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# EVALUATION OF REVERSE LOGISTICS SECTORAL AGREEMENTS AS MECHANISMS FOR PROMOTING THE CIRCULAR ECONOMY

*AVALIAÇÃO DOS ACORDOS SETORIAIS DE LOGÍSTICA REVERSA COMO MECANISMOS DE PROMOÇÃO DA ECONOMIA CIRCULAR*

*EVALUACIÓN DE LOS ACUERDOS SECTORIALES DE LOGÍSTICA INVERSA COMO MECANISMOS DE FOMENTO DE LA ECONOMÍA CIRCULAR*

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## ABSTRACT

The National Solid Waste Policy (PNRS) and Reverse Logistics (RL) are aligned with the principles of the Circular Economy (CE). However, this study aims to assess whether the Sectoral Agreements (SA) for Waste Reverse Logistics, provided in PNRS, contribute to the development of a more circular economy. Firstly, it was necessary to define the foundations of CE through a systematic review of other reviews. After analyzing 36 articles, it was possible to describe 9 CE themes related to life cycle, resource use, design and waste recovery. The SAs were evaluated to determine whether they aligned with the themes or not. The results show that the Agreements comply with the legislation in terms of stakeholder responsibility, but do not favor CE. The one that came closest to EC CE was the Agreement of lubricant oil packaging, by introducing recycled material into the manufacture of new products. There is plenty of room for improvement in SAs to make the reverse waste cycle more circular, such as industrial symbiosis, eco-design, life cycle extension and circular business models.

## RESUMO

*A Política Nacional de Resíduos Sólidos (PNRS) e a Logística Reversa (LR) estão alinhadas aos princípios da Economia Circular (EC). No entanto, este estudo tem como objetivo avaliar se os Acordos Setoriais (EA) para Logística Reversa de Resíduos, previstos na PNRS, contribuem para o desenvolvimento de uma economia mais circular. Primeiramente, foi necessário definir os fundamentos da EC por meio de uma revisão sistemática de outras revisões. Após a análise de 36 artigos, foi possível descrever 9 temas de EC relacionados a ciclo de vida, uso de recursos, design e recuperação de resíduos. Os EAs foram avaliados para determinar se estavam alinhados ou não aos temas. Os resultados mostram que os Acordos atendem à legislação em termos de responsabilidade dos stakeholders, mas não favorecem a EC. O que mais se aproximou da EC EC foi o Acordo de embalagens de óleo lubrificante, ao introduzir material reciclado na fabricação de novos produtos. Há muito espaço para melhorias nos EAs para tornar o ciclo reverso de resíduos mais circular, como simbiose industrial, ecodesign, extensão do ciclo de vida e modelos de negócios circulares*

## RESUMEN

*La Política Nacional de Residuos Sólidos (PNRS) y la Logística Inversa (LR) están alineadas con los principios de la Economía Circular (EC). Sin embargo, este estudio tiene como objetivo evaluar si los Acuerdos Sectoriales (AS) para la Logística Inversa de Residuos, previstos en el PNRS, contribuyen al desarrollo de una economía más circular. En primer lugar, fue necesario definir los fundamentos de la EC a través de una revisión sistemática de otras revisiones. Después de analizar 36 artículos, fue posible describir 9 temas de EC relacionados con el ciclo de vida, el uso de recursos, el diseño y la recuperación de residuos. Los AS se evaluaron para determinar si se alineaban con los temas o no. Los resultados muestran que los Acuerdos cumplen con la legislación en términos de responsabilidad de las partes interesadas, pero no favorecen la EC. El que más se acercó a la EC fue el Acuerdo de envases de aceite lubricante, al introducir material reciclado en la fabricación de nuevos productos. Hay mucho margen de mejora en los AS para hacer que el ciclo inverso de los residuos sea más circular, como la simbiosis industrial, el ecodiseño, la extensión del ciclo de vida y los modelos comerciales circulares.*

## INTRODUCTION

The perception of a consumerist lifestyle and its consequences has gained momentum with global discussions about holding individuals and companies accountable for their consumption practices (Bauman, 2022). According to Godecke et al. (2013), a defining characteristic of today's society is the creation of "needs" through the stimulation of individuals towards consumption practices; people end up spending financial resources to buy the promised "benefits." In this way, consumption and disposal happen quickly and successively, increasing the use of natural resources and waste production.

This linear production model, consume-discard, began during the Industrial Revolution in the 17th century, when environmental limits and the long-term damage being inflicted on society were ignored (Pietro-Sandoval et al., 2018). This process resulted in increased waste production, which is closely linked to the growing consumption of non-durable and disposable goods, combined with the accelerated process of population concentration in urban centers (Lima, 2015). In Brazil, according to the Brazilian Waste and Environment Association (Associação Brasileira de Resíduos e Meio Ambiente [ABREMA], 2023), there was a 1% increase in the rate of Municipal Solid Waste (MSW) generation from one year to the next, corresponding to nearly 7 million additional tons of waste.

In Brazil, an important milestone in this final stage of the product life cycle is the National Solid Waste Policy (PNRS), established by Law No. 12.305/10 (Brasil, 2010). According to Baldim et al. (2020), the PNRS has led to improvements in solid waste management, increased recycling rates, and established more waste sorting facilities and recycling cooperatives. It has also driven sustainable development by generating income, reducing pollution, and mitigating environmental impacts.

One of the key innovations introduced by the PNRS was the concept of shared responsibility for the product life cycle. This concept applies to all parties involved in the product life cycle, from manufacturers to final consumers, and is expressed through the Reverse Logistics (RL) instrument. Specifically, the PNRS addresses the obligation for manufacturers, importers, distributors, and retailers in their respective sectors to structure and implement Reverse Logistics Systems (RLS), ensuring the return of products after consumer use. This process must take place independently of public urban cleaning services and solid waste management (Brasil, 2010).

The concept of shared responsibility reflects and expands upon a principle of environmental law, known as Extended Producer Responsibility (EPR). According to Banguera et al. (2018), EPR refers to a producer's responsibility for a manufactured good, extended to the post-consumption stage of the product's life cycle. While EPR specifically focuses on producers, holding them accountable for managing products until the end of their useful life, shared responsibility distributes this accountability among all actors involved throughout the product life cycle.

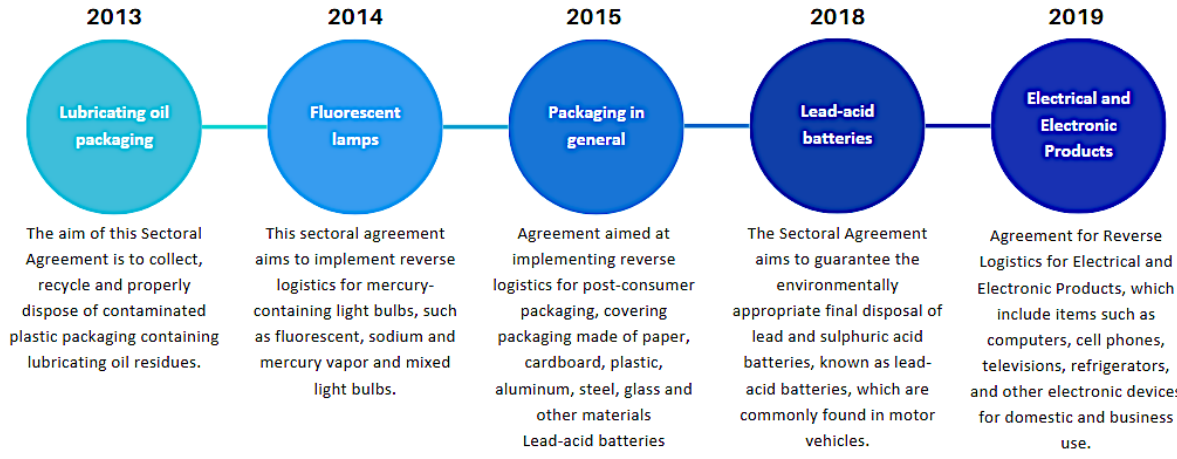
According to Milios (2018), the product life cycle can be divided into three parts: production or product design, which determines the amount of natural resources used and the environmental impact of the product throughout its useful life; the use or consumption phase, during which the product is utilized by the final consumer, which can significantly affect its durability; and the end of life or waste phase, in which the focus is on waste management, including disposal, recycling, and material recovery.

The Circular Economy (CE) emerges as an alternative to this linear production model, replacing current flows with new circular flows. CE aims to keep products, components, and materials at their highest level of utility and value over time, ultimately seeking to decouple economic development from the consumption of finite resources and to eliminate negative externalities from the economy (Ellen MacArthur Foundation [EMF], 2017).

Kim et al. (2018) identify similarities between the concept of CE and the PNRS, noting that PNRS is the Brazilian public policy that most closely encourages the transition to this new economic model, promoting efficiency and effectiveness in solid waste management. According to Cosenza et al. (2020), it aligns with the principles of CE by promoting the reuse, repair, and renewal of materials and energy.

Reverse logistics is essential for the success of the CE, as it allows materials to be returned to the production cycle. The PNRS has encouraged the implementation of RL practices in companies, thus supporting a transition to this CE model (Hernández & Bitencourt, 2024). The regulation of this reverse logistics is carried out through Sectoral Agreements, which are "contractual acts signed between the Public Authorities and manufacturers, importers, distributors, or retailers, aimed at implementing shared responsibility for the product life cycle" (Brasil, 2022) (Figure 1).

**Figure 1**. Timeline of sectoral agreements signed since the promulgation of PNRS




Source: Authors (2024)

The Sectoral Agreement (SA) establishes national targets for recovery through RL. This means that companies must understand and evaluate the life cycle of their products, determining the best way to implement the reverse flow of these materials, identifying consumer participation methods, and assessing the social and economic impacts of RL implementation (Brasil, 2022).

From the context, it is evident that the PNRS and RL are aligned with the CE. However, this study aims to assess whether the Sectoral Agreements contribute to the development of a more circular economy. To guide the discussions, this article is divided as follows: first, it was necessary to define what CE is, understand its relationship with RL, and finally, determine whether and how the Sectoral Agreements can serve as instruments of this new economic model; the methodology employed to determine the evaluation criteria for the SAs; the results of the evaluation of the Agreements and a discussion of their structure; and finally, considerations on the implications of the findings.

## THEORETICAL FOUNDATIONS

### Reverse Logistics and Sectoral Agreements

Aiming to regulate waste management, the PNRS establishes integrated tools for shared management throughout the entire life cycle of products. Reverse Logistics (RL) stands out as an instrument of economic and social development, characterized by a set of actions, procedures, and means aimed at enabling the collection and return of solid waste to the business sector for reuse, either within its own production cycle or in other production cycles, or for another environmentally appropriate destination (Brasil, 2010).

RL is focused on the logistical aspects of returning post-sale and post-consumer goods to the business and/or production cycle. According to Mota et al. (2023), RL fosters a collective responsibility among all links in the product life cycle, mitigating the environmental and social impacts resulting from improper waste disposal. In general, to implement RL, companies must evaluate the life cycle of their products and determine the best way to execute the reverse flow of these materials.

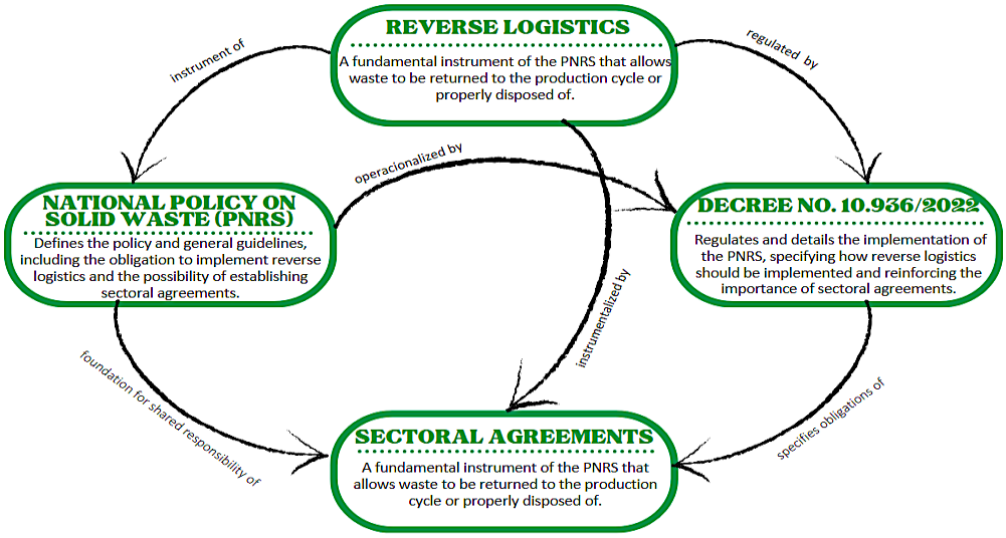
This approach, which involves the life cycle, seeks to integrate economic, social, and environmental aspects in a balanced way, promoting a positive impact across all these dimensions. By reassessing the life cycle of its product to enable RL, a company could rethink the linear "cradle-to-grave" production model, increasing the possibilities for implementing a restorative economy (Assunção, 2019).

The SAs are the legal instruments that support this practice at the national level and are regulated by the National Decree 10.936/2022. The Decree establishes the description of the life cycle stages in which the reverse logistics system operates, defines the forms of consumer participation, and assesses the social and economic impacts of the implementation of reverse logistics, ensuring that the system is comprehensive and transparent (Brasil, 2022). Additionally, the business sector that is part of the sectoral agreement will be subject to the penalties provided for in the agreement in the event of non-compliance (Brasil, 2022). Figure 2 summarizes the relationship between current legislation and Reverse Logistics Agreements.

Each SA has its own particularities depending on the cycle it covers. For example, the SA for Electrical and Electronic Products and Home Appliances includes disassembly and recycling as part of the destination process. In contrast, the Agreement for Fluorescent Lamps focuses only on decontamination and recycling. Another distinguishing feature is the parties involved and the role of the consumer as part of the shared responsibility for the product life cycle. In the SA for general packaging, the consumer plays a more active role, which includes proper sorting

and disposal. Meanwhile, in the Agreement for lead-acid batteries, the consumer's role is to return the waste to specific collection points, typically at the stores where the batteries are sold (Figure 2).

**Figure 2**. The relationship between reverse logistics, sectoral agreements, and legal instruments




Source: Authors (2024)

In the SAs, there is also the role of managing entities. These entities are responsible for the implementation, management, and monitoring of reverse logistics systems. These systems include the collection, sorting, and proper disposal of post-consumer waste. According to Guarnieri et al. (2020b), managing entities are also responsible for coordinating stakeholders, managing and monitoring activities, providing support and incentives, and promoting environmental education (Table 1).

**Table 1**. Compiled data on the sectoral agreements, which are essential for assessing their alignment with the CE

| Sectoral Agreement | Involved Parties | Covered Life Cycle Stages | Final Destination Method | Managing Entity | Consumer Participation Method |
|---|---|---|---|---|---|
| **Lubricant Oil Packaging** | Manufacturers, importers, distributors, retailers, government | Collection and recycling of post-consumer packaging | Decontamination and recycling | Instituto Jogue Limpo | Return used packaging at Voluntary Delivery Points (PEVs) |
| **Fluorescent Lamps** | Manufacturers, importers, distributors, retailers, government | Collection and recycling of mercury-containing lamps | Decontamination and recycling | Recicle | Return lamps to specific collection points |
| **General Packaging** | Manufacturers, importers, distributors, retailers, cooperatives, and government | Collection and recycling of post-consumer packaging (paper, plastic, glass, etc.) | Recycling in production cycles | Coalizão Embalagens | Properly sort and dispose of at voluntary delivery points or through selective collection |
| **Lead-Acid Batteries** | Manufacturers, distributors, retailers, cooperatives, and government | Collection, recycling, and disposal of used batteries | Lead recycling and acid neutralization | Associação Brasileira de Recicladores de Baterias Automotivas e Industriais (ABRABI) | Return batteries to specific collection points |
| **Electronic Products** | Manufacturers, importers, distributors, retailers, and government | Collection, recycling, and disposal of electronic products | Disassembly, material recovery, and recycling | Green Eletron e Associação Brasileira de Reciclagem de Eletroeletrônicos e Eletrodomésticos (ABRAEE) | Return electronic products to collection points or participating stores |

Source: Authors (2024)

## Circular Economy

CE is an economic model that seeks to maximize resource use and minimize waste generation (Deutz, 2020). Its central proposal revolves around the reduction, reuse, and recycling of materials, creating a closed-loop system (Heshmati, 2017; Kirchherr et al., 2017). The goal of CE is to integrate economic activities with environmental preservation (Murray et al., 2017), standing out for promoting economic prosperity alongside environmental quality (Kirchherr et al., 2017). However, there is no single, widely accepted definition of the concept, which leads to varying interpretations among experts and professionals in the field (Kirchherr et al., 2017).

Kirchherr et al. (2023), after evaluating 114 definitions of CE, propose the concept of "an economic system that replaces the 'end-of-life' concept by reducing, reusing, recycling, and recovering materials in alternative ways in production/distribution and consumption processes." This concept operates at the micro level (products, companies, and consumers) and at the macro level (city, region, or nation), with the goal of achieving sustainable development, "simultaneously creating environmental quality, economic prosperity, and social equity, for the benefit of present and future generations" (Kirchherr et al., 2017, p. 229).

CE incorporates elements from other approaches, such as industrial ecology and life cycle analysis (Deutz, 2020). Pietro-Sandoval et al. (2018) state that CE is not a one-size-fits-all solution to sustainability problems, but it represents the most advanced manifestation of the new economic paradigm, marking the transition from a linear economy.

According to Heshmati (2017), CE is considered a sustainable development strategy, although it does not adequately address social dimensions (Murray et al., 2017), and it is more common in developed countries, relying on robust policy guidelines (Deutz, 2020; Heshmati, 2017). Pietro-Sandoval et al. (2018) state that the implementation of CE depends on the interaction between three determinants of eco-innovation: regulation and policies, supply and demand (production and consumption), and interdependence.

## Reverse logistics for a Circular Economy

According to Oliveira et al. (2023), EPR assigns producers the obligation to ensure that their products are collected, recycled, or disposed of in an environmentally responsible manner, and one of the most common ways to implement this is through reverse logistics systems. As a principle, EPR guides the formulation of environmental policies by holding producers accountable for the impact of their products throughout their entire life cycle, including the disposal phase.

EPR, including Reverse Logistics, functions as a mechanism that transforms responsibility for the product life cycle into a sustainable practice, ensuring that materials are not simply discarded but reintegrated into the production cycle, protecting the environment and promoting the circular economy (Demajorovic & Massote, 2017). RL enables products to be returned to the production cycle, whether through material recycling, component reuse, or product remanufacturing, which can recover the value of resources invested in the initial production and reduce the need for virgin raw materials. This aligns with the concept of a circular economy, which seeks to transform waste into new resources (Mallick et al., 2023).

Sehnem and Pereira (2019) highlight CE as an intentionally regenerative industrial system that aims to keep materials and products in circulation for as long as possible. RL is one of the key tools that allow materials and products to return to the production cycle, directly aligning with the principles of the circular economy (Sehnem & Pereira, 2019).

Montag (2023) and Oliveira et al. (2017) assert that closed-loop supply chains are the foundation of a circular supply chain, and that RL is crucial in this process. According to Guarnieri et al. (2020a), RL can be interpreted as a tool of CE. Dimitrova and Gallucci (2017) emphasize that the concepts of CE and RL are moving in the same direction.

According to Geisendorf and Pietrulla (2018), although the need to organize functioning return systems is obvious in a CE, the literature is still in its early stages in discussing RL for the full operation of this new economic model. Julianelli et al. (2020) state that, from a holistic perspective, RL is a driving force for circularity in supply chains that enables CE, promoting potential value creation and opportunities for innovation in business models. By adopting CE as a tool for sustainable development, RL provides an overarching view that governments should consider when formulating RL policies (Julianelli et al., 2020).

In the field of RL, studies have found that there is a reduction in costs associated with final waste disposal, production costs, and negative environmental impacts, all linked to the implementation of a reverse logistics system in Brazil (Bouzon et al., 2016; Pereira et al., 2017; Oliveira et al., 2018; Guarnieri et al., 2020b). Cerqueira-Streit and Guarnieri (2023) emphasize that, although Brazil does not yet have specific legislation for the circular economy, a path is being developed, driven by recent public policies focused on solid waste management, creating a more favorable environment for its implementation in the country.

## METHODOLOGY

The selection of the articles that constituted the analysis of CE topics followed a process of database search, coding, and theme definition. Initially, the Scopus database was used, focusing on articles related to CE concepts. The search was restricted by the keyword "circular economy" in the title, limited to the last 10 years, and included only peer-reviewed articles.

Even with these criteria, there was a significant volume of published articles in the area. To narrow the focus towards the scope, the keyword "literature review" was included. The aim of evaluating only reviews was to assess the aggregated concepts presented by the authors, thus incorporating a range of perspectives from various other authors. This approach is referred to as a synthesis of systematic reviews, which encompasses reviews on the same topic derived from a systematic search of the literature (Pieper et al., 2012). According to Pollock et al. (2023), this type of work is valuable for addressing a new question that was not the focus of previous systematic reviews.

Thus, review articles that address definitions and conceptualizations of CE were included. Articles that discussed circular economy practices at the company (micro) or sector (meso) levels were excluded, as they were not aligned with the objective; only articles that discussed CE at the macro level (regions, countries, policies) were included.

From the selected articles, the process moved to coding. In this stage, relevant information was extracted, meaning that specific sections of the texts were marked or highlighted. For example, if an article discussed waste reuse or industrial symbiosis, those sections were marked and tabulated.

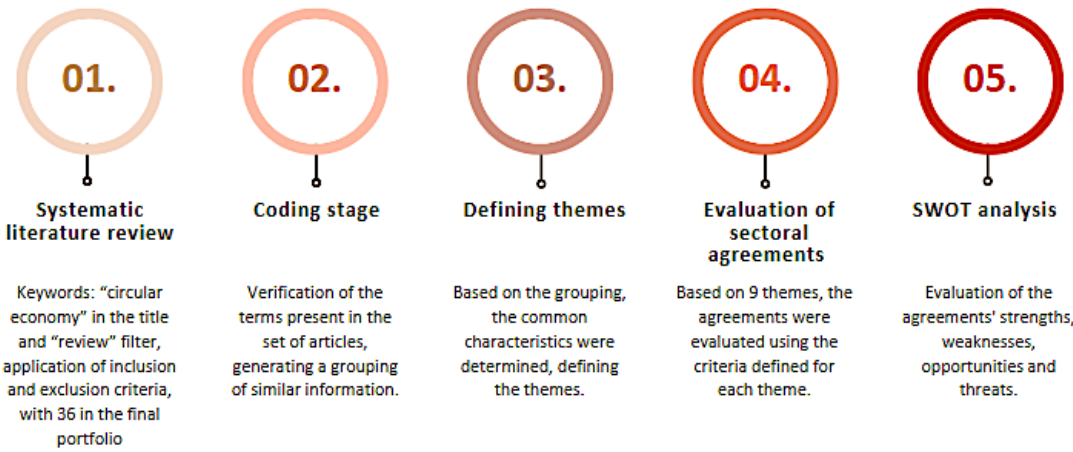
After this coding process, an analysis was conducted to identify emerging themes from the codes. It was observed that several articles mentioned the importance of closing material loops through recycling and reuse, leading to the identification of the theme "Closed Material Loops." Similar or related codes were grouped together to form larger themes. For example, codes related to recycling, remanufacturing, and reuse were grouped under the theme "Closed Material Loops."

The identified themes were refined, combined, or subdivided to better reflect the content of the articles. The theme "Innovation," for instance, was initially too broad, but, after review, was subdivided into "Innovation" and "Circular Business Models," focusing specifically on innovative practices that promote circularity. Finally, with the themes defined, they are presented along with their description and the criteria used to evaluate the Sectoral Agreements.

The final step was the SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats). SWOT analysis is a strategic planning tool used to assess an organization to build a strategy for it, dividing the analysis into two environments: internal and external (Bona et al., 2023). According to Ferreira et al. (2019), SWOT analysis is especially used to assist in the development of strategies and can be applied in various situations. Its main advantages are reduced costs, flexibility, integration, collaboration, and simplicity, as it does not require extensive training or technical skills for successful use.

According to Bozzini and Schalch (2022), this matrix describes "strengths" as internal, controllable variables; "weaknesses" are also internal, controllable variables that create unfavorable conditions for the organization. In the external environment, "opportunities" and "threats" are uncontrolled and often unpredictable variables for the organization, with "opportunities" being positive aspects and "threats" being negative factors that the organization needs to address to avoid or neutralize (Bozzini & Schalch, 2022) (Figure 3).

**Figure 3.** Graphical representation of each stage of methodology




Source: Authors (2024)

## RESULTS AND DISCUSSION

### Definition of circular economy themes

From this data, it becomes evident that there is an extensive analysis of various sources, all compiled within these articles. With this dataset from the 36 articles, it is possible to determine the most important factors when evaluating CE, allowing the establishment of themes (Table 2).

**Table 2.** Methodological details of the selected articles

| Authors | Methodology used by the articles |
|---|---|
| Alcalde-Calonge et al. (2022) | Bibliometric analysis of 5,819 documents |
| Alhawari et al. (2021) | Systematic literature review of 91 articles |
| Anaruma et al. (2022) | Systematic literature review of 1,396 articles |
| Arruda et al. (2021) | Systematic review of 46 articles with over 100 citations |
| Blomsma & Brennan (2017) | Narrative approach and conceptual analysis of articles |
| Friant et al. (2020) | Critical literature review of 107 articles |
| Castro et al. (2022) | Systematic literature review of 59 articles |
| Corona et al. (2019) | Literature review of 60 articles on circularity metrics |
| Corvellec et al. (2022) | Critical literature review of nearly 100 publications |
| Geissdoerfer et al. (2017) | Conceptual review of 67 articles |
| Ghisellini et al. (2016) | Literature review of 155 articles |
| Goyal et al. (2021) | Bibliometric analysis of 2,279 articles |
| Halog e Anieke (2019) | Systematic review of 70 articles |
| Harris et al. (2021) | Narrative literature review of 136 articles |
| Helander et al. (2019) | Literature review of 354 articles |
| Homrich et al. (2018) | Literature review of 327 articles on circular economy |
| Kalmykova et al. (2018) | Extensive literature review of 118 documents |
| Khan et al. (2022) | Systematic review of 91 articles |
| Kirchher et al. (2017) | Analysis of 221 definitions of circular economy |
| Kirchher et al. (2023) | Literature review of 114 concepts of circular economy |
| Koval et al. (2024) | Analysis of circular economy policies in 27 countries |
| Kuzma et al. (2022) | Systematic literature review of 125 articles |
| Lahane et al. (2021) | Systematic literature review of 587 articles |
| Marrucci et al. (2019) | Systematic literature review of 35 articles |
| Melo et al. (2022) | Systematic literature review of 29 articles |
| Merli et al. (2018) | Systematic literature review of 565 articles |
| Mhatre et al. (2021) | Systematic literature review of 455 articles |
| Milios (2018) | Quantitative study on circular economy policies |
| Millar et al. (2019) | Literature review on circular economy and its relationship with sustainable development |
| Pascale et al. (2021) | Systematic review of 137 documents |
| Rosa et al. (2019) | Systematic review of 283 articles exploring the research context of circular business models |
| Saidani et al. (2019) | Review of 55 circularity indicator sets |
| Sassanelli et al. (2019) | Systematic review of 55 articles on circular economy performance assessment |
| Sauvé et al. (2016) | Systematic literature review of 36 articles |
| Suárez-Eiroa et al. (2019) | Literature review of 68 articles |
| Tanveer et al. (2022) | Review of 1,118 articles in the context of the circular economy |

Source: Authors (2024)

Nine themes were defined based on the scope of CE present in the analyzed articles. To understand the process of evaluating the SAs, it is first necessary to comprehend the relevance of each theme, the codes used for identification, and, lastly, the criteria, in the form of questions, aimed at determining whether the SAs are aligned with these themes.

- Theme 1: Closed material and energy loops

**Description:** The circular economy aims to close material loops, ensuring that waste from one process is reintroduced as inputs in another (Kirchherr et al., 2017). This minimizes the use of natural resources and waste generation, promoting reuse, recycling, and remanufacturing. However, recycling or reusing alone does not represent a scenario where materials continuously flow through production systems. In this ideal scenario, all generated waste is reintegrated into the production process, effectively closing the loop.

**Criterion:** The focus of this theme is to assess whether the SAs suggest minimizing resource use and improving efficiency throughout the product's life cycle, from design to production and consumption. Does the agreement promote the reuse and recycling of materials, thereby closing the production loops?

- Theme 2: Decoupling economic growth from resource consumption

**Codes:** resource efficiency, sustainable growth.

**Description:** One of the pillars of the circular economy is the decoupling of economic growth from resource use (Kirchherr et al., 2023). The idea is that economies can grow without a proportional increase in material and energy consumption, which is essential for long-term sustainability.

**Criterion:** This theme aims to assess whether the SAs enable economic growth without increasing the consumption of natural resources. Does the agreement encourage practices that allow for economic growth with reduced resource use?

- Theme 3: Design for sustainability

**Codes:** sustainable design, eco-design, design for disassembly.

**Description:** Product and system design should incorporate sustainability principles from the outset, considering the entire product life cycle (Merli et al., 2018). This includes material selection, energy efficiency, and facilitating disassembly for recycling or reuse.

**Criterion:** The purpose of this theme is to assess whether sustainability is integrated into the design of products and systems from the beginning. Does the agreement encourage sustainable design, considering the complete product life cycle?

- Theme 4: Extension of product life cycle

**Codes:** Repair, maintenance, upgrading.

**Description:** The circular economy aims to extend the product life cycle as much as possible, which can be achieved through maintenance, repair, remanufacturing, and upgrading of existing products, rather than simply discarding them (Saidani et al., 2019).

**Criterion:** This theme seeks to evaluate whether the SAs suggest prolonging product life through maintenance, repair, and upgrading. Does the agreement include practices that encourage the extension of product life?

- Theme 5: Integration of industrial flows

**Codes:** inter-firm cooperation, industrial symbiosis, eco-industrial parks.

**Description:** Companies from different sectors collaborate to share resources, by-products, and waste in an integrated system, promoting collective efficiency and reducing overall environmental impact (Lahane et al., 2021).

**Criterion:** The objective of this theme is to assess whether the SAs encourage or promote cooperation between different industries to optimize the use of resources and waste. Does the agreement foster collaboration between companies for the sharing of resources and waste?

- Theme 6: Economic value of waste

**Codes:** waste valorization, material recovery.

**Description:** Waste is considered a resource that can be reintegrated into supply chains. The principle of CE is to transform the concept of waste into "secondary raw material," encouraging new forms of use and value recovery (Tanveer et al., 2022).

**Criterion:** This theme focuses on the economic utilization of already generated waste, aiming to transform what would otherwise be discarded into new revenue opportunities and products. Does the agreement establish mechanisms to valorize waste as inputs for new processes?

- Theme 7: Circular Business Models

**Codes:** circular innovation, sharing economy, product-as-a-service models.

**Description:** Innovation is a pathway to creating business models that support the circular economy, such as product-as-a-service models, sharing economy, and closed-loop supply chains (Rosa et al., 2019). This also involves new financial models that favor circularity.

**Criterion:** This theme aims to assess whether the SAs promote new business models that support circularity. Does the agreement encourage the adoption of circular business models?

- Theme 8: Integrated value chain vision

**Codes:** Multisectoral collaboration, systemic approach, stakeholder integration.

**Description:** The circular economy requires a systemic approach, where all actors (government, businesses, consumers) are interconnected and collaborate to maximize sustainability (Milios, 2018). This includes everything from the design phase to disposal and the reintegration of materials into the economy.

**Criterion:** This theme aims to assess whether the SAs promote an approach that connects all actors and stages of the value chain, from design to disposal, to maximize circularity and optimize material and resource flows. Does the agreement include mechanisms such as extended producer responsibility, like reverse logistics systems?

- Theme 9: Circularity policies and governance

**Codes:** Circularity public policies, governance for sustainability, environmental regulations

**Description:** Regulations, incentives, and regulatory frameworks help create a favorable environment for businesses and consumers to adopt circular practices. According to Rosa et al. (2019), effective governance is seen as essential for implementing circular practices on a large scale. Ghisellini et al. (2016) reinforce this view, including economic incentives and regulations to support this new economic model.

**Criterion:** Do the Agreements reinforce public policies and governance structures that promote the circular economy?

## Sectoral Agreement evaluation

The analysis was conducted based on the criteria questions and descriptions. The descriptions proved essential, as they were frequently referenced to validate the responses (Table 3).

**Table 3.** Aggregation of the results from applying the criteria to each Sectoral Agreement

| Sectoral Agreements | | | | | |
|---|---|---|---|---|---|
| **Tema** | **Lubricating Oil Packaging** | **Fluorescent Lamps** | **General Packaging** | **Lead-Acid Batteries** | **Electronic Products** |
| **1. Closed loops of materials and energy** | Yes | Yes | Yes | Yes | Yes |
| **2. Decoupling economic growth from resource consumption** | No | No | No | No | No |
| **3. Design for sustainability** | Yes | No | No | No | No |
| **4. Extension of product life cycle** | No | No | No | No | No |
| **5. Integration of industrial flows** | Yes | No | No | No | No |
| **6. Economic value of waste** | Yes | No | Yes | Yes | Yes |
| **7. Circular business models** | No | No | No | No | No |
| **8. Integrated value chain perspective** | Yes | Yes | Yes | Yes | Yes |
| **9. Policies and governance for circularity** | Yes | Yes | Yes | Yes | Yes |

Source: Authors (2024)

The theme of closed-loop systems is addressed in all sectoral agreements, as they all provide for the recycling of materials. According to a review conducted by Pascale et al. (2021), various authors propose differences between different closed-loop or circularity options, described as the 3Rs, 4Rs, 5Rs, and 6Rs principles. The authors state that the 3Rs - “Reduce, Reuse, and Recycle” - are the fundamental principles, while the others represent Recovery (R4), Remanufacturing (R5), and Redesign (R6) (Pascale et al., 2021).

However, as discussed by Corona et al. (2019), there are challenges related to recycled content and recycling rates within the context of the circular economy. The author highlights that when materials are recycled into the same product (closed-loop recycling), the quality of the material tends to be maintained, minimizing the need for additional processing and reducing environmental impacts. In cases where materials are recycled into new products or functions (open-loop recycling), the material may undergo degradation, resulting in lower-quality products (downcycling) (Corona et al., 2019).

Regarding the dissociation of economic growth, Kirchherr et al. (2023) suggest that this involves separating economic growth from negative impacts on natural resources. In other words, the economy can continue to grow without a corresponding increase in resource use or environmental degradation. From this perspective, although they discuss recycling, none of the agreements (AS) address whether or how this could be achieved.

In the study conducted by Harris et al. (2021), the authors highlight the importance of understanding whether circular products replace the creation of other products and the associated raw materials, often referring to reconditioned or remanufactured products. If this does not occur, additional markets may be created, such as in developing economies, without achieving resource dissociation. Kirchherr et al. (2023) consider this a significant challenge, especially in economic sectors that heavily depend on non-renewable natural resources.

Regarding design for sustainability, this theme is associated with "appropriate design," which emphasizes the importance of the design stage in proposing solutions to avoid waste disposal. According to Halog and Anieke (2019), the circular economy design and manufacturing approach adopted in Europe highlights the significance of "redesign" as a crucial step in transitioning from a linear to a circular economy. Only the agreement on lubricating oil packaging includes redesigning, proposing that 10% of the packaging material be recycled.

Marrucci et al. (2019), in addition to their systematic review, explore the European Union's Ecodesign Directive, which primarily focuses on improving energy efficiency. However, the authors highlight the importance of incorporating criteria that promote product durability, repairability, and recyclability, emphasizing the need for greater harmonization between product and waste policies, i.e., considering the product from its design to disposal (Marrucci et al., 2019). According to Milios (2018), for circular design to become viable on a large scale, stronger support from government policies and financial incentives is needed to facilitate the transition, as established companies and industries may be reluctant to adopt new practices and technologies, especially if they involve significant investments.

Regarding the extension of the product lifecycle, none of the sectoral agreements (SA) explicitly address this aspect, focusing instead on environmentally appropriate disposal. For Mhatre et al. (2021), extending the period of use for existing products includes delaying the flow of constituent materials in the economy and reducing the rate of resource extraction and waste generation. Lahane (2021) found that most research focuses on recycling and remanufacturing strategies to extend the life of used/second-hand products, extracting the maximum value and minimizing the need for material in supply chain operations.

Industrial symbiosis, as defined by Homrich et al. (2018) and Milios (2018), is the merging of two or more distinct sectors collaborating to create more efficient and sustainable production networks, where, for example, the waste from one industry can serve as input for another, creating a closed loop. The theme "Integration of Industrial Flows" is broader, including any type of collaboration between companies, not necessarily related to waste, by-products, or environmental performance. The only agreement that opens this possibility is the lubricating

oil packaging, as it promotes cooperation between different industries by proposing a percentage of recycled material in the product.

Regarding economic valorization, Tanveer et al. (2022) emphasize that waste should not be considered valueless material, but rather valuable resources that can be reintegrated into production processes, generating additional economic value. For Mhatre et al. (2021), this refers to the process of recovering products, components, or elements at the end of their useful life.

To evaluate this theme, the sectoral agreements were examined to see if they promote the use of waste as inputs for new processes. Except for the Fluorescent Lamp Agreement, all other agreements establish recycling as final disposal. This aligns with one of the goals of RL, to minimize the amount of waste without proper disposal, contributing to the preservation of natural resources (Guarnieri et al., 2020b). This theme indicates a significant compliance with the agreements with the PNRS.

About innovation and circular business models, Corona et al. (2019) argue that business models are an innovative way to create economic value by maintaining the embedded value of products after use and exploiting this value for new market opportunities. According to Henry et al. (2020), the adoption of business models that encourage the use of recycled products, extend product life cycles, and promote reuse can contribute for circular economy.

Concerning such initiatives, Merli et al. (2018) discuss "performance access" (in which the consumer pays for the use of a product instead of owning it) and "sufficiency" (promoting efficient use and reducing resource consumption). Henry et al. (2020) include service-based models in which the consumer pays for the use rather than the ownership of a product and models that encourage collection and recycling through deposit and return systems.

Although circular business models are not explicitly addressed in the sectoral agreements, they could promote the integration of formal and informal sectors, for example. Sengupta et al. (2022) proposed a modified EPR model to integrate informal waste collectors into the formal electronic waste recycling sector in India. This model seeks to leverage the significant impact of informal waste collectors on the supply of electronic waste by integrating them into formal recycling chains through incentives and regulation (Sengupta et al. 2022).

According to Reich et al. (2023), there is an excessive emphasis on policies focused on recycling, and a more holistic approach that includes business innovation strategies is needed. For the authors, circular business models can include practices such as "refuse" and "rethink," which go beyond mere recycling and involve redesigning products and processes to minimize material use and promote reuse (Reich et al. 2023).

Regarding Theme 8, integrated vision, Milios (2018) suggests that the circular economy is seen as a systemic approach in which all actors in the value chain are interconnected. Collaboration among all stakeholders (government, companies, consumers) is often cited as essential for the success of the circular economy (Khan et al. 2022; Lahane et al, 2021).

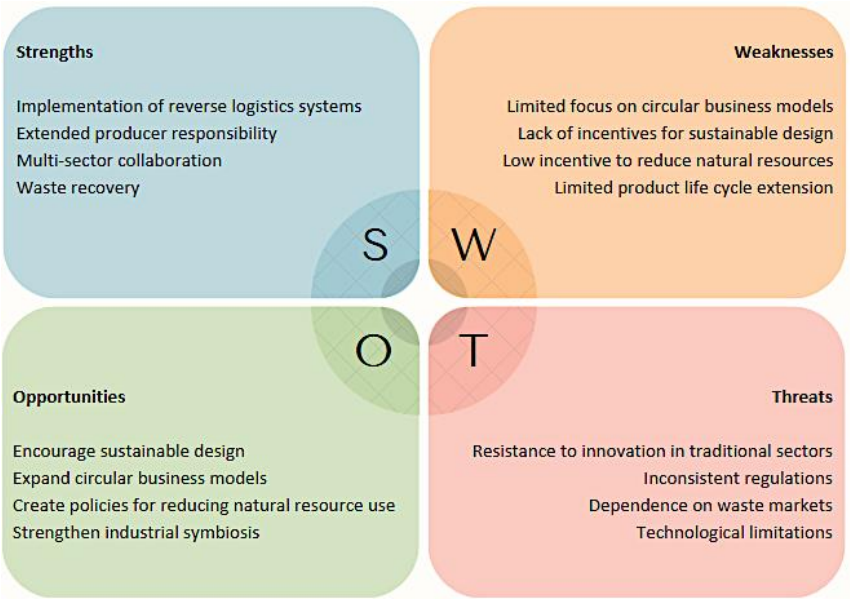
This is a basic assumption of the sectoral agreements, as the PNRS provides for shared responsibility for the product life cycle. Thus, all the agreements address this theme by taking a systemic perspective. Anaruma et al. (2022) emphasize the need for collaboration among companies, society, and government for the circular economy to succeed.

About policies for circularity, the compliance of the sectoral agreements with the PNRS is a factor that favors circularity. Rosa et al. (2019) found that regulations, incentives, and regulatory frameworks help create an enabling environment for companies and consumers to adopt circular practices. However, Pedroza et al. (2021) suggest that the Electronic Products Sectoral Agreement should be revised during its implementation to overcome these vulnerabilities and emphasize the need for new legislative measures that ensure effective control and oversight of reverse logistics.

Governance, in turn, refers to how political decisions and practices are structured, implemented, and monitored. According to Friant et al. (2020), the governance challenge in the circular economy involves creating systems that are inclusive, fair, and deliberative, ensuring that decisions are made with the participation of all stakeholders and that the benefits of circularity are distributed equitably. The sectoral agreements contribute to governance by addressing the production of reports on the results achieved (such as recycling rates) and ensuring transparency in these processes to ensure that the established targets are being met.

The SWOT analysis of the sectoral agreements (Figure 4) evaluated the internal aspects, strengths and weaknesses, and the external aspects, opportunities and threats, related to the implementation of circular economy principles. About strengths, all the sectoral agreements establish robust reverse logistics systems, promoting the collection and recycling of discarded products. They strengthen shared responsibility for the product life cycle and promote collaboration among stakeholders. Waste is recognized as a valuable resource, driving recycling efforts and the reintegration of materials into the production cycle.

**Figure 4.** SWOT analysis results framework applied to sectoral agreements




Source: Authors (2024).

Weaknesses include the lack of clear incentives for innovation and the promotion of circular business models, limited emphasis on design, and the absence of practices aimed at reducing resource consumption. A significant concern is the insufficient encouragement of practices that extend product lifespans.

Opportunities lie in the potential to develop designs focused on prolonging product lifecycles, exploring new circular business models that promote reuse and product upgrades. Additionally, there is scope for incentivizing industrial symbiosis practices, where by-products from one company serve as inputs for another, and for reducing the consumption of natural resources.

Threats include resistance to innovation, as many industries have established processes. Inconsistent regulations across regions or states can impede collaboration between different areas. The lack of advanced technologies for recycling and reusing complex materials may constrain the ability to efficiently close material loops, while instability in recycling and recycled material markets may undermine the economic viability of material recycling and reuse.

It is important to note that Bill No. 1874, introduced in 2022, seeks to establish a National Circular Economy Policy. This bill aims to promote strategic resource management, foster new business models based on circularity, strengthen value chains, encourage research and innovation, and raise public awareness about efficient resource use (Brasil, 2024).

This bill represents an opportunity to align with existing sectoral agreements. It broadens the scope of these agreements by incorporating circular economy principles in a more comprehensive and integrated way, aiming to harmonize waste policies with an economy focused on regeneration and efficient resource utilization.

## FINAL CONSIDERATIONS

This study evaluated the Sectoral Agreements for Reverse Logistics in Brazil considering Circular Economy principles. The predominant focus of the agreements is on post-consumer waste management through collection and recycling systems, which are insufficient to broadly promote a circular economy.

Based on the evaluated themes, the agreements are following the PNRS, particularly regarding shared responsibility for the product life cycle and governance, providing a solid framework for waste management. However, there is limited alignment with Circular Economy principles.

The agreements have a limited approach concerning product life cycle extension, sustainable design, and the promotion of circular business models. These aspects are crucial for a more robust transition to the Circular Economy, as they minimize waste generation and maximize resource use throughout the product life cycle. Furthermore, innovation and industrial symbiosis, which have the potential to enhance the efficiency of production chains, are also underemphasized in the evaluated agreements. To address more aspects of the Circular Economy, these agreements need to evolve to include practices that go beyond recycling,

promoting the reduction of natural resource consumption and the reintegration of materials into closed production cycles.

A limitation of this study was the lack of comparison with similar practices and policies in other countries. For future research, comparative studies between Brazil and other countries are recommended, as they may provide valuable insights into global best practices in the Circular Economy, and which are adaptable to the national context.

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