**Towards AI-based circular business models: Review and definition**

## 1. Introduction

Businesses are experiencing changes driven by technological innovations, evolving societal expectations, and the critical need for sustainable practices (Bag et al., 2021; Tseng & Lin, 2024). Sustainability, circularity, digitalization, artificial intelligence (AI), and ecosystems are key elements reshaping business strategies and operations (Furr et al., 2022). In this scenario, the circular economy (Kirchherr et al., 2017) necessitates a fundamental shift in traditional business models, focusing on applying AI to reduce waste and enhance resource efficiency (Dey et al., 2023; Schöggl et al., 2024). Central to this transformation, digital technologies like AI and blockchain are not just tools but are integral to reconfiguring the core of business models, fundamentally altering how value can be created, captured, and delivered (Pourranjbar & Shokouhyar, 2023). AI-based circular business models ensure economic sustainability and address significant environmental issues, paving the way for innovation and competitive advantages (Sjodin et al., 2023). For example, a company specializing in electric vehicle battery manufacturing implemented AI-enabled digital product passports to address sustainability and lifecycle management sensors on each battery collected performance data, which AI analyzed to predict lifespan and recommend preventive replacements. Replaced batteries were sent for recycling, where AI identified reusable materials, reducing waste and reliance on virgin resources. Additionally, a battery leasing program, supported by digital product passports, ensured efficient reuse and recycling, promoting a circular and sustainable business model (Langley et al., 2023).

Teece (2010, p. 191) offers a foundational definition of a business model as "the architecture of the value creation, delivery, and capture mechanisms a firm utilizes," encompassing the firm's value proposition, market segments, and value chain activities essential for realizing this proposition. Scholars in strategic management (Shepherd et al., 2023; Zott et al., 2011) emphasize the role of business models in generating customer value and fostering a company's competitive edge. Elaborating on that, the concept of the circular business model (CBM) (Geissdoerfer et al., 2017; Geissdoerfer et al., 2023; Neligan et al., 2023) has gained prominence and marks a significant shift from linear methods, focusing on eliminating waste from systems and establishing regenerative value cycles (Linder & Williander, 2017). Recently, scholars (Sjödin et al., 2023) have highlighted AI's role in enhancing value propositions by optimizing product utilization and lifecycle, reducing material usage, extending product lifespan, and improving resource efficiency and sustainability, thereby significantly contributing to the effectiveness of CBM and opens new avenues for innovation and competitive advantage.

The extant literature provides a rich repertory showing how companies apply AI to leverage CBM. However, the literature has progressed in a fragmented manner, and research so far has been ad hoc. Prior research has emphasized the use of AI to redefine AI-based circular offerings (Sjödin et al., 2023), manage internal resistance to AI CBM (Pinheiro et al., 2022), continuously applying business expertise to curating AI models for CBM (Qi et al., 2023), and creating AI solutions for circular proposals with ecosystem partners (Langley et al., 2023). However, the literature lacks an integrative review of the AI-based CBM that synthesizes the literature, potentially leading to new insights to explain how to make the transition to AI-based CBM (Cronin & George, 2023). In summary, academic research on CBM applying AI faces a challenge: the lack of an integrative review to guide research and practice.

To address these gaps, the present study seeks to answer the following research question: "*How are companies applying AI to leverage circular business models?*". We conducted a systematic

literature review (SLR) to produce rigorous conceptual clarity from existing AI and circular economy research.

Our main contribution to the CBM literature (Neligan et al., 2023) within the AI context (Sjödin et al., 2023) is proposing that transitioning to AI-based CBM involves strategic reframing, AI-driven dematerialization, and ecosystem platformization. These components foster technological advancements while fulfilling societal demands and sustainability objectives (Bag et al., 2021). Unlike previous studies (Linder & Williander, 2017) that discuss generic CBM strategies without AI specifics, we advance the CBM literature (Neligan et al., 2023) by detailing an AI-based reframing strategy. For example, we outline how to define an AI-based value proposition, redefine AI-based sustainability offerings, become an AI solution provider, expand product scope with AI, and communicate strategic shifts to stakeholders. We also draw on recent research (e.g., Fallahi et al., 2023; Neligan et al., 2023; Sjödin et al., 2023) to conceptualize AI-based CBM, which involves using AI and related technologies to create, capture, and deliver value using the ecosystem platform as a structure to leverage technological innovations while addressing societal expectations and sustainability needs.

This text is organized as follows: We present the methodological procedures after this introduction. Subsequently, we report the findings describing the AI-based circular business model. After that, we conclude by expressing this study's leading theoretical and practical contributions.

## 2. Research methods

We conducted an SLR to advance theoretical developments in the fragmented literature on AI and the circular economy by integrating different research streams. The SLR ensures quality, transparency, and validity by mitigating bias and subjectivity through a structured process (Tranfield et al., 2003). Following established protocols, our SLR process included formulating the research question, defining criteria for searching, filtering, and selecting articles, analyzing and coding the studies, and discussing the results.

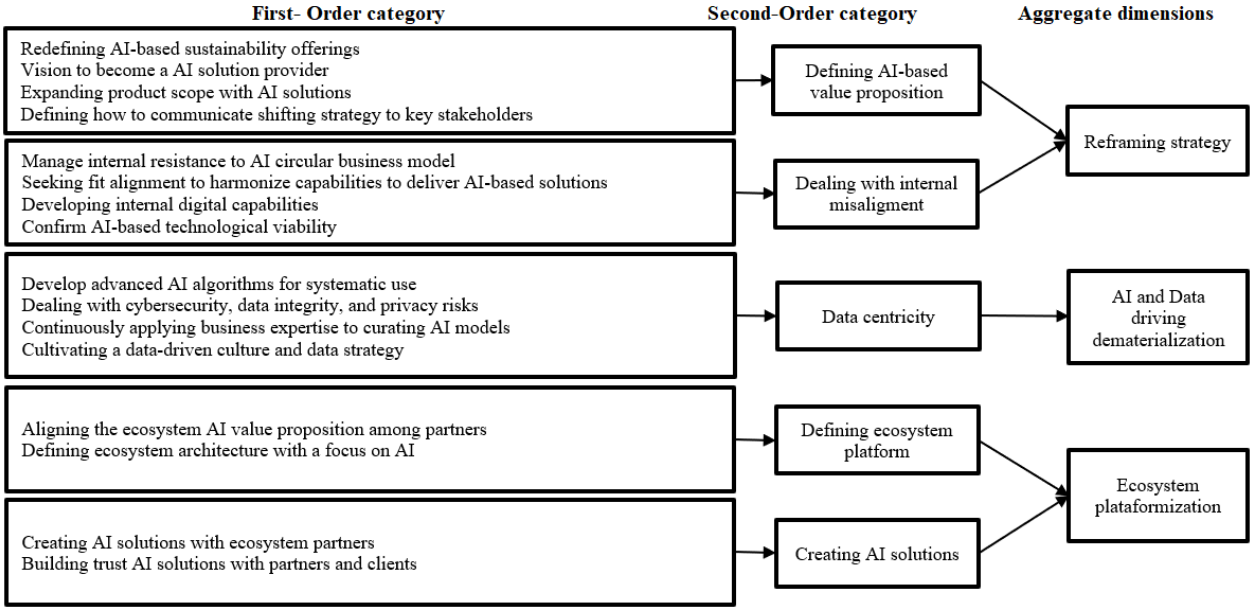
We performed a comprehensive and replicable literature search using the Web of Science (WoS) and Scopus databases for their extensive journal coverage and quality. The search keywords included "Artificial Intelligence" combined with "Circular Economy," "Circularity," "Resource Efficiency," "Reverse logistics," or "Zero Waste." We limited the search to English-language articles in the "management," "business," and "operations research management science" categories. Initially, 132 studies were identified in July 2024. After removing duplicates, the sample was reduced to 84. We then screened titles and abstracts, excluding 63 articles, and finally reviewed full texts for thematic alignment, resulting in a final sample of 46 articles from 2016 to July 2024. This rigorous approach allowed us to synthesize existing knowledge effectively and identify gaps, providing a comprehensive understanding of the intersection between AI and circular economy practices.

### 2.1 Data analysis

To address our research question, we conducted a comprehensive review of 46 articles, analyzing their scopes, objectives, contributions, and limitations. We employed thematic analysis (Clarke & Braun, 2013) to understand the underlying values and research paradigms for AI-based CBM. Our analysis involved four steps: First, the authors thoroughly reviewed the articles and agreed that the focus should be on reframing strategy, dematerialization, and ecosystem platformization. Second, using an inductive approach and coding techniques (Corbin & Strauss, 2008), we identified and coded key terms and categories related to AI-based CBM. This process yielded sixteen first-order categories, which were grouped into five second-order

themes by identifying their interrelationships. These themes were further condensed into three overarching themes, providing a higher level of abstraction that outlines the transition to AI-based CBM. Figure 1 depicts the data structure and derived categories from the literature.

Figure 1: Data structure for AI-based circular business model




Source: Authors.

## 3. Findings

Our analysis indicates that the first step towards an AI-based CBM is a reframing strategy involving redefining a company's value proposition and operational frameworks to leverage AI to enhance sustainability and resource efficiency (Sjödin et al., 2023). This strategic shift emphasizes the utilization of AI to minimize environmental impacts, optimize resource usage, and support renewable resource protection throughout the product lifecycle—from design and production to usage and disposal (Das et al., 2022). By integrating AI, companies can develop innovative solutions such as predictive maintenance, real-time quality control, and customized product designs, extending product lifespans and reducing material consumption and waste (Akhtar et al., 2024; Schöggl & Baumgartner, 2024). Furthermore, reframing strategy entails transforming the company into a solution provider using AI to analyze consumer behavior, optimize recycling programs, and enhance reverse logistics operations, thereby improving material reuse and cost efficiency (Pourranjbar & Shokouhyar, 2023). Effective communication and stakeholder engagement are critical in this transformation, ensuring alignment of organizational capabilities and fostering a data-driven culture that supports AI integration (Dey et al., 2023).

A second step towards AI-based CBM is the AI and data-driven dematerialization that can leveraged to minimize material consumption and optimize resource efficiency throughout the product lifecycle. This strategic approach focuses on developing AI algorithms that predict and enhance resource utilization, thereby reducing material usage and extending product longevity (Akhtar et al., 2024). Continuous research and development are essential to creating AI models capable of forecasting environmental impacts and guiding sustainable practices, such as recycling and waste reduction (Rajput & Singh, 2019). The accuracy and relevance of these AI models are ensured through parameterization, validation by specialized analysts, and iterative feedback cycles, which refine and optimize the models to adapt to evolving market and

environmental conditions (Dey et al., 2023). Moreover, effective data management strategies, including secure data storage and high-quality data collection, support AI-driven decision-making processes (Dey et al., 2023). Ensuring cybersecurity is paramount to protect sensitive environmental data and maintain the integrity of AI systems, thereby preventing breaches that could undermine sustainability efforts (Akbari & Hopkins, 2022). Cultivating a data-driven culture within organizations fosters collaboration, transparency, and trust, which are vital for successfully implementing dematerialization initiatives (Bag et al., 2021; Das et al., 2023).

Our analysis showed that in the third step, the focal companies define the architecture for ecosystem platformization to integrate a network of stakeholders that collaboratively leverage AI and digital technologies to enhance sustainability and resource efficiency to achieve AI-based CBM. This strategic approach requires aligning value delivery and capture across business models to benefit all participants, including suppliers, customers, regulators, and industrial partners (Sjödin et al., 2023). Successful implementation hinges on multi-stakeholder collaboration, where AI-driven solutions are co-created to embed circular economy principles throughout the value chain (Ajwani-Ramchandani et al., 2021`; Langley et al., 2023). Scholars (Fallahi et al., 2023) highlights that ecosystem platformization fosters innovation by incentivizing manufacturers to retain product ownership and generate long-term value through leasing, rental fees, and service contracts, supported by smart technologies that automate and optimize processes. Establishing a collaborative network with distinct roles ensures equitable value distribution and builds trust among partners, facilitated by transparent and reliable AI-based CBM (Akhtar et al., 2024). Additionally, integrating AI platforms enables real-time data sharing and insights, enhancing coordination and driving continuous improvement in product development and resource management (Langley et al., 2023). Furthermore, we found that ecosystem platformization addresses cybersecurity concerns through robust legal and regulatory frameworks, ensuring data integrity and protecting sensitive information vital for sustainable practices (Akbari & Hopkins, 2022; Tseng & Lin, 2024). By fostering a data-driven culture and ensuring ethical AI use, companies can build strong, trust-based relationships with stakeholders, ultimately advancing the circular economy through collaborative, AI-based CBM (Fallahi et al., 2023).

## 4. Discussion, implications, and limitations

Aligned with our theoretical perspective on AI diffusion and its application to circular economy initiatives, our study offers three theoretical contributions addressing how companies utilize AI to enhance CBMs. First, we contribute to CBM literature (Neligan et al., 2023) within the AI context (Sjödin et al., 2023) by presenting a data structure (Figure 1) that outlines the transition to AI-based CBM. This framework demonstrates that strategic reframing, AI-driven dematerialization, and ecosystem platformization foster technological advancements while fulfilling societal demands and sustainability objectives (Bag et al., 2021). Second, our research identifies a strategic path for adopting AI-based CBM. While previous studies (Linder & Williander, 2017) discuss generic CBM strategies without AI specifics, we advance the CBM literature (Neligan et al., 2023) by detailing an AI-based reframing strategy. For example, we explain how to define an AI-based value proposition, redefine AI sustainability offerings, become an AI solution provider, expand product scope with AI, and communicate strategic shifts to stakeholders. Third, we draw on recent research (e.g., Fallahi et al., 2023; Neligan et al., 2023; Sjödin et al., 2023) to conceptualize AI-based CBM, which involves using AI and related technologies to create, capture, and deliver value using the ecosystem platform as a structure to leverage technological innovations while addressing societal expectations and sustainability needs. Finally, the data structure (Figure 1) can be a practical guide for managers

implementing AI-based CBMs, maximizing AI benefits, and ensuring an effective transition to sustainable business models.

This research has typical SLR limitations, such as potentially excluding relevant articles among the 46 reviewed. However, considering the significant literature reviewed, we believe that the selected studies robustly reflect the research objective. Subjectivity in the analysis was mitigated through researcher triangulation and explicit coding guidelines. Nonetheless, it provides valuable insights into AI-based CBM for researchers and managers. It is important to note that due to the 6-page limitation as a rule submission, it was not possible to present an agenda for future research.

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