MOTIVATIONS BEHIND ACTORS' COOPERATION IN CIRCULAR ECOSYSTEMS: A SYSTEMATIC LITERATURE REVIEW AND A BRAZILIAN CASE STUDY

Barquete, Sophia;
Hofmann Trevisan, Adriana;
Gonçalves Castro, Camila;
Mascarenhas, Janaina

Department of Production Engineering, São Carlos School of Engineering, University of São Paulo

ABSTRACT

The circular economy (CE) aims at the cycling of resources through restorative and regenerative strategies. To achieve circularity, coordination of several actors is necessary. The interaction among actors allows the connection between the CE and ecosystem research fields. Although fundamental, the relationships, mainly cooperation, among actors within an ecosystem to foster circularity is not deeply explored in the literature. The objective of this study was to identify the possibilities of cooperation within circular ecosystems, in particular, the motivations that make the actors interact to achieve a CE. A systematic literature review (SLR) and a case study of a Brazilian ecosystem specialized in the recycling of carton packages to manufacture ecological tiles were conducted. The goal was to identify the motivations through the SLR and the case study so the theoretical and the empirical results could be compared. As a result, 28 motivations for actors to engage in ecosystems driven by circularity were identified. In order to achieve a complete and circular solution, actors must be able to clearly understand their roles and relationships so that they can establish new partnerships or reframe those already established.

Keywords: Circular economy, Cooperation, Collaborative design, Case study, Ecosystems

Contact:
Barquete, Sophia
University of São Paulo
Brazil
sophiabarquete@usp.br

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1 INTRODUCTION

The circular economy (CE) stands as an alternative to the traditional model of linear economy (Bocken et al., 2017), as it promotes the notion of waste and resource recycling (Blomsma and Brennan, 2017). CE involves entire production networks, in which there is diffusion of responsibilities among actors (Murray et al., 2017). Product development, information sharing and the organization of collection systems, for example, are activities that demand the establishment of collaborative platforms between companies (Ellen MacArthur Foundation, 2015).

Overall, companies cannot be seen as isolated entities to achieve circularity (Tate et al., 2019). The firm is no longer seen only as a member of a single industry, but as part of an ecosystem that permeates various industries (Moore, 1993). An ecosystem is characterized by heterogeneous and interdependent actors (Adner and Kapoor, 2010) with complementary roles (Gomes et al., 2018; Jacobides et al., 2018) and positions (Adner, 2017), who align their activities to make a value proposition tangible (Adner, 2017; Thomas and Autio, 2020). Generally, an ecosystem has an orchestrating company (Pidun, Reeves and Schüssler, 2019), which supports creating and sharing value within the ecosystem and facilitates communication between actors (Iansiti and Levien, 2004).

The need to introduce CE strategies within a business ecosystem is increasingly visible in order to maintain both business and environmental value (Hsieh et al., 2017). Recent studies have started to integrate the concept of an ecosystem with CE, e.g. (Ta et al., 2022; Trevisan et al., 2021b; 2022). Tate et al. (2019), for example, propose principles to assist in the transition from a business ecosystem under a linear bias to a circular value system, which addresses the need for a balanced, integrated and heterogeneous group of actors. Trevisan et al. (2022) presented elements of a circular ecosystem and approached the term as a system of interdependent actors that guides efforts towards a circular value proposition. Aminoff et al. (2017) proposed a framework for shaping industrial systems toward circular ecosystems, pointing out that value co-creation from various partners is crucial. Hsieh et al. (2017) showed how an orchestrator coordinates a glass ecosystem that promotes circularity.

The actors that integrate an ecosystem work together, in a cooperative and competitive way, aiming to develop products, satisfy customers and incorporate innovations (Moore, 1993). Unlike other concepts, such as supply chain and circular supply chain, which focus on hierarchies and bilateral relationships, ecosystems are based on non-hierarchical and multilateral relationships (Adner, 2017; Trevisan et al., 2022) among autonomous but interdependent actors (Gomes et al., 2023). However, within the context of circular ecosystems, there is a greater emphasis on cooperative relationships. An ecosystem consists of actors that agree to collaborate with one another (Pidun, Reeves and Schüssler, 2019). In terms of CE, transitioning to a system of circular values demands collaboration between the network to achieve mutual benefits (Tate et al., 2019). Thus, through cooperation, companies work together and are able to improve their collective performance by sharing resources and committing to common goals (Gnyawali and Madhavan, 2001).

Despite studies offering rich and insightful knowledge on ecosystems in circular contexts, the existing literature lacks studies that simultaneously address the actors' relationships within circular ecosystems. Cooperation, in particular, despite facing barriers to implementation, is essential to foster the value proposition of an ecosystem, given that a single company would hardly be able to hold all the necessary technology and know-how (Barquete et al., 2022). Scholars still call for more empirical research regarding the dynamics of a circular ecosystem and its complex relationships (Aminoff et al., 2017; Konietzko, Bocken and Hultink, 2020; Trevisan et al., 2022). Furthermore, cooperation is a crucial point within the ecosystems and CE literature. Therefore, studying this type of relationship is extremely important for establishing circular business.

Thus, in this study, we conduct a systematic literature review (SLR) and explore a case study of a Brazilian ecosystem specialized in recycling carton packaging to manufacture ecological tiles to understand the cooperation among actors within the context of ecosystems that adopt circular practices. More specifically, the study aims to identify the motivations that lead actors to integrate a circular ecosystem through theoretical and empirical analyzes that complement each other.

2 METHODOLOGY

We conducted a systematic literature review (SLR) (Tranfield, Denyer and Smart, 2003) and a case study (Eisenhardt and Graebner, 2007). The SLR aimed to identify the motivations by which actors

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relate within ecosystems to implement circular strategies. The case study, on the other hand, was carried out to empirically raise the motivations by which different actors relate and compare them with the motivations found in the literature. Five companies from a circular ecosystem located in Brazil were analyzed, whose value proposition is based on the recycling of carton packages to manufacture ecological tiles. The case is relevant within the Brazilian scenario since the ecosystem's orchestrator company, a multinational, holds 80% of the carton packaging production market share in Brazil (see Barquete et al., 2022).

To illustrate the main process of the studied ecosystem, the production of ecological tiles begins with the supply of raw materials to manufacture carton packages. National or multinational food companies buy these packages, which consumers later purchase. After being discarded, the post-consumer packaging arrives at the cooperatives through collectors or the selective collection system. The cooperatives separate the collected material and sell it to shavings markets or recyclers. These actors separate the elements of the carton packages and provide the material to manufacturers of ecological tiles, who manufacture the final product.

Another type of flow present in the ecosystem is related to pre-consumer material. This material, cleaner than post-consumer material, is constituted by damaged packages or carton scraps and can be obtained from the carton packaging manufacturer itself or the food industry companies. The pre-consumer material goes directly to the recyclers or even to the manufacturers of carton packages when they have the appropriate technology to separate the plastic from the aluminium. More information about the case study can be found at Barquete et al. (2022).

2.1 Data collection

For the SLR, the first stage focused on identifying relevant publications. Scopus and Web of Science databases were chosen due to their coverage of academic articles (Rosa et al., 2020). Only articles and conference papers in English were included to ensure reliability and to reduce publication bias (Miles, Huberman and Saldaña, 2014).

The research string was meant to cover the terms related to the three main spheres of this study: ecosystems, relationships and CE. To obtain rigor and reliability during the SLR process, through a relevant initial sample, not only the term "circular economy" was used, but also other terms related to circular practices. Based on Okorie et al. (2018), it was used a research string that considers a combination of the circular strategies that constitute the 3R's (reduce, reuse and recycle) and derived frameworks, the 4R's, 6R's and 9R's, in which more circular strategies are mentioned (Potting et al., 2017). Such structures have been widely used in academia to support CE thinking (Kirchherr, Reike and Hekkert, 2017). The 9R's has been proposed as a more comprehensive and integrated structure for circularity (Okorie et al., 2018).

In line with Damha et al. (2019), the SLR's unit of analysis was empirical studies already published in the literature. In this case, a paper can present more than one case to be examined. The empirical studies should address the relationships among actors within ecosystems that adopt circular practices. At the end of the SLR, seven papers were identified and twelve empirical studies from the literature were analyzed. Each stage of the SLR is described in Figure 1 to ensure the transparency and reproducibility of this research.

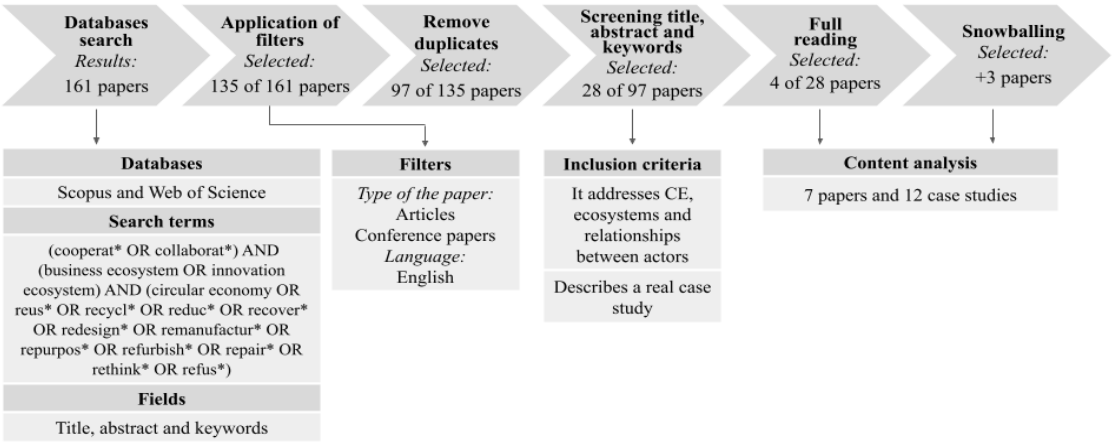

Figure 1. Methodological procedure of the SLR

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The main data collection methods for the circular ecosystem case study were interviews, archival materials including three sustainability reports from the orchestrating company, informal conversations to clear occasional doubts, and a site visit. An additional search was carried out on the official websites of the studied companies and social media. A protocol was elaborated to assist the researchers in conducting interviews. The questions addressed the following topics: the company's history, the ecosystem's actors and the relationship between them, company perceptions about CE, the CE practices adopted and others.

Interviews began with the carton packaging manufacturer (the orchestrator), which indicated other players from the ecosystem to be interviewed, according to the snowballing technique (Parker, Scott and Geddes, 2019). Therefore, seven interviews with five companies were conducted, including the ecosystem's orchestrator, two ecological tiles manufacturers, a recycling company, and a company responsible for waste management and value recovery from packaging. Table 1 presents a list of the interviews.

Table 1. Interviews list

Interviewee's Identification	Company	Interviewee's Position
Interviewee 1	Carton Packaging Manufacturer–Orchestrator	Sustainability Manager
Interviewee 2	Carton Packaging Manufacturer–Orchestrator	Sustainability Manager
Interviewee 3	Ecological Tiles Manufacturer–1	Specialist
Interviewee 4	Ecological Tiles Manufacturer–2	Administrative Manager
Interviewee 5	Ecological Tiles Manufacturer–2	CEO
Interviewee 6	Recycling Company	Business Specialist
Interviewee 7	Waste Management Company	Marketing Manager

2.2 Data analysis

For data analysis, we used the MAXQDA software. The analyzed data came from different sources: the papers obtained through the SLR, interviews and extra material related to the case study (e.g., reports, notes from the site visit and information from the official websites). All data was triangulated to obtain more reliable results (Grodal, Anteby and Holm, 2021).

For all documents selected for analysis, a first coding cycle was performed to summarize the data segments, followed by a second cycle, which aims to group the initial data into smaller categories (Miles, Huberman and Saldaña, 2014), which we call motivations. Thus, several codes developed in the first cycle were grouped according to their content to originate the motivations (e.g., codes from the first cycle related to knowledge sharing to develop products and services were grouped in the motivation "Share knowledge to develop business solutions"). In the end, 28 motivations were found and distributed in 9 major categories. Of these motivations, 13 were found through both methods: SLR and case study. 13 were found only through the SLR and 2 were found only through the case study.

3 RESULTS AND DISCUSSION

The circular ecosystem of ecological tiles is located in Brazil and is based on recovering the value of carton packages, which, after being recycled, are transformed into ecological tiles. According to data from 2020, Brazil generated around 225 tons of solid waste per day in 2020 (Brasil, 2022), and about 1.4% of the solid waste generated corresponds to multilayer packages (MMA, 2022), which are not always recycled. To increase the recycling rate and boost other circular practices, ecosystem actors must engage in cooperative relationships. In this way, they need to feel motivated to be part of a circular ecosystem. The Table below summarizes the motivations for the participation of actors in the circular ecosystem found through the SLR and the empirical study.

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Table 2. Motivations for cooperation between actors within a circular ecosystem

Category	Motivation	Motivation found in the literature	Motivation found in the case study	References
Sharing infrastructure	Share infrastructure for waste collection - M1	X	X	Stewart et al., 2018
	Share digital platform - M2	X	X	Konietzko, Bocken and Hultink, 2020; Ma et al., 2018; Vosman et al., 2021
	Share production equipment - M3	-	X	-
Obtaining financial support	Share costs - M4	X	X	Vosman et al., 2021, Parida et al., 2019, Stewart et al., 2018
	Obtain investments - M5	X	X	Konietzko, Bocken and Hultink, 2020; Ma et al., 2018; Parida et al., 2019
	Obtain financial support from the government - M6	X	-	Hsieh et al., 2017; Ma et al., 2018
Implementing R strategies	Promoting remanufacture - M7	X	-	Türkeli et al., 2019
	Promoting refurbishment - M8	X	-	Türkeli et al., 2019
	Promoting recycling - M9	X	X	Hsieh et al., 2017; Stewart et al., 2018; Türkeli et al., 2019
	Promoting repair - M10	X	-	Türkeli et al., 2019
Developing industry norms and standards	Contribute to the development of policies related to the sector - M11	X	-	Konietzko, Bocken and Hultink, 2020; Ma et al., 2018; Parida et al., 2019
	Contribute to the development of standardization criteria - M12	X	-	Parida et al., 2019
	Obtain government approval for systemic circular models - M13	X	-	Hsieh et al., 2017; Ma et al., 2018
Complying with political duties	Comply with regulations - M14	X	X	Hsieh et al., 2017; Ma et al., 2018; Parida et al., 2019; Stewart et al., 2018
	Contribute to government projects and goals - M15	X	-	Hsieh et al., 2017; Ma et al., 2018
Sharing knowledge	Share knowledge to develop business solutions - M16	X	X	Hsieh et al., 2017; Konietzko, Bocken and Hultink, 2020; Vosman et al., 2021

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	Share knowledge about the composition of materials - M17	X	X	Hsieh et al., 2017; Vosman et al., 2021
	Obtain intellectual support around circular opportunities - M18	X	X	Parida et al., 2019; Stewart et al., 2018
Developing products and services	Develop products together - M19	X	-	Konietzko, Bocken and Hultink, 2020; Parida et al., 2019; Vosman et al., 2021
	Develop product-service systems (PSS) - M20	X	-	Parida et al., 2019; Türkeli et al., 2019
	Develop technology for app-based services - M21	X	-	Ma et al., 2018
	Expand the range of products offered - M22	X	X	Hsieh et al., 2017
Collecting and properly disposing of waste	Collect large amounts of waste - M23	X	X	Hsieh et al., 2017; Stewart et al., 2018; Türkeli et al., 2019
	Obtain waste as input for new processes - M24	X	X	Hsieh et al., 2017; Türkeli et al., 2019
	Have access to partners for negotiating the purchase of waste - M25	-	X	-
Strengthening relationships with consumers/ users	Having consumers engaged in the correct disposal of waste - M26	X	X	Hsieh et al., 2017; Stewart et al., 2018
	Design products in line with consumer/user expectations - M27	X	-	Konietzko, Bocken and Hultink, 2020; Stewart et al., 2018
	Improve the green image of the business in front of consumers/users - M28	X	-	Hsieh et al., 2017; Stewart et al., 2018

The first category, **"Sharing infrastructure",** covers everything related to physical and digital resources shared within the ecosystem. In the M1, it is identified that, within an ecosystem, reverse logistics systems can be decentralized, especially regarding collection points and waste transport (Stewart et al., 2018). For example, to enable the birth of the ecosystem, the carton packaging manufacturer invested in research and development of technology and equipment necessary for the recycling processes of carton packages and the manufacture of ecological tiles. After that, the company actively sought to establish partnerships with actors that could implement such processes, providing, in addition to knowledge, the necessary equipment through loans or sales. The M2 is associated with using a platform by various actors in the ecosystem, which facilitates and drives cooperation among actors (Konietzko, Bocken and Hultink, 2020; Ma et al., 2018; Vosman et al., 2021). The use of platforms and other digital technologies is also an essential point in the strengthening of CE (Trevisan et al., 2021a; Lobo et al., 2021). Moreover, M3 is related to lending production equipment to implement necessary processes (carton packages recycling and ecological tiles manufacture).

As explained, the loan of equipment was a practice developed by the carton packaging manufacturer, considered the orchestrator of the ecosystem, which guaranteed the birth and development of the ecological tile ecosystem. This is an example of the fundamental role that the carton packaging manufacturer plays within the ecosystem, which justifies the title of the orchestrator of the ecosystem.

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The second category of motivations is called **"Obtaining financial support"**. M4, the first motivation, is related to cost-sharing among actors in an ecosystem (Parida et al., 2019; Stewart et al., 2018; Vosman et al., 2021). M5, referring to obtaining investments, is related to the possibility that majority actors or investors in the sector invest in minority actors in the ecosystem so that they actually participate in the network (Konietzko, Bocken and Hultink, 2020; Ma et al., 2018; Parida et al., 2019). Furthermore, M6, found only through the SLR, was identified in examples of ecosystems in which the government subsidy is linked to the adaptation of the ecosystem to government projects related to environmental sustainability (Hsieh et al., 2017; Ma et al., 2018).

The third category is called **"Implementing R Strategies"**. The motivations in this category refer to the promotion of remanufacturing, reconditioning, recycling and repair strategies (Hsieh et al., 2017; Stewart et al., 2018; Türkeli et al., 2019). All motivations were identified in the literature, and only the M9 was also found in the case study since the ecosystem of ecological tiles is based on recycling. The interpretation of these motivations can extend to other R strategies besides the four mentioned: several actors are needed for the strategy to be implemented and work.

The fourth category, **"Developing industrial norms and standards"**, has motivations identified only in the literature. In line with M11, actors may choose to integrate an ecosystem to influence the development of policies related to the sector (Konietzko, Bocken and Hultink, 2020; Ma et al., 2018; Parida et al., 2019). The same occurs for M12, since it is possible that orchestrators or ecosystem leaders actively influence the debate about the establishment of industrial standards (Parida et al., 2019). An example regarding M13 can be found in Ma et al. (2018), in which it was necessary to establish a partnership with the government to promote sustainable transport within a city. Given the relevance of the ecosystem, partnerships of this kind are facilitated and influence the participation of actors.

The fifth category, **"Complying with political duties"**, refers to compliance with regulations (Ma et al., 2018; Parida et al., 2019; Stewart et al., 2018) and contributions to government projects (Hsieh et al., 2017; Ma et al., 2018), elements represented by motivations M14 and M15, respectively. In the first case, the Brazilian National Policy on Solid Waste (PNRS) can be cited as an example mentioned in the ecological tiles ecosystem, which puts pressure on waste generators to dispose of their waste correctly. Thus, participating in the circular ecosystem guarantees and facilitates the fulfilment of duties by the actors. Similarly, to the motivation M15, some government projects establish compliance with some guidelines, which can be achieved together within an ecosystem.

The sixth category, related to **"knowledge sharing"**, has motivations that can be identified both in the literature and case study. In line with M16, M17 and M18, respectively, the actors engage in sharing of knowledge for the development of business solutions (Hsieh et al., 2017; Konietzko, Bocken and Hultink, 2020; Vosman et al., 2021), for research on the composition of materials (Hsieh et al., 2017; Vosman et al., 2021) or even to obtain support regarding circular opportunities (Parida et al., 2019; Stewart et al., 2018). These motivations were essential for the participation of actors within the ecosystem of ecological tiles. The orchestrating company was mainly responsible for providing the necessary conditions, including knowledge, for developing processes for recycling packaging and manufacturing tiles.

The seventh category is called **"Developing products and services"**. Within it, there are motivations related to product development – M19 – (Konietzko, Bocken and Hultink, 2020; Parida et al., 2019; Vosman et al., 2021), product-service systems – M20 – (Parida et al., 2019; Türkeli et al., 2019) and technology for application services – M21 – (Ma et al., 2018). Product development, in particular, favored by durable design, extends the product life cycle and promotes the CE, being considered more important than end-of-life strategies (Marconi and Germani, 2017). In addition to the motivations mentioned, there is also the M22 motivation regarding expanding the variety of products offered (Hsieh et al., 2017). In other words, several players that integrate an ecosystem are able to develop several functionalities together, even expanding the variety of what was originally offered by the ecosystem. Only the M20 was found in the literature and the case study, as the orchestrator lends equipment to recyclers and ecological tiles manufacturers, which corresponds to a type of PSS.

The eighth category, **"Collecting and properly disposing of waste"**, is based on the fact that, inside a network of actors, the collection and disposal of waste in large quantities is facilitated. Thus, obtaining and subsequently transforming these residues becomes easier, which motivates the participation of actors in the ecosystem (Hsieh et al., 2017; Stewart et al., 2018; Türkeli et al., 2019). Motivation M25, specifically identified in the ecosystem of ecological tiles, indicates that an actor can choose to integrate an ecosystem to gain access to partners that sell waste. This issue was very relevant at the beginning of

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the pandemic when the amount of waste collected drastically reduced due to collectors' difficulty going to the streets.

The carton packaging manufacturer's partnership with a waste management company is a concrete example of how participation within the ecosystem facilitates obtaining waste for processing. The partnership was signed to boost the recycling of carton packages. Based on blockchain technology to promote waste traceability, the partnership guarantees reverse logistics credits for those who prove, through invoices, the collection and correct destination of post-consumer packaging. Thus, collectors, cooperatives, shavings markets, recyclers and even the manufacturers of ecological tiles themselves can be financially rewarded for boosting the recycling of carton packages, while this partnership guarantees a more significant amount of post-consumer material available for the manufacture of ecological tiles or other products.

The last category refers to "**Strengthening relationships with consumers/users"**. The scope of an ecosystem can engage consumers regarding the correct disposal of waste, as well as enable the development of products aligned with the preferences of these consumers and users (Hsieh et al., 2017; Konietzko, Bocken and Hultink, 2020; Stewart et al., 2018), which is consistent with M26 and M27 found in the case study. For example, the company that orchestrates the ecological tiles ecosystem has an application that provides information about the correct disposal of carton packages and identifies collection points. In this way, more and more consumers are engaged in the correct waste disposal, which is vital for implementing the ecosystem's value proposition. Also, regarding the last motivation (M28), an actor can choose to cooperatively integrate an ecosystem that adopts circular strategies in order to improve its green image, which may be relevant in the view of investors, consumers and other stakeholders (Hsieh et al., 2017; Konietzko, Bocken and Hultink, 2020; Stewart et al., 2018).

4 CONCLUSION

This research contributes theoretically to the CE and ecosystems literature by identifying the main motivations that lead actors to integrate a circular ecosystem. Unlike existing studies, this paper sheds light on cooperative relationships within circular ecosystems, identifying opportunities for cooperation and thus facilitating the connections between actors from different backgrounds. Regarding practical contributions, this study allows companies to acquire insights about forming ecosystems driven by CE, adapting them according to their realities.

Based on an SLR and a case study, our analysis suggests that cooperation in ecosystems results in diverse benefits for each actor and the ecosystem as a whole. The nine motivations categories demonstrate some benefits: sharing infrastructure, obtaining financial support, implementing R strategies, fulfilling political duties, sharing knowledge, developing products and services, collecting and correctly disposing of waste and strengthening relationships with users and consumers.

It is notable that, in addition to the benefits for the actors themselves, cooperation brings benefits related to strengthening the CE, which are intrinsically present in the case study. The entire chain of recycling and manufacturing ecological tiles, from the disposal of carton packaging waste by end consumers, depends on cooperation between the actors. In other words, the transformation of what was discarded, whether pre- or post-consumption, into a viable final product, is the result of integration among participants from the entire ecosystem. Still, the increase in waste collection and correct disposal depends on various actors' performance and influence.

Despite the practical and theoretical contributions of this study, it has some limitations that can be converted into opportunities for future studies. First, there are limitations imposed by the single case study carried out in Brazil, which, despite allowing a deeper understanding of the object of study, also prevents the generalization of the results. Thus, there is an excellent opportunity to extend this study to different circular ecosystems in diverse contexts and locations. Furthermore, as the concept of circular ecosystems is still in its infancy, new literature reviews are welcome and will allow the discovery of new motivations that drive cooperation among actors.

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