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# Disruptive innovation and circularity in start-ups: A path to sustainable development

Simone Sehnem[1,2] | Tais Provensi[1] | Tiago Hilário Hennemann da Silva[2] | Susana Carla Farias Pereira[3]

[1]Department of Management, Universidade do Oeste de Santa Catarina—Unoesc, Joaçaba, Brazil

[2]Department of Management, Universidade do Sul de Santa Catarina—Unisul, Florianópolis, Brazil

[3]Department of Management, Fundação Getúlio Vargas—FGV, Rio de Janeiro, Brazil

**Correspondence**
Simone Sehnem, Department of Management, Universidade do Oeste de Santa Catarina—Unoesc, Joaçaba, Brazil.
Email: simonesehnem_adm@yahoo.com.br

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## Abstract

Start-ups are an increasingly important phenomenon in the Brazilian business ecosystem. Many such companies have been created over the past few years, illustrating the interest in and growth of such entrepreneurship. Emerging companies are more likely to be founded on sustainable business models. In many cases, such models incorporate the principles of the circular economy. Thus, this study reviewed the use of disruptive innovation and the circularity of resources in the business models of start-ups. The study consisted of 50 semistructured interviews with start-up owners and managers. We accessed the database of the Brazilian Start-ups Association to map the organisations to be surveyed. Our results show that start-ups are innovating in terms of the circularity of resources through a range of partially implemented initiatives. These initiatives allow start-ups to manage their data and microdata, create artefact integration systems, generate connectivity, accelerate digitisation, stimulate partnerships and cooperation between parties in the supply chain, generate new market opportunities and develop efficient transition systems for the circularity of resources. Thus, there is ample evidence that disruptive innovation supports the circular economy in Brazilian start-ups. This study makes two main contributions to the literature. First, it strengthens the existing understanding of the use of the circular economy in start-ups, supported by disruptive innovation. Second, it identifies the levels of adoption of the circular economy in different market segments. Based on these findings, it identifies several opportunities to encourage further advances in this area.

**KEYWORDS**
business models, circular economy, disruptive innovation, start-ups, sustainable development

## 1 | INTRODUCTION

The finite nature of natural resources is inconsistent with the linear production system adopted by most organisations, and companies are already being forced to manage the scarcity of raw materials. Thus, there is growing support for a gradual transition to a circular production system. These business models of such a system incorporate, from the outset, an emphasis on eliminating residues and reducing waste (Julianelli et al., 2020). Circular business models have allowed the creation of new markets. In this context, start-ups have been created to serve and enable innovative forms of production, marketing and consumption (Franco & Rodrigues, 2020).

**LIST OF ABBREVIATIONS/ACRONYMS:** CE, circular economy; SDGs, Sustainable Development Goals; EMF, Ellen MacArthur Foundation; ReSOLVE, regenerate, share, optimise, loop, virtualise and exchange; E1, ..., E51, Interview 1 until Interview 51; ESG, Environmental, Social and Governance; DNA, deoxyribonucleic acid.

  

In May 2021, the Brazilian Government approved new guidelines for start-ups and innovative entrepreneurship, which incorporated measures to support innovative businesses (Brasil, 2021). Likewise, entities such as the National Confederation of Industries have sought to encourage companies to invest in sustainable business models that involve, for example, sharing, reusing and recycling materials (Silva, 2020). However, there has been little research to date on the incorporation of innovation and the circularity of resources into sustainable business models used by start-ups. Suchek et al. (2021) found that the circular economy demands engagement in several sustainable practices. According to this approach, companies must adopt innovative business models, internalise digitisation practices (Kristoffersen et al., 2021), propose value to customers and retain value in their production chains (Weetman, 2019) by developing creative and inspiring alternative approaches that generate connections, partnerships and cooperation.

The global sustainability agenda highlights that economic development must also consider social and environmental aspects (Objetivos de Desenvolvimento Sustentável, 2015), including governments, industries, enterprises and universities. The circular economy has emerged as an alternative approach that seeks to regenerate ecosystems. Innovations must be able to support systemic changes within companies, industries and economies, as well as radical changes in people's values, norms, behaviours and attitudes (Sehnem et al., 2021).

Therefore, this study sought to fill the theoretical gap by investigating how innovation can support the implementation of the circular economy and circularity of resources (Suchek et al., 2021). The general objective of the study was to investigate the presence of disruptive innovation and the circularity of resources in the business models of Brazilian start-ups. To explore this gap, we performed a multiple case study, steered by the following research question: How is disruptive innovation used to enable the circularity of resources in the business models of Brazilian start-ups?

Companies that adopt sustainable business models generate significant impacts for the development of society, given that they prioritise environmental (Gonzáles-Benito & González-Benito, 2006) and social results in addition to economic yields. This study is valuable because it strengthens the understanding within the literature of the adoption of innovation and circularity by Brazilian start-ups. The research results also confirm that it is possible to achieve economic profits while preserving natural resources and promoting human development, thus supporting the achievement of the 12th SDG (i.e., Responsible Consumption and Production).

This article is divided into five main sections. Following this introduction, the Section 2 presents the theoretical background to the research, including innovation, the circularity of resources and circular and sustainable business models. Next, the Section 3 presents the methods used to develop the research; then, Section 4 describes and analyses the results of the research and discusses those results in light of the objectives of this work. Finally, Section 5 outlines our reflections on the study and makes recommendations for future research.

## 2 | INNOVATION AND CIRCULARITY OF RESOURCES

Circular economy is a regenerative system that aims to reduce raw material input, waste generation and greenhouse gas emissions, via deceleration and closing of material and energy cycles (Geissdoerfer et al., 2017). Therefore, preference is given to materials with greater durability involving the reuse and recycling of materials in order to include them again in the production cycle, without any loss of quality.

For Webster (2015), the central proposal of the circular economy is the elimination of waste through the creation of cyclical flows of resources. Thus, circularity in production processes via integrated production chains is one of the main characteristics of this system. Neder et al. (2019) indicate that the circularity of resources can be achieved through the design, maintenance, repair, reuse, manufacturing, renovation, and long-term recycling. The authors also point out that:

> Circular Economy proved to be a new trend for the production models of companies that seek to modify their production chain in a way that it generates less impact on the environment through integration between the chain's agents so that a residue can be used in another production process or through closed processes. (Neder et al., 2019, p. 196)

In order for a product, process or service to be more efficient and circular, there is a context of innovation (Neder et al., 2019). The act of creating new products or processes is characterised as innovation by Hill et al. (2014). For Trott (2012), innovation involves the management of all activities related to the processes of technology generation, production and marketing of a new product, or the improvement of an existing process or product. Thus, innovation and circularity of resources are related terms (Sehnem et al., 2021). Innovation has a fundamental role in the competitiveness of companies, as in the organisational environment, it is seen as a source of value to the market and competitors (Freeman, 2004). Disruptive innovation, in turn, is characterised by the presentation of innovative products and services that are simpler than those that already exist. In this way, disruptive innovation can be understood as an opportunity to enter new markets (Christensen, 2006). The OSLO manual, on the other hand, describes innovation as a new or improved product or business process (or a combination thereof) which significantly differs from the company's previous products or processes, which were introduced on the market or put into use (Organização para a Cooperação e Desenvolvimento, 2018).

From the studies by Avital et al. (2014), Lewandowski (2016) and Zhang et al. (2018), we derive some typologies of disruptive innovation, namely, at the internet level, at the big data level, at the cloud computing level, at the sharing level, at the process redesign level, peer-to-peer and at the business model level (Khan et al., 2020). In a case study developed by Sehnem et al. (2020), it was possible to identify that the circularity of resources is being inserted into corporate

environments, especially in the creation of closed cycles of natural resources and incorporation of clean energy, for example. The authors indicate that, among other factors, innovation was one of the aspects that contributed to the achievement of good results in the application of circularity of resources, enhancing its relationship with innovation. Industry 4.0 is a way to achieve the circular economy in supply chains (Awan et al., 2021).

### 2.1 | Circular business models

Business models as a whole are aimed at creating value. Considering the need to rethink the forms of production and consumption due to the finite nature of natural resources, the design of new business models (Scarpellini et al., 2019) can contribute to achieving economic success, while reducing the negative effects generated on the environment and on society (Boons et al., 2013). In this framework, sustainable business models (Ferasso et al., 2020) are found, which have great potential to generate social and environmental value besides the economic value (Fernandes et al., 2021).

Sustainable business models emerge as a tool for integrating the three pillars of sustainability, where the organisation's activities are planned and structured with the objective of achieving financial results and meeting social and environmental needs (Nosratabadi et al., 2019; Oftedal et al., 2021). Therefore, we addressed sustainable issues (Lozano et al., 2021). Schaltegger et al. (2016) indicate that sustainable business models contribute to the description, analysis, management and communication of three central aspects, namely, (i) the sustainable value that a company proposes to its stakeholders; (ii) how the company creates and delivers that value; and (iii) how the company captures economic value while maintaining or regenerating natural, social and economic capital beyond the organisation.

In many cases, sustainable business models adopt the principles of circular economy and are called circular business models (de Sousa Jabbour et al., 2019). In the literature, it is possible to find different types of circular economy business models. According to Webster (2015), a circular economy business model exhibits the following premises: circular supply, waste as a resource, second life and sharing platforms. For the Ellen MacArthur Foundation (2015), a circular business model, according to the ReSOLVE classification, must present the following characteristics: regenerate, share, optimise, cycle, virtualise and exchange. In practice, sustainable circular business models are gaining traction. Recently, Fernandes et al. (2021) carried out an in-depth study with Amana Katu, a company that has sustainability and circularity incorporated into its business model. The authors were able to observe that, in this case, it was possible to create sustainable value for customers, society and other stakeholders in the business; coparticipation of stakeholders was fundamental to the success of the enterprise.

de Sousa Jabbour et al. (2019) also highlight the initiatives of large companies such as Renault and Philips, which have adapted their business models to offer a product as a service. This adaptation resulted in more durable products, with extended useful life, and improvements in reverse logistics. Schaltegger et al. (2016) indicate that the growth of sustainable organisations tends to contribute to a structural change towards sustainability. The same authors report in their study examples of different sustainable enterprises that together are able to contribute to sustainable transformation. Thus, the emergence of new sustainable business models, as well as the adaptation to sustainability of existing models, is of fundamental importance for the dissemination of sustainable principles in the market.

## 3 | METHODOLOGICAL PROCEDURES

The research was developed based on Yin's (2010) guidelines for elaborating a case study. The start-ups were chosen nonprobabilistically, as they formed part of the Brazilian Start-ups Association's database, which is composed of approximately 6000 start-ups.

Start-ups from the database were randomly selected to be invited to semistructured interviews. The surveyors made contact via email or telephone with the companies to assess their interest in participating in an interview. If the manager confirmed that the start-up would participate, the day and time were scheduled, and the interviews took place using Zoom and Google Meet. This approach allowed us to perform 51 in-depth interviews. Before each interview, we requested the authorisation of the manager to record the survey data and use them for academic purposes, maintaining the anonymity of the respondents and start-ups. Table 1 shows the profiles of the start-up managers that were surveyed.

The interview script consisted of 18 open-ended questions, which were based on a literature review. The questions addressed the following topics: the history and characteristics of the start-up, the sustainability practices it had adopted, the innovation practices it had adopted and critical success factors and challenges for its business model. The data were collected remotely between April and June 2021.

Next, the interviews were transcribed in full. Content and categorical analyses were performed to map the key elements associated with the subject investigated. This process followed the assumptions of Yin (2010, 2016), which explained how to build a theory from a case. First, we performed a floating reading of the materials. Next, excerpts were highlighted in yellow, enabling us to link these excerpts to the analysis categories. Additional data were collected on the websites of the surveyed start-ups and a field diary complemented the study's data collection and enabled the triangulation of data. It included examples of practices, business models, innovations and new products.

The analysis categories concerning the start-ups' business models followed the ReSOLVE framework recommended by the Ellen MacArthur Foundation (2015): regenerate, share, optimise, cycle, virtualise and exchange. The data concerning the start-ups' adoption of circular business practices were categorised into circular supply, waste as a resource, second life and sharing platforms, as suggested by Kalmykova et al. (2018). Finally, the data on disruptive innovations were categorised into innovations concerning the internet, big data,

**TABLE 1** Profile of respondents

| Codes | Education | Activity sector | Length of experience in the company | Region | Interview duration | Interview transcript pages |
|---|---|---|---|---|---|---|
| E1 | Graduation | Health | 1 year and 7 months | South | 30 min | 4 pages |
| E2 | Post-graduation | Food | 5 years | South | 45 min | 6 pages |
| E3 | Graduation | Food | 5 years | South | 28 min | 4 pages |
| E4 | Doctorate | Health | 12 years | South | 48 min | 6 pages |
| E5 | Postdoctorate | Agribusiness | 3 years | South | 45 min | 6 pages |
| E6 | Graduation | Agribusiness | 3 years | South | 40 min | 5 pages |
| E7 | Post-graduation | Foods | 1 year and 7 months | North | 43 min | 6 pages |
| E8 | Graduation | Agribusiness | 2 years and 6 months | Southeast | 20 min | 3 pages |
| E9 | Graduation | Food | 8 years | Southeast | 30 min | 4 pages |
| E10 | Post-graduation | Foods | 5 years | Southeast | 40 min | 5 pages |
| E11 | Graduation | Textile | 3 years | South | 44 min | 6 pages |
| E12 | Graduation | Foods | 7 years | South | 48 min | 7 pages |
| E13 | Post-graduation | Foods | 14 years | South | 27 min | 4 pages |
| E14 | Graduation | Foods | 2 years | South | 28 min | 5 pages |
| E15 | Graduation | Foods | 1 year | Southeast | 57 min | 8 pages |
| E16 | Graduation | Foods | 3 years | South | 62 min | 9 pages |
| E17 | Graduation | Construction | 27 years | South | 68 min | 10 pages |
| E18 | Post-graduation | Paper and cellulose | 15 years | South | 32 min | 6 pages |
| E19 | Graduation | Information technology | 16 years | South | 28 min | 5 pages |
| E20 | Graduation | Information technology | 6 years | South | 28 min | 5 pages |
| E21 | Post-graduation | Wellness technology | 13 years | Northeast | 15 min | 3 pages |
| E22 | Post-graduation | Wellness technology | 8 years | South | 25 min | 4 pages |
| E23 | Graduation | Wellness technology | 3 years | Northeast | 15 min | 3 pages |
| E24 | Master's degree | Wellness technology | 9 years | Central-West | 12 min | 2 pages |
| E25 | Doctorate | Wellness technology | 5 years | Southeast | 11 min | 2 pages |
| E26 | Graduation | Wellness technology | 3 years | Northeast | 1 h and 15 min | 12 pages |
| E27 | Graduation | Agribusiness | 5 years | Southeast | 12 min | 2 pages |
| E28 | Graduation | Agribusiness | 4 years | South | 50 min | 9 pages |
| E29 | Graduation | Agribusiness | 3 years | Southeast | 20 min | 4 pages |
| E30 | Graduation | Furniture maker | 3 years | Southeast | 55 min | 7 pages |
| E31 | Post-graduation | Information technology | 6 years | South | 1 h and 7 min | 9 pages |
| E32 | Doctorate | Agribusiness | 5 years | Central-West | 68 min | 8 pages |
| E33 | Graduation | Agribusiness | 4 years | South | 20 min | 4 pages |
| E34 | Graduation | Foods | 12 years | Central-West | 48 min | 7 pages |
| E35 | Graduation | Biotechnology | 1 year | Southeast | 42 min | 6 pages |
| E36 | Graduation | Biotechnology | 6 years | Southeast | 69 min | 8 pages |

(Continues)

**TABLE 1** (Continued)

| Codes | Education | Activity sector | Length of experience in the company | Region | Interview duration | Interview transcript pages |
|---|---|---|---|---|---|---|
| E37 | Graduation | Information technology | 4 years and half | Northeast | 29 min | 5 pages |
| E38 | Doctorate | Information technology | 5 years | Southeast | 28 min | 5 pages |
| E39 | Graduation | Information technology | 5 years | South | 25 min | 4 pages |
| E40 | Doctor | Foods | 4 years | Southeast | 24 min | 4 pages |
| E41 | Graduation | Furniture maker | 4 years and half | South | 15 min | 3 pages |
| E42 | Graduation | Furniture maker | 1 year | South | 20 min | 4 pages |
| E43 | High school | Furniture maker | 8 years | South | 20 min | 4 pages |
| E44 | Post-graduation | Furniture maker | 12 years | South | 20 min | 4 pages |
| E45 | Post-graduation | Furniture maker | 20 years | South | 20 min | 4 pages |
| E46 | Post-graduation | Furniture maker | 18 years | South | 20 min | 4 pages |
| E47 | High school | Foods | 12 years | Southeast | 20 min | 4 pages |
| E48 | Graduation | Foods | 6 years | Southeast | 1 h and 8 min | 11 pages |
| E49 | Post-graduation | Biotechnology | 5 years | South | 1 h and 5 min | 11 pages |
| E50 | Graduation | Foods | 7 years | South | 1 h and 20 min | 13 pages |
| E51 | Master's degree | Foods | 4 years | Southeast | 1 h and 15 min | 9 pages |
| Total | | | | | 31 h and 54 min | 293 pages |

cloud computing, sharing, process redesign, peer-to-peer approaches and business models (Avital et al., 2014; Lewandowski, 2016; Zhang et al., 2018).

The logic used to conduct the process of data coding and analysis was associated with the presence or absence of the previously defined analysis categories, as shown in Table 2. The data were checked by two researchers that, based on the predefined subcategories, classified the start-ups according to their levels of adoption of circularity practices, business models and disruptive innovations. These levels were defined as (i) none (i.e., a lack of knowledge of the practice), (ii) embryonic (i.e., awareness of the importance of the practice, but not adopted), (iii) partial (i.e., in the initial stages of implementing the practice) and advanced (i.e., intermediate adoption of the practice) and (iv) full (i.e., full implementation of the practice).

After this categorisation, we analysed our findings in the context of the theoretical principles of circular economy and innovation. This allowed us to develop propositions for full adoption that will support future research to empirically validate these principles. To ensure the validity of the survey, we adopted the guidelines suggested by Yin (2010), which recommend the use of a research protocol, multiple sources of evidence and data triangulation (i.e., the triangulation of different units of analysis and data sources). Furthermore, we sought theoretical saturation for each of the analysis categories to obtain exhaustion, as well as drawing on distinct data sources (i.e., the transcribed interviews, field notes, and secondary webpage data).

## 4 | PRESENTATION AND ANALYSIS OF RESULTS

Table 3 presents the empirical evidence concerning the business models, in line with the premises of the ReSOLVE framework. The Purposes column refers to the purposes of the ReSOLVE framework typologies (i.e., what each typology is for and what it seeks to propose). The Implementation column contains the classification of the level of implementation of each business model, considering the evidence identified in the researched projects. We identified several asymmetries, suggesting that there are variations in the degree of implementation of sustainable practices in the surveyed start-ups, in line with the principle of the circular economy. However, in this study, our concern was to highlight the predominant pattern (i.e., the pattern that was most prominent in the empirical evidence analysed in this study). Finally, the Opportunities column proposes possible paths to the full adoption of circular practices.

As shown in Table 3, the practices of regenerating, optimising and virtualising have already been implemented by the start-ups surveyed.

**TABLE 2** Analysis categories and aspects observed in the empirical evidence of the study

| Analysis categories | Subcategories | Descriptive | Aspects observed |
|---|---|---|---|
| ReSOLVE (Ellen MacArthur Foundation, 2015) | Regenerate | Switch to renewable energy and materials; recover, retain and restore ecosystems' health; and return recovered biological resources to the biosphere. | None<br>Embryonic<br>Partial<br>Advanced<br>Full |
| | Share | Share assets (e.g., cars, rooms and appliances); reuse/use second-hand products; and extend the life of products through maintenance, design for durability, upgradeability and so on. | |
| | Optimise | Increase product performance/efficiency and remove waste in production and the supply chain, leverage big data, automation, remote sensing and driving. | |
| | Cycle | Remanufacture products or components, recycle materials, use anaerobic digestion and extract biochemical substances from organic waste. | |
| | Virtualise | Dematerialise directly (e.g., books, CDs, DVDs and travel) and indirectly dematerialise (e.g., online shopping). | None<br>Embryonic<br>Partial<br>Advanced<br>Full |
| | Exchange | Replace old non-renewable materials with more advanced ones, apply new technologies (e.g., 3D printing) and opt for new products and services (e.g., multimodal transport). | |
| Circular business models (Kalmykova et al., 2018) | Circular supply | Renewable energy, fuel and bio-based products. | None<br>Embryonic<br>Partial<br>Advanced<br>Full |
| | Waste as a resource. | Useful resources and energy recovery from waste and adoption of industrial symbiosis. | |
| | Second life | Extends product life through repair, modernisation, resale and durable, modular design. | |
| | Sharing platforms | Contribute to the dematerialisation of products. They provide access to the product and retain ownership of the producer. They use as a premise the adoption of a circular design. | |
| Typology of disruptive innovations (Avital et al., 2014; Lewandowski, 2016; Zhang et al., 2018) | At internet level | It fosters digital transformation, and for agility, it creates new patterns and new consumption habits. | None<br>Embryonic<br>Partial<br>Advanced<br>Full |
| | At big data level | It makes use of information technology, allowing the storage of a large volume of data under the support of speed, volume, variety, veracity and value. In addition to storing the data, it adopts strategies of analysis, capture, curation, research, sharing, storage, transfer, visualisation and information about data privacy. | |
| | At cloud computing level | It makes use of the infinitely available and flexible computing power through a cloud engine, which sits behind the connection. Therefore, it refers to the provision of computing services, namely, servers, storage, database, network, software and analytics through the internet (cloud computing). | |
| | Share level | It is associated with the sharing of products, services and processes in order to make them accessible to a wide range of people at competitive prices. It makes use of information technologies that support the amplification of the partition. | |

(Continues)

**TABLE 2** (Continued)

| Analysis categories | Subcategories | Descriptive | Aspects observed |
|---|---|---|---|
| | At process reformulation level | It consists of changing and restructuring traditional processes, so that new ones achieve superior visibility in a short period of time. It is usually generated by start-ups and innovation accelerators. | |
| | Peer-to-peer | It consists of a computer network format in which the main feature is the decentralisation of conventional network functions. In this framework, the computer of each connected user performs server and client functions simultaneously. Its objective is the transmission of files, and its emergence has contributed to the mass sharing of music and movies. | |
| | At business model level | They are those innovations that occur via regenerative mechanisms, that is, energy recovery, circular supplies, efficient construction, sustainable product locations and chemical location; sharing, whether through maintenance and repair mechanisms, collaborative consumption and sharing, platforms for offering products such as services, up cycling and dematerialisation services. | |

This was noted in the statements of the interviewed subjects. For example,

> 100% right, because the idea of retail is to buy and resell. When we propose to build a structure that shares that technological base for an unlimited number of producers, users, where they can, and we have the responsibility here to carry out this logistical operation. First, it was designed in forms that didn't exist, right, imagine you as a consumer, you'll receive at home a purchase from 20 different producers in the same package, in the same box, right, with an appearance at first that you bought it somewhere who buys and resells. But for that to happen, there was a whole design of the physical and digital process to be brought together, from the arrival of the product in our logistics centre to gather with all the purchases that the other producers made. All this was designed from scratch, it didn't exist. (E51)

> there is no waste, it's like I said, I take the vegetable from there, I bring it to the production, I use the peels in the production, I make broths, sauces, I leave it flavouring, I make a bouquet to flavour the Foods and that in the end I use bark, stalks, pieces that are left over in the production of vegetables, all of this I use when making the production and the processes, the broths, the foods, and it still goes to my organic waste and goes back to the land, to we make our fertilizer, our organic compost. (E2)

> we have an organization, it's even a job that the interns do here, of sorting the garbage, each garbage has a clean separation of organics, out here we also have the disposal of the boxes, there are people who collect, so it's well separated even, we were working with the interns, this is nutrition. (E3)

Next, Table 4 shows the assumptions within the circular business models adopted by the researched start-ups.

The evidence suggests that start-ups seek to develop business ecosystems that are capable of creating a network of partnerships and resources to sustain an agile, resilient value chain and generate strong prospects for the future. The close adherence to positive sustainability practices shows that start-ups are focused on solutions, relationships, partnerships and engagement with customers that are committed to the sustainability of natural resources. For example,

> What happens is a producer buys from another one inside the platform, so he uses that structure, 'ah, I need a mushroom to make my product, which is a preserve', so one producer buys from the other inside the platform, so he makes that a purchase structure for him too. (E51)

**TABLE 3** Circularity from the perspective of the ReSOLVE framework

| ReSOLVE | Purpose | Codes | Implementation | Opportunities |
|---|---|---|---|---|
| Regenerate | Switch to renewable energy and materials; recover, retain and restore ecosystem health; and return recovered biological resources to the biosphere. | E1, E2, E3, E5, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E19, E24, E32, E34, E35 and E49 | Advanced | Full adoption. Use of nanotechnology and biotechnology for regeneration is recommended. |
| Share | Share assets (e.g., cars, rooms and appliances); reuse/use second-hand products; and extend the life of products through maintenance, design for durability, upgradeability and so on. | E1, E3, E7, E8, E10, E11, E15, E16, E24, E28, E29, E33, E42, E44, E45 and E51 | Embryonic | Full adoption. Prospecting integration partnerships with other links in the supply chain is recommended. |
| Optimise | Increase product performance/efficiency and remove waste in production and the supply chain, leverage big data, automation, remote sensing and driving. | E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E21, E22, E23, E24, E25, E26, E27, E28, E29, E30, E31, E32, E33, E34, E35, E36, E37, E38, E39, E40, E42, E43, E44, E45, E46, E47, E48, E49, E50 and E51 | Advanced | Full adoption. Focus on efficiency, productivity and management of start-up microdata are recommended. |
| Cycle | Remanufacture products or components, recycle materials, use anaerobic digestion and extract biochemical substances from organic waste. | E2, E3, E10, E11, E13, E15, E21, E32, E34 and E40 | Embryonic | Full adoption. Partnerships and cooperation between start-ups to advance at this level are recommended. |
| Virtualise | Dematerialise directly (e.g., books, CDs, DVDs and travel) and indirectly dematerialise (e.g., online shopping). | E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E19, E20, E21, E34, E36, E37, E40, E43, E47, E50 and E51 | Advanced | Full adoption. Dematerialisation with integrated systems between players in the same business segment is recommended. |
| Exchange | Replace old non-renewable materials with more advanced ones, apply new technologies (e.g., 3D printing) and opt for new products and services (e.g., multimodal transport). | E1, E2, E3, E4, E5, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E22, E27, E35 and E43 | Partial | Full adoption. Sustainable substitute materials and use of technology to generate circularity is recommended. |

**TABLE 4** Assumptions of circular business models

| Assumptions | Purpose | Codes | Implementation | Opportunities |
|---|---|---|---|---|
| Circular supply | Renewable energy, fuel and bio-based products | E2, E3, E5, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E22, E27, E32, E35, E38, E43 and E49 | Partial | Full adoption. Transition to the use of the entire energy potential of the renewable matrix. |
| Waste as a resource | It recovers useful resources and energy from waste. It adopts industrial symbiosis. | E2, E3, E5, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E21, E24, E26, E34, E40, E44, E45 and E49 | Advanced | Full adoption. Transition to full waste recovery, for reinsertion in production systems. |
| Second life | Extends product life through repair, modernisation, resale and durable, modular design. | E5, E7, E8, E9, E10, E11, E12, E34, E36, E38, E40, E43, E44, E45, E46, E47, E48 and E49 | Partial | Full adoption. Transition to systems that prioritise lifecycle analysis, lifecycle extension and repair and reuse. |
| Sharing platforms | Contribute to the dematerialisation of products. They provide access to the product and retain ownership of the producer. They are premised on adopting a circular design. | E1, E3, E5, E7, E8, E9, E10, E11, E14, E15, E16, E42, E48 and E51 | Advanced | Full adoption. |

**TABLE 5** Mapped disruptive innovations

| Innovations | Description | Codename | Implementation | Opportunities |
|---|---|---|---|---|
| At internet level | Fosters digital transformation and quickly creates new patterns and new consumption habits. | E1, E4, E5, E6, E7, E8, E9, E10, E16, E11, E13, E14, E15, E20, E22, E23, E24, E25, E26, E29, E30, E31, E33, E36, E37, E38, E39, E47, E48, E49, E50 and E51 | Partial | Full adoption. Adherence to digitisation processes. |
| Big data level | It makes use of information technology, allowing the storage of a large volume of data supported by speed, volume, variety, veracity and value. In addition to storing the data, it adopts strategies of analysis, capture, curation, research, sharing, storage, transfer, visualisation and information about data privacy. | E1, E5, E7, E9, E15, E16, E20, E22, E28, E29, E30, E31, E33, E39, E47 and E49 | Embryonic | Full adoption. Adesão a big data para gestão de micro dados para tomada de decisão estratégica. |
| Cloud computing level | It makes use of the infinitely available and flexible computing power through a cloud engine, which sits behind the connection. Therefore, it refers to the provision of computing services, namely, servers, storage, database, network, software and analytics through the internet (cloud computing). | E1, E2, E11, E12, E13, E14, E15, E16, E18, E20, E21, E22, E23, E25, E29, E30, E31, E32, E33, E36, E37, E38, E39, E41, E43, E45, E47, E48, E49 and E51 | Partial | Full adoption. Adherence to reducing local storage costs and using large volumes of data to drive business. |
| Share level | It is associated with the sharing of products, services and processes in order to make them accessible to a wide range of people at competitive prices. It makes use of information technology that corroborate for the amplification of the partition. | E1, E2, E3, E5, E8, E9, E10, E11, E15, E16, E31, E33, E38, E42, E48 and E51 | Partial | Full adoption. Adherence to optimisation, use of total available capacity, breadth of coverage and capillarisation of opportunities. |
| Process | reformulation level | It consists of changing and restructuring traditional processes, so that new ones achieve superior visibility in a short period of time. It is usually generated by start-ups and innovation accelerators. | E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E15, E16, E17, E18, E19, E20, E21, E23, E25, E26, E27, E28, E29, E30, E31, E33, E37, E38, E39, E42, E43, E45, E46, E47, E49 and E51 | Partial |
| Full adoption. Adhesion to grow, expand, pivot or accelerate the | dissemination of the business model. | | | |
| Peer-to-peer | | E1, E15, E30 and E47 | Embryonic | |

**TABLE 5** (Continued)

| Innovations | Description | Codename | Implementation | Opportunities |
|---|---|---|---|---|
| | It consists of a computer network format in which the main feature is the decentralisation of conventional network functions. In this framework, the computer of each connected user performs server and client functions simultaneously. Its objective is the transmission of files, and its emergence has contributed to the mass sharing of music and movies. | | | Full adoption. Adherence to social inclusion, approach to the customer, real-time interaction and obtaining feedback. |
| Business model level | They are those innovations that occur via regenerative mechanisms, that is, energy recovery, circular supplies, efficient construction, sustainable product locations and chemical location; sharing, whether through maintenance and repair mechanisms, collaborative consumption and sharing, platforms for offering products such as services, upcycling and dematerialisation services. | E1, E3, E6 E4, E5, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E19, E20, E21, E25, E32, E34, E37, E38, E48, E49 and E51 | Partial | Full adoption. Adhesion to become a sustainable start-up, adept of the circular economy and the guidelines of good environmental and social governance with economic success. |

The most important thing is the trust that customers place in us and the certainty that they will receive food with a high level of quality. Our service is based on trust, as we work with very perishable Foods and our mission is to deliver them 100% fresh. (E50)

We were born with the digital mindset, E1 is 100% telemedicine, we like that, I don't know E1's doctors in person, it's the team too, we were born to a model very adapted to this new pandemic normal and even because of this new normal that we live, in E1 we focus on finding the cause, so what is actually causing this? (E1)

100% digital, this is a differential that we have, we store everything on the platform, we have the entire method of monitoring [health sector, medical appointments]. (E1)

our packaging is BPA free, they are 100% recyclable, they are beautiful, but they are 100% recyclable, we have the seals that we recycle, so all our packaging, most people return us and we send there to do the recycling and on the packaging itself it is written that it is 100% recyclable, so when it goes to waste, it is sent, then it will be transformed, right, reused. We are organic, so we believe that our way of growing, our way of distribution, our way of handling both production and logistics is totally sustainable. (E2)

We use solar energy on the site, so the energy comes from plates, right, it's a more sustainable, more economical way and our concern is always to use healthier products, more sustainable methods, everything you can include in this lifestyle more organic and in a way that is not harmful to the planet. For example, there we don't deforest, don't burn, don't use any pesticides, inside E2 the fumigation is done with neem oil, so nothing harms neither the cockroaches nor the insects. So it's all in a healthier and more coherent way. Today, for example, we have an audit, which takes place every 5 months, from our certifier, Ecocert. And I see that we are on the path of organic assumptions, I always thought it had to be as natural as possible. (E2)

We are starting more partnerships now. We started, for example, within Mundo Verde, that chain, is still starting in this store. In other cities we sell after emporiums. (E3)

We throw everything in the recycled trash, but anyway it is, but it's crazy. The inner part of the cartridges, which is plastic, we have to dispose of in a specific hospital waste, because it has contaminating material,

> so we have this waste management by a company that we hire and it disposes properly, depending on the type of substance you have there. And the kits too, they win a lot … In the past it was worse, in the past we left it at the clinics and then the professionals forgot, they didn't send it back to us and they sent it already overdue, it was an absurd loss. Today we don't do that anymore, if the professional wants to refer a client, he has to ask the client to call us and we send the kit. Nowadays, we buy in an amount since we know we won't have a problem winning and then we send it straight to the patient, so that we don't have this problem anymore. One or the other ends up forgetting, but then we get in touch with the customer and end up remembering. It minimized a lot, but there was a time like this that was crazy. Until today we still receive. Today it is registered in the system when a kit is about to expire, we call the person and give a deadline, to avoid waste. (E4)

Concerning sharing, there is an understanding among the participants in the interviews and also in the literature that different types of assets can be shared, including software programs, coworking spaces (e.g., buildings and infrastructure), objects (e.g., products, materials, equipment and unused industrial productive capacity), competencies (e.g., technical expertise and life experience) and services (e.g., facilities management systems, online platforms, exclusive algorithms and functionalities). Such business models tend to generate deeper social connections through reduced costs. They prioritise the efficient and sustainable use of resources, with an emphasis on alternatives that minimise and mitigate the pollution generated by business activities. They also contribute to a closer relationship with customers, listening to their feedback and needs, to prospect for long-lasting relationships.

Technological innovations were already in use in the start-ups surveyed. Such innovations contribute to the management of large volumes of data and microdata to increase productivity and efficiency. The diffusion of technologies throughout start-up ecosystems generates connectivity, partnerships, integration, business opportunities and effective solutions for all involved. The surveyed start-ups reported that they had adopted technologies such as the internet of things, virtual learning, blockchain and artificial intelligence. Such technologies generate solutions and practices that can be applied to each company's value chain. They help to improve employees' speed and accuracy and contribute to reducing costs and increasing profits. Furthermore, they support the creation of advanced systems for monitoring, control and traceability, enabling the accurate measurement of productivity gains and other environmental and economic performance indicators. Intelligent platforms allow the dynamic monitoring of productive activity within the geographic space in which it is developed. Drones were also already part of the surveyed start-ups' approaches to freight, deliveries and the monitoring of production activities. Finally, intelligent video monitoring, which is associated with georeferencing systems, also generates technological solutions, especially for agribusiness. We present some evidences from the interviews as follows.

> As of 2017, we created a model of direct sales to consumers, which in the United States they call retail consumer tests, and we ended up becoming a reference here in Brazil in this type of test. (E4)

> Nowadays, people can access our website; they can purchase our tests, without the need for any prescription, right? So, according to the law, this is not necessary, so people can buy this genetic test directly, they do not need a prescription doctor and then we started to work on this model, we created an internal structure of professionals to serve these clients, because we understand that genetic tests for most people are still something new, which most of the time they do not understand, so when the person buys her test, she does it and then receives the result and we have a team of professionals to explain that result since I tried to do this with outside professionals, but it didn't work so we had to internationalize, right. So today we also have a data platform, data from thousands of people, genetic data, microbiome data and the idea is to improve this and make it more and more digital, even maybe in the future I won't need a professional to explain, right the person can access everything through this platform, right. (E4)

> Oh, everyone wants it, it's no use denying it, everyone wants a healthy, affordable food that respects the environment, helps biodiversity, is socially fair, I think everyone wants that. But they didn't have a name, so in the food area we have this name, which is Panc, right, and the products we created are processed Foods, minimally processed, I won't say that there are many processed because there are very few processed. It is without preservatives, without colourings, with a high nutritional content, ham … with the different practices you can imagine, both in terms of conservation and elaboration, it is with different flavours, we can say that for sure, that our products have a flavour is very different, we are not that plant based or vegan company that makes a false, false protein, a … a false mayonnaise sauce, no, we really deliver flavours that are remarkable, right. And with regard to quality, it is also something that we always pay close attention to, and regarding the market itself, we have a very high pent-up demand for our products, which took this time for us to be able to plant the ingredients and for them to be able to the harvest. So it took us a little while to adapt, yes, it took us a while to make these harvests

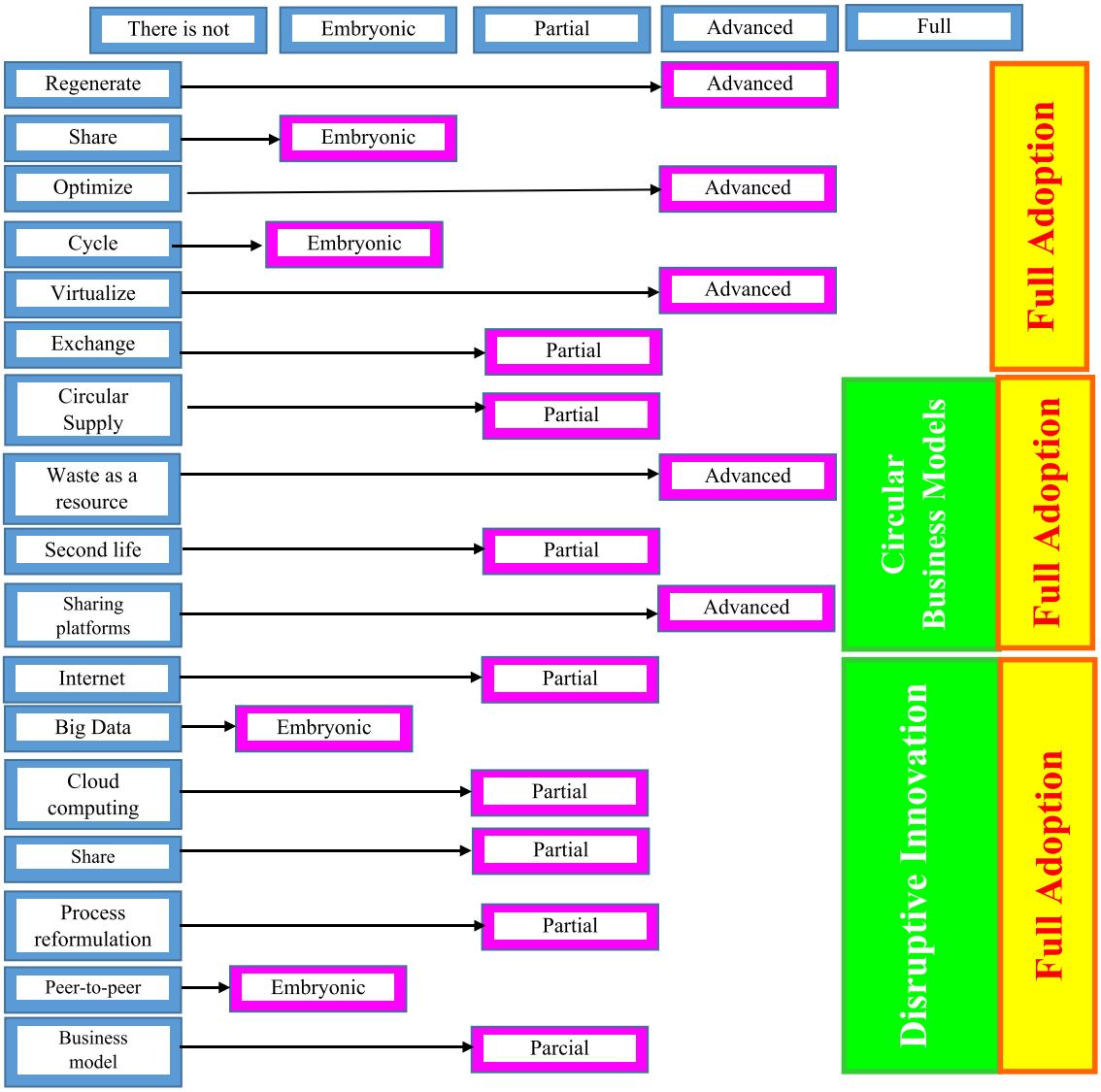


**FIGURE 1** The circular economy framework and disruptive innovation in start-ups

and multiply so we can deliver a product that won't be missing on the shelf. (E49)

Produtos alimentícios não convencionais (Pancs, Unconventional food products) … represents the movement of what people wanted, wanted, but had no name. Oh, everyone wants it, it's no use denying it, everyone wants a healthy, affordable food that respects the environment, helps biodiversity, is socially fair, I think everyone wants that. But they didn't have a name, so in the food area we have this name, which is Panc, right, and the products we created are processed Foods, minimally processed, I won't say that there are many processed because there are very few processed. It is without preservatives, without colourings, with a high nutritional content, ham … with the different practices you can imagine, both in terms of conservation and elaboration, it is with different flavours, we can say that for sure, that our products have a flavour is very different, we are not that plant based or vegan company that makes a false, false protein, a … a false mayonnaise sauce, no, we really deliver flavours that are remarkable, right. And with regard to quality, it is also something that we always pay close attention to, and regarding the market itself, we have a very high pent-up demand for our products, which took this time for us to be able to plant the ingredients and for them to be able to the harvest. So it took us a little while to adapt, yes, it took us a while to make these harvests and multiply so we can deliver a product that won't be missing on the shelf. (E49)

At the beginning we were talking about the following, and look let's put points in everything that happens in

here so if you ate a snack of ten (10) reais we'll score each real, three ranks is our currency in here and you get these ranks and then you can exchange, back then you exchanged for movie tickets these kinds of things, nowadays you exchange them for Gift Cards, Netflix, Google, Deezer, Spotify these kinds of things, or you can do a donation to a charity, so you can donate to the animal welfare society, the elderly, finally, we do a lot of donations, we have already donated a few good tons of Foods, and we have and have always had this issue very social, and now we, for example, we just released it was yesterday about two o'clock in the afternoon, we now have a skill on Alexia and you can, don't ask, I think it's too complex for an ifood app, you do the request by ALEXIA, but you can see your last orders or seeing the ranks knowing the status of the last order if it was delivered if it wasn't, anyway we have a skill at ALEXIA that I think helps these people with visual difficulties too, right, we even have a girl that we I was giving her an ALEXIA, for her to help us test it out to make the app closer to people with this visual impairment, for example. (E48)

## 4.1 | Discussion of results

Disruptive innovations are adopted by firms to increase the circularity of resources, retain value in production cycles and increase the value of the products or services provided to consumers (Weetman, 2019). For the start-ups surveyed in this study, disruptive innovations are directly associated with cost reductions, increased productivity, reduced water and energy consumption, nutritious food and healthy living, for example, a foodtech start-up offering more nutritious products. Innovation is also associated with scarcity, meaning that it induces the generation of applied solutions to support sustainability. The results indicate that the use of clean energy is seen as an important enabler of business success, as previously highlighted by Geissdoerfer et al. (2017).

The decision-making process within start-ups is supported by people who understand that human talent is critical to success in the circular economy. People need to purposefully create, innovate, rethink, adapt, change and persist to achieve sustainability. Circular inputs (i.e., recycled, renewable, safe and protected inputs, the quality of which is certified by health and safety bodies) have become desirable to start-ups. Lifecycle extension and analysis, reverse logistics and critical reflection on use (i.e., use less, use more, use better and use again) were all present in the production systems of the start-ups that were surveyed in this study. Start-ups have developed ways to extend the useful life of products and generate value, including through remanufacturing, renovation and recovery. Innovation plays an important role in these processes (Zhang et al., 2021).

Generating solutions to minimise waste and developing partnerships to use waste as resources in other businesses were also indicated as possible alternatives adopted by the start-ups within the sample. Circular flows incorporate reuse, remanufacturing, recycling, digitisation, virtualisation and sharing initiatives. Such practices have a positive social impact (Fernandes et al., 2021). Shared common values support business development initiatives that leverage marketplaces and coworking spaces to provide a firm's services to customers. Relationships, partnerships and collaboration are drivers of the incorporation of innovation into the circularity of start-ups (Webster, 2015). These practices were stimulated, enhanced and preserved in the start-ups surveyed. Furthermore, the results indicate that digital innovations have a significant impact on start-ups and their supply chain approaches (Weetman, 2019). 3D printing, for example, compacts the inputs to production so that they are introduced into the process as raw materials in the form of powder, liquid or resin. In addition to the benefits of using waste as an input, this method reduces the ecological transport footprint of the produced goods.

Some start-ups have already incorporated customisation and personalisation into their business identities as a result of the adoption of digital innovations. Such approaches enable firms to manufacture products that are tailored to consumers' tastes and desires and are produced on demand (Zhang et al., 2018). This allows firms to align production to their delivery schedule, reducing costs, waste and losses, an objective that is much desired by the circular economy. Finally, the use of sensors, machine-to-machine communication, the Internet of Things, predictive analytics and big data all contribute to the transformation of production systems, enabling the efficient use of resources.

The results of this study indicate that start-ups have adopted resilient business models that quickly and efficiently internalise disruptive innovations. Such innovations are capable of changing the market in which firms operate due to shifts in the production, use and disposal of products. There is interest among start-ups in optimising the recoverable value of resources, redirecting the flow of materials, components and products for reprocessing; and introducing sustainable practices (de Sousa Jabbour et al., 2019) to consolidate circular business models. Figure 1 summarises the circular economy framework and incorporation of disruptive innovations by start-ups and presents the level of adoption of each element.

## 4.2 | Implications of this research

The research findings have implications for the creation of business strategies to promote sustainable development. Those implications include:

a. the repositioning of business models to create and retain value from resource flows in supply chains;
b. the use of innovation as a mechanism for the differentiation and acceleration of the circular economy in start-up supply chains;
c. the creation of new markets in traditional segments through disruptive innovations, especially when aligned with the assumptions of circularity;

d. the development of an integrated set of practices in synergy with the relevant stakeholders within start-up supply chains, leveraging the circular economy in different productive sectors; and
e. the widely recognised role of technology as an enabler of disruptive innovations that internalise circular economy practices in start-ups.

Although the study focused on start-ups, its results may apply to different types of businesses that are willing to make the transition to circularity, no matter their size or level of maturity, including small and medium enterprises (SMEs) and multinational enterprises (MNEs). The findings of this study concerning the disruptive innovations implemented in start-ups may inspire other organisations to adopt alternative practices that support them to contribute to the circular economy.

We propose that the lessons of this study concerning innovation and entrepreneurship related to circularity may be grouped into the following dimensions:

a. People: the strategic role of people in the transition to circularity, supported by disruptive innovation.
b. Innovation: the need for firms to use creativity and disruption to create new markets, generate reinvention and strengthen their attractiveness to consumers.
c. Technology: the importance of infrastructure and technological support compatible with the new business models enabled by the circular economy (e.g., virtualisation, exchanges, sharing, consecutive material flow cycles, optimisation and regeneration).
d. Regulation: the role of policy within the circular flow of supply chains, serving to stimulate ideas that are pursued by companies with the support of governments.

Governments have a critical role to play in this area; there is a need to both reformulate existing laws and propose new laws to guide companies, encourage adherence to the circular economy, generate tax incentives to accelerate the circular economy and support a gradual transition from traditional production models to circular flows. Moreover, governments can define measurable targets and concrete deadlines for this transition, which encourage stakeholder engagement and buy-in. For example, in 2020, Portugal created a resolution to guide all public and private sector organisations to transition to the circular economy by 2030 (Council of Ministers Resolution No. 190-A/2017).

Above all, the findings of this study confirm that the circular economy, supported by disruptive innovation, can be a promising path for start-ups. The results also suggest that both SMEs and MNEs can follow this route to innovation. For example, if you look for E2, E3, E5, E7 and E19 cases.

## 5 | FINAL CONSIDERATIONS

This study analysed the use of disruptive innovation to enable the circularity of resources in the business models of Brazilian start-ups. Within the start-ups investigated, disruptive innovations support circular business models and other circularity practices. Several positive initiatives were identified through the research, specially about innovative practices supporting by technologies. Such initiatives are fully aligned with best practices of sustainability and global sustainable governance guidelines. However, there are still opportunities for further advancement in the organisations surveyed, especially concerning the full adoption of innovation and circular economy initiatives.

The main practical contribution of the study is the assessment of the organisational context of Brazilian start-ups. The results of the study indicate that there is an alignment between circularity and disruptive innovation, with the circular economy business models in force in the surveyed organisations illustrating the firms' commitment, engagement and focus on sustainability within their business and organisational approaches. The managers that were surveyed recognised the importance of adopting and adhering to disruptive innovations that support circular business models. Thus, in this work, we have identified opportunities for further advancement in terms of the implementation of innovation and the circular economy. Additionally, start-ups, in general, are embedded with a focus on sustainability from their inception. This facilitates the generation of results consistent with global needs. These needs are articulated by the SDGs, the Environmental, Social and Governance guidelines—on the United Nations (UN), and the circular economy roadmap for Latin America.

The managerial implications of the study include the recognition of possible alternative ways to apply disruptive innovations to enable the circular economy. Generating circular digital solutions for emerging businesses will support the future emergence of unicorns. Some of the implications of this research may also be useful for firms with other business models, including SMEs and MNEs.

The theoretical contribution of this study relates to the proposed classification and the identification of a partial maturity stage for the adoption of circular business models supported by disruptive innovations. This suggests the possibility of further advancement and encourages the engagement of companies in such practices. Consumers are likely to increase their adoption of circular initiatives in the future, given the growth of different social movements, the global health, economic and climate crises and poverty and unemployment, all of which lead people to rethink their practices, choices and access to information. This, in turn, stimulates changes in the behaviours, postures and attitudes of society as a whole.

One limitation of the study was that we interviewed only one respondent from each start-up in the sample, although additional information was gathered from the start-ups' websites and supplementary notes were generated during the data collection. Only interviewing one informant per surveyed organisation may have led to a perception bias associated with the profiles of the surveyed subjects. Even though those surveyed are the entrepreneurs, protagonists and creators of start-ups and who are the key informants, only one subject was interviewed per unit of analysis. There is an opportunity for future studies to develop metrics to measure the levels of circularity supported by disruptive innovations within start-ups, as well as

assessing the impact of the adoption of emerging technologies as an enabler of innovation for circularity.

## ORCID

*Simone Sehnem* https://orcid.org/0000-0002-2416-4881
*Tais Provensi* https://orcid.org/0000-0003-3905-1297
*Tiago Hilário Hennemann da Silva* https://orcid.org/0000-0002-5802-6508
*Susana Carla Farias Pereira* https://orcid.org/0000-0002-3952-7489

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