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Modelling an ecosystem of business models in a circular value chain: the circular business ecosystem model canvas

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Abstract

To advance the circular economy, there is a need to take an ecosystem view of business models for circularity in which different actors interact dynamically to create economic, environmental and social value. This research introduces the Circular Business Ecosystem Model Canvas, a novel method to prototype a circular ecosystem of business models. The case of ferric chloride, an inorganic coagulant for wastewater treatment, is used to demonstrate the new canvas and show how it supports the development of a more holistic perspective on sustainability-oriented business model innovation.

Keywords: sustainability, circular economy, business models, innovation

1. Introduction

1.1. Business model innovation: the shift from linear to circular economies

For a long time, business has operated in a linear economy, whereby raw materials are transformed into products that are used until their functional value diminishes, after which they are disposed of (Sharma et al., 2020). This has led to an increasing number of sustainability challenges with planetary boundaries like climate change, biodiversity loss and nitrogen and phosphorus loading having already been crossed (Rockström et al., 2009). The severity of these environmental challenges has led to its entanglement with social issues, such as the impact of natural disasters on the job market and deterioration of local economies. Business is under pressure to respond. As a result, initiatives towards sustainability and more efficient use of resources are increasing. Sustainability challenges are a risk for business but also an opportunity. The circular economy (CE), defined as "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops" (Geissdoerfer et al., 2017), provides a route for business to see these challenges as an opportunity. The CE provides strategies for more efficient resource management and stimulates progress towards the development of more robust and durable materials (Ghisellini et al., 2016). New circular business models are a driver for CE transitions (Gue et al., 2022). However, circular business models are not widespread as they require changing the key building blocks of business and current business paradigms (Bocken et al., 2019).

1.2. Research gaps, aims and contributions

To support business model design and innovation, there is a need to provide structure and guidance to frame and focus thought (Bocken et al., 2019). A broad variety of methods has been developed to support business model innovation (Bocken et al., 2019). However, they tend to focus on modelling the business model of a single organisation when this is not sufficient to close material loops. Focusing on

a single organisation is unlikely to make the CE work in practice (Takacs et al., 2020) as it does not allow to consider the high level of coordination between actors necessary to transition to a CE (Kanda et al., 2021). To advance and upscale the CE, there is a need to take an ecosystem view of business models for circularity in which different actors, networks and institutions interact dynamically to create environmental and socio-economic value (Takacs et al., 2020; Hansen et al., 2020; Zucchella and Previtali, 2018). Despite seminal work to conceptualise the ecosystem construct (Adner, 2016) and early attempts to support practitioners to think in business systems (Mentink, 2014), we still do not know how to model an ecosystem of business models and their interlinked resource flows. Further, early attempts to support business systems thinking fail to encourage organisations to design their business models with a strong focus on environmental and social impacts. The aim of this research is to develop a novel method to model a circular ecosystem from a business perspective to support economic, social and environmental value creation. This is important to move away from the view that a single organisation can be sustainable on its own and support the development of business models for networks of different organisations (Jakobsen et al., 2023). It is also key to help operationalise the CE and support business developers. This paper introduces the Circular Business Ecosystem Model Canvas (CBEMC) and validates its effectiveness by modelling an ecosystem of business models using a dataset from an industrial project. The paper contributes a new canvas showing how the actors in a closed-loop value chain can make business.

2. Literature review

2.1. 21st century economies and business

The CE is a manifestation of economic models that highlight business opportunities where cycles rather than linear processes dominate. However, the concept has limitations as, for example, it neglects social implications. There is neither a clear focus on society nor a suggestion on the strategies and impactful actions within the CE that could lead to future social equality (Murray et al., 2017; Padilla-Rivera et al., 2020). Furthermore, the CE fails to address UN Sustainable Development goals 3, 5, 10, 11, and 16, which all fall under the social pillar (Schroeder et al., 2019). Padilla-Rivera's review of the CE demonstrates the requirement of a framework that integrates economic, social, and ecological aspects (Everett, 2022).

The Doughnut economy points to the need to include multiple social and environmental concerns within economic development strategies (Raworth, 2017). It embodies an ecological ceiling and social foundation that act as boundaries between which business can safely occur without harming either. The ecological ceiling and social foundations consist of planetary and social boundaries which must not be pushed beyond their threshold, otherwise they will have detrimental effects on the planet and society.

2.2. Business modelling in a sustainable and circular economy

2.2.1. Sustainability-led evolutions of the traditional business model canvas

Created in 2010 by Osterwalder and Pigneur (Osterwalder and Pigneur, 2010), the traditional *Business model canvas* is a tool to map out a business model focusing on value proposition, creation, delivery and capture. It contains all the essential components to describe a business model prompting business to think about other actors they need to interact with and mapping internally used resources. It focuses on defining the business model of a single organisation within a linear economy logic and lacks consideration of sustainability issues.

The *Triple layered business model canvas* is a tool to integrate economic, environmental and social concerns into a holistic view of an organisation's business model (Joyce et al., 2016). It iterates upon the original business model canvas (economic) by adding two more canvases (environmental life cycle and social stakeholders), which focus on mapping environmental and social business considerations. The two new canvases allow to transcend a value capture logic centred on financial transactions only by capturing environmental and social benefits and costs. Further, the triple layered business model canvas prompts business to think in detail about the sourcing, production, use phase and end of life of

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products. However, it is still focussed on modelling the business of a single organisation and cannot map financial, resource and information flows within the system.
The *Template to develop circular business models* is a valuable step forward as it proposes to extend the traditional business model canvas by calling for horizontal and cross integration of actors' business models and offering five recovery modules (Braun et al., 2021). In particular, the sections to map out reverse logistics are linked to the main canvas using graphics to emphasise that business models must be created such that they can integrate with each other and help business understand the 'tightness' of resource loops. In the template there is no explicit field referring to environmental and social benefits and costs. Further, it lacks clarity on how actors' business models link with each other.
Other adaptations of the traditional business model canvas claim to address sustainability and circularity but they provide limited advancement, such as the *Ecocanvas* (Daou et al., 2020).

2.2.2. Circular business innovation canvases

There are also canvases that focus on bringing actors together to stimulate business model innovation. The *Boundary tool* is a canvas to help multiple actors engage with each other to innovate sustainable business models (Velter et al., 2022). It focuses on achieving alignment between actors by sharing potential contributions towards a circular system, understanding each other's interests and collaboratively coming up with a shared goal.
The *Circular collaboration canvas* is a tool to trigger questions that encourage discussion on the current challenges faced by the organisation coordinating the circular effort (Brown et al., 2021). It allows for ideation upon what challenges could be faced by other actors in the system and how they could be addressed to facilitate collaboration. Traditional business model canvases lack the element of collaboration that these canvases provide.

2.2.3. Industrial symbiosis business modelling canvases

In the field of industrial symbiosis, Gravert and Mattsson modelled the cooperation between a recycling company, an energy company and a real estate company using three instantiations of the traditional business model canvas (Gravert et al., 2016). However, they lack a specific tool to visualise the interactions between the three business models.
The *Industrial Symbiosis business model canvas* demonstrates the system-level value produced by industrial symbiosis (Cervo et al., 2019). The canvas is centred on the business model of a consortium including central, peripheral and external organisations. Key resources and activities summarise technical and organisational relevant aspects of the synergy. Partners relationships detail the nature of consortium members relations in the synergy (e.g. competition, cooperation, coopetition). The value proposition is split into economic, environmental, social and territorial. While economic value is captured in the traditional way through cost structure and revenue stream fields, environmental value is documented through four footprint balance fields and social cost through two private (non-)financial mechanism fields. In this canvas, tracing the contribution of the individual members of the consortium to the industrial symbiosis may be challenging. There is also a lack of a clear example to demonstrate efficacy of the value capture fields in the canvas. Finally, information, material and finance flows are not represented though they are essential to understand a circular system.

2.2.4. Business systems modelling canvases

The *Business cycle canvas* is a method to support practitioners to think in business systems and beyond the individual business model (Mentink, 2014). It allows mapping and linking in a circle (through flows of resources and finances) fields of the traditional business model canvas like key activities and key partners. It provides business with an instrument to visualise the resource and financial flows together facilitating the creation of a circular flow. It is still based on the traditional business model canvas and therefore it lacks fields like environmental and social benefits and costs.
The *Circular business model mapping tool* by Julia L.K. Nußholz (Nußholz, 2018) consists of a horizontal set of business model canvases that represent the chain of actors in the system. This form of integration of multiple canvases is more in-depth as it covers all the fields of the traditional business

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model canvas. However, resource and financial flows are not shown and neither are the environmental and social benefits and costs fields.

2.2.5. Summary of challenges with current canvases

Overall, the literature review shows that among current efforts to evolve the traditional business model canvas there are four streams. The first has focused on implementing either the triple bottom line (i.e. *Tripled layered business model canvas*) or circularity (i.e. *Template for circular business models*). The second has concentrated on facilitating multi-actor alignment for sustainable business model innovation (i.e. *Boundary tool*). The third has tried to combine concepts of cross-sector collaboration via industrial symbiosis with the traditional business model canvas (i.e. *Industrial Symbiosis business model canvas*). Finally, still departing from the traditional business model canvas, the fourth stream has focussed on modelling business systems (i.e. *Business cycle canvas* and *Circular business model mapping tool*). Despite their positive contributions, the canvases in this stream do not yet incorporate the triple bottom line, lack a comprehensive overview of flows in a closed-loop value chain and do not show what drives integration of inter-system business models within a value chain.

3. Methodology

3.1. Development of the Circular Business Ecosystem Model Canvas

The CBEMC stems from the analysis of new economic models, existing business model canvases, empirical understanding of businesses interested in operating into closed-loop value chains and the interest of the authors to develop a practical tool to support the development of business models for circular ecosystems. The development of the CBEMC underwent multiple iterations based on learnings from the literature, the data collected through the case study and the feedback from academic and industrial experts.

Building on the *Circular business model mapping tool* (Nußholz, 2018), the CBEMC integrates the business models of different actors to develop a joint value proposition for a circular ecosystem. The CBEMC is composed of a modelling template and business model cards both of which have fields to be filled in by actors, see Figure 1. At the centre of the modelling template is stated the **system value proposition** intended as the view of the network and derived from the *Boundary tool* (Velter et al., 2022). In its proximity there is a field to state the **system drivers**. The modelling template depicts cyclic flows of resources, information and finance as in the *Business Cycle Canvas* (Mentink, 2014) within the ecological ceiling and social foundation boundaries inspired from the Doughnut economy framework (Raworth, 2017). To configure an ecosystem of business models, business model cards, representing the business models of different actors, can be placed over the template in the forward or reverse logistics sections, which are in between the ecological ceiling and social foundation boundaries. This ensures that all business is conducted between the constraints of the environment and society. The business model card, apart from representing the business model of an organisation, has been designed to interlock with another business model card in order to represent the business interactions between consecutive organisations in a value chain and show how they exchange resources, information and finance.

The business model card, retaining the four types of value in the traditional Business model canvas (Osterwalder and Pigneur, 2010), splits *value proposition* (diagonal line pattern fields) into **economic value proposition**, **environmental value proposition** and **social value proposition** as in the *Triple layered business model canvas* (Joyce et al., 2016), see Figure 1. The **business pattern** is a means of classifying the business model of an actor within a circular economy. With regards to *value creation* (dotted pattern fields), the card displays the **business activities** of an organisation and presents its **internally used resources**. Partners at the core of value creation are shown as interlinked organisations, but extended **partners** in the broader ecosystem are also captured per each organisation. With respect to *value delivery* (grid patterned fields), **information** captures the exchange of data between actors on either side of the card, and the **core resource** describes how materials and components are transformed and which actors own them in that position within the loop. Lastly, **customer relationships** detail the strategies to engage with customers to understand their needs. Finally, the card maps *value capture*

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(chequer pattern fields) as in the Triple layered business model canvas (Joyce et al., 2016) that is by identifying economic value capture through **revenue**, **costs** and **profit and surplus stream**, environmental value capture through **environmental benefits** and **environmental costs** and social value capture through **social benefits** and **social costs**.

The CBEMC aims to support modelling and visualisation of: 1) an ecosystem (integrated network) of business models in harmony with the principles of the ecosystem and humanistic value and norms (Jakobsen et al., 2023); 2) the value propositions of businesses networked in a closed-loop and the interactions between them towards value creation, value delivery and economic value capture; and 3) the actions of businesses towards environmental and social value capture. This modelling is expected to support: business collaboration to create social and environmental value between actors with diverse background and values (Dentoni et al., 2021); cooperation for common good and to reduce tendencies to economic egoism (Jakobsen et al., 2023); coordination of actions by actors for proper ecosystem development and functioning (Barrie et al., 2020); and management of the relationships underpinning the ecosystem.

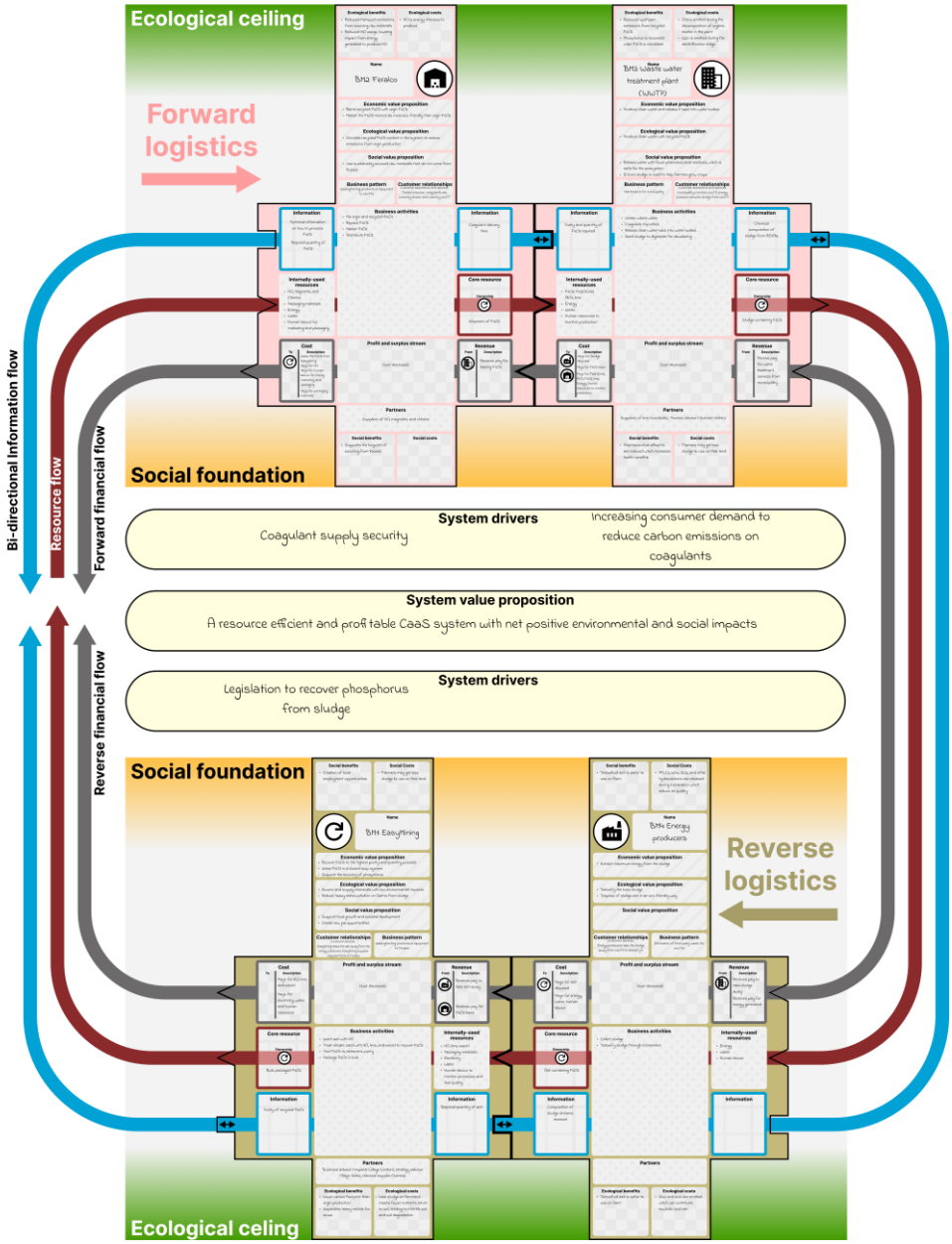

Figure 1. Circular Business Ecosystem Model Canvas

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3.2. Case study

The CBEMC was investigated and developed as part of the 'Water treatment plants as resource hubs' project. One of the work packages of the project aims to develop a Chemical as a Service (CaaS) business model for the actors operating in the value chain of ferric chloride, an inorganic coagulant used in wastewater treatment plants to remove impurities from water. This business model replaces conventional ownership exchange of ferric chloride for wastewater treatment with access. In the CaaS business model, it is, in fact, expected that the sludge collected post wastewater treatment is processed to recover ferric chloride and the chemical is subsequently leased first to a manufacturer of chemicals and then subleased to wastewater treatment companies.

The actors in the value chain of ferric chloride, including manufacturers of high performance water treatment chemicals (Feralco), wastewater treatment companies (Käppala, Sydvatten, Stockholm Vatten och Avfall), energy and material recovery companies (EasyMining) and the water association (Svenskt Vatten), were met in January 2023 as part of a workshop to facilitate alignment around the CaaS business model and subsequently interviewed between July and September 2023 to learn more about their views on the proposed business model.

In total, six semi-structured interviews with audio recording were conducted with actors from the above organisations. The interviewees covered the following roles: waste water treatment specialists (2), water coagulant expert (1), municipal water treatment expert (1) and water coagulant recovery experts (2). The interviews involved one or more participants and lasted approximately 1 hour. In the interviews the questions asked covered the following topics: the current business model of the partner organisations, the CaaS business model and alternative business models. The interview data were initially transcribed. Next, using a deductive approach, the data were coded to identify information chunks to fill in the fields of the canvas as it emerged from the synthesis of the features in previous canvases. Where data could not be fit to the canvas, new fields were proposed, such as system drivers. The evolution of the canvas fields and layout was also influenced from conversations with six academic and industrial experts as part of one-to-one meetings where the canvas was presented.

3.3. Modelling the CaaS business model in the CBEMC

The data collected through the interviews were used to model the CaaS business model case in the CBEMC. Specifically fragments from the transcripts were used to populate the fields of the CBEMC. This is an early-stage evaluation to demonstrate the feasibility of modelling an ecosystem of business models. The learnings from this modelling exercise are reported in the next section.

4. Circular Business Ecosystem Model Canvas

Ecosystem of business models. The CBEMC in Figure 1 details an ecosystem of business models for the organisations operating in the circular value chain of ferric chloride. At the centre of the canvas, the system value proposition states that the system aims to introduce a resource efficient and profitable CaaS model for ferric chloride. Among others, the system drivers are new environmental legislation and resource security as the supply of ferric chloride has recently been disrupted by geopolitical tensions.

The business models are organised in a clockwise arrangement describing a closed-loop system, see Figure 1. In particular, two business models are in the reverse value chain and two in the forward. The reverse value chain (bottom left part of the canvas) displays the business model of the material recovery company acting as the supplier of recycled ferric chloride (BM1, see Figure 1). The forward value chain (top part of the canvas) displays the business models of the manufacturer of wastewater treatment chemicals (BM2) and of the water treatment company (BM3). Finally, in the reverse value chain (bottom right part of the canvas), the business model of the energy recovery company is shown (BM4).

Value propositions, value creation and economic value capture. To achieve the mission to deliver a CaaS business model, the economic, environmental and social value propositions of the four businesses are stated in their business cards and linked to the system value proposition, see Figure 1. For example, the material recovery company aims to supply ferric chloride with low environmental impact by recovering it from sludge (environment), lease it in a closed-loop system (economic) and create new job opportunities (social).

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The CBEMC shows that the four businesses exchange flows of information, resources and value. The CaaS business model entails value creation by chemical treatment (V-Cre1) of sludge ashes (Input resource1) by the material recovery company (BM1) to recuperate ferric chloride (Output resource 1) and value capture by leasing the chemical (V-Cap1) to the manufacturer. Next, the manufacturer (BM2) creates value by producing a blend of ferric chloride containing virgin and recycled content and marketing it (V-Cre2) to water treatment companies. It captures value by subleasing (V-Cap2) the ferric chloride blend (Output resource 2) with a contractual obligation to return it. The ferric chloride with recycled content is then used by the wastewater treatment company (BM3) to purify water (V-Cre3) and outputting sludge (Output resource 3). The wastewater treatment company captures value through fees for water discharge (V-Cap3). Finally, the sludge (Input resource 4) is collected from wastewater treatment companies and value is created from the energy recovery company (BM4) by incinerating the sludge (V-Cre4) and outputting ashes (Output resource 4) for the material recovery company. As the material treatment technologies developed by the material recovery company allow to recapture almost all the ferric chloride, the chemical can flow in a very tight loop and the CBEMC allows to visualise the emergence and re-emergence of value over the first and the subsequent cycles of ferric chloride.

Handling ferric chloride as detailed above leads to a range of environmental and social impacts, which are now discussed in turn.

Environmental value capture. The manufacturer would source less raw materials from foreign countries to make ferric chloride, therefore lowering transportation emissions, see Figure 2. The wastewater treatment company would fulfil their aim to reduce upstream emissions associated with sourcing ferric chloride. It would also contribute to capturing ferric chloride and phosphorus from sludge as it makes a commitment to return the sludge to the energy recovery company. The energy recovery company would detoxify the sludge by removing pathogens and pharmaceutical residues and provide ashes to its downstream partner. Finally, the material recovery company would be able to lower the carbon footprint of ferric chloride production and separate heavy metals from the ashes.

Social value capture. By sourcing recycled ferric chloride, the manufacturer would be able to handle potential security supply threats more easily, increasing national resilience. The wastewater treatment company would no longer be able to offer sludge to farmers to use on agricultural land, but farmers will have the option to source high quality fertilisers as phosphorous is recovered alongside ferric chloride. As the sludge is not spread on land, crop plants would not risk being contaminated with pharmaceutical residues mitigating potential negative health effects on consumers. The combustion of organic matter in the sludge would release gases such as CO2, NOx and SO2, which may reduce air quality. Finally, the material recovery company would create new plants to produce ferric chloride from waste offering local employment opportunities.

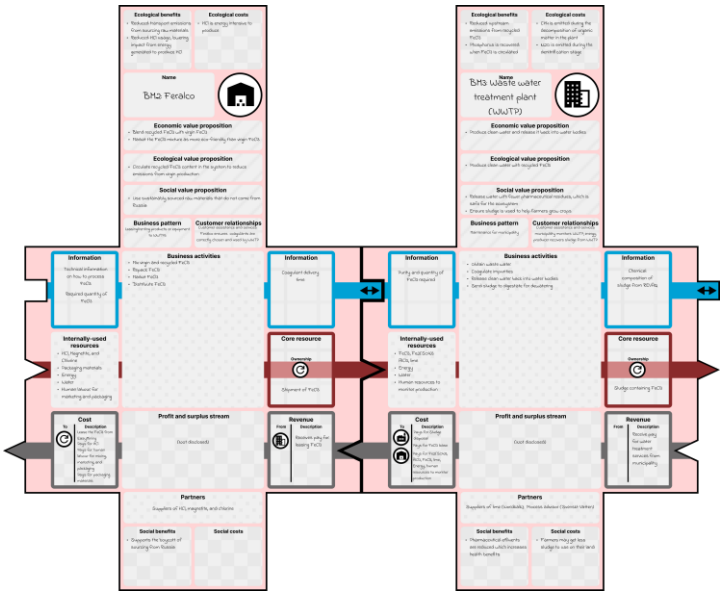

Figure 2. Business models in the forward logistics section of the CBEMC

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5. Discussion

This research makes a case for advancing current tools for business modelling and demonstrates how the CBEMC allows to configure an ecosystem of business models. The CBEMC extends methods, like the *Business cycle canvas* and *Circular business model mapping tool* for three reasons. First, it incorporates the triple bottom line with an intuitive layout. Second, it provides a comprehensive overview of flows in a closed-loop value chain. Third, it shows what drives integration of inter-system business models within a value chain.

Limitations and future work. The development of the CBEMC was informed by literature review and interviews with actors in the value chain of ferric chloride. More research is needed to present the CBEMC to actors and understand the value it generates for them. Researching the ferric chloride value chain, it was observed that an important dependency exists with the phosphorus value chain to the extent that business activities related to these two flows have to be considered in conjunction. This calls for an even broader ecosystem approach to business model innovation. Ferric chloride as a product has made the modelling of an ecosystem of business models more treatable as it is relatively simple. It is expected that modelling an ecosystem of business models for a more complex product will be more onerous and require focusing on selected materials. Finally, future research on circular ecosystems should consider investigating power shifts compared to linear ecosystems.

6. Conclusions

This paper contributes to the existing research on sustainable business models by providing a novel framework, i.e. the Circular Business Ecosystem Model Canvas, to enable the modelling of an ecosystem of business models taking a closed-loop perspective to sustainability. The CBEMC, expanding on standard and economic-centred approaches to business modelling, is the first attempt to integrate canvases built from a closed-loop perspective into an extended value network business model canvas. This expanded canvas supports developing a more holistic perspective on sustainability-oriented business model innovation. As such, the CBEMC has the potential to support those seeking ways to transform organisations for sustainability.

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