Why Circular Business Models Fail And What To Do About It

A Preliminary Framework And Lessons Learned From A Case In The European Union (Eu)

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ORIGINAL PAPER

Why Circular Business Models Fail And What To Do About It: A Preliminary Framework And Lessons Learned From A Case In The European Union (Eu)

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Abstract

The circular economy aims to decouple economic growth from negative environmental impacts. To achieve this goal, circular economy concepts and policies must be implemented in practice by organizations through new circular business models. However, organizations often fail to implement circular business models on the market at scale. This is a major problem in business innovation practice, while a knowledge gap about the underlying implementation challenges remains in the scientific literature. More research on the subject is needed. The objective of this study is contributing to shed light into the gap with empirical insights. Using an action research method within an EU innovation project, this article proposes a preliminary empirical framework that links the value proposition, creation, delivery, and capture dimensions of a circular business models with specific cultural, regulatory, economic, and technical barriers that might hinder implementation. Based on the framework, four lessons to support managerial action are provided. Future research might build upon this work by systematically collecting and structuring more granular empirical data about the specific reasons why new circular business models fail to be implemented by organizations, across different sectors and geographical areas.

Keywords Circular Economy · Business Model · Barrier · Implementation · Design · Sustainable innovation

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Introduction

The circular economy

The current economic system is based on a linear model [1]. At the start of the line, raw materials are extracted and used as inputs for industrial processes, and for the creation of products and services across disparate sectors. People and organizations eventually use these products and services. At the end of the line, waste is generated. Often, it is incinerated, dismissed in a landfill, or dispersed into the environment.

In the past decades, it became clear that this linear way of operating is not sustainable in the long run [2, 3]. It causes two major problems. The first problem, upstream, is resource depletion [4]. In other words, the resources found in the Earth's crust are becoming scarce, resulting in potential supply chain shortages and ultimately economic downturn [5]. The second problem, downstream, is waste management [6]. Managing increasing amounts of waste is challenging, yet essential to avoid ecological issues and related negative impacts on human health [7, 8].

To tackle these problems, the circular economy represents an alternative model where the line is turned into a circle [9]. The objective is optimizing resource consumption, while minimizing waste and pollution [2, 10]. The origins of this concept are rooted in engineering views about "closing the loop" of resources through different strategies – e.g., recycling materials and product life extension – aimed at eliminating waste by using it as an input for new processes [11]. Recently, the Ellen MacArthur Foundation, a British non-profit organization, played an important role in disseminating this concept across industry [1]. In parallel, the European Commission turned the circular economy into a policy program, with the ambition to lead a global transition to this new paradigm [12, 13]. To achieve this transition, circular economy concepts and policies must be implemented in practice by business organizations. This remains to date a major challenge [14, 15].

Circular economy research at the micro level: circular business models

A stream of academic literature focuses on enabling the transition to the circular economy at the micro level, from the perspective of business organizations. This literature clarifies that circular business models play an essential role [16–18]. A business model is a conceptual framework to define an organization's strategy along four dimensions: a value proposition offering a solution to customers; a value creation mechanism explaining how organizational resources, activities and partners are used to produce the value proposition; a value delivery mechanism explaining how customers can be reached via different channels; a value capture mechanism detailing underlying costs and revenues[19, 20].

Building upon seminal work connecting the business model framework to sustainability principles, more recent literature is incorporating circular economy principles into these four dimensions, with the aim of defining new business models that result in economic and environmental gains simultaneously [3, 21]. Organizations can indeed transform their business model from linear to circular, but this requires an experimental innovation process, which is challenging and time consuming, due to the high degree of uncertainties and risks involved [22–24]. Academic literature is now starting to provide guidance in this regard. Frishammar and Parida (2019) outlined a "four-phase roadmap for incumbent firms" (p.17): initiating the business model transformation; analyzing the current linear business model; designing a new circular business model; implementing the circular business model.

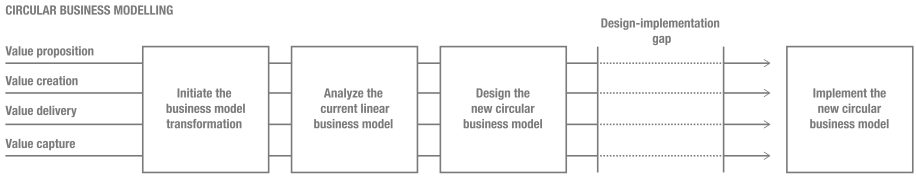

Fig. 1 The gap between design and implementation of circular business models

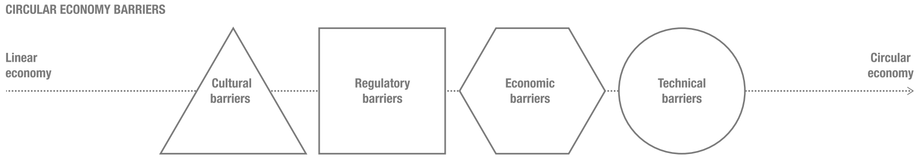

Fig. 2 Barriers to the transition from a linear to a circular economy

A key insight from this research is that moving from the design to the implementation of a new circular business model is difficult: all the eight global organizations involved in the study struggled to implement a circular business model successfully and all opted for a "small-scale rather than mass-market rollout" (p.23). This is consistent with Reim et al. (2021) stating that "it is vital that the implementation of circular business model is extended beyond pilot projects and local initiatives" (p.2745). Between the design and implementation of circular business models lies a gap, which must be addressed [25, 26]. Figure 1 visualizes this gap.

Circular economy research at the macro-level: circularity barriers

Another stream of literature focuses on the macro-level and adopts a helicopter view, typical in policymaking, to elaborate further on the challenges to implement the circular economy at large [2]. In line with EU policy documents [13] this literature explains that realizing this circular economy transition is a complex process, because it requires considerable and interrelated changes beyond specific business models, into the current economic system as a whole [8, 27]. Furthermore, it clarifies that the transition is burdened by several barriers, which have been categorized as technical, economic, regulatory and cultural [28, 29] (see Fig. 2). Cultural barriers consist of individual and collective ideas, opinions, intentions, and behaviors. For example, a cultural barrier is the reluctance of equipment manufacturers to collaborate with suppliers and recyclers to close the loops of resources embedded in their products. Regulatory barriers are related to institutional factors and dynamics. For example, current regulations on product safety may represent a regulatory barrier to the use of alternative and more sustainable material inputs within manufacturing processes. Economic barriers refer to financial and market factors. For instance, the relatively low price of virgin raw materials is an economic barrier to the uptake of secondary materials, because it makes their recovery and sale less attractive businesswise. Finally, technical barriers are issues related to technology, engineering and design. For example, a technical barrier could be the challenges that might arise when attempting to use waste material instead of virgin material as an input in the creation of a new product.

Research gap and objective

Efforts to study the transition to the circular economy at the micro and macro-level are to date mostly separate [30].

Macro-level research on circular economy barriers focuses on the whole system and does not explain how different circular economy barriers affect specific firms and business models [28, 31, 32]. This issue is complementary to the key problem of micro-level research on circular business models. "Accenture strategy recently surveyed more than 500 manufacturing companies with revenues over $1 billion and found that over 90% claimed to be implementing circular business models" [33] (p.1). However, scientific evidence shows that most circular business model ideas fail to reach the market [34, 35]. In the literature, this gap is presented as a "black box", with limited understanding of what lies inside it, especially on the managerial side [36, 37]. This is indeed a critical gap of knowledge and practice at the micro-level [14, 26, 38]. To address this gap, new research connecting to macro-level literature on circular economy barriers is now emerging. For example, Franzò et al. (2020), Vermunt et al. (2019), and Guldmann and Huulgard (2020) identified implementation barriers (macro-level research) in relation to specific circular business models (micro-level research). These recent efforts are relevant. In their reviews, Centobelli et al. (2020) and Ferasso et al. (2020) highlighted the need for more work in this direction, focusing on the macro-level barriers to circular business model implementation, with a view on managerial implications. Answering this call to action, the objective of this research is twofold. First, providing new insights into how macro-level barriers to circularity ultimately affect the design-implementation gap of circular business models at the micro-level. Second, deriving managerial implications based on these insights.

To this end, we employed an empirical action research method [39] anchored to CLEAN WATER, a large multi-stakeholder innovation project fitting into the circular economy strategy of the European Commission [40]. This project provided the basis for a four-year in-depth investigation inside the micro-level gap between the design and implementation phases of a new circular business model. Leveraging macro-level level research as a conceptual lens, we show that rather than being a "black box", the design implementation-gap of circular business models contains specific cultural, regulatory, economic, and technical barriers, which from the macro-level cascade down, affecting the circular value proposition, creation, delivery, and capture dimensions of a business model. The connection between the macro-level barriers and the micro-level dimensions of the circular business model is visualized in Fig. 3, and further developed in a preliminary empirical framework.

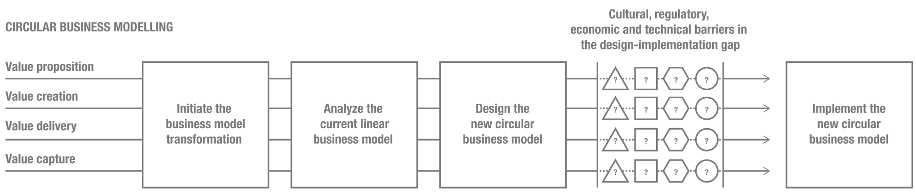

Fig. 3 Cultural, regulatory, economic and technical barriers located in the design-implementation gap of a circular business model

Contributions and structure of the paper

The proposed framework is a matrix showing how different types of implementation barriers affect specific circular business model dimensions. In the CLEAN WATER case, the framework is substantiated by empirical evidence, offering a clear understanding of why a first attempt to implement the circular business model did not work. Thus, the framework represents a starting point for more focused discussions among the CLEAN WATER stakeholders and the development of improved versions of the circular business model itself. More broadly, the framework is relevant for catalyzing important research translating macro-level implementation barriers into the micro-level of business models [41, 42]. Future research may use the framework as conceptual lens to cumulatively collect empirical data and derive a more granular classification of the specific reasons why new circular business models fail to be implemented. This is essential to make macro-level barriers more understandable and relatable for innovation managers, while providing them with guidance to operationalize the circular economy transition at the micro-level through the implementation of new circular business models [22, 43]. Consequently, we also leverage our CLEAN WATER experience to derive four lessons for managers on how to better navigate the design-implementation gap and overcome implementation barriers affecting circular business model dimensions.

The remainder of this paper is structured as follows. We first outline the action research process we employed throughout the CLEAN WATER project, including details on how we performed data collection and analysis. In section three we describe the results of our action research, by detailing the circular value proposition, creation, delivery, and capture dimensions for the CLEAN WATER business model, while also identifying specific cultural, regulatory, economic, and technical barriers hindering their implementation. In section four we discuss our preliminary framework and lessons for managers. We conclude the paper by summarizing the contributions of our work, its limitations, and a potential avenue for future research.

Research Process

Our research is anchored to CLEAN WATER, a large innovation project fitting into the circular economy strategy of the European Commission [40]. The project received 11 Million Euro of funding from public as well as private entities, involving over 20 partners from 10 European countries. The name of the project and its stakeholders have been replaced with pseudonyms to preserve anonymity. The project had a total duration of four years, and it is now completed. The objective was transforming the value and supply chain of water and minerals through a novel technology solution for recovering resources from industrial wastewater, and putting them back on the EU market. The project included a large-scale pilot of the technology solution in the Port of Metropolis, as well as the design of a new circular business model for its commercial implementation in the area. An initial concept for the design of this circular business model was originally outlined as follows. Industrialwater Inc., a company producing demineralized water in the Port of Metropolis would be the anchor manufacturer, the most central role in the circular business model [44, 45]. It would provide the streams of industrial wastewater (i.e., brines) as well as its facilities to treat and recover resources from them. Blue

Water, Cleanflow, Filtrator, Green University and Yellow University would be the technology suppliers, manufacturing key components of the technology solution needed for recovering the resources, including valuable magnesium hydroxide. Hydromag, a company that commercializes magnesium hydroxide would be able to commercialize this resource, after recovery. Finally, Chemix (or other neighboring industries) would supply the waste heat to increase energy efficiency of the technology solution. Our role in the project was to lead the design of the circular business model, going beyond this initial concept, and detailing with collaborating stakeholders how to move from the large-scale pilot to a full-scale commercial implementation. This task provided the basis for our investigation into the gap and underlying barriers between the design and the implementation of new circular business models.

Former literature on the implementation of circular business models has already stressed the importance of focusing on empirical cases [33]. Accordingly, our research process was based on a single case, using an action research method. In the context of management science, action research is used to practically address a business and / or organizational problem, while generating new theory through experiential knowledge [39]. The choice is appropriate because this method allows the researcher to navigate the circular business modelling process in person [46] (p.9) and thus to extrapolate "concrete steps toward implementation" [36] (p.7). Undertaking this action research while the large scale-pilot was happening in parallel, allowed us to personally dive and work with project stakeholders right into the gap between the design and implementation of the circular business model. Our action research took place in two phases. The first phase focused on detailing the value proposition, creation, delivery, and capture dimensions of the business model. It was approached through several one-to-one co-design conversations and workshop sessions with project stakeholders. The outcome was the specification of each one of the circular business model dimensions. The second phase focused on the cultural, regulatory, economic, and technical barriers hindering the implementation of these dimensions. It was approached through evaluative conversations and monthly meetings with the project management team and advisory board. It

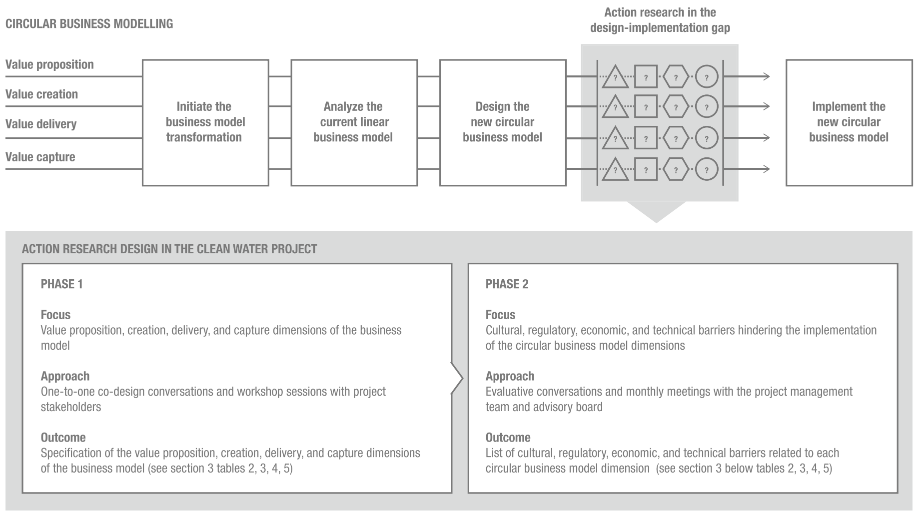

Fig. 4 Action research phases, objectives, and results

resulted in a list of barriers for each one of the dimensions. This is visualized in below (see Fig. 4) and further discussed in the following paragraphs.

The first phase had the objective of investigating whether involving stakeholders in a collaborative and iterative approach for detailing the different dimensions of the circular business model would facilitate implementation. To this end, we organized several one-to-one conversations and workshop sessions with project stakeholders to discuss the four dimensions of the circular business model for the case. To define the focus of these action research interventions (i.e., conversations and workshops) we built on former research about designing and implementing business models for sustainability and the circular economy [26, 47, 48]. Specifically, we created a template and a set of questions to facilitate bilateral and multilateral discussions with the project stakeholders. The template and the questions covered the different dimensions of the circular business model one by one, but also offered the opportunity to visualize and discuss interdependencies.

We also asked stakeholders about the different kinds of current and envisioned challenges for the implementation of the emerging business model, as well as about possible solutions. During the one-to-one conversations, one researcher probed the responding stakeholder in a bilateral discussion, while the other researcher took written notes. Some conversations took place in person and some over video conference calls. We recorded and consequently transcribed all of them. During the workshops, one researcher acted as moderator to facilitate a multilateral discussion amongst stakeholders, while the second researcher took written notes. Some workshops took place in a physical environment, using large poster templates and post it notes to plot emerging answers and insights, and some workshops took place over video conference calls, using a shared digital whiteboard environment. In total, research activities included 21 one-to-one conversations and 3 workshops, which are listed in Table 1. Furthermore, we conducted complementary research activities spread over the entire duration of the project. These included monthly meetings with the project management team; informal meetings with project stakeholders; email exchanges with project stakeholders; field visits to laboratories and pilot facilities. These additional contacts complemented the data from the stakeholder discussions with contextual data, in the form of written notes. Furthermore, they offered opportunities to reflect with some stakeholders on whether this iterative and collaborative approach was helping in reaching the goal of moving into the implementation of the circular business model. All the data from this first phase of the action research was progressively analyzed with a qualitative approach [49]. Specifically, emerging insights from the transcripts, notes and templates were gradually and inductively integrated into a structured output providing coherent specifications of the four dimensions of the circular business model. These specifications are reported in the results section of the paper. In line with the action research method, we reflected on these results, evaluating whether our intervention succeeded in moving the project consortium into the implementation of the circular business model. Unfortunately, that was not the case, due to multiple and important challenges reported by the stakeholders during the conversations and workshops.

By confronting the results of the first phase with insights and gaps in the literature, and by looking again at our data, we decided to focus the second phase of our action research on providing deeper insight on why the emerging circular business model for recovering resources from wastewater could not be implemented. Thus, this second phase had the objective of uncovering the cultural, regulatory, economic and technical barriers affecting the implementation of each dimension of the circular business model. This second objective arose in the course of action due to several stakeholder inputs on implementation challenges. Such rich and diverse inputs progressively emerged in our data next to the business

Table 1 List of interviews and workshops conducted in the first phase of the action research

	Activity	Stakeholders	Participants
1	Workshop	Industrialwater Inc	- Senior process engineer
		Blue Water	- Managing director - strategic advisor, MBA
		Green University	- Industrial ecologist, postdoctoral researcher
		Hydromag	- Senior chemical engineer
		BetaTester	- Owner, managing director
		Local Environmental Agency	- Senior sustainability and policy advisor - Senior sustainability and policy advisor
		CLEAN WATER advisory board	- Chairman, independent innovation advisor
			- Senior engineer in a large chemical company in MetropolisPort
			- Circular economy program manager in the public sector
			- Circular economy project manager in a large consultancy firm
2	Conversation	Hydromag	- Senior chemical engineer
3	Conversation	Green University	- Executive coordinator of the CLEAN WATER project
4	Conversation	Green University	- Scientific coordinator of the CLEAN WATER project
5	Conversation	Green University	- Director of the valorization center
6	Conversation	Industrialwater Inc	- Senior process engineer
7	Conversation	Blue Water	- Managing director

Table 1 (continued)

	Activity	Stakeholders	Participants
8	Workshop	Industrialwater Inc	- Senior process engineer
		Blue Water	- Managing director
		Cleanflow	- Managing director
		Filtrator	- Junior process engineer
		Green University	- Executive coordinator of the CLEAN WATER project - Industrial ecologist, professor
		Yellow University	- Chemical engineer, professor - Chemical engineer, doctoral researcher
		Superior Environmental Research Institute	- Project manager
		Hydromag	- Senior chemical engineer
		CLEAN WATER advisory board	- Chairman, independent innovation advisor
9	Conversation	Superior Environmental Research Institute	- Project manager
10	Conversation	Local Environmental Agency	- Senior sustainability and policy advisor
11	Conversation	Industrialwater Inc	- R&D manager
12	Conversation	Blue Water	- Managing director
13	Conversation	Blue Water	- Senior manager
14	Conversation	Green University	- Process engineer, professor
15	Conversation	Hydromag	- Managing director
16	Conversation	Cleanflow	- Managing director - Business developer
17	Conversation	Chemix	- Procurement director - Engineer
18	Conversation	Filtrator	- Director
19	Conversation	Green University	- Executive coordinator of the CLEAN WATER project

Table 1 (continued)

	Activity	Stakeholders	Participants
20	Conversation	Yellow University	- Industrial engineer, professor - Chemical engineer, professor - Chemical engineer, doctoral researcher) - Researcher
21	Conversation	CLEAN WATER advisory board	- Chairman, independent innovation advisor
22	Conversation	Industrialwater Inc	- R&D manager - Managing director
23	Conversation	Port of Metropolis	- Business development manager
24	Workshop	CLEAN WATER advisory board	- Chairman, independent innovation advisor - Circular economy program manager in the public sector - Circular economy project manager in a large consultancy firm - Head of water technology in an international think-tank - Biotechnology and water systems expert, professor - Water protection expert in the public sector, professor

model specifications as part of the collaborative, iterative process of action research [39, 46]. Considering that "documenting successes (of circular business models) is important, but failures, which are numerous, are just as interesting" and that "reasons for failure need to be more thoroughly investigated" [50] (p.250) we continued our research in this direction [51]. Consequently, in this second phase, we probed stakeholders deeper and more specifically on the implementation barriers. We collected data in the form of written notes through the following activities: additional conversations and informal meetings and email exchanges with project stakeholders; monthly meetings with the project management team; a final contact moment with the CLEAN WATER advisory board. We added this new data to the data collected in the first phase and analyzed all of it with a specific focus on extrapolating a comprehensive and coherent picture of implementation barriers. To this end, we employed a focused coding technique [52], using as a conceptual lens the categorization of circular economy barriers developed by Kirchherr et al. (2018). Specifically, we scanned all the transcripts, notes, and poster templates containing the specifications of the different circular business model dimensions and, within each dimension, we thematically clustered key stakeholder inputs relatable to the cultural, regulatory, economic and technical barriers to implementation. Ultimately, this led to four lists of different barriers, each associated to a specific dimension of the circular business model. These lists are reported in the results section. In line with the action research method, we reflected on these results, evaluating the relevance of a more granular definition of barriers for the implementation of circular business models, and ultimately deriving the preliminary framework and managerial lessons presented in the discussion section.

Results

In this section, we describe the dimensions of the circular business model for the CLEAN WATER solution, explaining identified barriers to its implementation.

Circular value proposition

Table 2 describes the specificities of the circular value proposition dimension. Further below, we briefly report the barriers to its implementation.

Barriers to the implementation of the circular value proposition

- Reactive approach to innovation (cultural barrier). Potential clients of the CLEAN WATER solution are large corporations, with a reactive approach to innovation, which reduces their interest in the value proposition. Industrialwater Inc. is not inclined to spend time and resources on the implementation of the solution unless obliged by environmental regulations, which are currently not in place.
- Unfavorable waste disposal regulations (regulatory barrier). Unfavorable waste disposal regulations undermine the rationale of a value proposition around the CLEAN WATER solution. At the project location there are no restrictions and related taxation for discharging brines because of limited ecological concerns in the area. Without an environmental and economic rationale, the Local Environmental Agency is unable to justify the need of a waste processor in the area, and therefore grant CLEAN WATER with a permit to operate.

Table 2 Summary of the specifications of the circular value proposition dimension for implementing the CLEAN WATER solution

What solution does Zero Brine offer?	Who will use and buy the solution?	Why would users be interested in the solution?	Why is the solution circular?	How is circularity measured?
CLEAN WATER offers a solution consisting of a modular combination of technologies for treating industrial wastewater (brines) while recovering valuable resources from it. Modularity lies in the possibility to combine different technologies in different ways depending on user requirements and wastewater characteristics	Potential clients include companies discharging brines in the Port of Metropolis. The lead user and first potential client is Industrialwater Inc., which produces demineralized water and generates brine effluents containing sodium chloride (NaCl), magnesium hydroxide ($MgOH_2$) and calcium (Ca). Additional potential clients include other chemical companies in the area	Users of the solution may benefit in three ways. First, by reducing or eliminating the taxes and or underlying costs for treating / discharging brines. Second, by recovering clean water. Third, by recovering resources ($MgOH_2$; NaCl; Ca), which can be either sold to third parties or, if possible, reused internally	CLEAN WATER fosters circularity by closing the loop of resources, while cleaning and reusing wastewater Additional positive environmental impacts include reducing the discharge of brines, which may negatively affect the salinity of surface waters, and achieving superior energy efficiency using residual heat from other industrial processes	Circularity can be measured in terms of kg or tons (t) of recovered materials, liters (L) or m3 of water saved. Full-scale continuous operation of the solution in the plant of Industrialwater Inc. would lead to the recovery of approximately 50t of $MgOH_2$ per year, 317t of Ca per year, 13,500 m3 of NaCl solution (9%). In addition, it would lead to small savings of clean water

- Lack of a solid business case (economic barrier). The lack of a solid business case for the CLEAN WATER value proposition results from three factors: lack of restrictions and related taxation for discharging brines; no water scarcity in the area to justify the need for water recovery; limited potential for recovering enough resources from a commercial perspective.
- Rebound effects (technical barrier). The value proposition around the CLEAN WATER technologies results in negative environmental impacts that outweigh the positive ones. In particular, the production and operation of the CLEAN WATER technologies results in: increased CO_2 emissions due to the energy needed to operate the technologies, increased resource use due to the production of chemicals needed to build the technologies, and increased freshwater eutrophication and acidification due to micropollutant released in the brines by the same technologies used to treat the brines.

Circular value creation

Table 3 describes the specificities of the circular value creation dimension. Further below, we briefly report the barriers to its implementation.

Barriers to the implementation of circular value creation

- Limited willingness to collaborate (cultural barrier). The stakeholders contributing to CLEAN WATER value creation show limited willingness to collaborate, mainly due to lack of trust and a firm-centric perspective that prioritizes individual over collective interests. Blue Water is hesitant to establish a joint enterprise, preferring to operate through a main contractor and subcontractor partnership formula. This hesitancy (which would increase the commitment of individual partners and streamline the integration of the different technologies) is shared by most partners. Filtrator is concerned about the ability of other suppliers to deliver market-ready technologies within the timeline agreed with prospective clients, which could compromise its reputation. Filtrator is thus unwilling to share its current client network with CLEAN WATER, while contributing only as subcontractor for its technologies and as independent consultant for design, installation and maintenance. Finally, while Industrialwater Inc. is considered by technology suppliers as a potential client, the firm is not willing to become one and considers its involvement in the collaboration a way to acquire know-how from technology suppliers to eventually implement the solution independently.
- Explorative vs. exploitative mindsets (cultural barrier). Conflicts between the explorative and exploitative mindset of the CLEAN WATER technology suppliers result in misalignment of joint value creation efforts, both in terms of expectations and collaborative activities. In particular, academic technology suppliers place a prominent focus on exploratory activities, considering research data a relevant output of their value creation activities. On the other hand, the industry technology suppliers focus their value creation efforts toward financial exploitation on the market.
- Issues with intellectual property rights (regulatory barrier). Concerns around intellectual property rights upon the CLEAN WATER solution hinder efforts towards joint value creation. While some of the CLEAN WATER technologies can be patented individually, their combination into the modular solution cannot be patented. Some technology suppliers are concerned that potential clients may attempt to learn about the solution and implement it independently without being charged. This concern is appli-

Table 3 Summary of the specifications of the circular value creation dimension for implementing the CLEAN WATER solution

Which stakeholder is involved?	How does it contribute?	How does it benefit?
Industrialwater Inc	Anchor manufacturer, lead user and first potential client. It contributes by: I) supplying brines rich in resources to be recovered; II) providing expertise in continuously operating a full-scale water treatment plant	It benefits from: I) implementing the solution into its plant, as a way to treat its wastewater while optimizing the water footprint and recovering NaCl that can be reused internally; II) having early access to innovative brine discharge know-how and technologies
Blue Water	Technology supplier and the main solution contractor. It contributes by: I) providing the evaporator technology to separate NaCl from brines using thermal energy; II) providing expertise, network and time	It benefits from making revenues I) as a supplier of the evaporator technology, and II) as main contractor (fee for the expertise and time invested in acquiring new clients, technology suppliers, and public funding)
Cleanflow	Technology supplier and supporter in business development. It contributes by: I) providing the technology for total removal of organics; II) supporting the main contractor in business development, through its own network of clients	It benefits from: I) making revenues as a technology supplier (a variable fraction of total revenues coming from a client); II) leveraging the modular solution and the networks of other technology suppliers, to acquire new clients
Filtrator	Technology supplier and consultant. It contributes by: I) providing the nanofiltration and reverse osmosis technologies; II) providing expertise in wastewater treatment design, needed to install and maintain the integrated solution in the facilities of a client	It benefits from making revenues I) as a technology supplier, exclusively as a subcontractor, and II) through a fee for system design, installation and maintenance. Revenues would be a variable fraction of total revenues coming from a client
Green University	Technology supplier and research partner. It contributes by: I) supplying the crystallization technology for recovering high purity resources d; II) providing the facilities for the lab-test and core competences to execute the pilot at the premises of potential clients; III) providing competences and resources to establish an enterprise encompassing all the stakeholders who provide the solution on the market	It benefits from: I) leveraging the technology as a platform to conduct academic work and establish new research projects; II) having an equity share of the commercial enterprise, to exploit the project technology commercially
Yellow University	Technology supplier and research partner. It contributes by providing the membrane crystallization technology using electricity to recover $MgOH_2$ and Ca from brines	It benefits by making revenues as a technology supplier. Revenues would be a variable fraction of total revenues coming from a client

Table 3 (continued)

Which stakeholder is involved?	How does it contribute?	How does it benefit?
Superior Environmental Research Institute	A research partner and consultant. It contributes by providing a complementary environmental impact assessment service to potential clients, which may help to increase the overall relevance of the value proposition	It benefits by charging a fee for the complementary service
Hydromag	A commercial partner. It contributes through its knowledge and client network in the European market of $MgOH_2$, needed to sell this resource after recovery	It benefits by making revenues through a commission on the sale of $MgOH_2$
BetaTester	The infrastructure provider. It contributes by providing the facility to run the pilot step using the brines initially supplied by Industrialwater Inc., and later by other potential clients	It benefits through the rental fee charged to the CLEAN WATER solution provider for using its facilities
Chemix	The energy provider. It contributes by providing residual heat from its own processes, as a thermal energy input for the evaporator within the technology solution	It benefits from: I) selling its residual heat to CLEAN WATER; II) reducing its emissions by turning them into an input for CLEAN WATER
Port of Metropolis	The landowner. It contributes by providing the space where the solution is implemented	It benefits from; I) Space rental fees; II) boosting circularity in the Port, in view of more stringent future EU regulations
Local Environmental Agency	A policy actor. It contributes by: I) providing the permit for CLEAN WATER to operate commercially as a waste processor in the Port; II) supporting in getting an official quality certification for the recovered resources	It benefits by ensuring compliance with environmental regulations

cable to Industrialwater Inc., who showed the competences and possibly the intentions to do so. The Yellow University, which has launched a spin-off to exploit commercially the results of cutting-edge research activities, is similarly concerned about the intellectual property and replicability of its membrane crystallizer technology.

- Low technology readiness level (technical barrier). The low technology readiness level (TRL) of some CLEAN WATER components makes it challenging to create the value needed for implementing at full-scale on the market. In particular, the EFC technology has TRL 5, on a scale from 1 to 9, where 1 equates to scientific research level and 9 to market-ready level. For this reason, it is not ready for full-scale market implementation.

Circular value delivery

Table 4 describes the specificities of the circular value delivery dimension. Further below, we briefly report the barriers to its implementation.

Barriers to the implementation of circular value delivery

- Limited availability of necessary infrastructure (technical barrier). BetaTester, which should provide the facility and infrastructure needed for piloting the CLEAN WATER solution with targeted clients, may be unable to do so, due to the overlapping commitments with own clients. Accordingly, the availability of the facility and infrastructure of BetaTester, needs to be discussed each time.
- Risk of damaging current infrastructure (technical barrier). Reusing recovered resources within industrial processes comes with the risk of damaging the current infrastructure that the CLEAN WATER solution should use for value delivery. In particular, Industrialwater Inc. is not willing to install the CLEAN WATER solution within its demineralized water plant due to the fact that using recovered sodium chloride (NaCl), unwarranted in quality, comes with a risk of damaging the ion-exchange columns for producing demineralized water. The provision of recovered NaCl to other parties in the area would face similar issues.
- Energy efficiency issues (technical barrier). Achieving superior energy efficiency, an important aspect of the CLEAN WATER solution, is not straightforward. In particular, the use of residual heat from nearby industries is essential to achieve positive environmental impact. However, Chemix is not able to supply CLEAN WATER with residual heat because its processes are already highly heat-integrated. Similarly, the Port of Metropolis mentioned that connecting the residual heat streams of its tenants has already proven to be a problematic issue both logistically and economically.

Circular value capture

Table 5 describes the specificities of the circular value capture dimension. Further below, we briefly report the barriers to its implementation.

Barriers to the implementation of circular value capture

- Unclear cost and revenue sharing criteria (cultural barrier). Unclear cost and revenue sharing criteria make it challenging to collaboratively capture value from the CLEAN WATER solution. In particular, the operation of the CLEAN WATER solution requires

Table 4 Summary of the specifications of the circular value delivery dimension for implementing the CLEAN WATER solution

How does CLEAN WATER reach its users and clients?				
Step 0 – client acquisition: CLEAN WATER gets in touch with potential clients in the Port of Metropolis area. The effort is led by Blue Water, the main contractor	Step 1 – lab-test: The client provides a sample of the brines, which is analyzed at Green University. Potential for brine treatment and resource recovery is discussed with the client. The following pilot step is discussed, specifying duration and which technologies are needed	Step 2 – Pilot: The technologies to run the pilot are installed at the premises of the client. If this is not a viable option, performing the pilot at BetaTester may also be a possibility. This needs to be discussed, taking into consideration additional costs and how to transport the brines from the client to BetaTester	Optional Step – Impact assessment: The Superior Environmental Research Institute offers the client the possibility to perform an environmental impact assessment using data from the pilot. If the economic rationale in the business case is uncertain, environmental impact assessment may determine whether it is sensible to proceed with full-scale implementation	Step 4 – Full-scale installation: If the results of the pilot are positive, follows full-scale implementation in the facilities of the client

Table 5 Summary of the specifications of the circular value capture dimension for implementing the CLEAN WATER solution

What are the CLEAN WATER costs and how are they shared?	What are the CLEAN WATER revenues and how are they shared?
The costs for the CLEAN WATER solution providers include: I) individual costs for technology manufacturing (variable per stakeholder); II) shared costs for financing the lab-test operation; III) shared costs for financing the pilot preparation and operation; IV) shared costs for financing the full-scale installation and maintenance The costs for the CLEAN WATER clients include costs for the continuous operation of the full-scale installation in their own industrial plant	The revenues for the CLEAN WATER solution providers include: I) shared revenues from the sale of recovered resources; II) shared revenues from one-off lab-test fee (approx. 6,000 EUR *); III) shared revenues from one-off pilot fee (approx. 18,000 EUR *); IV) shared revenues from full-scale installation fee (**) To charge the full-scale installation fee, two options are possible, to be negotiated ad-hoc between solution provider and client: I) CLEAN WATER sells the technology to the client up front, including in the contract support for operation and maintenance; II) service based / leasing where CLEAN WATER retains ownership of the technology over time as the client pays a recurring fee (e.g., yearly). When the equipment is depreciated (e.g., 20 years) ownership shifts to the client, which in the meantime has learned to operate and maintain it * Indicative estimation based on inputs from technology providers ** fee for full-scale implementation cannot be estimated

a collaborative effort from multiple stakeholders, which struggle to go beyond a firm centric view and agree upon how costs and revenues should be shared.

- Low price of virgin resources (economic barrier). The low price of virgin resources makes it challenging to capture value from the sale of resources recovered from wastewater. Furthermore, the commercial value of the recovered resources is relatively low, which further undermines the foundations of a business case for their recovery.
- Unwarranted quality of recovered resources (economic barrier). The unwarranted quality of resources recovered with the CLEAN WATER solution makes it challenging to gain the trust of potential clients and capture value from their sale. In particular, the recovery of NaCl, although not supported by a strong business case, could still be attractive. However, the purity of recovered NaCl is difficult to guarantee, making the purchase of its virgin version still a preferred option.
- Limited volumes of recovered resources (economic barrier). The limited volumes of the resources recovered with the CLEAN WATER solution make it difficult to reach the economies of scale needed to profit from their sale. Magnesium hydroxide ($MgOH_2$) is a commercially valuable resource currently imported from non-EU countries, making its recovery strategically and economically attractive. However, the economic viability of recovery is dependent upon volume. Full-scale continuous operation of the CLEAN WATER technology would allow the recovery of 50t of $MgOH_2$ per year. However, the minimum quantity that Hydromag would require to reach economies of scale is 2,000t per year, which is 40 times higher than the recovered amount. Recovering sufficient $MgOH_2$ from other potential clients in the vicinity is not possible due to the low concentration of these resources in the surface waters of the area.

- Increase of operational costs due to the new technology use (economic barrier). The full-scale operation would result in an increase of operating costs for the user and client of the CLEAN WATER solution, which disincentives adoption and value capture potential. According to the results of a life cycle cost analysis within the project, continuous technology operation in the plant of Industrialwater Inc. would lead to a 5 × increase of demineralized water production cost (from approx. 2 €/L to 10 €/L).
- Inability or unwillingness to cover initial investment (economic barrier). The full-scale implementation of the CLEAN WATER solution requires a substantial up-front investment, which no stakeholder is willing to cover. Initial investment for full-scale implementation was estimated at around 10 million Euros. The smaller industry stakeholders as well as the academic stakeholders do not have the financial means to cover this investment. On the other hand, the larger industry stakeholders are unwilling to cover the initial investment. Given the lack of a solid business case, Industrialwater Inc. and the Port of Metropolis considers it too risky, and do not intend to finance and own the necessary infrastructure and to provide the physical space for it.
- Reusing equipment within the service-based revenue model (technical barrier). The implementation of a service-based revenue model for the CLEAN WATER solution is hindered by technical challenges. Next to the initial investment to install the solution, disassembling and reusing the technologies with another client after the leasing contract expires may not always be possible, due to quality issues with used equipment and different specification needs.

Discussion

Empirical framework on the barriers to circular business model implementation

In this section, we look back at our empirical results on the implementation of a circular business model in the Port of Metropolis, to give a comprehensive overview of "why it didn't work". Consequently, we reflect on their relevance for informing future academic research.

Our empirical results point out that the implementation of the new circular business model in Port of Metropolis was hindered by various barriers specifically related to different dimensions of the business model itself. Figure 5 provides a comprehensive overview of these barriers and their direct connection to the dimensions of the circular business model.

This connection is important to concurrently advance circular economy research at the macro and micro-level. As explained, macro-level research has already examined and categorized barriers to the circular economy [28, 29]. However, due to the focus on the economic system as a whole, it often neglects to examine how these barriers ultimately affect the modus operandi of different business organizations within different sectors [29, 53]. On the other hand, micro-level research has focused extensively on the modus operandi of business organizations aiming to play a role in the circular economy transition, using circular business models as a lens [16, 54]. By doing so, it has uncovered that most new circular business models do not manage to make it "beyond pilot projects", resulting in a critical gap between their design and implementation [14, 26, 46]. Aiming to overcome these issues, recent research has tried to connect micro and macro-level research on the subject, for instance by explaining how different types of barriers affect specific types of circular business models [41]. With our

		IMPLEMENTATION BARRIERS			
		Cultural barriers	Regulatory barriers	Economic barriers	Technical barriers
CIRCULAR BUSINESS MODEL	Circular value proposition	Reactive approach to innovation	Unfavorable waste disposal regulations	Lack of a solid business case	Rebound effects
	Circular value creation	Limited willingness to collaborate Explorative vs. exploitative mindsets	Issues with intellectual property rights	-	Low technology readiness level
	Circular value delivery	-	-	-	Limited availability of necessary infrastructure Risk of damaging current infrastructure Energy efficiency issues
	Circular value capture	Unclear cost and revenue sharing criteria	-	Low price of virgin resources Unwarranted quality of recovered resources Limited volumes of recovered resources Increase of operational costs due to new technology use Inability or unwillingness to cover initial investment	Reusing equipment within the service-based revenue model

Fig. 5 Preliminary framework on the barriers to circular business model implementation

study we make a further step toward superior granularity and show how different implementation barriers can be related not only with specific circular business model types, but also, to a deeper level, with the circular value proposition, creation, delivery and capture dimensions. This granularity at the business model level is "necessary to support managers for making the transition towards a circular economy" [43] (p.6). This argument is also aligned with the conclusions of the empirical work carried out by Frishammar and Parida (2019, p.25) who state that: "for successful circular business model implementation […] managers must seek changes […] within each dimension (i.e., value proposition, value creation, value delivery, value capture), and across dimensions". Macro-level barriers are likely to be perceived as distant from the micro day-to-day activities of individual firms, and thus might not be easily relatable and addressable for managers. In contrast, our in-depth analysis of the CLEAN WATER project highlights that these barriers, from the macro-level, ultimately cascade down to the micro-level, where it is possible to show more clearly how they concretely affect specific dimensions of a new circular business model, and to consequently perform targeted actions. Building on this argument and acknowledging the limitations of our study based on a single case in a single sector, we position Table 2 as a preliminary empirical framework to guide both future research and practice. Researchers may apply and expand this framework by cumulatively collecting and structuring empirical data about the specific reasons why new circular business models fail to be implemented. From a theory perspective, such an overview based on cumulative empirical evidence would be relevant to complement the current investigation of circular economy barriers at the macro-level, with their parallel investigation at the micro-level geared toward shedding light into the "black box" of the design-implementation gap. Indeed, this would contribute to catalyze emerging research work in this direction [22, 41, 42]. At the same time, managers may also use this framework as they navigate the iterative process to implement a new circular business model, by using it as a template to note down how different barriers affect different dimensions, and accordingly define a strategy on how to revise each dimension. In the next section, we further expand our contribution to managerial practice by providing concrete lessons on how to deal with the barriers they may encounter.

Lessons for managers

In this section, we leverage our findings to derive four preliminary lessons which may guide future managerial action in overcoming the barriers to circular business model implementation.

> Lesson 1—Iteratively detailing the dimensions of a circular business model is functional to identify implementation barriers with more specificity and accuracy.

Investing resources into iteratively and collaboratively detailing each dimension of a new circular business is not only functional to put forward a more coherent outcome "on paper", but also to identify specific micro-level barriers as a starting point to concretely bridge the design-implementation gap. In practice, a good way of doing this is sketching each business model dimension on the same tangible support (e.g., a physical poster or a digital whiteboard) to be progressively filled in during the discussions with the different stakeholders. In this way, the visualized outcomes of a conversation can be used to inspire and/or trigger deeper insights in the following one. For example, detailing the circular value delivery dimension through a sequence of conversations with different stakeholders was functional to discover that some of the necessary infrastructure may be available to a limited extent (technical barrier to circular value delivery). This insight from our empirical study is in line with former literature clarifying that "testing ideas on paper" may "help stakeholders uncover and identify challenges (i.e., barriers)" [48] (p. 10, 11) within a necessary process of "continuous alignment of the four key dimensions of the business model […], as well as additional changes within each dimension" [46] (p. 24). In line with previous research [55] our empirical case suggests that the value proposition should be the starting point of the entire process, as the barriers to this dimension are the most problematic ones and with consequences for the implementation of the entire business model (e.g., the lack of a business case, unfavorable waste disposal regulations, the reactive approach of some stakeholders to circular innovation in general).

> Lesson 2—Understanding chain reactions of barriers across business model dimensions is functional to target the root causes behind implementation failure.

A more thorough and granular overview of the implementation barriers can help managers to better understand the chain reactions inhibiting the implementation of a circular business model, and importantly how to leverage them in a virtuous path of change. Indeed, former research has already highlighted that chain reactions across barriers do exists (Kirchherr et al., 2018). Furthermore, it has also explicitly called for the need to "systematically investigate interrelations between barriers" [56] (p.9). On these grounds, our case shows that such interrelations occur simultaneously on different levels, namely across different types of barriers but at the same time also across different business model dimensions. For example, unfavorable waste disposal regulations that allow discharging brines in the Port of Metropolis without taxation (regulatory barrier to the value proposition), contribute to determining a comparatively lower price of virgin sodium chloride and magnesium hydroxide (economic barrier to circular value capture), ultimately undermining the foundations of a solid business case for recovering these resources with the CLEAN WATER solution (economic barrier to the value proposition). In line with previous studies [29, 57], we argue that understanding how barriers relate to specific circular business model dimensions is important to help managers identifying root causes of failure at the micro-level, and to consequently take target actions towards implementation. Thus, differently from the CLEAN WATER project, if managers are able to identify, early on, unfavorable waste disposal regulations as the root cause behind the lack of a solid business case for a circular value proposition, they can consequently direct their efforts to target this issue in the first place, before committing to move forward when the risk of failure is too high.

Lesson 3—Involving a matchmaker who leads the circular business modeling process with no direct economic stakes is important to overcome cultural barriers.

Very often organizations join circular innovation projects with an overly firm-centric focus, where own interests and benefits drive decision making and lack of reciprocal trust delays disclosure of individual drivers and challenges [58]. Working collaboratively on detailing circular business model dimensions and barriers allows to create mutual trust across stakeholders, which is important not only to move the entire circular business model forward but, more specifically, to overcome cultural barriers to its implementation. Relatedly, a key question arises on which (kind of) stakeholder should take the lead in this process of identifying the needs and expectations of all the other stakeholders involved. In this regard, Schaltegger et al. (2019) explained that conceptually "such identification is of crucial importance for managers, as it can guide decision making and can help overcome trade-offs" (p.205). In the context of our empirical case, we were ourselves tasked with this role while "wearing the hat" of external researchers with no direct economic stakes in the circular business model. While doing this, we found our neutrality to be a very important aspect for mediating between often diverging stakeholder views and split incentives, and ultimately overcoming cultural barriers. This finding resonates with recent literature calling for the need of a matchmaker facilitating interorganizational collaboration within circular business innovation efforts [50]. Going a step further, our case provides additional insight into how this matchmaker role can be played concretely. We as matchmakers led the way by adopting an experimental approach [3]. Borrowing knowledge and practices from recent circular business model experimentation research [48, 59] our empirical study shows that an iterative and progressively deeper discussion focused around a concrete business model prototype triggers a sharing attitude in the involved stakeholders and an improved ability to verbalize the individual goals and challenges that normally lie behind barriers. This was functional not only to detail the circular business model dimensions, but also and importantly, to systematically identify the underlying barriers to implementation, while also addressing the cultural barriers [50].

Lesson 4 – Involving policy makers in the discussion of the economic barriers to circular value capture is essential to reach implementation.

Our empirical results highlight that the economic barriers to circular value capture are the most numerous of all. Despite considering such economic barriers to value capture is perhaps the most crucial thing to do while attempting to achieve financial viability on the market, most stakeholders involved in the CLEAN WATER project placed a more prominent focus and sense of urgency on the technical barriers instead. This empirical insight relates to extant literature noting that most circular innovation efforts have prevalently focused on advancing technical knowledge rather on the economic considerations needed to bring new solutions into the market [60]. As a result, circular value capture is often treated as an afterthought, leading many organizations to the decision of delaying mass market roll-out of the circular business model [46]. To disrupt this problematic pattern, managers should not only foster a timely discussion on the economic barriers to value capture, but also ensure that all the key stakeholders are involved in such a discussion [43]. In particular, policy makers should be involved as well because (as illustrated by our case) economic barriers often find their root cause in regulatory barriers. Indeed, policy makers shape the regulatory environment in which new circular business models are developed and implemented [13]. For example, they may play a role through the creation of more financial instruments to cover the large initial investments often needed to implement new circular business models at scale (economic barrier to circular value capture).

Conclusion

This paper connects macro-level research on the barriers to the circular economy [28, 29], with micro-level research on circular business models [23, 57]. Using an action research method our study puts forward a preliminary empirical framework capturing how different types of barriers (cultural, regulatory, economic and technical) hinder the implementation of specific circular business model dimensions (value proposition, creation, delivery and capture). From a theory perspective, the framework is thus relevant to address the call for a more granular approach in the investigation of circular economy barriers at the micro-level [41, 61] and ultimately shed light into the "black box" of circular business model implementation [36, 37]. From a practice perspective, this effort is relevant to make macro-level barriers more understandable and relatable for innovation managers, while providing them with actionable knowledge for iteratively adjusting circular business model dimensions toward implementation [46]. Centobelli et al. (2020) and Hofmann et al. (2022) argued that a more prominent focus on how managerial practice can overcome the barriers to circular business model implementation is essential. Consequently, we also put forward four lessons to start supporting managerial action in this direction. The main limitation of our study is that it is based on a single case in a single sector. For this reason, the empirical content of our framework (i.e., the specific barriers that we identified) may not be generalized beyond the wastewater industry sector. Nevertheless, by conducting such an in-depth study on a single project allowed us to gain insight into different implementation barriers affect specifically the different circular business model dimensions. We encourage future research to build on this insight, expanding our preliminary framework by cumulatively collecting and structuring empirical data about the specific reasons why new circular business models fail to be implemented, case by case, sector by sector.

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References

1. Ellen MacArthur Foundation (2013). Towards the circular economy. https://doi.org/10.1007/b116400
2. Allwood JM (2018) Unrealistic techno-optimism is holding back progress on resource efficiency. Nat Mater 17:1050–1051. https://doi.org/10.1038/s41563-018-0229-8
3. Linder M, Williander M (2017) Circular Business Model Innovation: Inherent Uncertainties. Bus Strateg Environ 26:182–196. https://doi.org/10.1002/bse.1906
4. Peck D (2016) Prometheus Missing: Critical Materials and Product Design.https://doi.org/10.4233/uuid
5. Commission E (2020) Critical Raw Materials for Strategic Technologies and Sectors in the EU: A Foresight Study. Publ Off Eur Union. https://doi.org/10.2873/58081
6. McDowall W, Geng Y, Huang B, Barteková E, Bleischwitz R, Türkeli S, Kemp R, Doménech T (2017) Circular Economy Policies in China and Europe. J Ind Ecol 21:651–661. https://doi.org/10.1111/jiec.12597
7. European Commission (2018) Plastic Waste: a European strategy to protect the planet, defend our citizens. Publ Off Eur Union. 16–18
8. Mathews JA, Tan H, Hu MC (2018) Moving to a Circular Economy in China: Transforming Industrial Parks into Eco-industrial Parks, Calif. Manage Rev 60:157–181. https://doi.org/10.1177/0008125617752692
9. Geissdoerfer M, Savaget P, Bocken N, Hultink EJ (2017) The Circular Economy – A new sustainability paradigm? J Clean Prod 143:757–768. https://doi.org/10.1016/j.jclepro.2016.12.048
10. Blomsma F, Brennan G (2017) The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. J Ind Ecol 21:603–614. https://doi.org/10.1111/jiec.12603
11. Stahel WR (1994) The Utilization-Focused Service Economy. Resource Efficiency and Product Life Extension., Green. Ind. Ecosyst. 178–190. https://books.google.com/books?hl=de&lr=&id=60XT8qeb1UoC&pgis=1
12. Commission E (2015) Closing the loop - An EU action plan for the Circular Economy. Publ Off Eur, Union
13 Commission European (2020) Circular Economy Action Plan. Publ. Off. Eur, Union
14. Reim W, Sjödin D, Parida V (2021) Circular business model implementation: A capability development case study from the manufacturing industry. Bus Strateg Environ 30:2745–2757. https://doi.org/10.1002/bse.2891
15. Van Dam K, Simeone L, Keskin D, Baldassarre B, Niero M, Morelli N (2020) Circular Economy in Industrial Design Research: A review, Sustainability
16. Ferasso M, Beliaeva T, Kraus S, Clauss T, Ribeiro-Soriano D (2020) Circular economy business models: The state of research and avenues ahead. Bus Strateg Environ 29:3006–3024. https://doi.org/10.1002/bse.2554

17. Bocken N, Boons F, Baldassarre B (2019) Sustainable business model experimentation by understanding ecologies of business models. J Clean Prod 208:1498–1512. https://doi.org/10.1016/J.JCLEPRO.2018.10.159
18. Baldassarre B, Schepers M, Bocken N, Cuppen E, Korevaar G, Calabretta G (2019) Industrial Symbiosis: towards a design process for eco-industrial clusters by integrating Circular Economy and Industrial Ecology perspectives. J Clean Prod 216:446–460. https://doi.org/10.1016/j.jclepro.2019.01.091
19. Osterwalder A, Pigneur Y (2010) Business model generation: a handbook for visionaries, game changers, and challengers. https://doi.org/10.1111/j.1540-5885.2012.00977_2.x
20. Teece DJ (2010) Business models, business strategy and innovation. Long Range Plann 43:172–194. https://doi.org/10.1016/j.lrp.2009.07.003
21. Stubbs W, Cocklin C (2008) Conceptualizing a "Sustainability Business Model." Organ Environ. https://doi.org/10.1177/1086026608318042
22. Franzò S, Urbinati A, Chiaroni D, Chiesa V (2021) Unravelling the design process of business models from linear to circular: An empirical investigation. Bus Strateg Environ 30:2758–2772. https://doi.org/10.1002/bse.2892
23. Hofmann F, zu Knyphausen-Aufseß D (2022) Circular business model experimentation capabilities—A case study approach. Bus Strateg Environ. 1–20. https://doi.org/10.1002/bse.3038
24. Baldassarre B, Calabretta G, Bocken N, Diehl JC, Keskin D (2019) The evolution of the Strategic role of Designers for Sustainable Development, in: Acad Des Innov Manag London, 807–821–807–821
25. Palmié M, Boehm J, Lekkas CK, Parida V, Wincent J, Gassmann O (2021) Circular business model implementation: Design choices, orchestration strategies, and transition pathways for resource-sharing solutions. J Clean Prod 280. https://doi.org/10.1016/j.jclepro.2020.124399.
26. Baldassarre B, Konietzko J, Brown P, Calabretta G, Bocken N, Karpen IO, Hultink EJ (2020) Addressing the design-implementation gap of sustainable business models by prototyping: A tool for planning and executing small-scale pilots. J Clean Prod 255:120295. https://doi.org/10.1016/j.jclepro.2020.120295
27. García-Quevedo J, Jové-Llopis E, Martínez-Ros E (2020) Barriers to the circular economy in European small and medium-sized firms. Bus Strateg Environ 29:2450–2464. https://doi.org/10.1002/bse.2513
28. de Jesus A, Mendonça S (2018) Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. Ecol Econ 145:75–89. https://doi.org/10.1016/j.ecolecon.2017.08.001
29. Kirchherr J, Piscicelli L, Bour R, Kostense-Smit E, Muller J, Huibrechtse-Truijens A, Hekkert M (2018) Barriers to the Circular Economy: Evidence From the European Union (EU). Ecol Econ 150:264–272. https://doi.org/10.1016/j.ecolecon.2018.04.028
30. Ghisellini P, Cialani C, Ulgiati S (2016) A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. J Clean Prod 114:11–32. https://doi.org/10.1016/j.jclepro.2015.09.007
31. Baldassarre B, Maury T, Mathieux F, Garbarino E, Antonopoulos I, Sala S (2022) Drivers and Barriers to the Circular Economy Transition: the case of Recycled Plastics in the Automotive Sector in the European Union, in: Procedia CIRP, Elsevier BV 37–42. https://doi.org/10.1016/j.procir.2022.02.007
32. Baldassarre B, Buesa A, Albizzati PF, Jakimow M, Tercero L, Stijepic D (2023) Titanium metal circularity in the EU Status quo and future potential, in: IRTC 2023 – Raw Material for a Sustainable Future, Lille, France. https://doi.org/10.13140/RG.2.2.12128.97286.
33. Colucci M, Vecchi A (2021) Close the loop: Evidence on the implementation of the circular economy from the Italian fashion industry. Bus Strateg Environ 30:856–873. https://doi.org/10.1002/bse.2658
34. Ritala P, Huotari P, Bocken N, Albareda L, Puumalainen K (2018) Sustainable business model adoption among S&P 500 firms: A longitudinal content analysis study. J Clean Prod 170:216–226. https://doi.org/10.1016/j.jclepro.2017.09.159
35. Tukker A (2015) Product services for a resource-efficient and circular economy - A review. J Clean Prod 97:76–91. https://doi.org/10.1016/j.jclepro.2013.11.049
36. Esposito M, Tse T, Soufani K (2018) Introducing a Circular Economy: New Thinking with New Managerial and Policy Implications, Calif. Manage Rev 60:5–19. https://doi.org/10.1177/0008125618764691
37. Roome N, Louche C (2016) Journeying Toward Business Models for Sustainability: A Conceptual Model Found Inside the Black Box of Organisational Transformation. Organ Environ 29:11–35. https://doi.org/10.1177/1086026615595084
38. Baldassarre B, Keskin D, Carel J, Bocken N, Calabretta G (2020) Implementing sustainable design theory in business practice: A call to action. J Clean Prod 273:123113. https://doi.org/10.1016/j.jclepro.2020.123113
39. Coghlan D (2011) Action research: Exploring perspectives on a philosophy of practical knowing. Acad Manag Ann 5:53–87. https://doi.org/10.1080/19416520.2011.571520

40. Commission E (2019) Research & Innovation Projects relevant to the Circular Economy Strategy CALLS 2016–2018 HORIZON 2020. Publ. Off. Eur, Union
41. Vermunt DA, Negro SO, Verweij PA, Kuppens DV, Hekkert MP (2019) Exploring barriers to implementing different circular business models. J Clean Prod 222:891–902. https://doi.org/10.1016/j.jclepro.2019.03.052
42. Guldmann E, Huulgaard RD (2020) Barriers to circular business model innovation: A multiple-case study. J Clean Prod 243:118160. https://doi.org/10.1016/j.jclepro.2019.118160
43. Centobelli P, Cerchione R, Chiaroni D, Del Vecchio P, Urbinati A (2020) Designing business models in circular economy: A systematic literature review and research agenda. Bus Strateg Environ 29:1734–1749. https://doi.org/10.1002/bse.2466
44. Mulrow JS, Derrible S, Ashton WS, Chopra SS (2017) Industrial Symbiosis at the Facility Scale. J Ind Ecol 21:559–571. https://doi.org/10.1111/jiec.12592
45. Sun L, Spekkink W, Cuppen E, Korevaar G (2017) Coordination of industrial symbiosis through anchoring. Sustain 9. https://doi.org/10.3390/su9040549.
46. Frishammar J, Parida V (2019) Circular business model transformation: A roadmap for incumbent firms, Calif. Manage Rev 61:5–29. https://doi.org/10.1177/0008125618811926
47. Manninen K, Koskela S, Antikainen R, Bocken N, Dahlbo H, Aminoff A (2018) Do circular economy business models capture intended environmental value propositions? J Clean Prod 171:413–422. https://doi.org/10.1016/j.jclepro.2017.10.003
48. Brown P, Baldassarre B, Konietzko J, Bocken N, Balkenende R (2021) A tool for collaborative circular proposition design. J Clean Prod 297:126354. https://doi.org/10.1016/j.jclepro.2021.126354
49. Corbin J, Strauss A (2008) Basics of qualitative research: Techniques and procedures for developing grounded theory. Sage, Thousands Oaks, California
50. Zaoual AR, Lecocq X (2018) Orchestrating Circularity within Industrial Ecosystems: Lessons from Iconic Cases in Three Different Countries, Calif. Manage Rev 60:133–156. https://doi.org/10.1177/0008125617752693
51. Baldassarre B, Micciché N (2014) Into the grey: towards successful implementation and effective evaluation of "Design for Development" projects, in: Des Dev Res Conf Cape Town 97–98
52. Charmaz K (2006) Constructing grounded theory: A practical guide through qualitative analysis. Sage
53. Bilal M, Khan KIA, Thaheem MJ, Nasir AR (2020) Current state and barriers to the circular economy in the building sector: Towards a mitigation framework. J Clean Prod 276:123250. https://doi.org/10.1016/j.jclepro.2020.123250.
54. Pieroni MPP, McAloone TC, Pigosso DCA (2019) Business model innovation for circular economy and sustainability: A review of approaches. J Clean Prod 215:198–216. https://doi.org/10.1016/j.jclepro.2019.01.036
55. Bocken N, Schuit C, Kraaijenhagen C (2018) Experimenting with a circular business model: Lessons from eight cases. Environ Innov Soc Transitions. https://doi.org/10.1016/j.eist.2018.02.001
56. Bening CR, Pruess JT, Blum NU (2021) Towards a circular plastics economy: Interacting barriers and contested solutions for flexible packaging recycling. J Clean Prod 302:126966. https://doi.org/10.1016/j.jclepro.2021.126966
57. Hopkinson P, Zils M, Hawkins P, Roper S (2018) Managing a Complex Global Circular Economy Business Model: Opportunities and Challenges, Calif. Manage Rev 60:71–94. https://doi.org/10.1177/0008125618764692
58. Talmar M, Walrave B, Podoynitsyna KS, Holmström J, Romme AGL (2018) Mapping, analyzing and designing innovation ecosystems: The Ecosystem Pie Model, Long Range Plann. 0–1. https://doi.org/10.1016/j.lrp.2018.09.002
59. Bocken N, Kraaijenhagen C, Konietzko J, Baldassarre B, Brown P, Schuit C (2021) Experimenting with new business model strategies for the circular economy. In: Res Handb Innov a Circ Econ Edward Elgar Publishing. 1–16
60. Yang M, Evans S, Vladimirova D, Rana P (2017) Value uncaptured perspective for sustainable business model innovation. J Clean Prod 140:1794–1804. https://doi.org/10.1016/j.jclepro.2016.07.102
61. Agyemang M, Kusi-Sarpong S, Khan SA, Mani V, Rehman ST, Kusi-Sarpong H (2019) Drivers and barriers to circular economy implementation: An explorative study in Pakistan's automobile industry. Manag Decis 57:971–994. https://doi.org/10.1108/MD-11-2018-1178