CIRCULAR ECOSYSTEM STRUCTURE AND ORCHESTRATION: OUTLINING ACTIONS TO INNOVATE, INTEGRATE, AND INVEST

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ABSTRACT

Circular ecosystem is a growing research field that is gaining attention due to representing a more robust alignment structure than a single firm. However, prior research lacks empirical evidence on how circular ecosystems are structured and how orchestrators coordinate a set of actors towards a coherent circular value proposition. By studying nine organizations related to the carton packaging recycling ecosystem, we reveal the complexity of recovering and co-creating value in a systemic network with actors competing and collaborating simultaneously. Based on that, we propose a framework for orchestrating circular ecosystems. Our results indicate that orchestrators should integrate strategic actors, invest in infrastructure, and innovate in product design. We also discuss ecosystem resilience during and after the covid 19 pandemic, showing how the orchestrator was fundamental to the sustainability of the ecosystem. Overall, this paper contributes to increasing the understanding of inter-organizational relationships towards the circularity of resources.

Keywords: Circular economy, Sustainability, Case study, ecosystems

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1 INTRODUCTION

The circular ecosystem concept is being perceived as an essential strategy to systematically advance towards the Circular Economy (CE). According to Trevisan *et al.* (2022, p. 292), a circular ecosystem is "a system of interdependent and heterogeneous actors that go beyond industrial boundaries and direct the collective efforts towards a circular value proposition, providing opportunities for economic and environmental sustainability". Several authors recognize that a single firm is unlikely to have all the capabilities and resources required for a CE and therefore, in this case, inter-organizational collaboration is essential (Mishra *et al.*, 2019; Paavilainen *et al.*, 2021). Since the transition to the CE model requires collaboration, change in the business model, the flow of materials, and the relationship between companies (Aarikka-Stenroos *et al.*, 2021), circular ecosystems provide a more robust alignment structure and coordination to reach circular goals compared to a single firm (Kanda *et al.*, 2021).

New businesses that generate circular ecosystems must deeply understand principles and elements to innovate within this systemic structure. The principles are grounded on high collaboration, continuing experimentation, and platformization (Konietzko *et al.*, 2020). Trevisan *et al.* (2022) extended the literature by identifying the main elements of a circular ecosystem, such as actors, value, circular activities, governance, and data, materials, and flows. Therefore, in order to develop a circular ecosystem, sharing knowledge, infrastructure, and values must be present (Moggi and Dameri, 2021).

Although there is a consensus among studies that a structure built around cooperation between companies facilitates the achievement of a CE, little is known about how organizations with different purposes and strategies work together within a circular ecosystem. The existing literature has focused on defining a circular ecosystem (Aarikka-Stenroos *et al.*, 2021; Trevisan *et al.*, 2022) and how to move from the circular business model view to incorporate the ecosystem perspective (Asgari and Asgari, 2021; Kanda *et al.*, 2021). While these studies provide insightful discussions on the circular ecosystem domain, there is a lack of clarity about the empirical characteristics of this phenomenon. Furthermore, as Trevisan *et al.* (2022) and Kanda *et al.* (2021) have discussed, there is a greater need for studies to extend the understanding of ecosystem structure in practical contexts.

To fill this gap, this study contrasts the theoretical elements of a circular ecosystem by presenting empirical evidence from a rich case study. This paper thoroughly analyses nine organizations related to the carton packaging recycling ecosystem. In particular, the study focuses on understanding the circular ecosystem structure and the role of an orchestrator in this context. According to Parida *et al.* (2019) and Iansiti and Levien (2004), orchestrators have critical responsibilities to ensure the ecosystem's health. Understanding the role of the orchestrator clarifies the coordination process that involves different actors in implementing the CE. In addition, we explored how the orchestrator played a crucial role in the resilience of the circular ecosystem during the Covid 19 pandemic.

The paper is structured as follows: In section 2 we review the literature on circular ecosystems, describing the background of the study. The research methodology is presented in Section 3. Section 4 explores the findings and discussion. Lastly, the conclusion and opportunities for further research are described in section 5.

2 CIRCULAR ECOSYSTEM AND ORCHESTRATION

The term "circular ecosystem" and its variations, such as "Circular economy ecosystems" and "Circular business ecosystem", derive from the integration between the business/innovation ecosystem and circular economy literature (Konietzko *et al.*, 2020; Trevisan *et al.*, 2022). Scholars suggest that circular ecosystems are structures that comprise interdependent actors, not hierarchically controlled, that go beyond the industrial system and that integrate resources to collectively generate a sustainable outcome - enabling economic and environmental gains (Aarikka-Stenroos *et al.*, 2021; Aminoff *et al.*, 2017; Trevisan *et al.*, 2022).

In order to clarify and characterize the concept, Trevisan *et al.* (2022) developed a framework explaining the elements of the circular ecosystem. The framework is a comprehensive tool for understanding the nuances of this unique phenomenon. The first element presented is value, which corresponds to the most crucial aspect by which actors engage collectively. Through the creation and continuous capture of value, the actors remain linked to the community and materialize a sustainable outcome. The second element is the actors, who must be heterogeneous and interdependent, with defined roles and aligned interests. The third element is the multiple circular strategies and activities

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that are often carried out in parallel by different actors. Then there is the flow element. This one represents the entire flow of data and materials that run through the circular ecosystem. Finally, the last element is governance. Similar to what (Jacobides *et al.*, 2018) argue in the ecosystem theory, circular ecosystem governance needs to be collaborative and non-hierarchical. In other words, actors work collaboratively for circularity, developing activities without hierarchical power over others.

However, establishing partnerships with heterogeneous actors is a significant challenge. Barquete *et al.* (2022) identified 17 barriers to achieving circularity within ecosystems. Among the barriers, those in which the alignment between the actors is weak, such as the lack of environmental awareness of consumers and companies, stand out. In addition, the lack of specific actors like recyclers can weaken the structure (Tate *et al.*, 2019). Therefore, each actor must have a well-defined responsibility within the network (Parida *et al.*, 2019). In particular, the role of the orchestrator must be clear, as it is responsible for connecting the different stakeholders (Iansiti and Levien, 2004).

Being an orchestrator is a demanding task since the other players may contest the role as the ecosystem evolves (Pidun *et al.*, 2020). Thus, the orchestrators need to be accepted by the other participants, and for that, they must share the value with the community (Iansiti and Levien, 2004). According to Pidun *et al.* (2020), there are four ways for an orchestrator to maintain their leadership and be successful. First, it needs to control the existing resources in the ecosystem (e.g., strategic skills). Second, the orchestrator needs to coordinate the community through strong interdependencies with other participants. Third, the orchestrator cannot be seen as a threat, but rather as a supporter. Finally, the orchestrator must have the financial capacity to invest in the ecosystem. This keystone needs to be perceived as a creator of new partnerships and business opportunities (Parida *et al.*, 2019).

Thus, the orchestrator is directly responsible for the community's productivity (Iansiti and Levien, 2004). This focal actor can bring legitimacy to the other players, encouraging new sustainable actions (Press *et al.*, 2019) and business resilience. The concept of resilience in ecology is related to changes that occur over time in natural ecosystems due to the emergence of abrupt events (Handmer and Dovers, 1996). According to Graça and Camarinha-Matos (2017, p. 250), “Resilience is the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly”. In a circular ecosystem, it is not different, as the elements need to adapt to events that change the dynamics and stability of the community. The structures of collaboration, coordination, value creation and value capture evolve continually (Jacobides *et al.*, 2018), and changes are necessary to maintain healthy relationships and business configurations.

In this paper, we argue that the orchestrator can also help ecosystem resilience. Gomes *et al.* (2022) examined how four focal firms deal with uncertainty to succeed along with their ecosystems. The authors observed that focal firms use internal resources and structures, such as digital platforms, to respond to uncertainties. The government can also play an essential role in this regard, for example, by mapping barriers that prevent actors from joining the network or even nurturing interdependence relationships between players so that they create foundations to deal with unforeseen circumstances (Gomes and Barros, 2022). Overall, uncertainty and risk management are key resilience mechanisms to address disruptions and long-term sustainability (Scholten and Fynes, 2017). A well-planned orchestration fosters the creation of collaborative ties, which consists in another strategy to deal with stressful and disruptive events (Ramezani and Camarinha-Matos, 2019). In this vein, our contributions reveal that the actions taken by the orchestrator of the circular ecosystem were imperative to engage other members in new business relationships and to strengthen ecosystem health and resilience.

3 METHODOLOGY

3.1 Research design

This paper adopts a case study approach (Eisenhardt, 1989) to empirically understand a circular ecosystem. This method was chosen for three main reasons. Firstly, qualitative research through case studies facilitates the description and explanation of the investigated phenomenon (Lee *et al.*, 1999). Secondly, case studies allow building (Eisenhardt and Graebner, 2007), elaborating and refining the theory (Lee *et al.*, 1999) based on analysis within and cross-organizational instances (Ketokivi and Choi, 2014). Finally, the case study approach provides empirical evidence for a stronger base of knowledge creation (Eisenhardt and Graebner, 2007; Ketokivi and Choi, 2014), which is suitable for exploring the circular ecosystem phenomenon. In the next sections we explain the data collection and analysis process adopted in this study.

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3.1.1 Data collection

We adopted two strategies to collect the data. First, an extensive collection of secondary data was performed in company reports, news and social media. These data were used to identify which circular strategies were adopted and which actors were related to the ecosystem's output. Second, interviews were carried out with the key actors of the circular ecosystem. The selection of companies considered heterogeneous actors and the description of their functions are detailed in Table 1. The interviews were carried out following a semi-structured protocol, and an informed consent form was signed by all interviewees, consenting to the use of data and guaranteeing anonymity. Afterwards, the interviews were recorded and transcribed. Face-to-face visits were made to roofing tiles companies to deeply understand the manufacturing activities and collect additional data for analysis.

Table 1. Detailed information regarding the actors interviewed.

ID (Actor)	Description	Circular Ecosystem Actors/Interviews
A1	Orchestrator. Actor who coordinates the main activities of the ecosystem and enables the development of other actors.	Carton packaging manufacturer/ two interviews
A2	Facilitator - smart waste management providers	Waste Management Startup A/ two interviews
A3	Facilitator - smart waste management providers	Waste Management Startup B/ two interviews
A4	Decomposer - processing of post-consumer packaging	Recycling company/ one interview
A5	Converter - manufacturing tiles with post-consumer packaging	Ecological roofing tiles Manufacturer A/two interviews
A6	Converter - manufacturing tiles with post-consumer packaging	Ecological roofing tiles Manufacturer B/one interview
A7	Facilitator - association to promote recycling initiatives in collaboration with public sector, private companies and society.	Business Commitment to Recycling/one interview
A8	Supporter - structuring and environmental education	Non-Governmental Organization (NGO) A/one interview
A9	Supporter - structuring and environmental education	NGO B/one interview

3.1.2 Data analysis

Data analysis involved coding secondary data and interviews in the MAXQDA qualitative analysis software. Analytical categorization techniques were used to ensure greater rigour in the analysis process (Grodal *et al.*, 2021). The coding approach was performed in cycles, following the recommendations of (Gioia *et al.*, 2012), with a first initial coding of secondary data and interviews based on informant-centric codes. After this cycle, the codes were organized into second-order categories with themes relevant to the case study, and a third coding cycle grouped the elements into theory construct dimensions. The Framework developed by Trevisan *et al.* (2022) was used as a guide to analysing the data related to the characterization of the circular ecosystem. Greater attention was given to orchestration, triangulating primary and secondary data to understand the performance and actions developed during the ecosystem development (Figure 1). This analysis resulted in the proposition of the framework 3is for orchestration, detailed in Figure 2.

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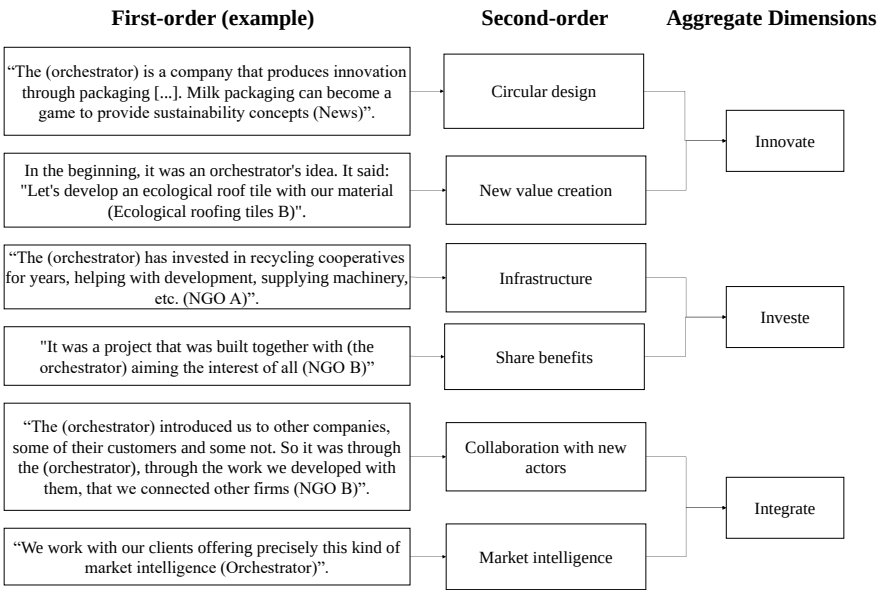

Figure 1. Code tree.

4 RESULTS AND DISCUSSION

4.1 Evidence from the case: the circular ecosystem of carton packaging recycling

Grounded on the previous literature, we empirically explored the five elements of a circular ecosystem. Our study reveals the complexity of recovering and co-creating value in a systemic network with actors competing and collaborating simultaneously. The structure of the circular ecosystem of carton packaging recycling is presented in detail below:

Value. Circular value guides the activities performed within circular ecosystems. In our case study, circular value refers to recovering the value through recycling carton packs and transforming recycled material into new products (i.e., ecological tiles). Konietzko *et al.* (2020) points out that in circular ecosystems, the value capture needs to be fair among the players so that they remain engaged in the network. However, in the analyzed circular ecosystem, there is tension regarding the capture of value, and the most fragile and vulnerable actor (i.e., waste collectors) cannot achieve all the benefits of being part of an ecosystem. According to Waste Management Startup B (A3), food manufacturers and consumers are unwilling to pay waste pickers for the material collection service. While waste pickers play a crucial role in circularity, they capture only a tiny fraction of the shared value in the ecosystem. Consequently, the orchestrator needs a greater effort to keep them tied to the community. Recently, the orchestrator has been seeking to expand the collection of materials through financial incentives to the most vulnerable actors. The role of the orchestrator is critical to ensuring that circular value is realized.

Actors. Circular ecosystems are formed by heterogeneous actors who play different roles and have individual and collective interests. These actors have positions within the ecosystem that can evolve over time (Adner and Kapoor, 2010). In the carton packaging recycling ecosystem, the orchestrator plays a decisive role in circular activities. The circularity of materials is only made possible through various projects and initiatives conducted by the orchestrator in partnership with other players. Although other actors have defined roles, many perform overlapping activities. For instance, the ecological tile manufacturer (A5), in addition to manufacturing activities, also started buying carton packs to resell, a move mainly carried out by recyclers and cooperatives. This dynamic fosters the emergence of coopetition relationships, where players compete and cooperate at the same time (Paavo *et al.*, 2009). As the carton packaging recycling market expands, many competitors share strategic information to strengthen the ecosystem structure. Waste Management Startup A (A2) interviewee said, "we have a culture of understanding that our competitors and we are heading in the same direction." Therefore, coopetition allows the emergence of a strategic interdependence that supports value creation (Dagnino and Padula, 2002). Interdependence is one of the main attributes of the ecosystem concept (Gomes *et al.*, 2021), but if there is not an appropriate balance of actors within the ecosystem with their well-defined roles, circular activities are harmed. Similar to the study by Tate *et al.* (2019), in this ecosystem, there is a need for more actors to act at the end of life for material

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recycling. Currently, many waste pickers are excluded from the ecosystem because they are not associated with a waste picker cooperative. Therefore, as important as having enough actors to play essential roles for circularity, it is necessary to include and formalize them.

Data, materials, and flows. The circularity of ecosystems is made possible by restructuring the flow of data and materials. Unfortunately, the data flow fragmented and underexplored in the circular ecosystem under investigation. Neither the orchestrator nor the waste management startups can make integrated management of information. Consequently, getting an overview of how data governance is structured within the circular ecosystem is complex. There are fears on the part of actors when sharing data, and the accessibility to this data is hampered due to the high informality of unregulated actors (i.e., waste pickers). Thus, much data that could support the circularity of materials are lost. Regarding the flow of materials, the actors work continuously to increase the selective collection of carton packs. However, some of the initiatives that increase the efficiency of material flow go beyond the limits of the ecosystem, requiring a macroeconomic effort from public policies.

Circular activities and strategies. Although circular ecosystems focus on circular value, other activities are performed by actors contributing to circularity. As Trevisan *et al.* (2021) observed, circular activities and strategies are associated with products, process optimization and the provision of services. In the analyzed ecosystem, other circular strategies are encouraged in addition to recovering the value through recycling. For example, waste management startups use digital technologies to trace post-consumer packaging. This finding reinforces what the literature has already been discussing about digitalization being promising for CE (Liu *et al.*, 2022). Besides, NGOs conduct environmental education and assistance activities for cooperatives and waste pickers. These activities are essential in the formalization and visibility of these actors. The orchestrator also offers products (machinery) as a service to support the manufacture of ecological tiles. In addition to the circular activities fostered in the ecosystem, the orchestrator also internally seeks a more sustainable production.. Each circular strategy that is performed individually and collectively contributes to the actors creating a sense of belonging and facilitating the activities performed by other community members.

Governance. A governance structure in a circular ecosystem is challenging, as circular ecosystems have interdependent actors with distinct circular goals performed through non-contractual relationships. Although the orchestrator represents a power figure in the ecosystem, the other actors are not hierarchically controlled by the orchestrator. It is the case of several cooperatives and collectors of carton packs that have no relationship with the focal company and, even so, contribute to the recycling of the material. Furthermore, unlike other types of ecosystems (e.g., entrepreneurial ecosystem) where the consumer is not essential to materialize the value proposition, in a circular ecosystem, the consumer is a key actor since it is from them that product reverse logistics begins. Without consumer collaboration with other members of the circular ecosystem, the circularity of packaging is unfeasible. Therefore, governance needs to consider all the actors that promote material circulation.

4.2 Understanding the framework 3is for orchestrating circular ecosystems

In this case study, we identified three key roles of the orchestrator to enable material recirculation. The Orchestration 3Is framework (Figure 2) presents these roles. The framework can be used to analyze what activities are being performed within the ecosystem that drives circular goals.

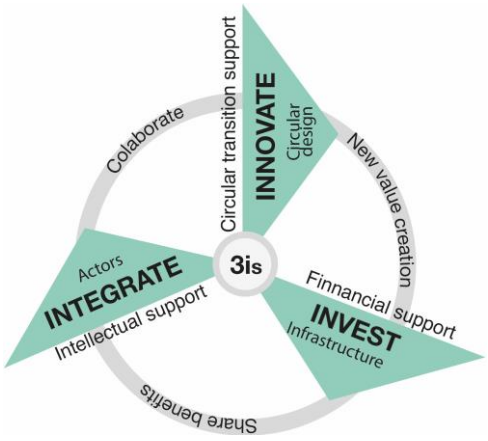

Figure 2. Orchestration 3Is Framework.

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Innovate. The circular ecosystem needs to continually innovate to adapt materials and data flow towards a CE. Innovations can be in the product or the processes that enable the transition to a value recovery system. Innovations allow the creation of new value not only for the orchestrator but also for other players. In our case, the orchestrator innovates within the ecosystem in two different ways. At first, the package was designed to provide a game via a QR code. This game allows the consumer to interact with the product and gain knowledge about the environmentally appropriate destination of post-consumption packaging. The consumer-product interaction permits the entire ecosystem to benefit from disseminating sustainable practices. Second, the orchestrator also innovates by creating new products from packaging recycling. At the formation of the ecosystem, the orchestrator sought new ways to create value from recycled material. The orchestrator attracted new actors to the ecosystem and enabled the development of ecological roofing tiles, which today represent approximately 98% of the final destination of packaging collected for recycling.

Invest. The orchestrator should invest in the ecosystem by providing infrastructure and financial support. Investments are needed so that the post-consumer packaging recycling rate continues to increase. The orchestrator invests by providing equipment or sponsoring projects developed in collaboration with other actors. Various pieces of equipment for the ecological roofing tiles manufacturer were made available via a loan to tile manufacturers. The Ecological roofing tiles Manufacturer B (A3) said, "Here at the company, I have several machines that [the orchestrator] provided us to improve our working conditions". Regarding the financial investment, the orchestrator pays an additional fee for waste pickers to collect carton packs. This investment benefits the waste pickers who increase their income, the recyclers who receive more waste, the orchestrator's customers (food manufacturers) who must do reverse logistics, and the Waste Management Startups that are the link to conduct the project. Although the financial investments directly benefit the actors at the end-of-life stage, the entire ecosystem reaps the benefits of increasing the recycling rate. Therefore, in a circular ecosystem, the orchestrator must invest not only in seeking its own gain but sharing the environmental and economic benefits with other actors.

Integrate. One of the primary roles of the orchestrator is to integrate new actors in the circular ecosystem that will aggregate in the sustainability field. In other words, it is essential that the orchestrator creates collaborative ties and fosters win-win relationships with other members. For example, the orchestrator established a partnership with the private packaging collection company (A10), and this collaboration attracted new actors. Food manufacturers that use carton packaging became interested in projects for the proper disposal of the material and began to integrate the ecosystem and invest in projects as the orchestrator did. Since the composition of the carton pack consists of aluminum, plastic and cardboard, the orchestrator needs more effort to dialogue with three different material markets. Therefore, including new players is crucial in promoting the recycling of each packaging material. Furthermore, the focal company provides intellectual support in carrying out recycling projects and in supporting the formation of environmental policies. This activity allows good recycling practices applied in the southeastern region of Brazil to expand to other less developed areas of the country.

4.3 Circular ecosystem resilience

We explored the studied ecosystem's evolutionary dynamics, and in particular, our analysis revealed important aspects of circular ecosystem resilience. Building on Ponomarov and Holcomb's work (2009), four aspects of resilience are presented in the case during and after the Covid-19 pandemic (Table 2).

Table 2. Circular ecosystem resilience based on Ponomarov and Holcomb (2009).

Resilience aspects	Evidence from the circular ecosystem
Flexibility	Manufacturers of ecological roofing tiles have combined various materials (e.g., coffee and toothpaste packaging) to manufacture the ecological roofing tiles to meet the demand for materials.
Reduction of uncertainty	Currently, the possibility of manufacturing ecological roofing tiles from other materials (e.g., plastic) - as a primary raw material source - is being studied to reduce the uncertainty of the availability of carton packages.
Agility, responsiveness	After social isolation was discontinued, the orchestrator invested financially in waste collection, paying for each additional kilogram of carton package collected.

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First, the circular ecosystem needed **flexibility** to maintain the recycling of carton packages when there was a shortage of raw materials. The pandemic caused an increasing generation of household waste due to people staying longer in their homes. Therefore, according to Ecological roofing tiles Manufacturer A (A2), waste pickers could not collect post-consumer packaging due to social isolation. Consequently, there was a drastic reduction in raw materials to manufacture roofing tiles. Several ecological tile factories did not survive the period, and some had a 55% reduction in their production capacity. While there was an increase in the generation of waste, there was, contradictorily, a reduction in the recycled rate. In order to overcome the shortage of raw materials, new materials were incorporated into the composition of ecological roofing tiles, such as coffee, animal feed and toothpaste packaging. This initiative reduced the demand for carton packages and included new material flows in the circular ecosystem.

Another aspect of the circular ecosystem's resilience is the reduction of uncertainty. Eco-tile manufacturers have noted that they cannot be held hostage only by carton packs. Currently, new materials (i.e., plastic) are being studied to be used as the primary raw material to manufacture roofing tiles without compromising quality. The Ecological roofing tiles Manufacturer B (A3) said: “We are looking for alternative materials to meet our demand”. By expanding the possibilities of new raw material sources, the circular ecosystem increases the number of recycled materials, opens new sustainable businesses, enhances its circularity, and reduces uncertainty.

After the population isolation measures were discontinued, the orchestrator was required to make a more significant effort to return post-consumption packaging collection to pre-pandemic levels. Combining **agility** and **collaboration**, the orchestrator had to make an additional payment to the waste pickers for each kilogram of carton packs collected. This financial incentive caused the recycled material rate to rise again. To manage the entire financial transfer process, the orchestrator established a collaboration with a new actor (startup). The startup provided a digital waste management platform based on digital technologies such as big data, cloud computing and blockchain. Collaboration between established actors (i.e., orchestrators) and small digital services providers (i.e., startups) accelerates innovation processes within the circular ecosystem. Therefore, it has been observed that digitalization is critical to achieving business resilience and sustainability.

4.4 Theoretical implications

Our major contribution is the Framework 3is for orchestrating circular ecosystems. The proposed framework consists of three combined roles, namely: innovate, integrate, and invest. The finding of the study suggests that the orchestrator needs to innovate in circular product design, integrate strategic actors, and invest in infrastructure within the community. This keystone should provide a foundation for circular processes and financial and intellectual support.

This paper also starts to build a bridge between circular ecosystems and resilience literature. In a comprehensive study, Graça and Camarinha-Matos (2017) discuss performance indicators to increase the sustainability and resilience of business ecosystems. Further study (Ramezani and Camarinha-Matos, 2019) indicates that collaboration and governance actions are essential to deal with abrupt situations. In our study, besides the collaboration argument, we provided early evidence that the orchestrator has a significant role in increasing responsiveness and agility during stressful events.

Finally, this study contributes to aggregate empirical knowledge on circular ecosystem construct. Complementing previous work (Aarikka-Stenroos *et al.*, 2021; Kanda *et al.*, 2021; Trevisan *et al.*, 2022) that called for practical evidence, our findings reveal the complexity of co-create circular values when tensions permeate vulnerable actors. Overall, this paper advances the current scholarship by highlighting important aspects of our case study, such as the provision of the physical infrastructure to drive circular value collectively.

4.5 Practical implications

This paper has significant implications for firms participating in a circular ecosystem. First, our findings indicate that business opportunities can be lost if data and material flows are poorly structured. Managers should clearly draw the ecosystem flows, paying attention to the inputs and outputs that generate new circular businesses and strengthen relationships with strategic partners. Second, the ability to adapt and engage in partnerships is crucial. Collaboration and flexibility, along with uncertainty reduction, were primordial for the circular ecosystem of carton packaging recycling

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to manage the unexpected COVID-19 crisis and maintain satisfactory waste collection levels. Additionally, the findings indicate that entrepreneurs and the government must ensure a fair capture and distribution of value to more economically vulnerable actors. For example, in our case study, many waste collectors do not absorb all the benefits of being part of a circular ecosystem. Consequently, the orchestrator needs to make great efforts to keep these actors engaged in the community. Finally, our framework provides guidance on how to orchestrate circular ecosystems and become more resilient to future events based on actions already taken in the past.

5 CONCLUSION

This research contributed to the growing circular ecosystem field by investigating an in-depth case study of a circular ecosystem of carton packaging recycling. We focus on understanding the circular ecosystem structure and the role of an orchestrator in guiding the transition towards the circularity of resources. Based on that, one of the major contributions of this paper is the Orchestration 3is Framework. Also, building on previous work, the paper explores the nuances of recovering value in a systemic network with heterogeneous actors competing and collaborating simultaneously. The study provides extra contributions to the resilience and sustainability literature by demonstrating aspects of resilience, such as flexibility and agility, that were essential for the circular structure during and after the Covid 19 pandemic. The article shows how the circular ecosystem survived during a period when the rate of waste generation increased, but the material collection decreased due to social isolation measures. Future research could explore other circular ecosystem configurations and validate the 3is framework with other focal companies. The framework may be expanded to include other roles. Scholars can examine whether the roles played by orchestrators are essential to circularity. We strongly recommend that multi-stakeholder workshops and case studies be conducted to strengthen the proposed framework. Finally, more studies are required to understand how the circular ecosystem can increase its responsiveness and resilience during disruptive events.

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