessments of individual studies. Rather, these terms reflect the procedural steps taken to ensure dataset relevance and manageability.

Results

This section systematically presents and interprets the results derived from the bibliometric analyses and qualitative validation. We first provide a general overview of the descriptive findings, including annual publication trends, influential contributors, and journal analysis. Subsequently, we delve into the thematic outcomes, including keyword analysis, thematic mapping, thematic evolution, and bibliometric coupling. Finally, we present the outcomes of our qualitative expert validation, summarizing the refined thematic clusters and future research trends identified by the expert panel. Together, the maps and the Delphi surface three decision-relevant insights: motor themes with immediate commercialization potential, emergent themes with high option value, and collaboration gaps that depress diffusion.

Analysis of Annual Publications

The review of publications from 1975 to 2024 on entrepreneurship within the circular economy reveals a distinctive evolutionary trajectory punctuated by pivotal shifts. In the early decades, academic activity in this domain was sporadic and modest due to limited engagement with circular economy principles in entrepreneurial contexts. However, starting around 2015, there was a marked surge in research outputs—an upswing likely spurred by increasing global awareness of sustainable development, evolving policy frameworks, and a growing interdisciplinary interest in circular practices. This upward trajectory is clearly depicted in Fig. 4, culminating in a peak in 2023 when the interconnections between entrepreneurship and circular economy strategies were receiving heightened attention from both scholars and policymakers.

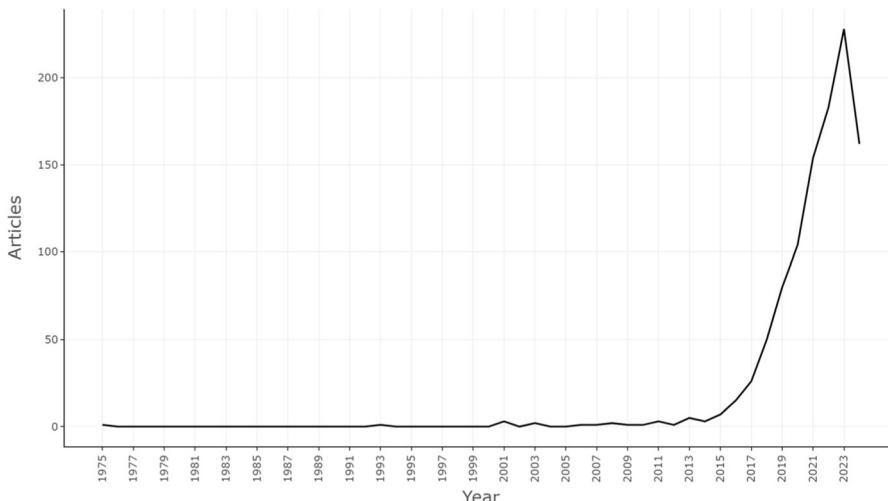


Fig. 4 Annual scientific production

The modest decline in publications observed in 2024 suggests that the field may be undergoing a phase of consolidation and increased specialization. Rather than indicating waning interest, this shift implies that foundational questions have largely been addressed, prompting researchers to pursue more focused, in-depth studies. Alternatively, changes in funding priorities or a strategic evolution toward interdisciplinary applications may be redirecting scholarly efforts away from topics that have reached saturation. Overall, these dynamics reflect a reorientation of the research agenda as the field matures and refines its focus, rather than a sign of diminished scholarly engagement.

Key Contributors and Collaborative Networks

Most Productive Authors and Their Trends

Understanding who contributes most actively to a field provides insight into the intellectual anchors and evolving leadership shaping the domain. The distribution of publications among key authors in the field of entrepreneurship within the circular economy highlights a group of highly productive researchers who have significantly shaped the discourse in this domain. These scholars vary in their publication outputs, ranging from 16 to 7 articles each, contributing extensively to the academic conversation. The analysis identified 2987 authors contributing to the 1034 analyzed articles. Among these, Nancy Bocken (Maastricht University) emerged as the most productive author (16 articles), followed by Alvarez Risco (10 articles). Figure 5 highlights their publication trends over time, reflecting their influential roles within the academic landscape.

To complement the identification of key contributors, it is equally important to examine how their scholarly influence has evolved over time. The temporal analysis

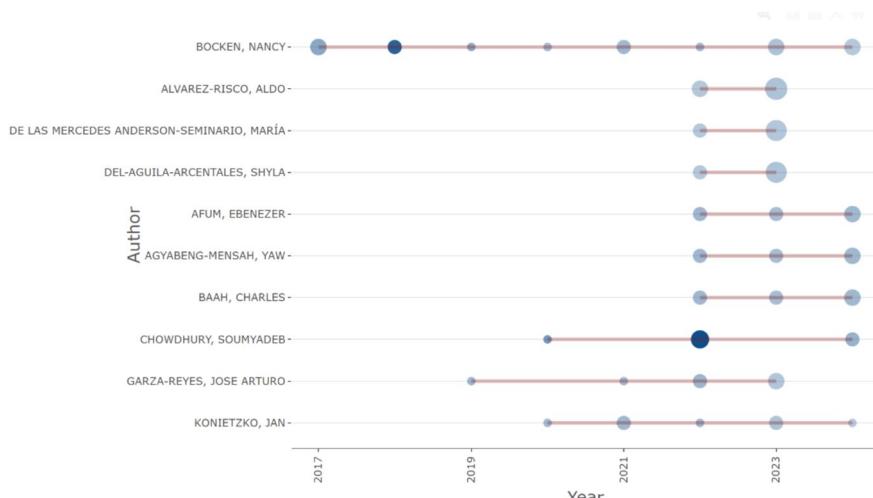


Fig. 5 Trend of authors in time periods

of author productivity (as depicted in Fig. 5) offers a nuanced view of publication trends and the evolving impact of key scholars in the field of circular economy entrepreneurship. Several prominent authors demonstrate consistent contributions over multiple years, while others exhibit more recent yet rapidly increasing publication outputs.

Collaborative Network of Authors

Beyond individual productivity, the structure of scholarly collaboration offers further insight into how knowledge is collectively produced and disseminated within the field. The co-authorship network in the field of circular economy entrepreneurship (as illustrated in Fig. 6) reveals a complex structure, characterized by distinct clusters and relatively isolated groups of researchers. This network can be divided into multiple independent clusters with limited interconnections, reflecting a tendency for researchers to collaborate within defined groups rather than forming broad, interdisciplinary partnerships. The co-authorship network reveals several distinct collaboration clusters. Although certain authors act as bridges across clusters (e.g., Soumyadeb Chowdhury, José Arturo Garza-Reyes), overall network connectivity remains fragmented, suggesting opportunities for enhancing interdisciplinary collaborations.

Most Productive Affiliations and Their Collaborations

The analysis of affiliations regarding publication output in the field of entrepreneurship within the circular economy highlights the significant contributions of various academic institutions globally. This examination provides insights into which universities are leading the charge in research in this rapidly evolving area. A total of

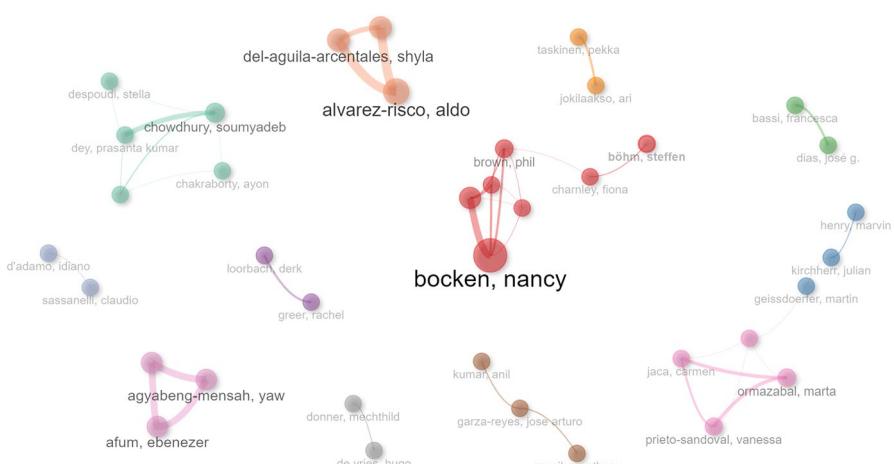


Fig. 6 Collaborative network of authors

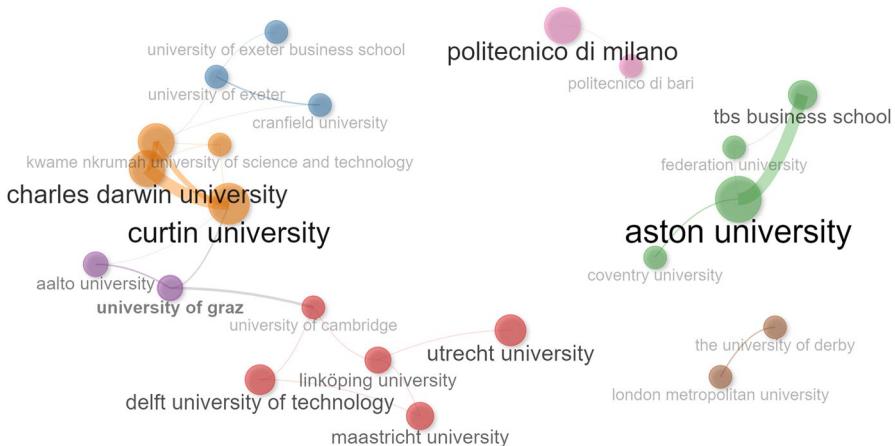


Fig. 7 Collaborative network of affiliations

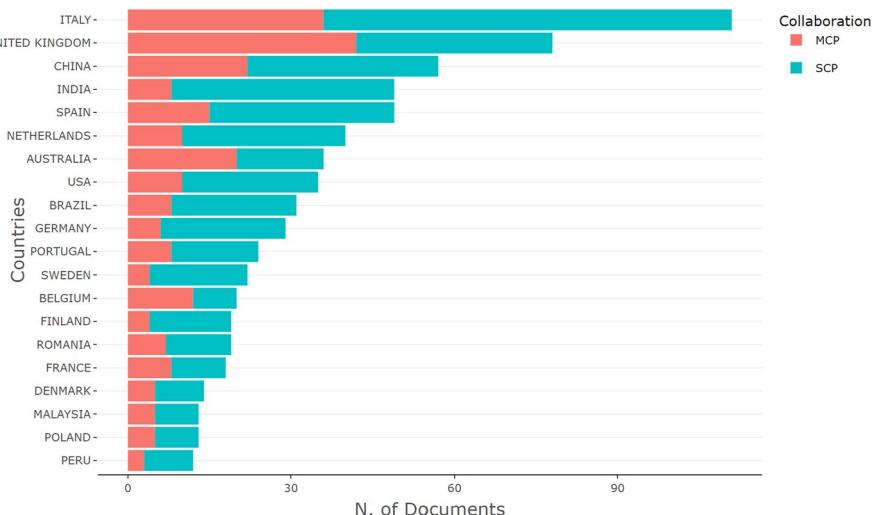
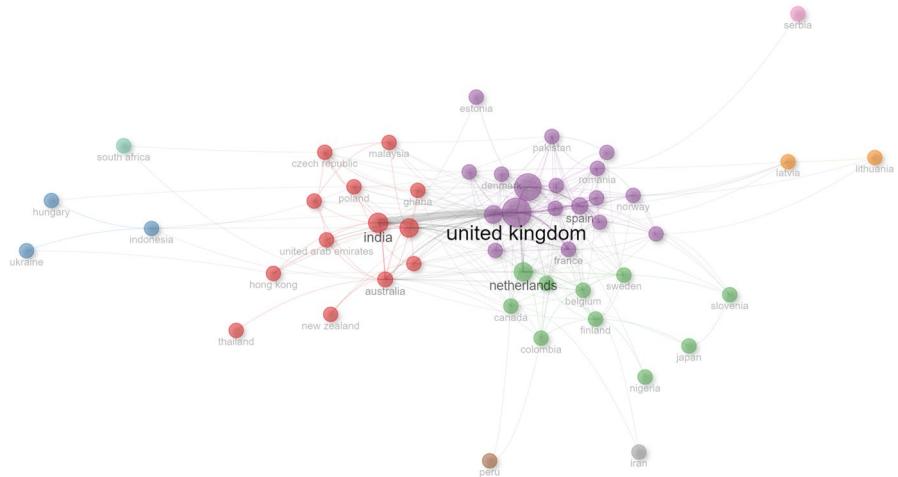
2612 institutions contributed to the dataset. Delft University of Technology, Politecnico di Milano, and Universidad de Lima stood out, each with 31 publications.

As illustrated in Fig. 7, the institution collaboration networks provide deeper insights into the dynamics of research in entrepreneurship within the circular economy. The analysis reveals approximately seven clusters of cooperation among universities, reflecting the collaborative efforts across various regions. The institutional collaboration network further illustrates research dynamics and highlights opportunities for cross-institutional partnerships.

Country-Level Productivity and Collaboration Dynamics

The extracted data on the contributions of different countries to the field of entrepreneurship in the circular economy provides an overview of global research efforts and patterns of international collaboration. As shown in Fig. 8, this analysis distinguishes between publications arising from single-country participation (SCP) and those from multiple-country participation (MCP), revealing insights into the dynamics of scholarly contributions. With contributions from 94 countries, Italy, the United Kingdom, China, India, and Spain emerge as leading contributors.

The final part of this section highlights the country collaboration network, which offers valuable insights into global research partnerships in the field of entrepreneurship within the circular economy. The collaborative network among countries (Fig. 9) emphasizes strong intra-European collaborations and identifies potential gaps in global inclusivity, particularly involving emerging economies. By interrelating the collaborative networks of countries, authors, and affiliations, this section demonstrates how individual and institutional efforts collectively shape national research outputs. The interconnectedness of these networks underscores the potential for targeted collaborations to drive innovation and expand the field of entrepreneurship within the circular economy.

**Fig. 8** Top 20 productive countries**Fig. 9** Collaborative network of countries

Journal Analysis and Influential Publications

Analysis of Leading Journals

When analyzing the allocation of articles among different journals in the domain of entrepreneurship and circular economy, it provides valuable insights into the academic platforms that are most receptive to research on this interdisciplinary field. The main

journals that contributed to the publication of research on entrepreneurship within the context of circular economy have been ranked. “Sustainability (Switzerland)” (121 articles) and “Journal of Cleaner Production” (98 articles) dominate publication volume. AJG 2024 rankings are explicitly noted, clarifying journal credibility. Notably, concerns regarding predatory practices associated with “Sustainability” are acknowledged, suggesting cautious interpretation of findings published therein.

Most Cited Articles

The most cited articles in circular economy and entrepreneurship reveal critical advancements shaping the field. Leading the field is the influential work of Rizos et al. (2016) and offers a comprehensive analysis of SMEs' barriers to circular practices, influencing both policy and research agendas. Following closely, Linder and Williander (2017) propose a strategic framework of circular business models that balance sustainability and profitability, bridging theory, and practice.

An article by Guide et al. (2003) pioneered research on closed-loop supply chains, emphasizing economic and environmental benefits of remanufacturing, foundational to circular logistics. De Angelis et al. (2018) explore digital innovations like blockchain and IoT, highlighting technology's role in enhancing transparency and traceability (De Angelis et al., 2018).

In a broader context, Tura et al. (2019) with 379 citations in the Journal of Cleaner Production, analyze circular business models within regulatory and social contexts, emphasizing access-based consumption and service-oriented strategies. Adams et al. (2017) focus on waste management in construction, providing actionable insights for resource efficiency in infrastructure. Focusing on technological innovation, Despeisse et al. (2017) investigate advanced manufacturing, notably 3D printing, as a tool for waste reduction and product lifecycle extension. Moreno et al. (2016) in sustainability emphasize eco-design's role in creating repairable and recyclable products, fundamental to sustainable lifecycle management.

Ormazabal et al. (2018) highlight the integration of corporate social responsibility with circular economy efforts, demonstrating how ethical practices motivate sustainable innovation. Lastly, Todeschini et al. (2017) examine circular business models in the fashion industry, showing how consumer-driven sustainability disrupts traditional models and opens new research directions. These articles together span a diverse array of topics, from technology integration and business model innovation to the role of waste management and eco-design, offering a comprehensive overview of the academic and practical advancements that continue to shape the circular economy.

Keyword and Thematic Analyses

Keyword Frequency Analysis

Figure 10 offers a visual summary of the most frequent terms related to circular economy studies, providing key insights into the current research landscape. Visualizing these terms allows for an efficient analysis of prevalent themes, helping

to identify the major trends and focal areas in the field. Analyzing the term frequencies reveals significant emphasis on concepts such as “circular economy,” “sustainable development,” and “sustainability,” with frequencies of 181, 154, and 112, respectively. These keywords reflect the central role these concepts play in shaping the discourse around the circular economy. Their interconnectedness highlights how the transition to circularity is viewed as a pathway to achieving sustainability goals, particularly through sustainable resource management and development initiatives.

Strategic Thematic Map Analysis

The thematic map (Fig. 11) reveals five key clusters in circular economy research, classified by centrality (interaction with other themes) and density (internal cohesiveness). The motor themes, circular economy and recycling, demonstrate high centrality and density, highlighting their fundamental and well-established roles. The circular economy cluster, with the highest centrality (10.779) and 1046 papers, is central to the field, while recycling shows strong internal development (density 28.979).

Sustainability acts as a motor and transitional theme, bridging foundational and emerging topics with a centrality of 6.685 and density of 24.867, underscoring its broad influence.

Niche themes like metal recovery and biogas show high internal development but lower centrality, reflecting specialized focus areas. Metal recovery (density 38.052) is highly developed internally, and biogas (density 32.61) is an emerging theme with growing interest, especially in renewable energy.

Temporal analysis indicates newer themes like biogas (mean publication year 2021) are gaining momentum, signaling a shift toward emerging research within sustainability and circular economy.



Fig. 10 Word cloud based on keywords

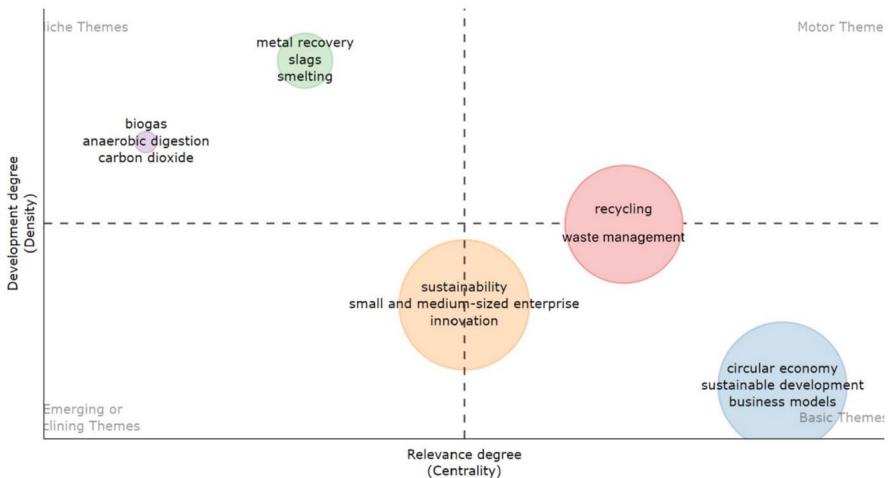


Fig. 11 Thematic map of keywords

Thematic Evolution Over Time

To better understand how research themes in circular economy entrepreneurship have developed and shifted over time, a thematic evolution is depicted through a Sankey diagram (Fig. 12), which visualizes the continuity and diversification of key topics across three distinct periods: 1975–2017, 2018–2021, and 2022–2024.

In the first period, foundational themes such as “circular economy,” “recycling,” “life cycle assessment,” and “environmental management” dominated, laying the theoretical groundwork.

The second period shows diversification into specialized topics like “metal recovery,” “industrial waste,” and “electronic waste,” while core themes like “life cycle assessment” and “environmental management” remained central, reflecting their ongoing interdisciplinary importance.

In the most recent period, emerging keywords such as “biogas,” “business development,” “business model innovation,” “SMEs,” and “supply chain management” indicate a shift towards integrating circular economy principles into broader economic and industrial practices, emphasizing practical and systemic solutions.

Overall, the diagram captures both the persistence of foundational themes and the emergence of specialized, sector-specific research areas, reflecting the field’s dynamic and evolving nature.

Figure 13 illustrates keyword trends in circular economy entrepreneurship over the past decade, showing the prominence and continuity of key themes. Core concepts like “circular economy,” “sustainable development,” “sustainability,” and “recycling” consistently dominate, with “circular economy” peaking in 2022 alongside rising global policy focus. The figure also reveals emerging niche keywords such as “cobalt,” “sulfuric acid,” and “oxygen,” reflecting growing specialization in materials and industrial processes. Interdisciplinary terms like

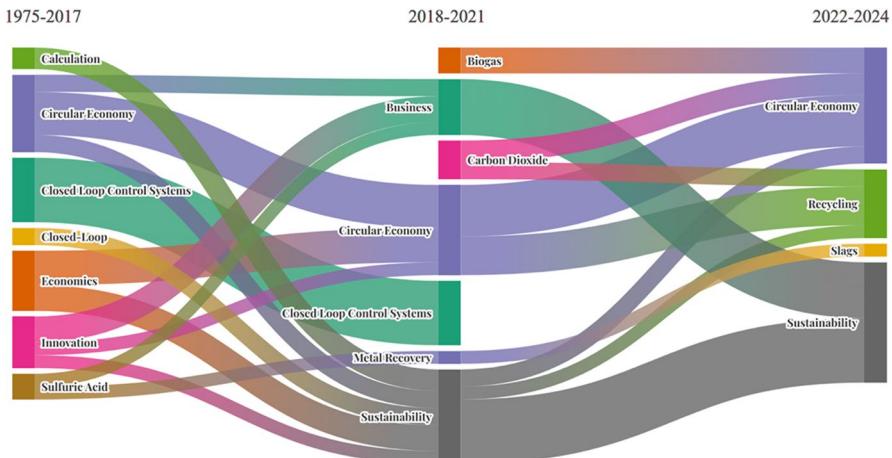


Fig. 12 Thematic evolution of keywords

“business,” “economics,” and “industrial symbiosis” highlight the integration of economic and organizational perspectives, with “business” gaining prominence since 2020. Overall, the visualization captures both the stability of foundational themes and the diversification into specialized, interdisciplinary areas, offering insights into evolving academic priorities in the field.

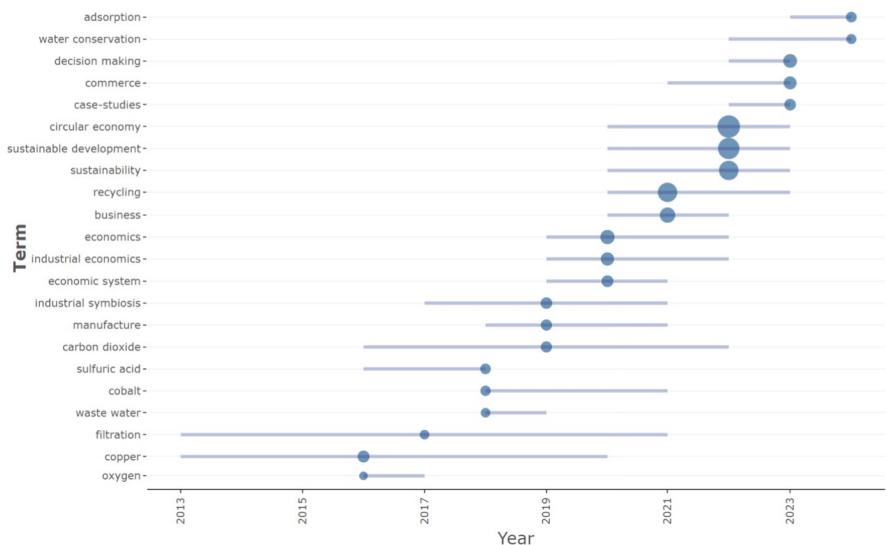


Fig. 13 Comprehensive overview of keyword trends

Thematic Evolution of Keywords (to 2017)

The thematic evolution of keywords in circular economy (CE) entrepreneurship research up to 2017, presented in Fig. 14, demonstrates a rich and evolving field with shifting research priorities. This thematic mapping categorizes topics based on their development and centrality, highlighting both well-established and underdeveloped areas. Motor themes such as copper and life cycle represent core topics with substantial research, emphasizing resource efficiency and lifecycle management that directly influence environmental policies and business practices. Conversely, basic themes like circular economy, sustainability, and business, despite their fundamental importance, remain less developed, revealing significant gaps and opportunities for further study. Niche themes, including coolants and high-temperature reactors, are specialized areas with solid development but limited connection to the central CE entrepreneurship discourse.

The analysis divides the research timeline into three periods: up to 2017, 2018–2021, and 2022–present, reflecting distinct phases of academic focus and methodology. The initial period established foundational concepts such as sustainability and resource management. The second period saw increased specialization, focusing on metal recovery and recycling processes, addressing sector-specific environmental challenges. The current period shows further maturation and diversification with new themes like business models and socio-economic impacts emerging alongside traditional topics like waste management.

This comprehensive thematic mapping not only reveals where research efforts have concentrated but also identifies underexplored areas ripe for future inquiry. It underscores the necessity to bridge these gaps through comprehensive network and thematic trend analyses, as done in this study, to weave disparate CE research strands into a coherent academic and practical framework. This approach supports strategic

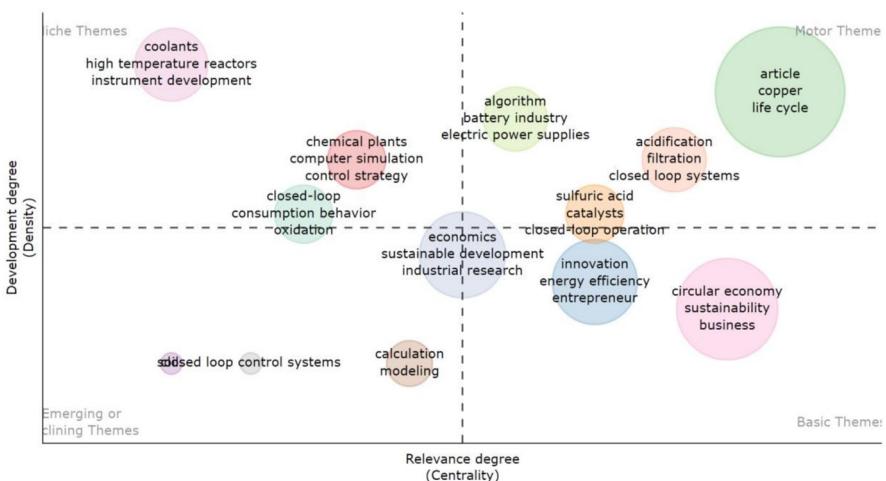


Fig. 14 Thematic evolution of keywords (to 2017)

development in CE entrepreneurship by ensuring both emerging and foundational themes receive the focused attention required to advance the field effectively.

Thematic Evolution of Keywords (2018–2021)

The thematic map for the 2018–2021 timeframe, illustrated in Fig. 15, showcases notable shifts and expansions in CE research compared to the “until 2017” analysis, highlighting evolving focus areas and enduring themes. Newly emerging motor themes such as metal recovery, slags, and smelting point to a growing emphasis on specific recycling and recovery processes. This represents a significant development from earlier themes, which were primarily centered around more general concepts such as life cycle analysis and basic material usage like copper. This shift suggests a move towards specialized industrial applications within CE, indicating a deeper exploration of material-specific recovery techniques and their environmental impacts.

The continuation of basic themes such as circular economy, sustainability, and waste management underscores the ongoing foundational research in these areas, reflecting their sustained importance in academic discourse. Additionally, the emergence of themes related to business innovation and economic conditions as basic themes illustrates an increased academic focus on the economic and business dimensions of CE. This expansion highlights a growing interest in how economic frameworks and business innovation either facilitate or hinder the implementation of CE practices, especially in the context of market dynamics and policy environments.

Moreover, the focus on SMEs within the basic themes suggests a sharper focus on the role of SMEs in advancing CE. This could indicate a broader acknowledgment of their critical role in driving innovation and adaptation within CE frameworks. Meanwhile, niche themes continue to address targeted environmental issues such as carbon dioxide, methane, and wastewater, emphasizing a sustained yet specialized

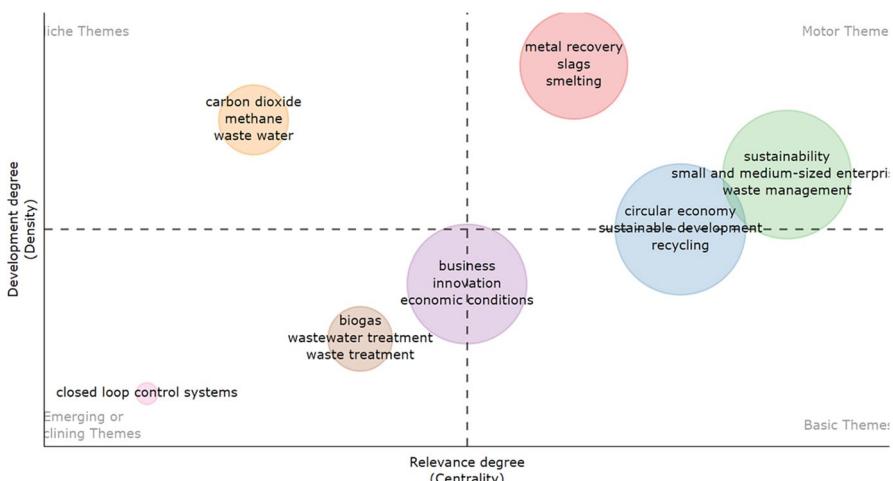


Fig. 15 Thematic evolution of keywords (2018–2021)

focus on mitigating specific environmental impacts within the broader scope of CE. This progression from the “until 2017” map to “2018–2021” illustrates not only the maturation of the CE research field but also highlights new research priorities and directions that have emerged, signaling a dynamic and diversifying academic landscape.

Thematic Evolution of Keywords (2022–2024)

The thematic map for the period 2022–present, shown in Fig. 16, illustrates significant evolutions and continuations within CE research, showcasing the field’s dynamic nature as it adapts and responds to emerging challenges and opportunities. Notably, the motor themes of recycling, waste management, and environmental impact indicate a maturation of these areas into well-developed and central aspects of CE research. This suggests a focused push towards practical implementations of CE principles and a deeper investigation into their environmental outcomes, reflecting a natural progression from broader, earlier discussions to more specific, actionable outcomes.

In addition, the map introduces business models as a new basic theme, aligning with the enduring themes of circular economy and sustainable development. This inclusion points to a broadening interest in how CE practices are being integrated into actual business operations, particularly examining their scalability and economic viability. Moreover, the presence of themes such as economic and social effects and life cycle within the basic themes quadrant signifies a holistic approach in CE research, expanding beyond environmental impacts to include broader socio-economic implications and lifecycle considerations. This shift indicates a more comprehensive understanding of CE’s impact on economies and societies, emphasizing the need for a multifaceted exploration of CE practices.

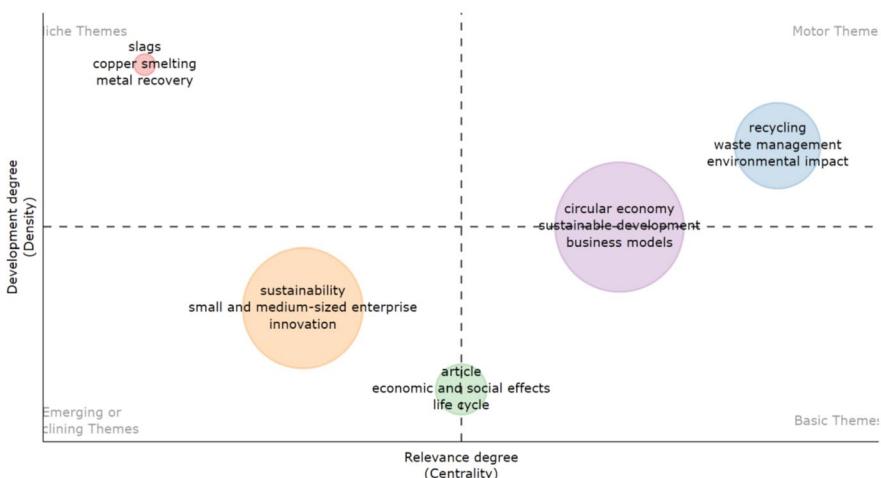


Fig. 16 Thematic evolution of keywords (2022–present)

The emergence of specific industrial processes like slags, copper smelting, and metal recovery as niche themes underscores a sharper focus on particular sectors that have significant potential for resource recovery and recycling. Additionally, the spotlight on sustainability and innovation within SMEs in the emerging or declining quadrant highlights a growing research interest in how smaller enterprises contribute to the CE landscape. This focus on SMEs suggests that while these areas are critical for the future development of CE, they may currently be underexplored or just beginning to gain traction in CE discussions. Together, these developments in the thematic landscape from 2022 to present indicate a clear progression towards more specialized, practical, and economically integrated research in CE, demonstrating the field's ongoing evolution from theoretical frameworks to real-world applications.

Qualitative Expert Validation of Clusters

To complement the quantitative bibliometric analyses and ensure robust interpretation and practical relevance of the identified clusters, we undertook a structured and rigorous qualitative validation process involving a panel of carefully selected experts. This qualitative validation addresses the sole reliance on quantitative bibliometric methods by integrating field-specific insights, thereby enhancing the validity, interpretability, and applicability of the identified thematic clusters.

We assembled a diverse panel consisting of 10 experts from various relevant academic and professional backgrounds. Experts were chosen based on their significant academic credentials, extensive professional experience, and recognized contributions to the fields related to circular economy entrepreneurship. To maintain confidentiality and research ethics, all individual identities are anonymized. The detailed anonymous expert profiles are summarized in Table 2.

The qualitative validation followed a structured online meeting, three-step process designed to systematically integrate expert insights:

Step 1: Initial Briefing and Information Distribution.

We provided each expert with comprehensive materials, including:

- Clearly defined cluster descriptions, thematic maps, and keyword network diagrams derived from bibliometric analyses (representing the most recent thematic evolution from 2022 onward).
- Detailed methodological notes explaining cluster formation and bibliometric metrics.

Step 2: Individual Expert Review and Initial Feedback.

Each expert individually reviewed the provided materials, assessing the clusters' coherence, relevance, and practical implications. They provided written comments

Table 2 Expert panel details

Expert ID	Academic qualification	Professional expertise and research interests	Years of experience
Expert 1	Ph.D. in Environmental Economics	Circular economy policy, sustainable business practices, environmental economics	20
Expert 2	Ph.D. in Industrial Engineering	Recycling technologies, industrial symbiosis, sustainable industrial systems	15
Expert 3	Ph.D. in Environmental Management	Waste management, resource recovery, urban mining	12
Expert 4	Ph.D. in Entrepreneurship	Circular business models, SMEs innovation, sustainable entrepreneurship	18
Expert 5	Ph.D. in Public Policy	Circular economy governance, policy frameworks, sustainability policy	17
Expert 6	Ph.D. in Computer Science and MBA	Digital transformation, blockchain-enabled circular economy, AI applications in sustainability	14
Expert 7	Ph.D. in Environmental Engineering	Life cycle assessment (LCA), environmental impact analysis, sustainability metrics	16
Expert 8	Ph.D. in Operations Management	Circular supply chains, logistics, operational strategies in sustainability	13
Expert 9	Master's in Social Innovation	Social entrepreneurship, circular economy in developing economies, community-based innovation	14
Expert 10	Master's in Environmental Law	Circular economy regulations, compliance, international environmental law	19

on cluster interpretations, suggested refinements, and identified gaps or emerging issues not captured in the original bibliometric analysis.

Step 3: Consensus Workshop and Delphi Process.

We conducted two online Delphi rounds, where experts collectively discussed initial findings, resolved discrepancies, refined cluster themes, and reached consensus on the relevance and significance of each cluster. This iterative discussion facilitated deeper understanding and richer interpretation, resulting in refined cluster names and descriptions.

Expert-Validated Bibliometric Clusters

Based on this rigorous qualitative validation, the experts provided a refined interpretation of bibliometric clusters, particularly those identified in the latest period (2022 onward). The refined thematic framework, integrating both quantitative clustering and qualitative interpretation, is presented in Table 3.

The qualitative validation process further allowed experts to identify and articulate key future trends likely to shape the circular economy entrepreneurship landscape based on the current research trajectory:

1. Digital Circularity: Increasing integration of advanced digital technologies to optimize resource use, supply chain transparency, and business model innovation. Technologies such as blockchain, IoT, and AI will significantly influence future circular economy practices.
2. Localized Circular Economy Ecosystems: Growing importance of localized and regional circular economy networks, particularly driven by SMEs, fostering collaboration and industrial symbiosis tailored to specific community needs and resources.
3. Policy Harmonization and Global Standards: A clear trend toward international standardization and harmonization of circular economy regulatory frameworks, certification schemes, and metrics to facilitate global scalability and comparability of circular practices.
4. Circular Finance and Investment Models: Emergence of specialized financing instruments, circular economy investment funds, and impact investment strategies explicitly aimed at supporting circular startups and enterprise transitions.
5. Circular Economy Education and Capacity-Building: Increased emphasis on specialized education programs, skill development, and capacity-building initiatives preparing professionals, entrepreneurs, and policymakers to effectively implement circular principles.
6. Inclusivity and Societal Engagement: Growing recognition of the need for inclusive circular economy transitions, addressing social equity, community participation, and just transition principles to ensure broad societal acceptance and support.

Table 3 Expert-validated clusters and refined interpretations

Cluster ID	Expert-validated theme	Detailed interpretation and insights
Cluster 1	Advanced recycling and waste management systems	Experts emphasized this cluster's focus on technological innovations in recycling processes, waste-to-value strategies, and integrated waste management solutions. They highlighted trends toward digital-enabled smart recycling, AI-powered sorting technologies, and blockchain for traceability
Cluster 2	Circular business model innovation	Experts confirmed the growing importance of innovative circular business models such as product-as-a-service, remanufacturing models, and sharing economy approaches. They stressed emerging trends where traditional business sectors actively adopt circularity to maintain competitive advantage and regulatory compliance
Cluster 3	SME-driven circular innovations	The panel recognized SMEs as critical drivers of circular economy innovation, particularly in niche markets and specialized industries. They validated the cluster's focus on agile SMEs pioneering novel eco-design practices, industrial symbiosis, and regional circular economy networks
Cluster 4	Circular economy policy and governance	Experts validated the importance of robust policy frameworks and governance mechanisms facilitating circular economy transitions. They identified an increased global emphasis on supportive regulations, incentives for circular enterprise development, and international cooperation for circular economy standardization
Cluster 5	Socio-economic and environmental impacts	This cluster was interpreted as reflecting increased attention toward comprehensive impact assessments, incorporating social, economic, and environmental metrics. Experts emphasized the significance of holistic sustainability evaluations, life-cycle assessments, and socio-economic equity considerations within circular economy initiatives
Cluster 6	Digital transformation in the circular economy	Experts identified this emerging area as highly significant, recognizing the transformative role of digital technologies (e.g., IoT, AI, digital twins) in optimizing circular practices, enhancing resource efficiency, and enabling transparency and accountability across supply chains

This qualitative expert validation significantly enhances the interpretability, robustness, and practical relevance of our bibliometric clusters. The refined thematic clusters and identified trends provide a detailed, actionable roadmap for future research, policy development, entrepreneurial strategy, and societal engagement in the circular economy. These expert-validated clusters convert bibliometric regularities into entrepreneurial guidance (e.g., AI-enabled sorting under “advanced recycling,” PaaS under “circular business models,” and SME-centric innovation pathways). By integrating expert insights, this study bridges the gap between quantitative bibliometric analysis and practical, real-world applicability, offering a comprehensive and authoritative understanding of current and future developments in circular economy entrepreneurship.

Discussion

This study systematically examined the academic landscape of entrepreneurship within the circular economy (CE) by combining bibliometric and expert-based analyses to explore thematic trajectories and scholarly collaborations. The integration of bibliometrics with Delphi reframes the field from static structures to knowledge dynamics with economic traction. This is why motor themes align with near-term commercialization, while emergent themes map to investable options and capability bets. Findings indicate a sharp increase in research activity from 2015 onward, driven by heightened global attention to sustainability and the introduction of influential policy frameworks, such as the European Green Deal. The peak in publication volume in 2023 underscores this momentum. Nevertheless, it is important to acknowledge that the reasoning attributing the slight decline after 2023 to a temporary adjustment or realignment in research focus remains speculative, as empirical data on citation trends, funding allocations, or regional publication shifts were not systematically analyzed in this study. This downturn may stem from several interrelated factors, including shifts in funding priorities, a redistribution of scholarly attention toward adjacent sustainability topics, or saturation of broad, well-explored themes. Additionally, it is possible that reduced output from key geographic regions—such as Europe or specific Asian economies—played a role in the observed dip, warranting further investigation into regional publication trends and institutional engagement.

The thematic evolution analysis reveals a steady intellectual shift—from general foundational themes such as recycling, sustainability, and life cycle assessment—to more specialized and application-oriented areas. Notable themes emerging in recent years include digital circularity, SME-led innovation, and new circular business models. This trend indicates a growing focus on actionable strategies and technological enablers. SMEs, in particular, emerged as central agents of change due to their flexibility and innovation capacity. However, recurring challenges—including limited access to capital, regulatory inconsistencies, and technological barriers—remain prevalent. Interestingly, while SME-driven models are gaining prominence, the role of social entrepreneurship remains relatively

underexplored despite its alignment with CE values such as community resilience and equitable resource use.

Collaboration network analysis shows the field is still somewhat fragmented but increasingly interconnected. European institutions—especially Delft University of Technology and Politecnico di Milano—are leading the way, serving as hubs for knowledge production and dissemination. Yet, the low visibility of institutions from the Global South reveals a significant geographical gap. Regions such as Latin America, Sub-Saharan Africa, and Southeast Asia remain under-represented, in both publication volume and international collaboration. This imbalance limits the global inclusivity and relevance of CE entrepreneurship scholarship and suggests a critical need to build stronger cross-regional research linkages, encourage knowledge co-production, and ensure that CE strategies are adaptable across diverse economic and institutional contexts.

The qualitative expert validation added meaningful insights, confirming the practical relevance of identified clusters while pointing toward future research frontiers. Experts highlighted the transformative potential of digital tools—such as blockchain and artificial intelligence—in enhancing circular transparency and efficiency. They also stressed the importance of supportive policies, measurable socio-economic outcomes, and multi-stakeholder collaboration. These findings support the need for integrative approaches that combine technological development with policy innovation and inclusive governance structures.

Moreover, the results strongly align with the principles of the knowledge-based economy. Entrepreneurial efforts within the CE framework are not only generating innovative solutions but also fostering the diffusion of knowledge through industrial ecosystems and regional innovation networks. SMEs play a vital role in this dynamic by translating localized expertise into scalable models that advance both sustainability and competitiveness. The integration of domain-specific knowledge—such as waste valorization or digital traceability—into business practices reflects how CE entrepreneurship contributes to long-term value creation and systemic transformation.

This research distinguishes itself from previous reviews by offering a methodologically integrative approach that combines quantitative bibliometric analysis with qualitative expert validation, a dimension often missing in earlier studies. While prior works have mapped thematic structures (e.g., Goyal et al., 2021) or identified conceptual gaps through systematic reviews (e.g., Suchek et al., 2022), they typically stop short of empirically validating emergent themes or connecting bibliometric trends with practical realities on the ground. In contrast, our study bridges this gap by not only visualizing the intellectual and collaborative structure of CE entrepreneurship but also grounding these findings in expert knowledge, ensuring both scholarly rigor and real-world relevance. This dual-layered analysis enables a more holistic understanding of how circular entrepreneurship evolves across regions and sectors, particularly through the lens of SMEs and digitally-enabled innovations. In doing so, the study advances the state of knowledge by translating bibliometric insights into validated, actionable pathways for research, policy, and entrepreneurial practice.

In summary, the field of CE entrepreneurship continues to evolve through increasing specialization, regional diversification, and digital transformation. Rather than signaling a decline, recent trends point to a recalibration of research priorities, offering opportunities to deepen understanding, expand participation, and enhance the real-world impact of circular innovations.

Theoretical Analysis Through the Knowledge-Based View

Building upon the knowledge-based view introduced in the theoretical framework, this section interprets the empirical findings to highlight how knowledge dynamics shape the evolution of entrepreneurship within the circular economy. According to the KBV, knowledge is the primary resource for achieving competitive advantage and fostering innovation. The results of this study empirically support this proposition, showing that knowledge creation, diffusion, and integration are central to the development of CE entrepreneurship as an academic and practical field.

The sharp rise in scholarly publications after 2015 reflects an acceleration in both the creation and dissemination of knowledge related to CE. This growing body of research signals the emergence of a more accessible and structured knowledge base that supports entrepreneurs, policymakers, and academics alike. Moreover, CE entrepreneurial activities themselves generate valuable knowledge assets, including process knowledge, technological know-how, and organizational routines, which feed back into the broader knowledge ecosystem. The thematic analysis offers further insights: “motor” and “basic” themes represent well-established domains of knowledge, while emerging “niche” themes—particularly those related to digital circularity and circular business model innovation—highlight areas of active knowledge generation. These emerging themes signal future knowledge assets with high potential impact, particularly for CE entrepreneurs navigating complex sustainability challenges. Expert validation confirmed the practical relevance of these knowledge domains, reinforcing their value for real-world CE transitions. Importantly, the bibliometric findings indicate that academic collaborations act as catalysts for knowledge spillovers, enabling tacit and codified knowledge to move across institutions, sectors, and regions. Co-authorship networks, institutional clusters, and international partnerships not only facilitate the diffusion of insights but also create environments where digital circularity initiatives and policy frameworks can be effectively developed and applied.

Collaboration networks across authors, institutions, and countries provide an additional layer of insight into knowledge transfer and integration. Leading institutions function as influential hubs that facilitate the diffusion of explicit knowledge and the co-creation of new ideas through interdisciplinary collaboration. Through these networks, tacit knowledge embedded in SMEs, industrial practices, and digital platforms is codified, shared, and recombined, demonstrating how CE entrepreneurship operationalizes KBV principles. Strong intra-European connections suggest effective regional knowledge sharing and recombination, while the underrepresentation of institutions from other global regions reveals critical knowledge gaps. These disparities may impede the global scalability of CE solutions and highlight

the need for broader geographic inclusion in knowledge networks. Furthermore, digital circularity and emerging policy mechanisms can be conceptualized as knowledge-enabling tools within the KBV framework. Digital technologies (e.g., IoT, AI, blockchain) serve as mediums through which knowledge is captured, codified, and operationalized, while supportive policy frameworks provide structured guidance that amplifies the dissemination and application of best practices in CE entrepreneurship. This interplay underscores the centrality of knowledge-intensive practices in driving sustainable innovation and systemic transformation.

Importantly, the expert-emphasized role of SMEs illustrates the KBV in action at both meso- and micro-levels. SMEs often rely on embedded tacit knowledge, which enables agile decision-making and context-specific innovation. Their ability to adapt circular principles is closely tied to effective mechanisms for acquiring, internalizing, and applying knowledge. For instance, SMEs leverage digital tools (IoT, AI, blockchain) to capture operational data, convert it into actionable knowledge, and integrate it into circular business models, highlighting the knowledge-intensive nature of CE entrepreneurship. This is particularly evident in emerging research trends such as “Digital Circularity” and “Circular Finance and Investment Models,” which underscore the ongoing demand for new knowledge assets and sophisticated approaches to knowledge governance.

This study contributes to the advancement of the knowledge-based view by empirically mapping how knowledge flows within the CE entrepreneurship ecosystem. Through the integration of thematic clustering and collaborative network analysis, it illustrates the mechanisms by which knowledge is created, shared, and applied in this interdisciplinary domain. These findings extend the KBV framework by emphasizing the upstream processes of knowledge generation—within academia and through cross-sector collaboration—that enable downstream entrepreneurial innovation. By explicitly linking CE entrepreneurial practices to knowledge asset creation and application, this study demonstrates that CE transitions are fundamentally driven by knowledge-intensive processes, from SMEs’ operational learning to policy-driven knowledge dissemination.

Ultimately, this research offers a comprehensive, integrative analysis of CE entrepreneurship, advancing theoretical understanding by illustrating how knowledge functions as both the foundation and driver of innovation in circular economic systems.

Implications

This study introduces several novel insights that differentiate it from previous literature and enhance both theoretical understanding and practical applicability in the field of circular economy (CE) entrepreneurship. Our analysis yields distinct new insights: (1) SME-led digital circularity is now a motor theme with immediate pay-off pathways; (2) circular finance instruments and education/capacity-building are emergent leverage points that accelerate diffusion; (3) collaboration asymmetries explain why some regions lag despite thematic maturity.

Theoretical Implications

While prior reviews such as Suchek et al. (2022) and Goyal et al. (2021) primarily focused on thematic categorization or macro-level trends, our integrative approach—combining bibliometric mapping with expert-driven qualitative validation—offers a unique contribution by revealing the structural dynamics of academic collaboration and the evolution of knowledge domains over time. This dual-layered methodology extends the knowledge-based view by illustrating how both codified (e.g., published research clusters) and tacit (e.g., practitioner insights) knowledge co-evolve in CE ecosystems. Specifically, CE entrepreneurship activities generate and leverage knowledge assets—including technological know-how, circular process knowledge, and organizational learning—that are essential for sustaining innovation and competitive advantage. In particular, the identification of emerging themes such as digital circularity, circular finance, and entrepreneurial ecosystem readiness provides a forward-looking lens for theory-building around innovation diffusion, SME capabilities, and institutional support mechanisms within circular contexts. These findings reinforce the notion that knowledge-intensive practices are central drivers of CE transitions, with SMEs and innovative actors acting as both producers and carriers of critical knowledge. Furthermore, our mapping of underrepresented regions and weak collaboration ties advances theoretical discourse by revealing asymmetries in global knowledge flows—an area largely overlooked in prior studies. Understanding these asymmetries is crucial, as they indicate where knowledge creation and diffusion are hindered, which in turn affects the scalability and implementation of circular economy practices worldwide. The bibliometric results indicate that collaborations among authors, institutions, and countries act as crucial mechanisms for knowledge spillovers, fostering both the creation and diffusion of CE-related knowledge. Digital circularity initiatives and policy frameworks emerge as knowledge-enabling mechanisms, illustrating how codified knowledge (e.g., research findings, standards) and tacit knowledge (e.g., SME expertise) are mobilized to generate practical value. By linking CE entrepreneurial activities to these knowledge assets, we demonstrate that CE transitions are fundamentally knowledge-intensive processes, reliant on both formal networks and embedded experiential know-how.

Practical Implications

From a practical perspective, this study delivers actionable insights for entrepreneurs, policymakers, and innovation agencies. For entrepreneurs, especially SMEs, our findings underscore the value of joining knowledge-sharing networks and codifying their tacit know-how into accessible practices. By engaging in collaborative platforms, SMEs can reduce experimentation costs, accelerate diffusion of successful models, and strengthen their legitimacy with investors and regulators.

For policymakers, the expert-validated clusters highlight clear opportunities to foster systemic change. Governments can (1) establish knowledge-sharing platforms that aggregate case studies, technical standards, and funding opportunities; (2) incentivize SMEs to contribute non-sensitive data and practices to these platforms through tax credits or procurement preferences; and (3) support regional symbiosis

hubs that link entrepreneurs, research institutions, and municipalities to accelerate replication of circular models. Embedding circular economy education in training programs and public campaigns can further ensure societal buy-in. Recognizing consumer resistance and regulatory rigidity as barriers, policies should combine regulatory sandboxes with inclusive public engagement to build trust and acceptance. Finally, by addressing global imbalances in participation, international bodies can back cross-regional initiatives that extend knowledge diffusion beyond Europe and Asia.

Together, these steps provide both governments and entrepreneurs with implementable levers to strengthen circular economy ecosystems.

Limitations and Future Research Directions

Despite methodological rigor, this study acknowledges several limitations. First, reliance on the Scopus database introduces potential linguistic and regional biases, predominantly capturing English-language publications and possibly excluding valuable contributions from non-English-speaking regions. This reliance on the Scopus database, as noted, not only introduces potential linguistic biases but also likely means that valuable circular economy innovations and entrepreneurial approaches emerging in underrepresented geographies like Latin America, Africa, and Asia are systematically overlooked in this analysis. Future research should incorporate multilingual databases and grey literature to provide a more inclusive global perspective. Also, while qualitative expert validation enhanced interpretative robustness, the limited number of experts (ten) may constrain generalizability. Addressing this geographical imbalance is crucial, and future research should actively seek to include studies and perspectives from these underrepresented regions to gain a more comprehensive global understanding of circular economy entrepreneurship. Future studies could expand qualitative validation through broader expert panels, practitioner consultations, or case studies to deepen practical insights and validate thematic relevance.

The bibliometric approach inherently emphasizes quantitative relationships, potentially overlooking qualitative nuances. Future research could integrate qualitative methodologies, such as in-depth case studies or interviews, to explore contextual factors influencing CE entrepreneurship, particularly in diverse geographical and industrial contexts. Future research should therefore dedicate specific attention to the unique contributions and challenges of social entrepreneurship within the circular economy, particularly as noted by experts in areas like developing economies and community-based innovation. Finally, emerging themes identified—such as digital circularity, blockchain-enabled transparency, and AI-driven resource optimization—warrant further empirical investigation. Future studies should explore practical applications, scalability, and socio-economic impacts of these technologies within CE entrepreneurship, providing actionable insights for practitioners and policymakers.

In conclusion, this study significantly enhances understanding of entrepreneurship within the circular economy by systematically mapping thematic evolutions and collaborative networks. By integrating quantitative bibliometric analyses with qualitative expert validation, it provides comprehensive insights into current research dynamics, identifies critical gaps, and outlines clear directions for future theoretical and practical advancements.

Conclusion

This study offers a comprehensive mapping of the academic landscape at the intersection of entrepreneurship and the circular economy through an integrated approach combining quantitative bibliometric analysis and qualitative expert validation. By fusing bibliometric mapping with Delphi validation, we convert descriptive maps into validated knowledge dynamics with clear entrepreneurial, investment, and policy consequences. This dual lens advances prior reviews by empirically verifying which themes matter for markets and capability building now versus which represent near-term options. The bibliometric phase revealed notable growth in research outputs since 2015, marked by evolving thematic foci—from foundational topics such as recycling, life-cycle assessment, and sustainable development to more specialized issues including digital circularity, advanced waste management technologies, and innovative circular business models. The network analyses further underscored the presence of fragmented yet emerging collaborative clusters among authors, affiliations, and countries, suggesting significant opportunities for cross-disciplinary and global research partnerships.

Importantly, the qualitative phase—conducted through a structured Delphi process with a panel of 10 experts—enhanced interpretability and practical relevance. Experts validated and refined the thematic clusters, emphasizing critical topics such as advanced recycling and waste management systems, innovative circular business models, and the pivotal role of SMEs as agile drivers of sustainable change. They also highlighted emerging trends in digital transformation and the need for robust policy and governance frameworks to support the scaling up of circular practices. The consensus from this expert-driven phase reinforces the importance of integrating technological innovation and socio-economic considerations to fully operationalize circular economy practices in entrepreneurial contexts. Unlike previous studies, which primarily mapped bibliometric patterns, this study contributes a validated, multi-level perspective on CE entrepreneurship—linking network dynamics, expert insights, and thematic trajectories to provide a holistic and original contribution to the field.

Collectively, the findings of this study not only chart the evolution of circular economy entrepreneurship research but also provide actionable insights for researchers, practitioners, and policymakers. Furthermore, by interpreting these findings through the knowledge-based view, the study empirically demonstrates how knowledge dynamics within the academic ecosystem drive the evolution and application of

knowledge essential for CE entrepreneurship, thereby illustrating upstream knowledge generation mechanisms that foster systemic transformation, organizational learning, and individual entrepreneurial action. The clear identification of central themes and the validation of emerging trends pave the way for future investigations aimed at strengthening interdisciplinary collaborations and addressing global sustainability challenges. Moving forward, focusing on digital integration, localized circular ecosystems, and enhanced policy frameworks will be instrumental in accelerating the transition toward a more sustainable and resilient economic model. To translate these insights into practice, governments should prioritize building knowledge-sharing platforms and regional hubs that diffuse circular economy practices, while entrepreneurs can leverage these networks to codify and exchange know-how. Such steps ensure that the societal implications identified in this study lead to actionable outcomes for both policymakers and businesses. Ultimately, this research highlights that fostering circular economy entrepreneurship is not just an economic or environmental endeavor but also a societal one, with the potential to shape public policy, educational agendas, and social norms towards sustainability, especially when considering the need for inclusive approaches that encompass social entrepreneurship and diverse geographical contexts.

In line with the core themes of the Journal of the Knowledge Economy, this study also illustrates how knowledge is created, diffused, and applied within the circular economy entrepreneurship ecosystem. Also, by mapping scholarly collaborations and validating thematic clusters through expert insight, the study contributes to understanding how knowledge-intensive practices are shaping economic transformation toward sustainability.

Data Availability The data that support the findings of this study are available upon request.

Declarations

Conflict of Interest The authors declare no competing interests.

References

- Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Proceedings of the institution of civil engineers-waste and resource management*. <https://doi.org/10.1680/jwarm.16.00011>
- Alka, T., Raman, R., & Suresh, M. (2024). Research trends in innovation ecosystem and circular economy. *Discover Sustainability*, 5(1), Article 323.
- Ambaye, T. G., Djellabi, R., Vaccari, M., Prasad, S., Aminabhavi, T. M., & Rtimi, S. (2023). Emerging technologies and sustainable strategies for municipal solid waste valorization: Challenges of circular economy implementation. *Journal of Cleaner Production*, 423, Article 138708.
- Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal Of Informetrics*, 11(4), 959–975.
- Atstaja, D., Koval, V., Grasis, J., Kalina, I., Kryshnal, H., & Mikhno, I. (2022). Sharing model in circular economy towards rational use in sustainable production. *Energies*, 15(3), Article 939.

- Audretsch, D. B., & Fiedler, A. (2024). Bringing the knowledge spillover theory of entrepreneurship to circular economies: Knowledge and values in entrepreneurial ecosystems. *International Small Business Journal: Researching Entrepreneurship*, 42(4), 480–505.
- Baiocco, S., & Paniccia, P. M. (2023). Business model innovation in sustainable entrepreneurship: Co-evolutionary evidence from small accommodation firms. *Business Process Management Journal*, 29(8), 260–292.
- Basit, A., Samdani, H., & Kamal, N. (2024). Knowledge entrepreneurship in higher education institutions: A perspective of knowledge sharing and entrepreneurial leadership in Pakistani HEIs. *Foresight*, 26(6), 1001–1029.
- Curado, M., Rodriguez, R., Tortosa, L., & Vicent, J. F. (2022). Anew centrality measure in dense networks based on two-way random walk betweenness. *Applied Mathematics and Computation*, 412, Article 126560.
- Dantas, R. M., Ilyas, A., Martins, J. M., & Rita, J. X. (2022). Circular entrepreneurship in emerging markets through the lens of sustainability. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(4), 211.
- De Angelis, R., Howard, M., & Miemczyk, J. (2018). Supply chain management and the circular economy: Towards the circular supply chain. *Production Planning & Control*, 29(6), 425–437.
- Despesse, M., Baumers, M., Brown, P., Charnley, F., Ford, S. J., Garmulewicz, A., Knowles, S., Minshall, T., Mortara, L., & Reed-Tsochas, F. (2017). Unlocking value for a circular economy through 3D printing: A research agenda. *Technological Forecasting And Social Change*, 115, 75–84.
- Domenech, T., & Borrión, A. (2022). Embedding circular economy principles into urban regeneration and waste management: Framework and metrics. *Sustainability*, 14(3), Article 1293.
- Ferasso, M., Beliaeva, T., Kraus, S., Clauss, T., & Ribeiro-Soriano, D. (2020). Circular economy business models: The state of research and avenues ahead. *Business Strategy and the Environment*, 29(8), 3006–3024.
- Ferreira, J. J., C Fernandes, A. J., & Ramirez-Pasillas, M. (2024). Start-ups and entrepreneurial ecosystems in the circular economy: A multi-level approach for safe and just planetary boundaries. *International Small Business Journal*, 42(4), 416–445. <https://doi.org/10.1177/02662426231210765>
- Geissdoerfer, M., Pieroni, M. P. P., Pigozzo, D. C. A., & Soufani, K. (2020). Circular business models: A review. *Journal of Cleaner Production*, 277, Article 123741.
- Govindan, K., & Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards circular economy: A supply chain perspective. *International Journal of Production Research*, 56(1–2), 278–311. <https://doi.org/10.1080/00207543.2017.1402141>
- Goyal, S., Chauhan, S., & Mishra, P. (2021). Circular economy research: A bibliometric analysis (2000–2019) and future research insights. *Journal of Cleaner Production*, 287, Article 125011.
- Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17(S2), 109–122.
- Guide, V. D. R., Harrison, T. P., & Van Wassenhove, L. N. (2003). The challenge of closed-loop supply chains. *Interfaces*, 33(6), 3–6.
- Hartini, S., Rumita, R., & Al Huda, M. H. (2022). Upcycle strategy on tree branches to improve eco-efficiency towards a circular economy using life cycle assessment. *IOP Conference Series: Earth and Environmental Science*. <https://doi.org/10.1088/1755-1315/1098/1/012024>
- Homrich, A. S., Galvão, G., Abadia, L. G., & Carvalho, M. M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, 175, 525–543.
- Khitous, F., Strozzi, F., Urbinati, A., & Alberti, F. (2020). A systematic literature network analysis of existing themes and emerging research trends in circular economy. *Sustainability*. <https://doi.org/10.3390/su12041633>
- Linder, M., & Williander, M. (2017). Circular business model innovation: Inherent uncertainties. *Business Strategy and the Environment*, 26(2), 182–196.
- Lüdeke-Freund, F., Gold, S., & Bocken, N. M. (2019). A review and typology of circular economy business model patterns. *Journal of Industrial Ecology*, 23(1), 36–61.
- Maghsoudi, M., Mohammadi, N., Soghi, M., & Sabet, M. (2025). Technological trajectories in circular economy: Bridging patent analytics with sustainable development goals. *Journal Of Environmental Management*, 379, Article 124752.
- Maghsoudi, M., Shokouhyar, S., Ataei, A., Ahmadi, S., & Shokouhyar, S. (2023). Co-authorship network analysis of AI applications in sustainable supply chains: Key players and themes. *Journal of Cleaner Production*, 422, Article 138472.

- Maher, R., Yarnold, J., & Pushpamali, N. (2023). Circular economy 4 business: A program and framework for small-to-medium enterprises (SMEs) with three case studies. *Journal of Cleaner Production*, 412, Article 137114.
- Mehrotra, S., & Jaladi, S. R. (2022). How start-ups in emerging economies embrace circular business models and contribute towards a circular economy. *Journal of Entrepreneurship in Emerging Economies*, 14(5), 727–753.
- Mohammadi, N., Maghsoudi, M., Sabet, M., & Soghi, M. (2025). Unveiling the evolution of educational technologies: A patent-based clustering and life cycle analysis. *IEEE Access*. <https://doi.org/10.1109/ACCESS.2025.3554741>
- Moreno, M., De los Rios, C., Rowe, Z., & Charnley, F. (2016). A conceptual framework for circular design. *Sustainability*, 8(9), Article 937.
- Okorie, O., Salonitis, K., Charnley, F., Moreno, M., Turner, C., & Tiwari, A. (2018). Digitisation and the circular economy: A review of current research and future trends. *Energies*. <https://doi.org/10.3390/en1113009>
- Onyeaka, H., Tamasiga, P., Nwauzoma, U. M., Miri, T., Juliet, U. C., Nwaiwu, O., & Akinsemolu, A. A. (2023). Using artificial intelligence to tackle food waste and enhance the circular economy: Maximising resource efficiency and minimising environmental impact: A review. *Sustainability*, 15(13), Article 10482.
- Ormazabal, M., Prieto-Sandoval, V., Puga-Leal, R., & Jaca, C. (2018). Circular economy in Spanish SMEs: Challenges and opportunities. *Journal of Cleaner Production*, 185, 157–167.
- Pu, R., Chankoson, T., Dong, R. K., & Song, L. (2023). Bibliometrics-based visualization analysis of knowledge-based economy and implications to environmental, social and governance (ESG). *Library Hi Tech*, 41(2), 622–641.
- Razmjooei, D., Alimohammadalou, M., Ranaei Kordshouli, H.-A., & Askarifar, K. (2024). A bibliometric analysis of the literature on circular economy and sustainability in maritime studies. *Environment, Development and Sustainability*, 26(3), 5509–5536. <https://doi.org/10.1007/s10668-023-02942-6>
- Rizos, V., Behrens, A., Van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papadelis, S., & Hirschmidt-Garbers, M. (2016). Implementation of circular economy business models by small and medium-sized enterprises (SMEs): Barriers and enablers. *Sustainability*, 8(11), Article 1212.
- Roleders, V., Oriekhova, T., & Sysoieva, I. (2022). Trends in a global circular economy. *Management Theory and Studies for Rural Business and Infrastructure Development*, 44(2), 176–184.
- Rovanto, S., & Finne, M. (2023). What motivates entrepreneurs into circular economy action? Evidence from Japan and Finland. *Journal of Business Ethics*, 184(1), 71–91. <https://doi.org/10.1007/s10551-022-05122-0>
- Sabet, M., & Soghi, M. (2025). Unveiling the internet of things innovation landscape: A patent mining and network analysis approach to technology: M. Sabet, M. Soghi. *Computing*, 107(8), 171.
- Sánchez-García, E., Martínez-Falcó, J., Marco-Lajara, B., & Manresa-Marhuenda, E. (2024). Revolutionizing the circular economy through new technologies: A new era of sustainable progress. *Environmental Technology & Innovation*, 33, Article 103509.
- Schützenhofer, S., Kovacic, I., Rechberger, H., & Mack, S. (2022). Improvement of environmental sustainability and circular economy through construction waste management for material reuse. *Sustainability*, 14(17), Article 11087.
- Suchek, N., Ferreira, J. J., & Fernandes, P. O. (2022). A review of entrepreneurship and circular economy research: State of the art and future directions. *Business Strategy and the Environment*, 31(5), 2256–2283.
- Todeschini, B. V., Cortimiglia, M. N., Callegaro-de-Menezes, D., & Ghezzi, A. (2017). Innovative and sustainable business models in the fashion industry: Entrepreneurial drivers, opportunities, and challenges. *Business Horizons*, 60(6), 759–770.
- Tura, N., Hanski, J., Ahola, T., Stähle, M., Piiparinens, S., & Valkokari, P. (2019). Unlocking circular business: A framework of barriers and drivers. *Journal of Cleaner Production*, 212, 90–98.
- Voukkali, I., Papamichael, I., Loizia, P., Lekkas, D. F., Rodríguez-Espínosa, T., Navarro-Pedreño, J., & Zorpas, A. A. (2023). Waste metrics in the framework of circular economy. *Waste Management & Research*, 41(12), 1741–1753.
- Vu, O. T. K., Duarte Alonso, A., Bressan, A., Kok, S. K., Quang Nguyen, T., Akbari, M., & Nguyen, H. T. T. (2023). Enabling environmentally sustainable practices in Vietnam through knowledge management: The case of TONTOTON. *Knowledge Management Research & Practice*, 21(6), 1109–1123.
- Wells, P., & Skeete, J.-P. (2023). Circular Business models as instruments of corporate power.

Zaccone, M. C., Santhià, C., & Bosone, M. (2022). How hybrid organizations adopt circular economy models to foster sustainable development. *Sustainability*, 14(5), Article 2679.

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