Circular Economy and Frugal Innovation: Pathways to Advancing the Sustainable Development Goals

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1 Introduction

The capitalist ethic of rampant consumption, established at the height of modernism (Leff, 2008; Matos & Santos, 2018; Silva, 2016; Zanatta Zupelari & Leite Wick, 2015), contributed to the construction of an unprecedented socio-environmental scenario, permeated by global dangers and risks that threaten the resilience of natural ecosystems and the subsistence of species on the planet (Beck, 2010; Silva, 2016; Zanatta Zupelari & Leite Wick, 2015). Factors such as overpopulation, extreme poverty, social inequality, and violence, combined with the expansion of deserts, rising sea levels, biodiversity loss, and soil, water, and air degradation, project a sense of fear and insecurity in contemporary societies (Korhonen et al., 2018; Prabhu, 2017; Zanatta Zupelari & Leite Wick, 2015) and provide evidence that humanity has irreversibly surpassed some of the planetary boundaries that support its existence (Rockström et al., 2009).

The emergence of these challenges is closely related to the unsustainability of the prevailing Linear Economy, whose essence is based on the idea of "take, make, dispose": extracting resources from the environment to manufacture goods; producing merchandise for commercialization; and discarding the waste from this operation (Sariatli, 2017). By disregarding the functioning of Earth as a closed system, linearity contributes to the imminent depletion of natural resources and the accumulation of waste on the planet (Matos & Santos, 2018; Murray et al., 2017; Tilio Neto, 2010).

According to the United Nations Environment Programme, in its most recent report published in 2024, the world's population produces more than 2 billion tons of municipal solid waste annually, without considering the significant amounts of other types of waste (agricultural; construction and demolition; industrial and commercial; and health). Also, according to UNEP (2024), the consumption of natural resources to support the functioning of the global linear economy has increased dramatically. The scale of global extraction of materials is staggering, showing an average annual growth of 2.3%, rising from 30 billion tons in 1970 to a whopping 106.6 billion tons in 2024.

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In this context, the Circular Economy presents itself as a viable alternative to the aforementioned linear model. As a regenerative economic system that redefines the concept of "end of life" for products (Kirchherr et al., 2017; Korhonen et al., 2018; Sariatli, 2017; Upadhayay & Alqassimi, 2018), the Circular Economy enables the internalization of environmental externalities through closed material loops and processes of reduction, maintenance, repair, reuse, remanufacture, refurbishment, and recycling (Geissdoerfer et al., 2017; Kirchherr et al., 2017; Korhonen et al., 2018; Rizos et al., 2017; Sauvé et al., 2016).

In line with circularity, Frugal Innovation proposes a similar approach to addressing the dual problems of resource scarcity and waste generation. This innovation consists of a solution (product, service, process, or business model) designed from a context permeated by constraints (financial, technological, material, or other resources), whose result, despite being significantly more affordable, efficiently meets the basic needs of customers not covered by the current market options (Hossain et al., 2016, 2023). Like the Circular Economy, Frugal Innovation focuses on minimizing the use of natural resources and reducing waste generation from the production process (Pisoni et al., 2018; Rao, 2013; Sariatli, 2017), encouraging the design of simpler, lighter, more efficient, cheaper, robust, and environmentally friendly products (Hossain et al., 2023; Pansera & Sarkar, 2016; Rao, 2013; Weyrauch & Herstatt, 2017).

Given these similarities, there is an established relationship between the Circular Economy and Frugal Innovation. Frugal entrepreneurs contribute to circularity by frequently using discarded or locally abundant raw materials and repurposing existing devices and components to create their businesses (Hossain et al., 2023; Pansera & Sarkar, 2016; Rao, 2013; Rosca et al., 2017). Frugality can thus favor the consolidation of a sustainable and inclusive world, supporting the strengthening of a more circular economy (Herstatt & Tiwari, 2020; Hindocha et al., 2021; Prabhu, 2017).

Despite sharing common points, there are still few studies dedicated to analyzing the affinities and correlations between these two themes (Ezeudu et al., 2022; Fulconis et al., 2019). In the absence of an integrative model, it is therefore opportune to simultaneously study the definitions, characteristics, and attributes of Frugal Innovation and the Circular Economy (Hossain et al., 2023; Yousaf et al., 2022a). Thus, the following research question arises: how can the theoretical-conceptual approaches, intersections, and possibilities between the Circular Economy and Frugal Innovation be analyzed and categorized to contribute to Sustainable Development?

Aiming to enhance academic understanding of the link between Circular Economy and Frugal Innovation, this study proposes to analyze the theoretical-conceptual approaches, intersections, and possibilities established between the two concepts. For this purpose, the integrative literature review method was considered the most appropriate to achieve the proposed objective, as it allows a comprehensive synthesis of various studies published on a topic (Botelho et al., 2011; Fossatti et al., 2019).

To achieve the proposed objective, in addition to this introduction, this work will be divided into three sections: the first encompasses a theoretical discussion on Circular Economy and Frugal Innovation; the second is dedicated to a description of the methodological procedures adopted; and the last presents the results obtained from the data analysis. Finally, the final considerations, main limitations, and suggestions for future research are presented.

2 Theoretical Framework

2.1 Circular Economy: Foundations and Applications

The prevailing Linear Economy (LE) model, whose principles are based on a unidirectional flow of materials and energy between the environment and the human economy (Korhonen et al., 2018), disregards the finite boundaries of the planet and challenges the natural environment's capacity to withstand the current level of resource exploitation (Sariatli, 2017; Sauvé et al.,

2016; Upadhayay & Alqassimi, 2018). Thus, linearity contributes to the destruction of the global natural ecosystem and the generation of a large volume of waste in the environment (Korhonen et al., 2018; Sariatli, 2017).

As an alternative to this model of extraction, production, consumption, and disposal, the Circular Economy (CE) emerges based on the premise of material reuse. In general, besides prolonging the availability of the stock of available resources, CE is committed to permanently increasing the efficiency of the economic system, ensuring the prolonged satisfaction of human needs (Sariatli, 2017).

Due to its cyclical and regenerative approach (Sariatli, 2017; Upadhayay & Alqassimi, 2018), CE is considered a restorative system by nature, and it rests on three basic principles: eliminate waste and pollution; circulate products and materials at their highest values; and regenerate the environment (Ellen MacArthur Foundation, 2023).

Although its popularization began in 1990 with the work of Pearce and Turner on natural resources and the environment, the precursor article of CE was written in 1966. In this pioneering work, the author Boulding mentions closed and open economic systems, advocating for the adoption of a cyclical ecological system instead of a linear one (Sariatli, 2017; Su et al., 2013).

Through closed-loop and cascading approaches, CE helps reduce material losses in the production process and overcome its dependence on material and energy inputs (Murray et al., 2017; Sariatli, 2017). In this economic model, the production process is rethought from the planning and resource acquisition phase to the reprocessing phase to maximize the functioning of the ecosystem and human well-being (Murray et al., 2017).

Within the Circular Economy (CE), materials must follow a continuous flow through two main cycles: the biological cycle, which reinserts the nutrients of biodegradable materials into the biosphere to restore nature through practices such as regeneration, agriculture, composting, cascades, and biochemical raw material extraction; and the technical cycle, where products and materials circulate within the system through techniques such as sharing, maintenance, reuse, redistribution, refurbishment, remanufacturing, and recycling (Ellen MacArthur Foundation, 2023). The Butterfly Diagram (Fig. 1) illustrates the constant movement of materials between the technical cycle (on the right) and the biological cycle (on the left) of the CE.

Replacing the linear economic model—which has persisted since the beginning of the Industrial Revolution until today—with a Circular Economy, although possible and realistic, is not a simple task. This paradigm shift will only be consolidated through the collective commitment of various social actors, who must work synergistically at individual, regional, governmental, and intergovernmental levels to change the current production and consumption patterns (Rizos et al., 2017; Sariatli, 2017; Upadhayay & Alqassimi, 2018).

Moreover, the application of the CE concept lacks specific guidelines for its implementation, resulting in a highly heterogeneous landscape of practical cases. It is observed that circularity affects companies differently across various economic sectors. Therefore, to avoid reductionist interpretations, the adoption of CE must consider all parameters and variables that might be relevant in the process of shifting from linearity to circularity (Ferasso et al., 2020; Rizos et al., 2017; Sariatli, 2017).

Finally, it is worth noting the contribution of CE to the consolidation of Sustainable Development. If successful, circularity encompasses the three dimensions of global liquid sustainability, promoting environmental quality, economic resilience, and social equity for current and future generations (Kirchherr et al., 2017; Sariatli, 2017; Sauvé et al., 2016; Upadhayay & Alqassimi, 2018).

With its emphasis on resource reuse and waste reduction, CE establishes an important foundation for the approach of Frugal Innovation. Like CE, Frugal Innovation aims to optimize resource use but focuses on developing creative and accessible solutions for contexts of constraint. This synergy between CE and Frugal Innovation can be explored to create products and processes that

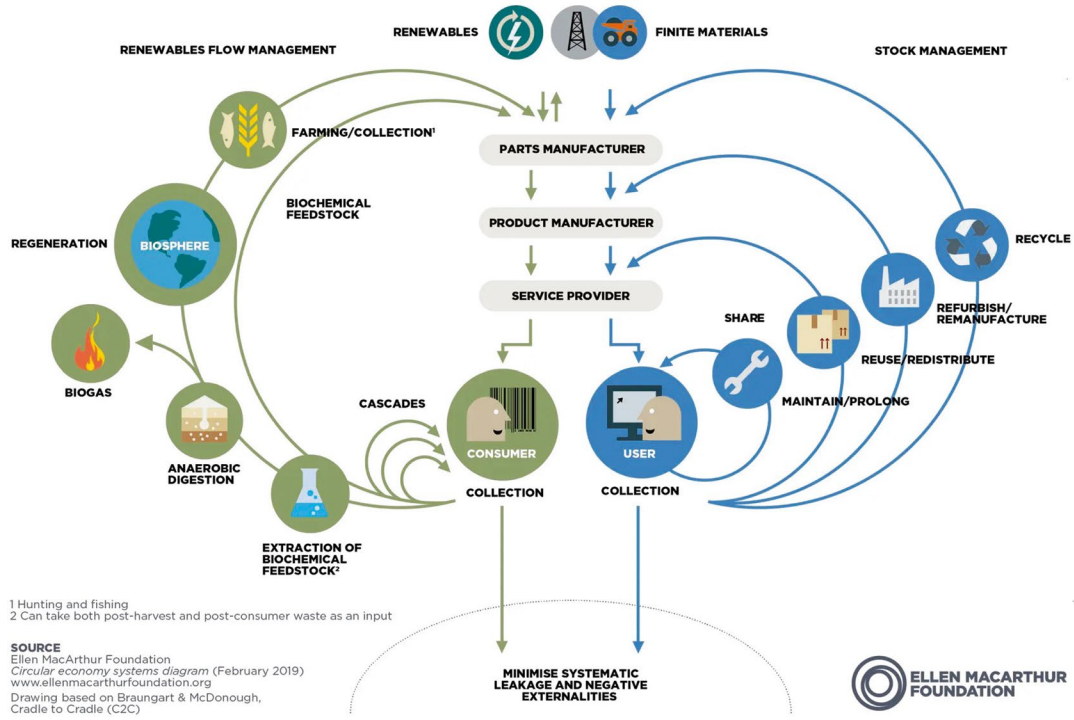

Fig. 1 Systemic diagram of the Circular Economy. Source: Extracted from Ellen MacArthur Foundation (2023)

not only minimize waste but are also tailored to meet the needs of emerging markets and low-income communities. The next section will address how Frugal Innovation complements CE by offering practical strategies to tackle socio-economic and environmental challenges.

2.2 Frugal Innovation: Principles and Social Impacts

Considered a disruptive management approach based on an entirely new value proposition, Frugal Innovation (FI) originates from emerging market contexts—such as India and China—where a large portion of the population has extremely limited purchasing power and a significant range of unmet basic needs (Khan, 2016; Prabhu, 2017; Weyrauch & Herstatt, 2017; Zeschky et al., 2014). In these scenarios of constraints, FI presents itself as a solution (product, service, process, or business model) that is both accessible and efficient in meeting the basic needs of customers who would otherwise remain neglected (Hossain et al., 2016, 2023). In this sense, FI creates consumption opportunities for low-income communities, supporting the design of reasonably priced goods that adequately meet specific demands related to different regional circumstances of poverty and requirement (Brem & Wolfram, 2014; Hossain et al., 2023; Weyrauch & Herstatt, 2017).

For these characteristics, FI supports the development, production, and management of items for the Base of the Pyramid (BoP) market, comprising more than four billion people who survive on less than $2 a day (Brem & Wolfram, 2014; Prahalad, 2012). Despite their financial constraints, the BoP consists of highly diverse and heterogeneous groups, with multiple cultures, ethnicities, literacy levels, capabilities, and needs (Prahalad, 2012), representing a set of opportunities for adopting FI in this context.

Despite the focus on vulnerable populations from emerging economies, FI has also gained relevance in developed economies (Khan, 2016;

Pisoni et al., 2018; Prabhu, 2017; Weyrauch & Herstatt, 2017). Due to contemporary and global challenges such as population growth, uncontrolled greenhouse gas emissions, and the advancement of global warming, rich countries currently face numerous environmental constraints and pressures, increasing the demand for frugal production and consumption models to ensure more efficient resource management (Hossain et al., 2016).

Based on the premise of "doing more with less," FI significantly reduces resource use in the production process (Rosca et al., 2017), meeting the needs of more people with radically fewer resources. That is, it simultaneously promotes the maximization of value and the minimization of resources required to generate that value, whether these resources are financial, natural, or even temporal (Prabhu, 2017). Thus, FI is characterized by the simultaneous presence of three defining criteria: substantial cost reduction; focus on essential product functionalities; and optimized performance level (Weyrauch & Herstatt, 2017).

As a result, products created using frugal techniques are highly innovative. Developed with a focus on essential benefits and basic functionalities, these products are easy to use, lightweight, and simple. Despite this, they are robust, durable, and of high quality. They have a considerably lower purchase price due to reduced production costs. Moreover, they are sustainable and environmentally friendly, causing little environmental intervention (Brem & Wolfram, 2014; Hossain, 2020; Hossain et al., 2023; Rosca et al., 2017; Weyrauch & Herstatt, 2017).

Beyond the perspective of physical products, the application of FI includes innovations in terms of services (health, energy, water, information, communication technologies, etc.) and manifests in different sectors (manufacturing, food, automotive, etc.) and various geographical areas around the globe (Prabhu, 2017; Rosca et al., 2017).

In general terms, FI supports the emergence of quick, effective, and cheaper solutions for individuals affected by poverty who cannot meet their demands through traditional market mechanisms (Hossain et al., 2023; Prabhu, 2017). Additionally, FI creates business opportunities for marginalized people, encourages community involvement through the development of local competencies, and promotes the empowerment of impoverished individuals and disadvantaged classes (Hossain, 2020; Hossain et al., 2023; Rosca et al., 2017).

FI has great potential to generate consistent social impacts, providing quality of life, justice, inclusion, poverty reduction, learning capacity, and many other themes of great relevance to the well-being of human communities (Khan, 2016; Prabhu, 2017; Rosca et al., 2017).

Consequently, Frugal Innovation (FI) directly contributes to achieving the social dimension of Sustainable Development (Fig. 2), as its adoption can strengthen the protection of vulnerable groups, respect for social diversity, and the satisfaction of basic needs such as happiness, security, freedom, dignity, and affection (Khan, 2016). Thus, FI is not just a necessity but a promising tool to ensure the prosperity and well-being of billions of people on a fragile and finite planet (Prabhu, 2017).

However, as a radical and systemic innovation, the adoption of FI requires significant changes at the organizational, sectoral, and global levels. This involves the solid and integrated commitment of various social actors, such as companies, in adopting more circular production practices and using renewable sources of energy and other resources; consumers, in modifying their consumption patterns to be more conscious and responsible; and governments, in creating legal frameworks, regulations, and incentives to support the consolidation of a more frugal and sustainable economy (Hossain et al., 2023; Prabhu, 2017; Rao, 2013).

3 Methodological Procedures

Aiming to analyze the theoretical-conceptual approaches, intersections, and possibilities established between the concepts of Circular Economy and Frugal Innovation, we opted for the integrative literature review method, which provides a comprehensive perception of a particular phenomenon by identifying, analyzing, and syn-

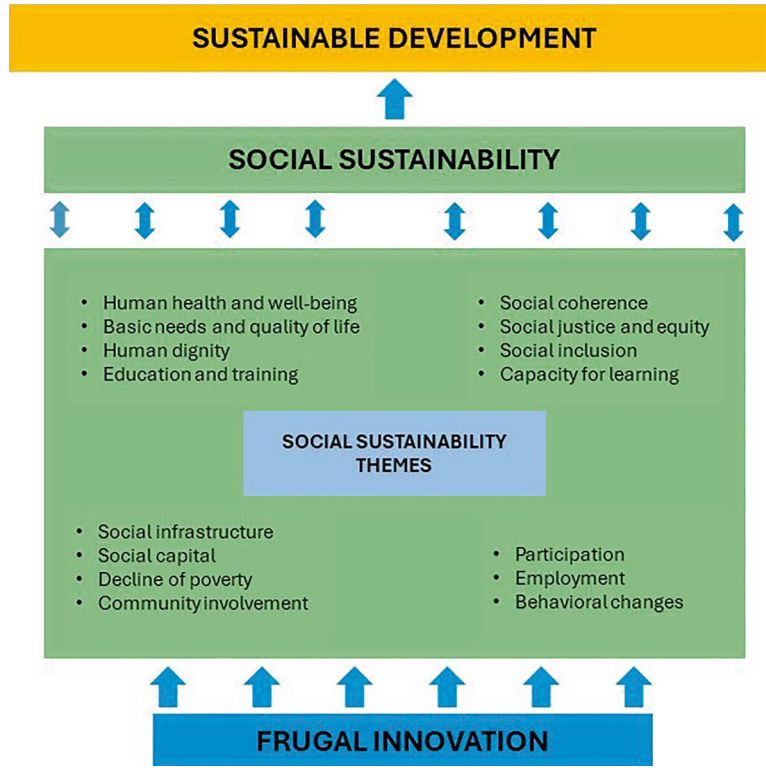

Fig. 2 Connection between Frugal Innovation and Social Sustainability. Source: Based on Khan (2016)

thesizing the research already developed in a specific scientific field (Botelho et al., 2011; Fossatti et al., 2019).

To ensure the transparency and organization of the research process, the protocol of the methodological steps was operationalized according to the recommendations proposed by Botelho et al. (2011): identification of the theme and research question; establishment of inclusion and exclusion criteria; identification of preselected and selected studies; categorization of selected studies; analysis and interpretation of results; and presentation of the knowledge synthesis.

The database was generated in May 2024, based on the search for academic productions indexed on the Web of Science (WoS) and Scopus platforms. From the definition of the research question (What are the theoretical-conceptual approaches, intersections, and possibilities established between the concepts of Circular Economy and Frugal Innovation?), the relevant keywords were defined for the study's objective. Subsequently, the search for these keywords was conducted in the selected databases, resulting in 57 documents, distributed as shown in Fig. 3.

Reading the titles, abstracts, and keywords of the 39 resulting publications allowed the selection of nine articles to compose the final research base, considering the following exclusion criteria: the document does not have free access for full content consultation; and the document does not clearly address the relationship between the concepts of Circular Economy and Frugal Innovation.

The publications in the final base were read in full to recognize the relationships established between Circular Economy and Frugal Innovation in the investigated literature. The analysis and interpretation of the results were developed from the perspective of content analysis (Bardin, 2016), which allowed: identifying the connections between Circular Economy and Frugal Innovation; coding these connections according to their characteristics; and analytically categorizing the common characteristics that interlink the selected fields (Bardin, 2016; Botelho et al., 2011).

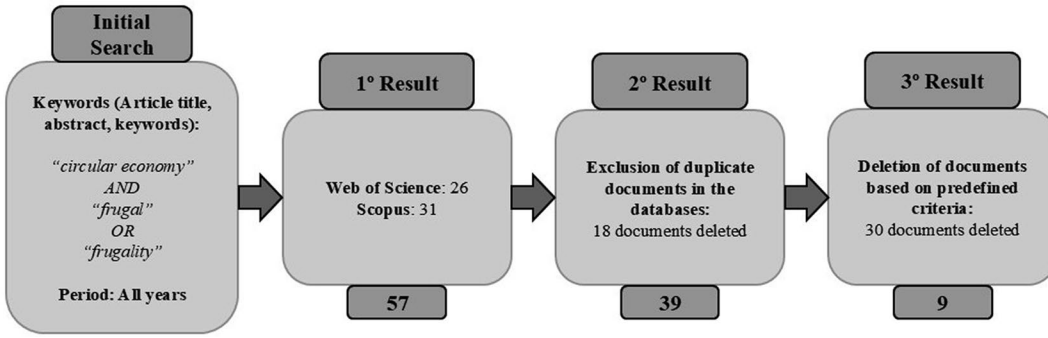

Fig. 3 Research protocol. Source: Based on Botelho et al. (2011)

Table 1 Studies used to investigate the relationship between CE and FI

Artigo	Autor(es/as)	Periódico	Ano
Opportunities of frugality in the post-corona era	Herstatt, C., & Tiwari, R.	International Journal of Technology Management	2020
Black Americans past and present created frugal innovations and embraced circular economy principles: The marketing dilemma	Hamilton, C.	11th Annual Conference of the EuroMed Academy of Business Research Advancements in National and Global Business Theory and Practice	2018
Frugal supply chains: a managerial and societal perspective	Fulconis, F., Pache, G., & Reynaud, E.	Society and Business Review	2019
Value creation through frugal innovation, innovation capability and knowledge sharing in a circular economy	Yousaf, Z., Panait, M., Tanveer, U., Cretu, A., Hrebenciuc, A., & Zahid, S. M.	Sustainability	2022
Organizational innovativeness in the circular economy: The interplay of innovation networks, frugal innovation, and organizational readiness	Yousaf, Z., Mihai, D., Tanveer, U., Brutu, M., Toma, S., & Zahid, S. M.	Sustainability	2022
Innovation strategies and implementation of various circular Economy Practices: Findings from an Empirical Study in France	Arfaoui, N., Le Bas, C., Vernier, M. F., & Vo, L. C.	Journal of Innovation Economics & Management	2023
Sustainable frugal innovation-The connection between frugal innovation and sustainability	Albert, M.	Journal of Cleaner Production	2019
Determinants of the purchase of secondhand products: An approach by the theory of planned behaviour	Rodrigues, M., Proença, J. F., & Macedo, R.	Sustainability	2023
Frugal innovation approaches to sustainable domestic energy: Two cases of solar water heating from Brazil	Busch, H. C., Dauth, T., Fischer, L., & Souza, M.	International journal of technological learning, innovation and development	2018

4 Presentation and Discussion of Results

The evaluation of the theoretical corpus depicted in Table 1 confirms the relationship between Frugal Innovation (FI) and the principles of Circular Economy (CE). In general, the two concepts have a high degree of complementarity, as the overlap of their conceptions generates solutions that simultaneously offer monetary accessibility and meet current environmental preservation requirements (Herstatt & Tiwari, 2020).

In many contexts, FI is understood as an enabling tool for the adoption of CE principles, as frugal innovators apply these principles in their actions at the local level, being considered key elements for promoting circularity (Albert, 2019; Hamilton, 2018). In this sense, FI is seen as an innovation strategy that can significantly contribute to the implementation of a CE (Arfaoui et al., 2023; Fulconis et al., 2019).

The analysis of the presented studies allowed the categorization of the theoretical-conceptual approaches, intersections, and possibilities between CE and FI into four dimensions, which are: (1) solutions to address resource scarcity and overproduction of waste; (2) establishment of new production and consumption models; (3) dependence on the commitment of various social actors; and (4) contribution to the consolidation of Sustainable Development (Fig. 4).

Considering the complexity and subjectivity that permeate the application of these phenomena in their real contexts, it is emphasized that the objective is not to provide a definitive and complete list of these relationships. Therefore, the theoretical model shown above encompasses the relationships most frequently identified in the selected studies between the concepts of CE and FI.

4.1 Solutions to Address Resource Scarcity and Overproduction of Waste

Given the essence of CE and FI, it is not surprising that both concepts provide solutions focused on the efficient management of the planet's available resource stocks. In all the studies of the selected base, there are direct or indirect mentions of the dual problem related to the current scenario of resource constraints and the overproduction of waste arising from the functioning of the modern capitalist system.

The adoption of unsustainable business practices, such as planned obsolescence, is responsible for the rapid depletion of natural resources and the increase in waste levels in the environment (Albert, 2019; Fulconis et al., 2019). In this scenario, CE and FI techniques, based on the cradle-to-cradle principle, can contribute to

Fig. 4 Theoretical-conceptual approaches, intersections, and possibilities between CE and FI. Fonte

resource preservation and waste minimization (Albert, 2019; Fulconis et al., 2019; Hamilton, 2018).

Empirically, frugal innovators engage in various practices related to resource management in CE, such as: reducing waste through recycling or resale; reducing the consumption of materials, energy, and water by reviewing the use of these resources (Albert, 2019; Arfaoui et al., 2023); using recycled raw materials to create new products (Busch et al., 2018); among others.

Converging with this assumption, Hamilton (2018) states that black frugal innovators, during slavery and the post-slavery reconstruction period, implemented circular practices of reduced material and product use, reuse, recycling, redesign, remanufacturing, and repair of old goods.

From the perspective of frugality, CE has, therefore, a real possibility of promoting the functioning of the value chain in a closed loop (Fulconis et al., 2019), providing efficient management of resources and waste throughout the production cycle. This outcome aligns with the propositions of Upadhayay and Alqassimi (2018) and Rosca et al. (2017), who argue that CE and FI are based on the premises of "take, make, and reuse" and "doing more with less," respectively.

4.2 Establishment of New Production and Consumption Models

The current production and consumption patterns outlined under the dominant capitalist paradigm have caused lasting and irreparable damage to the environment (Herstatt & Tiwari, 2020). Thus, there is a need to radically rethink the functioning of the current economic model to implement a profound change in the relationships established between Nature, Economy, and Society (Arfaoui et al., 2023).

The considerable increase in meetings (international, national, regional, or local) between representatives of various social sectors to reconsider the functioning of the economic system in recent decades provides significant evidence that contemporary production and consumption patterns need to be reviewed. In this scenario, a collective awareness related to the development of a new economic model based on circular principles has emerged to allow a more frugal use of available resources (Fulconis et al., 2019).

From this perspective, CE and FI, by considering Nature as a relevant stakeholder in business operations, present themselves as precursors of a new techno-organizational paradigm, offering a push for humanity to advance on the path of sustainable evolution (Arfaoui et al., 2023; Fulconis et al., 2019).

Frugal and circular business models, in addition to redefining and weakening the idea of ownership (Herstatt & Tiwari, 2020), reshape the conventional conception of product and service creation aiming to minimize resource use and effectively and ecologically meet consumer needs (Herstatt & Tiwari, 2020).

4.3 Dependence on the Commitment of Various Social Actors (Consumers, Companies, and Governments)

The paradigm shift described in the previous section will only be realized through the commitment of various social actors (Arfaoui et al., 2023). In this regard, the actions and behaviors of consumers, companies, and political representatives are central to the process of establishing an economy based on frugal and circular principles. This outcome is corroborated by other studies developed separately in the fields of CE and FI, such as Hossain et al. (2023), Prabhu (2017), Rao (2013), Rizos et al. (2017), Sariatli (2017), and Upadhayay and Alqassimi (2018).

From the consumer perspective, the authors point out that a mentality of voluntary simplicity has emerged in certain social segments. Satisfying

the requirements of this simplicity, frugality tends to become a global megatrend, as it provides the creation of products, services, technologies, and business models that are financially accessible and ecologically responsible (Herstatt & Tiwari, 2020). Frugality, therefore, corresponds to a new lifestyle, related to sustainable behaviors and conscious consumption (Hamilton, 2018; Herstatt & Tiwari, 2020; Rodrigues et al., 2023).

In the current scenario of resource constraints, the consumer is a dynamic actor (Fulconis et al., 2019), needing to adopt practices of waste sorting, using recycled products, etc. Their purchase, consumption, and disposal decisions should prioritize simple and functional solutions, aligning with a frugal lifestyle that is more responsible towards the environment and other human beings. This frugal lifestyle is highly compatible with the concept of CE, as it simultaneously promotes good resource utilization and waste minimization (Fulconis et al., 2019; Herstatt & Tiwari, 2020).

Given the changes evident on the demand side, companies need to adopt balanced postures and adjust their operations towards circular production based on a frugal logic of closed-loop supply (Fulconis et al., 2019; Rodrigues et al., 2023). Thus, frugal entrepreneurs need to promote institutional redesign (Fulconis et al., 2019; Yousaf et al., 2022a, b), ensuring the financial, social, infrastructural, and ecological accessibility of their goods (Busch et al., 2018; Fulconis et al., 2019; Herstatt & Tiwari, 2020).

In the context of supply, skills such as improvisation, creative thinking, and frugal innovation, in addition to strengthening the value creation of these new products and services (Yousaf et al., 2022b), help to break away from the traditional linear production paradigm and favor the establishment of CE principles (Fulconis et al., 2019; Hamilton, 2018; Yousaf et al., 2022b).

From a governmental standpoint, political actors are responsible for driving the transformation of patterns in the current economic system to ensure the conservation of natural resources (common goods) for the benefit of future generations (Fulconis et al., 2019). This process involves regulating the legal-normative framework that addresses CE and FI (Herstatt & Tiwari, 2020) and creating public policies that encourage the use of circular and frugal practices and penalize unsustainable business behaviors (Fulconis et al., 2019; Hamilton, 2018; Herstatt & Tiwari, 2020).

4.4 Contribution to the Consolidation of Sustainable Development

Confirming the studies of Geissdoerfer et al. (2017), Kirchherr et al. (2017), Korhonen et al. (2018), Murray et al. (2017), and Khan (2016), both CE and FI contribute, each in their own way, to the consolidation of Sustainable Development in its three dimensions (Arfaoui et al., 2023; Fulconis et al., 2019; Herstatt & Tiwari, 2020).

Generally, in the environmental dimension, CE reduces the extraction of virgin materials, energy use, and waste emissions in the production system (Korhonen et al., 2018); in turn, FI minimizes the use of resources (raw materials, energy, fuel, water, waste) and the adoption of fossil fuels in the creation of green products, maximizing energy and material efficiency in the production cycle (Albert, 2019; Busch et al., 2018; Herstatt & Tiwari, 2020).

In the economic dimension, CE reduces costs related to the acquisition of raw materials and energy, waste management, compliance with environmental regulations, and increases revenues related to public image and the possibility of opening new businesses (Korhonen et al., 2018); FI, on the other hand, strengthens business competitive advantage and provides greater productivity and cost reduction per unit related to the processes of acquisition, production, and distribution (Albert, 2019).

In the social dimension, CE promotes job creation, encourages participatory democracy, and enables the efficient use of existing material capacity by strengthening the cooperative and communal use of values, services, and functions, rather than the use of physical products (Korhonen et al., 2018); FI, in turn, promotes justice and social equity, fosters the development of disad-

vantaged communities (by meeting their basic needs, training, and creating job opportunities), alleviates hunger and global poverty, stimulates more democratic management mechanisms, and contributes to the inclusion of marginalized populations, improving quality of life and positively affecting the well-being of these populations (Albert, 2019).

Despite the correspondences identified between CE and FI regarding their potential to contribute to the achievement of the three dimensions of Sustainable Development, it is noted that most studies in the field of CE focus only on the results concerning the environmental dimension (Geissdoerfer et al., 2017; Kirchherr et al., 2017; Murray et al., 2017), while in the field of FI, the impacts reported by the authors are more related to the social pillar (Albert, 2019; Hamilton, 2018), rather than addressing a holistic view of the triad of dimensions.

Given this gap, future researchers should dedicate themselves to investigating the human and social dimensions of CE, as well as deepening the knowledge of the ecological benefits of FI, through a significant reexamination of consolidated theory and the adoption of innovative research practices (Albert, 2019; Murray et al., 2017). In this sense, studies related to FI can add relevant contributions to the field of CE, as this innovation directly contributes to achieving social sustainability (Khan, 2016).

4.5 Research Theoretical Findings

The research provides new insights for Circular Economy (CE) and Frugal Innovation (FI) from its theoretical findings, showing both connections and synergies between CE and FI.

Synergies between Circular Economy and Frugal Innovation: The study found that CE and FI ethos align in their ultimate aims of minimizing resource needs, waste production, and promoting sustainability. Finally, they both highlight the need for the involvement of various social actors, proposing innovative models of production and consumption to solve socio-environmental problems.

Relevance for CE of the Research: The research provides a more in-depth insight into the synergies with FI and the need for innovative and accessible approaches offerings to facilitate the transition to a circular economy. From a theoretical perspective, the findings shed light on the extent to which frugality intersects with and reinforces CE principles, behaviors and practices towards enhancing the solutions and viability of circular initiatives.

Significance of the research for frugal innovation: The research highlights the value of frugal innovation by showing how CE principles can be incorporated to make frugal innovation more impactful and scalable. The research provides a reference of how frugal innovation strategies can be enhanced with circularity elements towards more inclusive and sustainable approaches by highlighting the interrelations between both concepts.

Filling Research Gaps: Besides, the research expands the research existing understanding by serving a four-dimensional theoretical model classifying link between CE and FI. The model outlines an integrated approach to sustainability that is never without its challengers but serves as a path for researchers, practitioners, and policymakers who are interested in advancing integrated sustainability practice.

In conclusion, the study provides an overview of various links between Circular Economy and Frugal Innovation in terms of commonalities, the importance of both concepts, and the necessary conditions which may allow Circular Economy and Frugal Innovation to coincide. By analyzing and engaging with these interactions, the research furthers the theoretical and practical development of both subjects, informing a path towards a just and resilient future.

5 Conclusion

The objective of this research was to analyze the theoretical-conceptual approaches, intersections, and possibilities established between Circular Economy (CE) and Frugal Innovation (FI). To achieve this, it was necessary to undertake a com-

prehensive synthesis of the scientific contributions developed around the topics of interest, which was operationalized through the integrative literature review method (Botelho et al., 2011).

The analysis of the studies selected to compose the final base allowed the categorization of the relationships between Circular Economy and Frugal Innovation into four dimensions, in which it is found that the two concepts (1) provide solutions to address resource scarcity and overproduction of waste; (2) establish new models of production and consumption; (3) depend on the commitment of various social actors; and (4) contribute to the consolidation of Sustainable Development.

Firstly, the study contributes to organizational theory by providing a systematic and aggregative grouping of the identified links between the concepts of Circular Economy and Frugal Innovation, responding to calls in the literature that indicated the need to explore this interface (Hossain et al., 2023). Thus, it offers a holistic understanding of the interrelationship between the investigated phenomena, presenting a theoretical model that can be useful to academics and future researchers.

In terms of practical contributions, the panoramic delimitation of the similarities between the concepts of Circular Economy and Frugal Innovation benefits two groups: political representatives, who, by becoming aware of the similarities between the themes, can propose the creation of public policies and regulations that simultaneously promote the adoption of frugal innovations and the implementation of circular production chains; and the entrepreneurs themselves, who can strengthen the sustainability of their solutions by implementing frugal and, at the same time, circular production techniques.

Among the limitations of the study, the use of only two international databases and the small number of studies used to compose the theoretical model stand out. Therefore, it is suggested that future work be operationalized based on documents from diverse repositories, which may provide an increase in the scope of the literature and allow for a greater apprehension of the interactions between the examined phenomena. Moreover, conducting empirical studies that identify Circular Economy practices in real Frugal Innovation initiatives can offer a comparative framework that confirms or rectifies the findings of this research.

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