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Cradle-to-cradle business model tool: Innovating circular business models for startups

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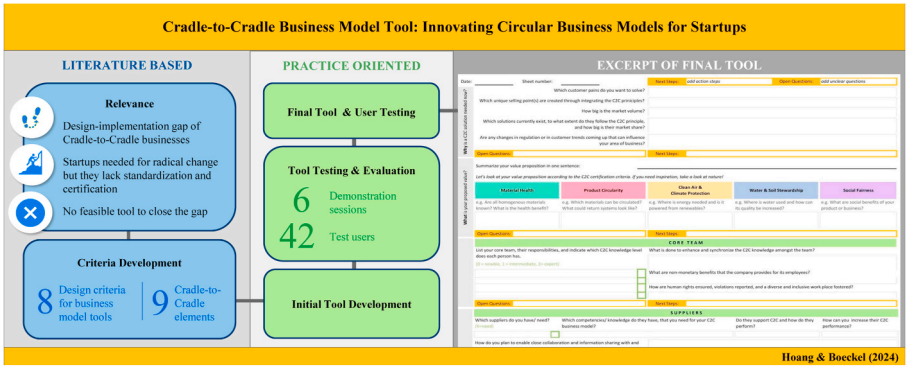
HIGHLIGHTS

- Circular startups face great challenges when innovating for circular business models.
- Cradle-to-Cradle principles can enable high level circularity in business models.
- Cradle-to-Cradle as a product level concept can be integrated in business models.
- Proposed business model tool can support startups with Cradle-to-Cradle innovation.
- Design science research contributes to bridging design-implementation gap.

GRAPHICAL ABSTRACT



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ABSTRACT

Born circular startups play a pivotal role in implementing high-level circularity to fight resource depletion and address climate change. In developing circular business model innovation, circular startups face the challenge of lacking legitimacy, which can be approached by certifications provided by concepts like Cradle-to-Cradle. As there is currently no supporting tool to develop such business models, this paper employs a design science research approach and proposes a Cradle-to-Cradle (C2C) Business Model Tool. The tool is developed based on a literature review, feedback from 42 users in six demonstration workshops and is finally tested with eight startups. It succeeds in aiding born circular startups in navigating the venturing process with a focus on high-level circularity. In this paper, C2C principles developed for the product level are theoretically linked to the business model level. The tool addresses elements such as partnerships, communication, and action-taking, thereby contributing to the literature on circular business model innovation and serving as a practical resource for born circular startups.

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1. Introduction

The development of circular business models (CBMs) by born circular startups has been deemed crucial to advance the realization of the circular economy (Suchek et al., 2021). Born circular startups tend to follow circular strategies with higher hierarchical levels as corporates (refuse, rethink, reuse) (Henry et al., 2020; van Opstal and Borms, 2023). With the current goal of achieving an absolute reduction in material and resource use (Bjørn and Hauschild, 2013), products should safeguard biological and technical material cycles through product return and design with harmless materials (Braungart and McDonough, 2002). This high-level circularity includes using products and materials repeatedly without decreasing quality and value (Ünal and Shao, 2019), higher value retention (Reike et al., 2018), and a life-cycle perspective on the environmental impacts during the product use (such as energy consumption) (Bjørn and Hauschild, 2013).

With corresponding business models, products and materials can be returned while encouraging a maximum number of uses and, thus, supporting the lowest environmental impact possible (Das et al., 2023). The concept of Cradle-to-Cradle (C2C) goes beyond this eco-efficient perspective and promotes an eco-effective use of materials (Ünal and Shao, 2019). It encourages positive impacts on the environment and human health instead of only reducing negative consequences (Braungart et al., 2007). C2C provides measurable criteria on the product level and functions as an "operationalized version of the circular economy" (Ünal and Shao, 2019, p. 754). C2C was originally developed as a concept on the product level, but it accentuates the relevance of business model strategies through material return such as product-service-systems. C2C business models combine C2C product design with high-level circularity in order to achieve absolute sustainability meaning an absolute material reduction.

Such a radical approach is shown by born circular startups as they demonstrate greater flexibility and openness when newly entering the market (Henry et al., 2020). Nevertheless, they face certain challenges, such as conceptual ambiguity (Corvellec et al., 2022) and the lack of standardization, such as certification (van Opstal and Borms, 2023). This can evoke a design-implementation gap (Geissdoerfer et al., 2018), meaning that C2C-inspired startups fail to successfully innovate their business models to implement C2C principles and cannot prevail in the market. These challenges can lead to difficulties in acquiring funding, communicating these new business models to their employees, and gaining legitimacy (van Opstal and Borms, 2023). Consequently, born circular startups need support in the circular business model innovation process when focusing on high-level circularity (Awana et al., 2023).

Circular business model innovation (CBMI) tools have generally been proven to support startups in their development of CBMs (Pieroni et al., 2021). Previous research has developed tools with a focus on collaboration (Brown et al., 2021), the process of design thinking (Santa-Maria et al., 2022), experimentation (Bocken et al., 2018), and rebound effects (Das et al., 2023). To this point, studies at the intersection of CBMs and C2C literature have examined strategies for implementing circularity (Ünal and Shao, 2019), reverse logistics strategies (Kumar and Putnam, 2008), and the barriers in orchestrating C2C innovation (Hansen and Schmitt, 2020). Nevertheless, no study addresses the needs of born circular startups to guide their CBMI processes integrating C2C principles. This research gap is both of practical and theoretical importance and requests the outcome of an artifact that can be used in practice (van Aken and Romme, 2009). Hence, this study addresses the research question: *How can the design of a circular business model tool for born circular startups reflect Cradle-to-Cradle principles?*

To address this question, this study follows previous research (e.g., Baldassarre et al., 2020; Coffay and Bocken, 2023) and applies a design science research (DSR) approach (van Aken and Romme, 2009). DSR emphasizes 'users' and their problems (van Aken and Romme, 2009). In this study, born circular startups are at the core because early integration of high-level circularity is crucial as previous studies have shown that path dependencies are created early in the innovation process of CBMs (Bakker et al., 2010). With that, the study 1) enables born circular startups to develop CBMs integrating C2C principles and 2) contributes to CBMI literature connecting C2C principles from a product to a business model level.

The remainder of the study is structured as follows: Section 2 provides a review of 1) CBMI literature with regards to born circular startups and their challenges, 2) the design of CBMI tools, and 3) the core principles of C2C and their implementation in business models. From this literature review, both key criteria to design successful CBMI tools and key elements of C2C business models are derived to lay the foundation for the C2C Business Model Tool. In Section 3, the DSR process is explained, including the initial tool as well as the feedback from the first demonstration sessions. Section 4 introduces the final version of the C2C Business Model Tool and the results from the assessment workshop of the final tool. Section 5 provides a discussion on the development of the tool along with the users' feedback as well as the contributions to the CBMI literature. Section 6 draws a conclusion on this study. The tool is accessible for free in the supplementary material.

2. Literature review

2.1. Circular business model innovation of born circular startups

In business model innovation for sustainability, value creation is extended to addressing environmental, economic, and social problems (Evans et al., 2017) while catering to a variety of stakeholders, such as society (Shakeel et al., 2020). In relation to that, circular business models go further and explicitly include resource flows (Geissdoerfer et al., 2020), hence conceptualizing and implementing circular economy principles into business models. The CBMI process can be segmented into the stages of visioning, sensing, seizing, and transforming (Bocken and Konietzko, 2022). The first stage creates a common future vision and goals for a circular economy. The second stage identifies opportunities and the needs of the target group. In the third stage, business models are designed and redefined, structures and cultures are realigned, and in the fourth stage, business models are adapted and implemented.

The involvement of more actors and uncertainties in CBMI increase its complexity compared to common business model innovation processes (Pieroni et al., 2019). Through several loops of usage, value (re) creation, value (re)delivery, value (re)capture, and an extended value proposition is entailed (Guldmann and Huulgaard, 2020). Using materials and products eco-effectively and retaining maximum resource value implies "conservation of resources closest to their original state, and in the case of finished goods retaining their state or reusing them with a minimum of entropy as to be able to give them consecutive lives" (Reike et al., 2018, p. 254).

CBMI covers four approaches, namely CBM transformation, CBM diversification, CBM acquisition, and born circular startups (Geissdoerfer et al., 2020). To integrate high-level circularity in CBMs, born circular startups are crucial as they "take a holistic perspective at their business model and monetize design-to-last and maintenance efforts" (Henry et al., 2020, p. 3). Further, they are open to more radical and disruptive approaches for strong sustainability (Neligan et al., 2023), e.g., through regenerative CBM strategies (Henry et al., 2020). Geissdoerfer et al. (2020) refer to born circular startups as newly started CBMs that integrate circularity from the very beginning.

Previous research illustrates the challenges circular startups face in the CBMI process (e.g., Guldmann and Huulgaard, 2020; van Opstal and Borms, 2023; Awana et al., 2023). The most comprehensive and recent study of Kanda et al. (2024) highlights the following challenges. Born circular startups have to deal with financial (access to resources, high upfront investment costs), organizational (limited human resources, lacking skills and knowledge on organizational structures), knowledge and technology related (lacking technology available, competencies),

supply chain (setting up reverse logistics, building strategic partnerships), market (customers' willingness to pay and to buy, stiff competition with incumbents, difficult market entrance), and institutional challenges (tax conditions, waste legislations and, long permit processes). This is due to the type of their circular business model, the industrial sector, the institutional context, and the liabilities of new ventures generally. Paramount to all born circular startups is to build legitimacy and trust as they offer new business models that contrast the dominant market logic.

One response to that is the implementation of certifications. Certifications by decentralized institutions are strategically used to reduce information asymmetries between businesses and partners (King et al., 2005), can signal quality to investors, and increase the chances of investments (Shahid et al., 2023). Equally, startups with a product certification, especially in combination with prominent customers or social proofs, have a higher likelihood of receiving investment (Bapna, 2017). Additionally, third-party certifications can be used to communicate a dedication to sustainability and circularity goals (Daddi et al., 2019). Concentrating on the key challenge of building legitimacy, the goal of this study is to integrate C2C principles in a circular business model tool in order to prepare for a C2C certification.

2.2. Business model tools for sustainability and circularity

Previous research has shown that business model tools can support startups in exploring and reframing new business models and serve as a boundary object in the process (Athanasopoulou and De Reuver, 2020). Tools are designed to guide practitioners and can be used in entrepreneurship classes or incubation or acceleration programs and, therefore, serve educational purposes (Bocken et al., 2019). These tools structure and guide thoughts (Bocken et al., 2019), visualize the current or future business model ideas (Nuβholz, 2018), and provide a holistic view of the business environment (Antikainen and Valkokari, 2016) such as relevant stakeholders (Breuer et al., 2018).

Various business model tools for the circular economy have been developed (Pieroni et al., 2019) based on previous sustainable business model and design science research on tools in that context (Breuer et al., 2018). User-friendliness is particularly decisive (Pepin et al., 2024) in counteracting the design-implementation gap (Geissdoerfer et al., 2018). The application of a tool should be simple and intuitive, not too time-consuming, and feasible for companies of all industries (Bocken et al., 2019). A tool should help to consider all elements of a business model (Zott and Amit, 2010), detect non-obvious links (Osterwalder et al., 2010), decide between different business models (Pieroni et al., 2021), and finally, translate the model into practice (Baldassarre et al., 2020), hence facilitating implementation (Hansen and Schaltegger, 2018). For the tool's legitimacy, the development process must be documented transparently (Bocken et al., 2019) and all necessary knowledge should be embedded in the tool (Pieroni et al., 2021). These aspects are summarized as design criteria in Table 1 and - comparable to Coffay and Bocken (2023) - function as guidelines for the tool design process.

Table 1
Design criteria for circular business model tools.

Design criteria	References
Does reality check, provides a holistic view, and supports communication	Antikainen and Valkokari (2016); Breuer et al. (2018); Joyce and Paquin (2016); Osterwalder et al. (2010); Zott and Amit (2010)
Helps discover links (systems thinking) and facilitates action	Baldassarre et al. (2020); Geissdoerfer et al. (2018); Hansen and Schaltegger (2018); Nuβholz (2018); Osterwalder et al. (2010);
Includes all important elements of a business model of the firm and the external environment	Breuer et al. (2018); Pepin et al. (2024); Pieroni et al. (2021); Zott and Amit (2010)
Iteratively tested with practitioners	Baldassarre et al. (2020); Joyce and Paquin (2016); Pepin et al. (2024)
Knowledge embedded in tool	Bocken et al. (2019); Pepin et al. (2024); Pieroni et al. (2021)
Not too time-consuming and user-friendly application	Bocken et al. (2019); Joyce and Paquin (2016); Pepin et al. (2024); Pieroni et al. (2021)
Simple, intuitive design, and visualizes business model	Joyce and Paquin (2016); Nuβholz (2018); Osterwalder et al. (2010); Täuscher and Abdelkafi (2017)
Transparency about tool development process	Bocken et al. (2019); Pieroni et al. (2021)

2.3. Cradle-to-cradle

High-level circularity entails the continuous reuse of materials without value loss (Geissdoerfer et al., 2020) in accordance with human health and nature (Ünal and Shao, 2019) and refers to the environmental performance of both products and business models (Harris et al., 2021). Although scholars claim that a circular economy is needed to decouple economic growth from resource depletion and forward the sustainability transformation (Leipold et al., 2023), business implementations show a misunderstanding of the concept. Elia et al. (2020) surveyed 98 circular companies and found that businesses tend to implement end-of-life processes without considering the design and material procurement stage. However, these stages are crucial for end-of-life treatment without value loss (Reike et al., 2018).

The C2C concept provides guidance towards high-level circularity (Ünal and Shao, 2019) and offers certification. C2C enables high-level circularity by 1) thinking in biological and technical material cycles, 2) designing products that can be returned to their respective cycles, 3) considering material health to ensure long-term material circulation in accordance with humans and nature, and 4) implementing business models that facilitate the return of materials while encouraging a maximum number of uses beforehand (Braungart et al., 2007). The underlying aim of C2C is 'eco-effectiveness', meaning humans become useful to the ecosystem in contrast to 'eco-efficiency' which refers to minimizing negative impact (Braungart et al., 2007). Eco-effectiveness entails the three principles: 'waste equals food', 'use current solar income', and 'celebrate diversity' (Braungart and McDonough, 2002). These conceptual principles are operationalized into five measurable certification criteria: material health, product circularity, clean air and climate protection, water and soil stewardship, and social fairness (Ünal and Shao, 2019).

Material health measures the non-toxicity of all used substances. Product circularity reduces material use by looping all materials in technical or biological cycles by incorporating renewable or recycled materials on the one hand and ensuring that they are recyclable, compostable, or biodegradable on the other hand. Clean air and climate protection emphasizes the need for renewable electricity and reduction of greenhouse gas emissions. Water and soil stewardship safeguards high water and soil quality. Social fairness addresses human rights and positive social impacts. There are four achievable levels for each certification criterion, whereby the lowest achieved level determines the overall certification level of the product. As each product must be recertified every two years, implementation plans are updated regularly, creating incentives for improvements (C2CPII, 2023).

2.4. Cradle-to-cradle business models

A circular business model generally describes which value is provided to customers and how the value is (re)created, (re)delivered, and (re)captured (Guldmann and Huulgaard, 2020). In its most fundamental form, it includes key activities of the firm, its suppliers and partners, the value proposition, its customers, and revenue and cost streams (Zott and Amit, 2010). In the context of circular business models, the value proposition exceeds the offering to customers and also describes the value created for other stakeholders, such as the value network (Urbinati

et al., 2017). Further, customers can perceive improved environmental conditions (such as clean air and climate protection) as valuable (Norris, 2023).

Subsequently, distinct requirements for C2C business models are presented. Although the C2C certification only focuses on products, the C2C concept goes beyond the product scope and challenges existing business models (Bakker et al., 2010). A C2C product cannot persevere without a business model that enables C2C principles. As an example, C2C-specific elements of a business model are the integration of production partners that adhere to strict material health and environmentally and socially sound manufacturing guidelines, educating consumers on handling products with care or establishing alternative ownership models in product-service-systems. Building on the definition of circular business models by Geissdoerfer et al. (2020), a C2C business model is defined as *a business model that is designed for a C2C product being used as long and as often as possible through cycling, extending, and intensifying, and being returned as a nutrient to the biological or technical life-cycle*.

For example, C2C carpet tile manufacturer *Tarkett* goes far beyond carpet production. They developed new materials from the waste of other companies, set up a take-back program, closely collaborated with recycling facilities that specialize in separating the materials, and implemented a product-service-system to provide a C2C business model (Stucki et al., 2023).

Literature shows that C2C business models should further integrate circular product design (de Pauw et al., 2014), close collaboration and extensive information sharing in a value network (Schmitt and Hansen, 2018), rooting the C2C vision in the company (Roome and Louche, 2016), and continuous organizational learning and experimentation (Bocken et al., 2018). Moreover, striving for eco-effectiveness by upholding the five C2C certification dimensions (Bjørn and Hauschild, 2018) drives the value proposition of a C2C business model. While material health is directly beneficial to the customer as it affects their own health (Rey-Álvarez et al., 2022), clean air and climate protection and water and soil stewardship are either directly or indirectly tied to customers' well-being (Bocken et al., 2018). Product circularity (da Costa Fernandes et al., 2020) and social fairness address customers' interest in increasing sustainability (Patala et al., 2016). In addition to being customer centric as a general attitude to value propositions, new propositions of ownership and consumption (Röhr, 2021) as value (re) delivery and alternative revenue streams as well as financial funding as value (re)capture should be included. Also, considering macro-level developments (Antikainen and Valkokari, 2016) and technologies (Baden-Fuller and Haefliger, 2013) can support a successful implementation. These characteristics of C2C business models are described in the following.

Circular product design refers to the early integration of C2C principles in the product and business model development process (de Pauw et al., 2014). It is estimated that most of a product's environmental impact is already determined in the product development stage, while later circularity adaptations are related to higher costs and time consumption (Go et al., 2015). Anchoring C2C design in the value creation of the business model eliminates the problem that product designers lack decision-making power to enable true circularity (Bakker et al., 2010).

Collaboration and extensive information sharing in a value network support C2C innovations and address the major barrier of intellectual property concerns (Hansen and Schmitt, 2020). C2C value creation is based on information from multiple departments within the company (Roome and Louche, 2016), the supply chain (Bakker et al., 2010), and the wider C2C network (Roome and Louche, 2016), which must be constantly exchanged to be able to meet the strict specifications. Especially across the supply chain, expertise from different stages and disclosure of sensitive information for material health assessments and appropriate end-of-life treatment is fundamental. Integrating customers' expectations can counteract resistance or lacking awareness of C2C innovations (Röhr, 2021). Additionally, sharing C2C information with customers can also be important during value (re)delivery, as their usual consumption behavior could hinder the adoption of circularity (Mostaghel and Chirumalla, 2021).

A rooted C2C vision in the business is the foundation and enabler of C2C collaboration (Roome and Louche, 2016), both internally and in the value network. Otherwise, resistance to change or insufficient innovation can hinder the C2C development process (Hansen and Schmitt, 2020). Internally, founders and employees must support the C2C vision equally to ensure a strategic C2C orientation in all decisions (Drabe and Herstatt, 2016). Choosing partner firms, such as suppliers, that share the C2C vision increases the willingness to try unconventional and new business practices (Röhr, 2021) or share sensitive information (Roome and Louche, 2016).

Continuous experimenting, learning, and improvement help with testing and learning about circular value propositions and revenue models in the real world (Bocken et al., 2018). In the C2C development process, launching and celebrating trial projects is vital for persistence during the long certification process (Schmitt and Hansen, 2018). Only C2C-specific knowledge has shown to advance innovation processes compared to general knowledge of engineering and R&D (Drabe and Herstatt, 2016). The C2C certification itself also calls for continuous improvement, as it has to be renewed and improved every three years (C2CPII, 2023).

Striving for eco-effectiveness by upholding the five C2C certification dimensions guides the startup in embedding the C2C principles in its value proposition. The five certification dimensions attempt to translate the C2C philosophy into quantifiable indicators and support radical redesign, which is needed for eco-effectiveness (Bjørn and Hauschild, 2018). At the same time, eco-efficiency is acknowledged, and the absolute reduction of materials is intended (Bjørn and Hauschild, 2013).

Defining material ownership and alternative revenue streams is a way to guarantee that products return to their intended cycle. Establishing rental systems, subscription models, or product-service-systems ensure that products are returned to the startup after a defined period as they stay material owners of the product. This is also a new way of value (re)delivery, and at the same time, it opens new pathways to value (re)capture besides product sales (Röhr, 2021).

Customer-centric value creation enhances the acceptance and use of return systems (Röhr, 2021). This new proposed way of value (re) delivery and re(capture) relies on customers' awareness and willingness, which can be a deciding barrier (Hansen and Schmitt, 2020). Integrating customers' preferences significantly enhances the value proposition.

Table 2
C2C business model elements in business models.

Value (re)creation	Extended value proposition	Value (re) delivery and (re) capture	Supporting activities
● Circular product design ● Close collaboration and extensive information sharing with value networks, especially customers ● Rooted C2C vision in businesses across the value network ● Continuous experimentation and learning	● Striving for eco-effectiveness (positive impact on the environment and human health) ● Customer-centric value creation to enhance acceptance and use of return systems	● Keeping material ownership to facilitate take-back-systems and taking the burden away from customers ● Alternative revenue (e.g., subscriptions, rental fees, usage fees) ● Financial funding for product/ material development and certification	● Considering macro-level developments ● Support of technologies (e.g., sensors, distributed ledger tools)

Financial funding is an important aspect, especially for circular startups, as they have high initial costs such as innovating new circular products (Guldmann and Huulgaard, 2020), setting up a product-service-system, or paying certification fees (C2CPII, 2023).

Macro-level developments should be considered as changing legislation, e.g., on waste or regulatory barriers significantly influencing the implementation of C2C (Schmitt and Hansen, 2018) as well as changing consumer preferences (Antikainen and Valkokari, 2016).

Support of technology is frequently discussed to advance the circular economy and also in the context of C2C, e.g., to facilitate information exchange (Braungart et al., 2007). Technologies such as RFID chips or sensors can enable product-service systems to be remanufactured or refurbished (Alcayaga et al., 2019). Distributed ledger tools such as blockchain are useful in some cases to communicate and transfer information between actors in the supply chain, e.g., in digital product passports (Langley et al., 2023).

How these C2C elements are integrated on a business model level is summarized in Table 2.

2.5. Research gap and user problem

In summary, while most CBMs focus on lower levels of circularity (Elia et al., 2020), business model innovation by born circular startups bears great potential for the implementation of high-level circularity (Henry et al., 2020). Yet, circular startups face challenges such as acquiring financial means or lacking trust and legitimacy from partners (van Opstal and Borms, 2023). Certification has been proven to function as a positive signal to investors (Shahid et al., 2023) and C2C provides these operationalization and certification options for high-level circularity (Ünal and Shao, 2019). Nonetheless, no circular business model tool has integrated C2C principles, even though tools can support startups in the exploration and realization of CBMI (Athanasopoulou and De Reuver, 2020). On top of that, previous research has only implicitly discussed the implementation of C2C principles in business models and has linked the product concept to the business model level. This constitutes both a crucial research gap and a user problem. Therefore, this study sets out to 1) define design criteria of circular business model tools, 2) detect C2C business model elements, and 3) design, test, and revise a benefitting C2C business model tool.

3. Methodology

3.1. Design science research process

The described research aim requires a balance between rigor and relevance (Dimov et al., 2023), grounding the content and design of the tool in scholarly knowledge while designing it for practitioners. Combining both requirements is made possible through the DSR cycle proposed by van Aken and Romme (2009). Design science has the goal of creating solutions to complex problems and is perceived as fundamental to fostering the transformation to a circular economy (Blomsma et al., 2023). The DSR cycle starts with the identification and definition of a problem in the field, proceeds with reviewing existing literature, synthesizing these insights in a design proposition, and testing it with practitioners which then informs the further development (van Aken and Romme, 2009). In the context of the circular economy, this research process has been successfully introduced by Brown et al. (2021), who developed a canvas for collaboration of different partners in the circular economy. The application of the DSR cycle in this study is portrayed in Fig. 1.

3.2. Literature-based tool development process

The backbone of the initial C2C Business Model Tool is embedded in circular and sustainable business model literature. Literature reviews on existing business model tools (Nuβholz, 2018; Osterwalder et al., 2010) and on circular business models (Bocken et al., 2019; Pieroni et al., 2021) define goals and functions of both models and tools and are applied to the C2C Business Model Tool as *design criteria* (see Table 1). Literature on C2C as an overarching concept (Braungart et al., 2007) as well as its implementation barriers (Hansen and Schmitt, 2020) and success factors in businesses (Drabe and Herstatt, 2016) reveal important *C2C business model elements* (see Table 2) for the tool. Google Scholar was used to identify key publications for these literature streams with keywords such as 'circular business model tool', 'sustainable business model tool', 'business model tool design' 'cradle-to-cradle innovation', and 'cradle-to-cradle certification'. Additionally, snowballing facilitated pinpointing further publications. This summary is not intended to provide a systematic literature review of all criteria discussed in the realm of C2C business models but to distill core characteristics.

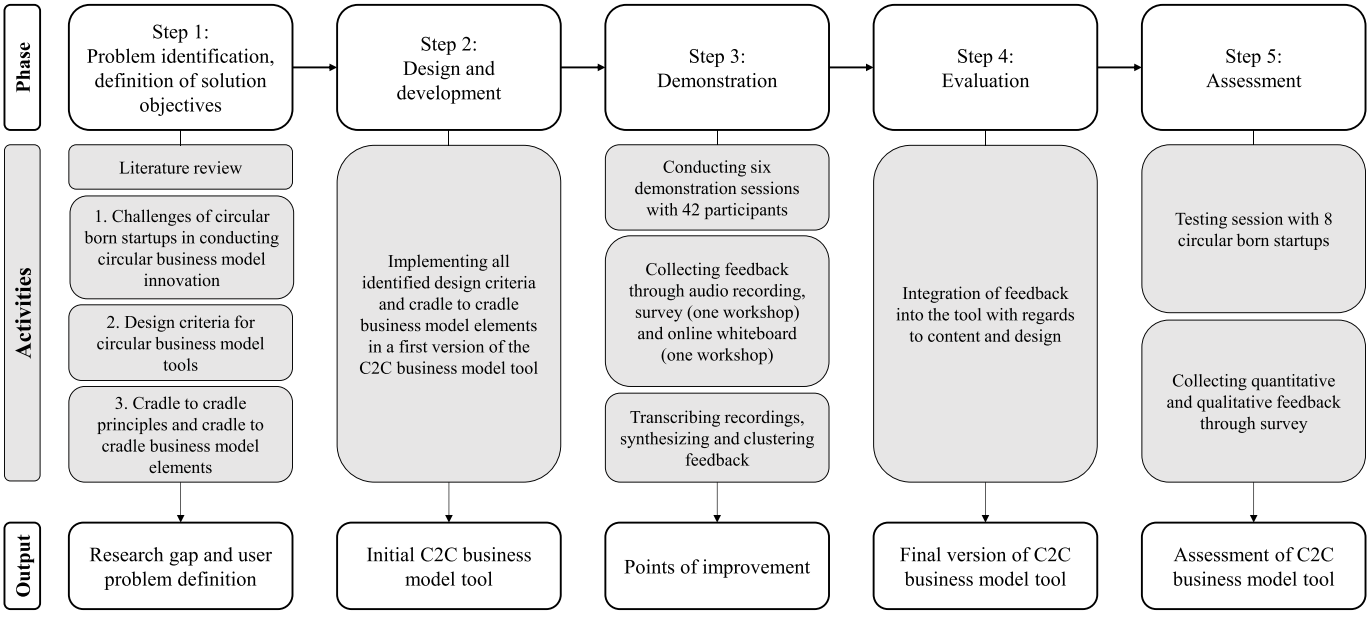

Fig. 1. Applied DSR cycle (adapted from van Aken and Romme (2009) and Coffay and Bocken (2023)).

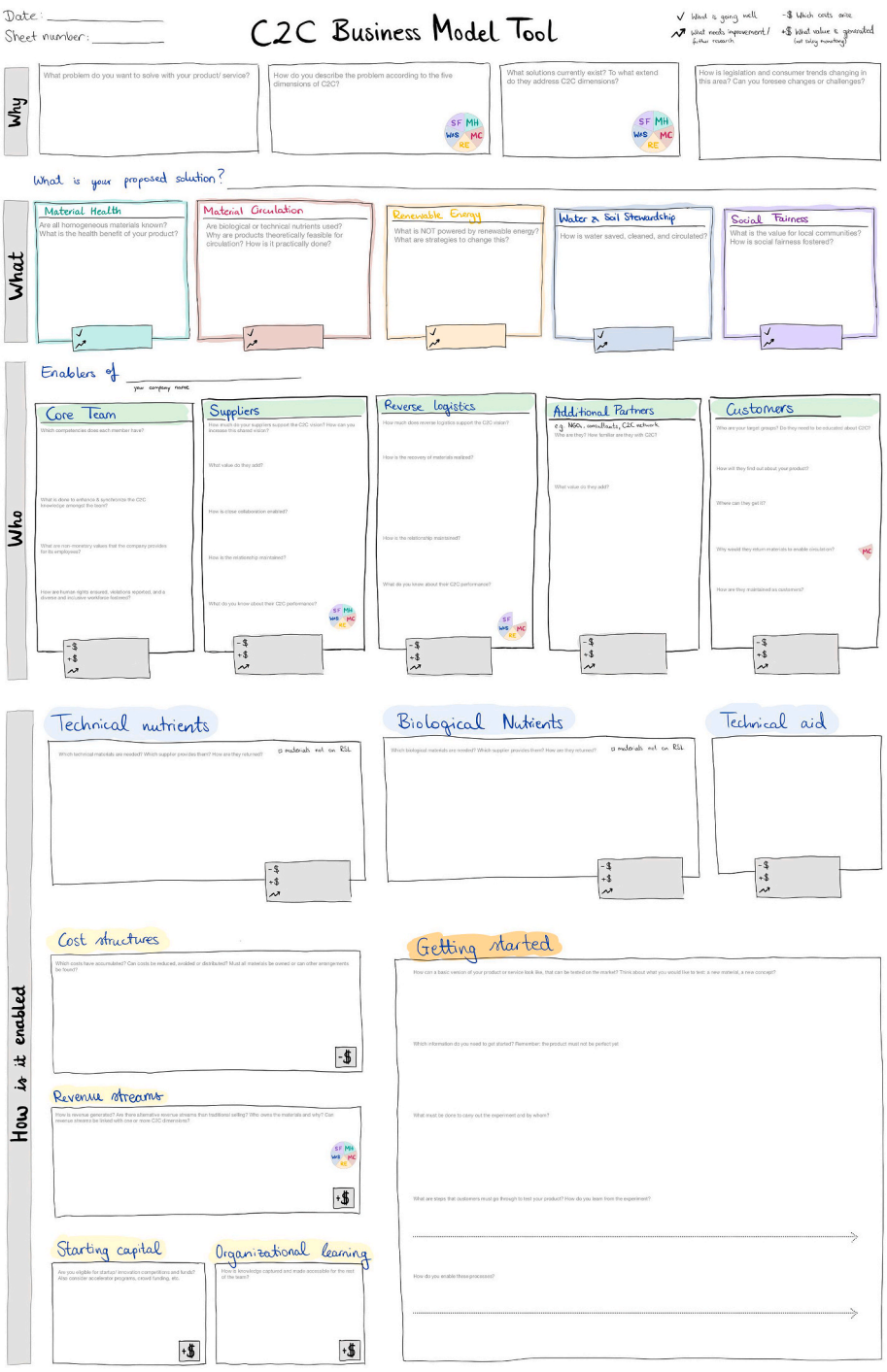

Fig. 2. Initial version of C2C Business Model Tool.

3.3. Introduction of the initial tool

The initial tool (see Fig. 2) is inspired by the general design of the conventional business model canvas (Osterwalder et al., 2010) and is composed of four main categories to guide the user: Why, What, Who, and How. The tool starts with 'Why' to anchor the business model in the motivation and the mission of the users (Henry et al., 2023). This category asks users to state the problem and identify existing solutions. This sets the foundation for developing a desired value proposition. Lastly, it encourages thinking about future trends or legislative changes (Antikainen and Valkokari, 2016). The 'What' category gives space to describe and assess the value proposition based on the C2C certification criteria. The 'Who' category specifies all actors involved in the value creation, namely the core team, suppliers, reverse logistics, additional partners, and customers. Questions are included about the actors' C2C knowledge, vision, training, and performance, as well as how a close relationship can be built that facilitates information sharing.

In the final category, the 'How' is addressed, including value (re)

Table 3
Overview of demonstration session participants.

	S1	S2	S3	S4	S5	S6
Maturity of startup	Ideation phase, pre-seed	Ideation phase, pre-seed	Just founded, pre-seed	Just founded, pre-seed	Startup, founded in 2019	Expansion, founded in 2017
Sector/product/service	Various sectors	Various sectors	Baby clothing rental	Female hygiene products	Yoga mats	Food packaging
User position	Bachelor students in various majors with founding interest	Master students in Sustainable Management & Technology with founding interest	Co-founders	Co-founders	Founder	Co-founder
Years of experience	<1 year	<1 year	1–2 years	2 years	4 years	6 years
Expertise on C2C	Intermediate knowledge	Basic knowledge	Mixed knowledge: from basic to advanced	Intermediate knowledge	Inter-mediate knowledge	Basic knowledge
Status of startup in spring 2024	No startup founded	No startup founded	Dissolution	Product development	On market	On market

Table 4
Overview of user testing and data collection.

	S1	S2	S3	S4	S5	S6
Context of use Location of users	Digital workshop Leuphana University Lüneburg, Germany	On-site workshop Technical University of Munich, Germany	Digital workshop Lüneburg/ Hamburg, Germany	Digital workshop Lüneburg/Hamburg, Germany	Digital session Hamburg, Germany	Digital session Munich, Germany
Number of participants	30 in 8 groups	5 in 2 groups	3	2	1	1
Duration of use	120 min	90 min	60 min	60 min	60 min	60 min
Protocol	Miro board	Sound recording & transcription	Survey	Sound recording & transcription	Sound recording & transcription	Sound recording & transcription
Time	Mar 2022	Jan 2023	Feb 2022	Mar 2023	Mar 2023	Jan 2023
Feedback on impact of tool use in spring 2024	No, no contact details were given	Yes	Yes	Yes	No, founder on maternity leave	Yes

delivery and value (re)capture. The technical and biological compositions of the product are differentiated, financial structures are elaborated, and a system for organizational learning is defined. Alternative revenue mechanisms to traditional selling and to material ownership are promoted. The tool also encourages linking the revenue streams to one or more C2C dimensions, e.g., offering product-service-systems to enhance material health and material circulation and exploring financial funding opportunities. Finally, action steps are derived in the form of business experiments.

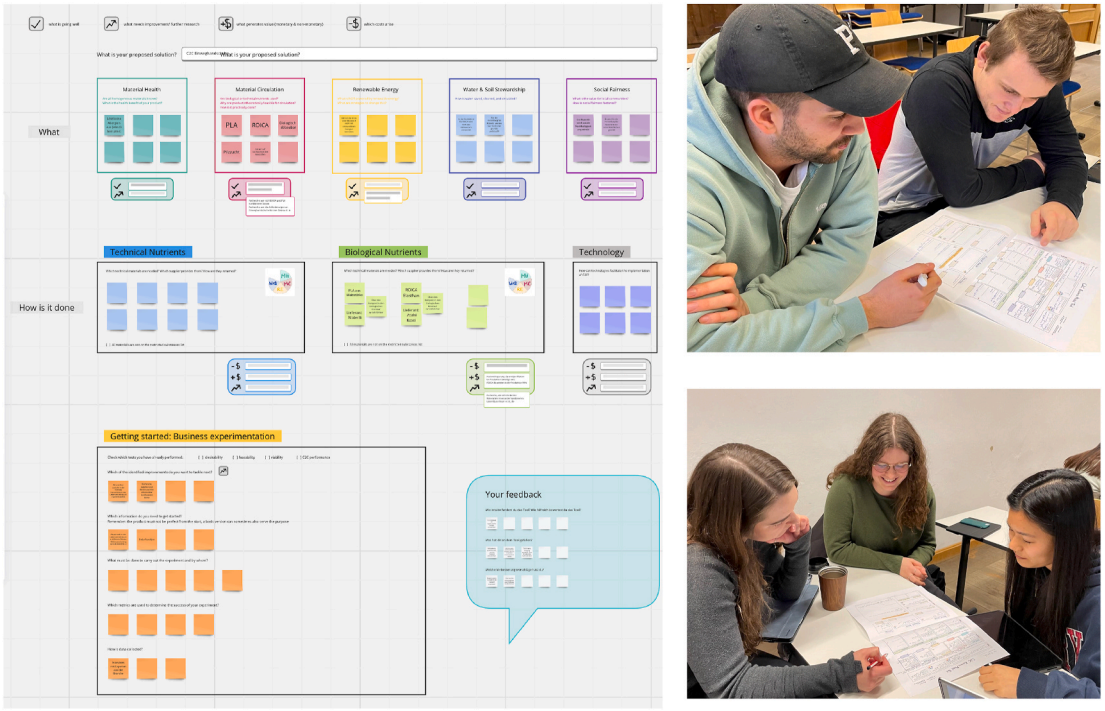

Fig. 3. Impressions of demonstration session S2 and S3.

3.4. Demonstration workshops

Engaging with practitioners in testing and evaluating the tool ensures that this "knowledge produced by design science research is (…) used in solving field problems" (van Aken and Romme, 2009, p. 8). Following the proposition of 'demonstration workshops' (Brown et al., 2021), the initial tool was interactively tested and discussed in six instances in different settings (online and offline, groups and single users). In this study, born circular startups as one type of CBMI are in the focus, and the participants were chosen according to the different phases of startups (pre-seed, seed, startup, expansion; Di Vaio et al., 2022) and different sectors, such as sustainable food packaging or hygiene products.

The participants either had an interest in founding a C2C startup (this was ensured through voluntary participation for the students), were in the process of founding a C2C business, or have successfully entered the market. In total, 42 participants tested the tool in the demonstration sessions and gave feedback. As business model tools are often part of entrepreneurship classes, students with this background are familiar with the use of such tools and represent a part of the target user group (Pepin et al., 2024). Thus, ten student groups with founding interests were included in two sessions (Schoormann et al., 2022). An overview of the demonstration sessions and the participants can be found in Table 4.

All participants had first knowledge about C2C principles and business models but different levels of expertise. Their level of expertise was asked at the beginning of each session based on the participants' self-assessment. The sessions lasted from 60 to 120 min and if possible, audio was recorded to keep track of the participants' interactions with the tool and their feedback on usability, usefulness, challenges, and suggestions for improvement. As the tool should require little expert support (Pieroni et al., 2021), the researchers only held a moderation role.

The workshops started with an introduction to the C2C concept, followed by a tool introduction, a test, and a feedback phase. Some impressions from the workshops are displayed below in Fig. 3.

After all workshops were held, the researchers transcribed the audio recordings verbatim, scanned the miro board and the survey, and synthesized positive feedback and suggestions.

In spring 2024, the researchers surveyed all participants of the demonstration sessions through open-ended questions: 1) whether their startup is still active, 2) how the tool helped them in hindsight, and 3) which impact the use of the tool had on the development of their startup (idea). The status of the startups in spring 2024 is indicated in Table 3, and the reported impacts are detailed in Section 4.2.

3.5. Evaluation and advancement of the initial tool

The overall feedback on the content, structure, and logic of the tool was very positive, independent from the innovation phase or the startup stage the participants are in. In the following, it is indicated in brackets which C2C element (e.g. 1E) or design criteria (e.g. 2D) is addressed in the comment, as well as which session the comment stems from and which phase the startup is in (e.g. S3 - just founded). The users highlighted that they gained a holistic view of their business model idea (1D) in relation to the whole circular ecosystem and how other actors are connected (2D): "I thought it was great that you really looked at the whole company and understood all the interactions with other stakeholders" (S3 - just founded). Other users explicitly say that the tool encourages them to go beyond the product and consider supply chains and reverse logistics (S4 - just founded; S5 - startup), which shows that important actors of the business model are integrated (3D) and collaboration is encouraged (2E).

The tool's focus on collaboration with partners, intensive information sharing, and a shared mindset was not noticed by users on their own. If at all, startups early in their venturing process perceived the detailed elaboration on suppliers as too early (S3 - just founded). Upon explanation of the theoretical background, however, it was perceived as helpful guidance for future supplier selection by multiple users (S3 - just founded; S4 - just founded; S5 - startup). One user emphasized that their customers need further education on C2C (2E), and henceforth, the tool addresses an important aspect (S4 - just founded).

The participants expressed that the design of the tool motivates users to take sustainability and circularity seriously (S6 - expansion) and forces them to "think about the product in detail" (S1 - ideation) (1E). Nevertheless, even the participants who have already founded a startup expressed that they were not fully familiar with the certification criteria (5D). Additionally, the tool testing revealed that the users were not aware that normative aspects such as values, mindsets, and information sharing are of importance (3E), and they seemed to be overwhelmed by remembering and integrating all of them. For them, the C2C Business Model Tool serves as a checklist and gives a roadmap through the C2C business model innovation process (5E). Another user reported from experience that looking at changing legislature is underestimated yet critical (S6 - expansion), which shows that integrating macro-level developments is relevant for the users (7E).

Regarding application scenarios, several participants highlighted that the tool can be useful across different product groups and for startups as well as incumbents: "[with this tool] you can support companies that are just beginning and include Cradle-to-Cradle from the start, and then you can also encourage companies that want to pivot to a more Cradle-to-Cradle product" (S2 - ideation) (1E, 3E).

Additionally, participants shared that the tool serves to show them avenues forward similar to a "roadmap" (S1 - ideation) and appreciated the summary into action steps (S2 - ideation; S6 - expansion) (2D). The

Table 5
Improvements of tool based on user feedback.

	Feedback from	Points of improvement	Changes in tool
C2C elements			
1	Just founded (C2C mixed), Startup (C2C intermediate)	2nd "Why" question unclear (Describing the problem according to the five dimensions of C2C)	Question reformulated to "Which unique selling point(s) are created through integrating the C2C principles?"
2	Expansion (C2C basic)	"Why" lacks market size and deeper analysis of competitors	Added question about market volume and market share of competitors
3	Startup (C2C intermediate)	Confusing order of "supplier" questions	Added question about listing suppliers and restructured order of questions
4	Just founded (C2C intermediate)	"Customer" should include marketing/ communication strategy of C2C performance	Added question about how to communicate C2C benefits and the business model
5	Ideation (C2C basic), Just founded (C2C intermediate)	"Technology" question unclear (How can technology facilitate implementation of C2C?)	Questions reformulated to "How can technology, artificial intelligence, automation, or other innovations help your business?"
6	Ideation (C2C basic & intermediate)	More information on C2C certification knowledge necessary	Supplementary sheet with background information and further information
Design criteria			
7	Ideation, Just-founded, Startup, Expansion	Digitalize tool, enlarge font	Created Excel sheet which is in a printable format but allows for more space and some automation
8	Ideation (C2C basic), Just-founded	C2C wheel, dollar and improvement symbols unclear	Substituting symbols by fields for "Open Question" and "Next Steps" after each section. Removal of C2C wheel but incorporating it in the question.

users could imagine using the tool iteratively during the venturing process (4E) (S1 - ideation; S3 - just founded). Other users added that they felt like the use of the tool "speeds things up" (S1 - ideation) as it is easy to use and intuitive (S1 - ideation) (7D). While working on the tool with an interdisciplinary team, the tool helps to align C2C knowledge and gives opportunities for discussions: "I think it was helpful for us in the team because we all got more on the same page in terms of sustainability and C2C" (S3 - just founded). Overall, the usefulness of the tool was perceived as positive, but its usability revealed a few challenges.

Whereas the very nascent startups that are in the ideation phase appreciated the overview that the tool gives both on business models and on C2C, just-founded startups emphasized the guiding nature of the tool and appreciated relevant criteria for supplier selection. Startups in the expansion phase requested and acknowledged contextual factors such as legislation and market size and valued the action steps. In the following, the points of improvement are summarized in Table 5 and how they are implemented in the final tool.

3.6. Assessment workshop on the final tool

In addition to the demonstration sessions with the initial tool, the final tool was tested in an assessment workshop. The workshop was advertised on social media for born circular startups, and 21 potential attendees filled out the application form. After eliminating all interested attendees without a founding idea or running startups (such as consultants or students during their studies), 12 persons were invited and eight participated in the workshop and gave feedback.

All of the participants were founders, co-founders, or involved in a C2C business model innovation process (the participants came from ventures of different ages; three in the ideation phase, three between 1 and 5 years, and two older than 5 years) and from different sectors (three from IT and electronics, one in beverages, two from textiles, one from sports gear, one from furniture). Following a brief introduction to the C2C concept, the participants tested the tool and completed a feedback form containing two quantitative (Likert Scales) and qualitative items (open-ended questions), similar to the process from Coffay and Bocken (2023). The feedback of the participants is summarized in Section 4.2.

4. Results

The aim of this research is to reflect C2C principles in a business model tool for circular startups. An initial tool was designed based on literature and reworked based on user feedback. In the following, the final version of the C2C Business Model Tool and results from the assessment workshop are presented.

4.1. Final C2C business model tool

The main novelty in the final C2C Business Model Tool is the change from a physical canvas to a digital Excel spreadsheet. Designing the tool as an automated Excel spreadsheet follows the calls for increased usability, i.e., digital worksheet, more space, and including additional information. In case a user prefers a printed form, the tool fits on a horizontal DIN A4 sheet and can be printed out. The spreadsheet consists of four tabs: Read Me First, Help, C2C Template, and Action Plan.

As the tool is designed for practitioners, the first tab, 'Read Me First', summarizes the theoretical foundations of the tool outlined in this paper together with the explanation of the C2C certification criteria. The second tab, 'Help', gives detailed instructions and guidance on using the tool, draws connections to the before explained theory, and emphasizes the iterative use of the tool.

The initial version of the tool is split into tab three, 'C2C Template', and four, 'Action Plan'. In the C2C Template, the structure of 'Why', 'What', 'Who', and 'How' was kept but is followed by two commentary fields at the end of each section where 'Open Questions' and 'Next Steps' can be noted. This allows users to document questions immediately as they arise. After completion of the C2C Template, the tool automatically

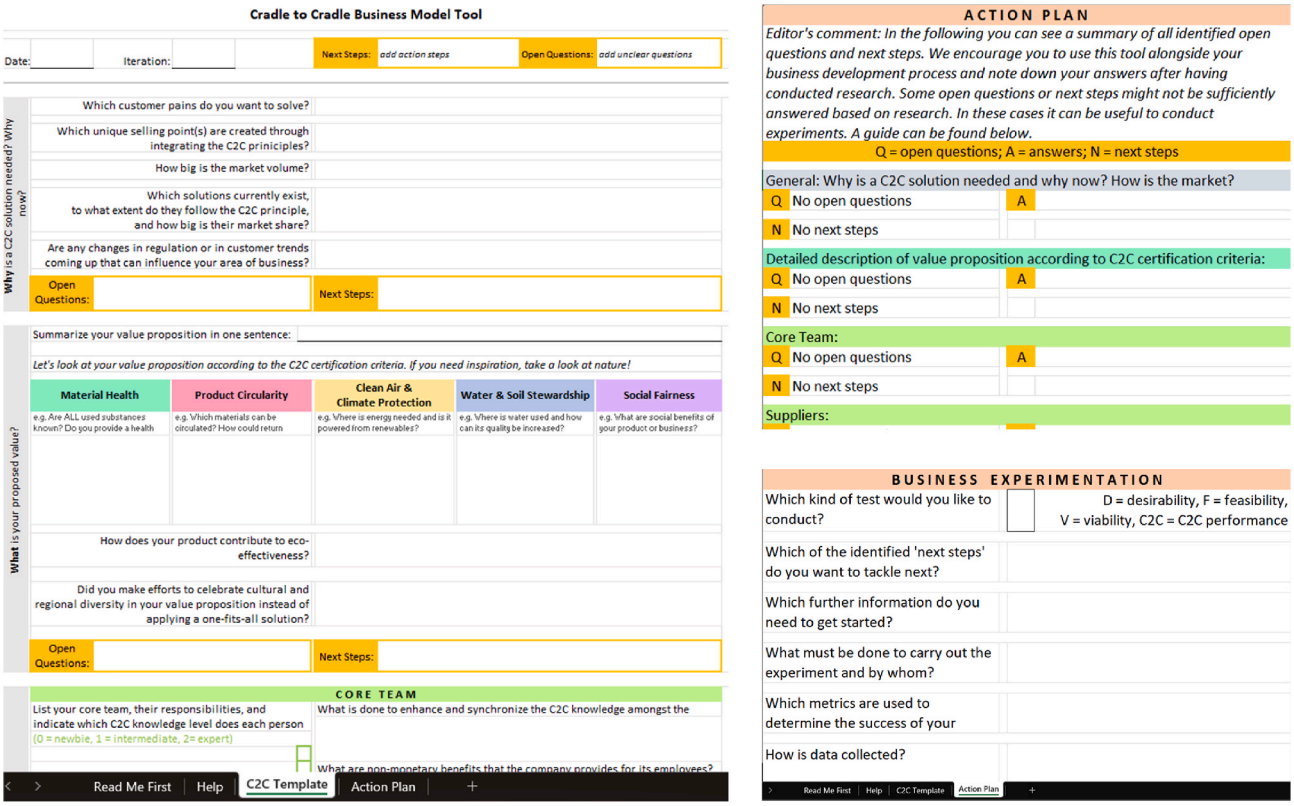

Fig. 4. Excerpts of the final version of the C2C Business Model Tool.

Table 6
Implementation of literature-based elements in C2C Business Model Tool.

	Criteria	Implementation in Tool
	Design	
1D	Does reality check, provides holistic view, and supports communication	By filling out the tool, users reflect on the value proposition, value creation, value delivery, and value capture of their business model. Thus, providing a check of the concept while considering the most important C2C elements. This helps users to communicate their business model clearly.
2D	Helps discover links (systems thinking) and facilitates action	The guiding questions of the tool elements connect different elements with each other, e.g., suppliers with reverse logistics partners or revenue streams with social aspects. The tab "Action Plan" provides an overview with "Open Questions" and "Next Steps" as well as a planning template for business experimentation to initiate action.
3D	Includes all important elements of a business model of the firm and the external environment	The tool analyzes the business model of the firm: key activities, core team, its partners, customers, the value proposition, revenue and cost streams. Additionally, it looks at the external environment by analyzing C2C performance of suppliers, competitors, and reverse logistics; customers' C2C knowledge, customer trends, and changing legislation.
4D	Tested with practitioners	Feedback from six demonstration sessions with 42 users was worked into the initial tool. The usefulness of the final tool was then assessed with nine startups and experts.
5D	Knowledge embedded in tool	The tool comes in an Excel sheet consisting of two additional tabs with information about the theoretical background of the tool and instructions for filling it out. Within the tool, guiding questions nudge users to consider all relevant C2C criteria.
6D	Not too time consuming and user-friendly application	The digital nature of the tool allows online co-working, integration in digital workflow, and easy file saving or copying for iterative use. When used digitally, 'Action Steps' and 'Next Steps' are automatically summarized. However, the tool also fits the DIN A4 format for printing and offline editing.
7D	Simple, intuitive design, and visualizes BM	The structure of the tool is based on 'why', 'what', 'who', and 'how'. Colored frames around topics make the design intuitive and visual.
8D	Transparency about tool development process	Design criteria and C2C business model elements are derived from previous research, the tool is tested with a diverse set of participants, and it is described how the feedback is integrated into the final version of the tool.
	C2C business model elements	
1E	Circular product design	Integration of C2C certification dimensions, making users aware of technical and biological materials, checking for restricted substances, and considering return systems.
2E	Collaboration and extensive information sharing	All key actors of the value network are individually listed, guiding questions encourage users to analyze their value network, reflect on close collaboration with key actors, and establish information sharing infrastructures.
3E	Rooted C2C vision	Reflection question about C2C vision of core team, suppliers, and reverse logistics/recyclers. Guiding question asks about synchronizing C2C knowledge in the core team.
4E	Continuous experimentation, learning, and improvement	The tool encourages business experimentation in the fields of desirability, feasibility, viability, and C2C performance. Organizational learning is accounted for by the field "Knowledge Management". Users are motivated to continuously work with the tool and improve their model.
5E	Upholding the five certification dimensions	The proposed solution is assessed against each certification dimension.
6E	Defining material ownership	Users are encouraged to find alternative forms of ownership through guiding questions in the fields of cost structure and revenue streams.
7E	Considering macro-level developments	One field addresses future trends or legislative changes.
8E	Support of technology	One field is dedicated to 'Technology' and how it can facilitate C2C innovation.
9E	Financial funding	The tool encourages its users to inform themselves about eligible innovation funds, accelerator programs, etc.

Table 7
Quantitative feedback from assessment workshop.

Number of participants in assessment workshop	How useful is the tool for you? (1 = not useful, 5 = very useful)	How helpful is the tool to integrate C2C principles and prepare for certification? (1 = not helpful, 5 = very helpful)	In which phase of a circular business model innovation process is the tool helpful? (after Bocken and Konietzko, 2022, multiple choice)
8	Mean = 4,25 Standard deviation = 1,04	Mean = 4,63 Standard deviation = 0,52	Seizing = 62,5% Visioning = 50,00% Transforming = 37,5% Sensing = 25%

creates an overview of all open questions and next steps sorted by section in tab four, the Action Plan. This serves as a starting point to plan business experimentation and encourages continuous improvement of the business model. The last section of the Action Plan supports the planning, monitoring, and learning from pilot projects inspired by the SBM Pilot Canvas by Baldassarre et al. (2020). Through several questions in each section, users are encouraged to think about their C2C business model in detail. However, depending on the maturity or application intention, the sections of the tool can be edited with more or less detail or postponed to a later iteration. This way, the tool can be adapted to the stage in which the startup finds itself. The final version of the C2C business model tool is partly depicted in Fig. 4 and can be fully retrieved from the supplementary information. Table 6 gives an overview of how each design criterion and C2C business model element is implemented in the tool.

4.2. Assessment and impact of the C2C business model tool

In the assessment workshop, similar to the demonstration workshop, the feedback on the usefulness and the support in integrating C2C principles in business models and preparing for certification was very positive, which is mirrored in the quantitative feedback in Table 7. Further, the participants highlighted that the tool is mainly helpful in

the seizing phase of circular business model innovation while it also supports in the visioning and transforming phase.

The qualitative feedback is comparable to the statements given in the demonstration workshops. It is highlighted that the tool enables gap spotting, to involve all departments, getting an overview, thinking in the C2C framework as well as to think in systems and to increase the speed of the business model innovation process. Concerning the necessity of certification, they stated that the C2C certification helps them to give transparency to measure the circularity, to form partnerships, and to hold themselves accountable. The tool is perceived as most helpful in the seizing phase of designing the business model, and a certain maturity and knowledge of detail are necessary. For example, one founder commented that the needed details require to have moved beyond the idea stage and by that level of expertise, the tool encourages several rounds of usage.

In addition to the feedback to the initial tool (demonstration sessions) and to the final tool (assessment workshop), the participants from the demonstration sessions were asked to reflect on the impact of the tool in hindsight. The positive evaluation persists over time as the users in the ideation phase (S2) consider the tool as helpful to understand the complexity of C2C, think carefully about material selection and include return systems and functions as guidance and a checklist. The users from the just founded startups (S3, S4) report that the tool encouraged them to align their co-founders' and employees' knowledge on C2C over time and understand their unique selling points better (S3). However, it supports them in raising capital in competitions or stipends, writing their business plan, and further developments of their business model (S4).

5. Discussion and limitations

This study examined how a business model innovation tool can integrate C2C principles to support born circular startups with defining their C2C business model. It applies a DSR approach in order to address the formulated research gap and to create an artifact for the user group. In this section, theoretical contributions, practical implications, and further research is discussed.

5.1. Theoretical contributions

Only recently, research has started to investigate born circular startups (Henry et al., 2023) and the current research has covered business models from circular startups, motivations (Henry et al., 2020), and barriers and drivers (van Opstal and Borms, 2023). Nevertheless, little research has been conducted on how business model innovation tools can contribute to overcoming these challenges. Through developing and testing this tool specifically for and with circular startups, this study was able to contribute to a better understanding of circular business model innovation by circular startups as follows.

While incumbents are rather concerned with analyzing their existing business models and partnerships and how these can be transformed into circular business models (Geissdoerfer et al., 2023), circular startups aim to integrate high-level circularity from the start. In doing that, they face the challenge of balancing requirements such as defining a C2C vision for themselves and the potential team, developing a business model, adhering to all C2C principles, and finding financial means. In that time of turbulence and insecurity, especially in the contested context of the circular economy (Corvellec et al., 2022), the results from the testing workshops show that guidance is highly appreciated. In line with previous research, the users expressed a need to capture and communicate their business model more comprehensively (Awana et al., 2023) and align their various ambitions (Henry et al., 2023).

Concerning the different stages of CBMI, tools for circular startups are requested to be adaptable to the different needs within these stages and fulfill different roles as a boundary object (Athanasopoulou and De Reuver, 2020). While being in the vision phase, the tool enables the founders (and team) to discuss their understanding of C2C. In the sensing phase, the tool equips the startups to better understand the needs of customers and potential partners in the supply chain. The action steps then guide the startups through the seizing and transforming stages and support them in developing a holistic viewpoint and check their business model for consistency.

Apart from uncovering further insights into the challenges of circular startups, the concept of C2C was extended to the business model level through linking product level criteria to fundamental business model elements such a value (re)creation, value (re)delivery, value (re)capture, and extended value propositions. This can serve as a foundation to further examine CBMI and how they contribute to high-level circularity. Even though researchers state that C2C functions as an operationalization of the circular economy concept (Ünal and Shao, 2019), only a very limited number of studies have addressed C2C elements in current circular business models (e.g. Hansen and Schmitt, 2020).

This study shows how the DSR methodology addresses practice-oriented research gaps and contributes to solving practitioners' challenges. This approach is increasingly encouraged in entrepreneurship research and is perceived as instrumental to advance both theory and practice (Dimov et al., 2023). Due to this approach, the tool is embedded in the state of the art of research while incorporating the direct feedback by diverse practitioners which increases the likelihood of usage. Consequently, DSR proved to be an effective approach to synthesize theoretical and practical knowledge.

5.2. Practical and policy implications

The demonstration workshops have shown that the C2C business model serves educational purposes and supports entrepreneurs in different phases of their startup concerning product and CBM design (Borms et al., 2023). Building on the feedback from the demonstration sessions, the assessment workshop and the reported impact of the tool use, it can be concluded that the tool caters to different needs depending on the maturity of the startups.

In the pre-seed phase, ideation processes are crucial, and the tool helps entrepreneurs at the very beginning of their journey (often in entrepreneurship classes or incubation programs) to gain a holistic overview of business model elements that have to be designed for high-level circularity (von Kolpinski et al., 2023). Entrepreneurs with very little expertise in C2C and a vague idea in mind will not be able to answer all questions from the start.

In the seed and startup phase, the tool encourages entrepreneurs to implement high circularity standards from the beginning. As soon as startups face the challenge of gaining partners and signaling legitimacy, they have prepared the groundwork for certification. Engaging with the tool can also prepare for funding applications as reported by users. Especially for circular startups in the startup and expansion phase, certification is important as it has shown to be an indicator of high sustainability outcomes for investors (Hirschmann and Block, 2022). As C2C mostly focuses on eco-effectiveness as the key concept, eco-efficiency falls rather short in comparison to life-cycle assessment perspectives (Bjørn and Hauschild, 2013). Hence, it is advised, especially in the startup and expansion phase, to supplement the C2C business model tool with life-cycle assessments. As the certification is rather complex, information-intensive and expensive, a certain maturity and financial means can be beneficial.

Concerning policy implications, this study underlines the challenges that come along with the contested nature of the circular economy concept and how a clear operationalization is crucial for circular startups to be successful. Consequently, public funding opportunities for circular startups should be precise in describing their understanding of the circular economy. Additionally, public funding should motivate circular startups to contribute to high-level circularity and to check for a holistic perspective on circular business models.

5.3. Limitations and future research

While this study has contributed to filling a research gap and solving a practical user problem, some limitations exist that create avenues for further research. First, the developed tool has been tested by users in different phases of their startups and the business model innovation process. Hence, while this study has found indications that the tool serves different purposes for the users, further longitudinal research could examine how the tool is applied in different stages of one circular startup. Another relevant avenue is the tool's utility for the certification process. Second, the demonstration sessions solicited direct feedback from the participants. Building on the first limitation, a longitudinal approach can also test what kind of business models are designed through the tool and to which levels of circularity these business models contribute. How the tool performs in several rounds of development and in continuous certification processes could also be examined. Third, the tool mainly supports use cases of material products rather than intangible services. This is grounded in the C2C concept (Braungart et al., 2007). As supportive activities for the circular economy, such as networks and platforms, are necessary (Henry et al., 2020), further research could dive into designing tools for service providers.

6. Conclusion

While circular startups are open and motivated to develop circular business models that contribute to high-level circularity, they face significant challenges in the circular business model innovation process. This research applies a DSR approach to develop a business model tool that enables startups to integrate C2C principles at the very beginning of developing products and business models and examines C2C in the context of CBM. With six demonstration sessions with the initial tool, a survey on the impact of the tool use, and one feedback session with the final tool, this study was able to design a tool that is perceived as useful and that shifts the focus from the own businesses to the whole value network. It acknowledges the complexity that is ingrained in circular endeavors, guides users through the development process, and accelerates it.

With this study, the authors answer the call for tools that enable businesses to design circular products and business models (Blomsma et al., 2023), encourage continuous improvement (Pieroni et al., 2019), and integrate C2C principles at the very beginning (de Pauw et al., 2014). While several scholars have used DSR in the circular economy to support business model development (e.g., Brown et al., 2021; Santa-Maria et al., 2022), this tool is the first to integrate C2C principles.

CRediT authorship contribution statement

Kim-Mai Hoang: Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Conceptualization. **Alexa Böckel:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The C2C Business Model Tool is available for free in the supplementary material.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2024.142949.

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