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An Insight into the Application of Gradations of Circularity in the Food Packaging Industry: A Systematic Literature Review and a Multiple Case Study

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Abstract: Given its unsustainable growth, the food packaging industry (FPI) has become a priority industry in the circular economy. Given the academic significance attributed to the gradations of circularity in maximising resource efficiency in the food packaging industry, this paper aims to identify the current state of the application of those gradations of circularity in the FPI by finding the least and most commonly used circular strategies in the FPI. Moreover, it aims to identify the drivers of and barriers to the implementation of the gradations of circularity and the levers for overcoming such barriers through SLR using multiple case studies, namely five small-medium enterprises (SMEs) in the FPI that each represent one of the five least implemented circular strategies. The research identified that the efforts of the FPI toward adopting circular strategies were not aligned with the gradations of circularity. Based on the research findings, a lever–barrier matrix is proposed as a toolkit for SMEs planning a transition toward the circular economy or are in the transition phase.

Keywords: circular economy (CE); food packaging industry (FPI); drivers; barriers and levers; lever–barrier matrix

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1. Introduction

Packaging is an essential component across the food transportation supply chain. Food packaging may take the form of plastic, paper, cardboard, glass, aluminium, and wood, depending on the nature of the product, its cost, purpose, and the distance it has to travel to reach the end users. Unfortunately, most food packaging is designed as single-use and will end up in a landfill with little proportion given to reuse and recycling [1].

In view of the current unsustainable growth of the FPI, the FPI warrants a transition towards the circular economy (CE) as a priority in the sustainable growth agenda but has not received much attention [1]. Transitioning efforts from linear systems to circular systems have been initiated; however, rethinking value at the end of a product's lifecycle in terms of the recycled materials has predominated in the food packaging industry (FPI).

The circular economy concept builds on the natural capitalism and industrial ecology schools of thought, as well as the blue economy, performance economy, regenerative design, cradle-to-cradle, and biomimicry concepts. Many factors have motivated the need for the transition from a linear to a circular economy, including the rising global population, which has put pressure on areas such as scarce resources [2] and economic challenges at the individual, company, and countries levels, as well as increasing environmental challenges: biodiversity loss and the depletion of natural resources and social issues, such as unemployment and poor working conditions in some parts of the world [3].

The CE concept proposes a complete redesign of the conventional linear economic models of 'take-make-waste' practices into regenerative and restorative economic systems [4] where the CE concept can be divided into clear themes of the closed loop, sustainable economic development, and supply chain practices [5]. The fundamental principles of the CE are to out-design waste and pollution, maximising materials and product utilisation and improve natural regenerative systems [6,7].

The closed-loop concept of the CE, which proposes reduced resource consumption and waste production, is crucial for the sustainable growth of the food packaging industry. Currently, the demand for packaging in the FPI accounts for two-thirds of the total packaging produced [8,9]. Despite the beneficial contributions of packaging to the FPI, it exhibits negative environmental impacts due to high resource consumption rates, production volumes, single-use purposes, non-recyclability, and waste management issues [10]. After its single use, most packaging ends up in landfills or becomes litter in the ecosystems [11], where they degrade slowly, and their labelling inks and dyes contaminate the groundwater [12].

Circular economy literature identifies many circular strategies to reduce resource depletion waste production issues and prevent stakeholder emphasis on strategies that do not foster circular progression [12–14]. Gradations of circularity refer to the placement of circular strategies in the order of priority for the circularity (as shown in Figure 1) based on how long the material (retaining its original quality) remains in the product chain and can be used again after the product is discarded [12–16].

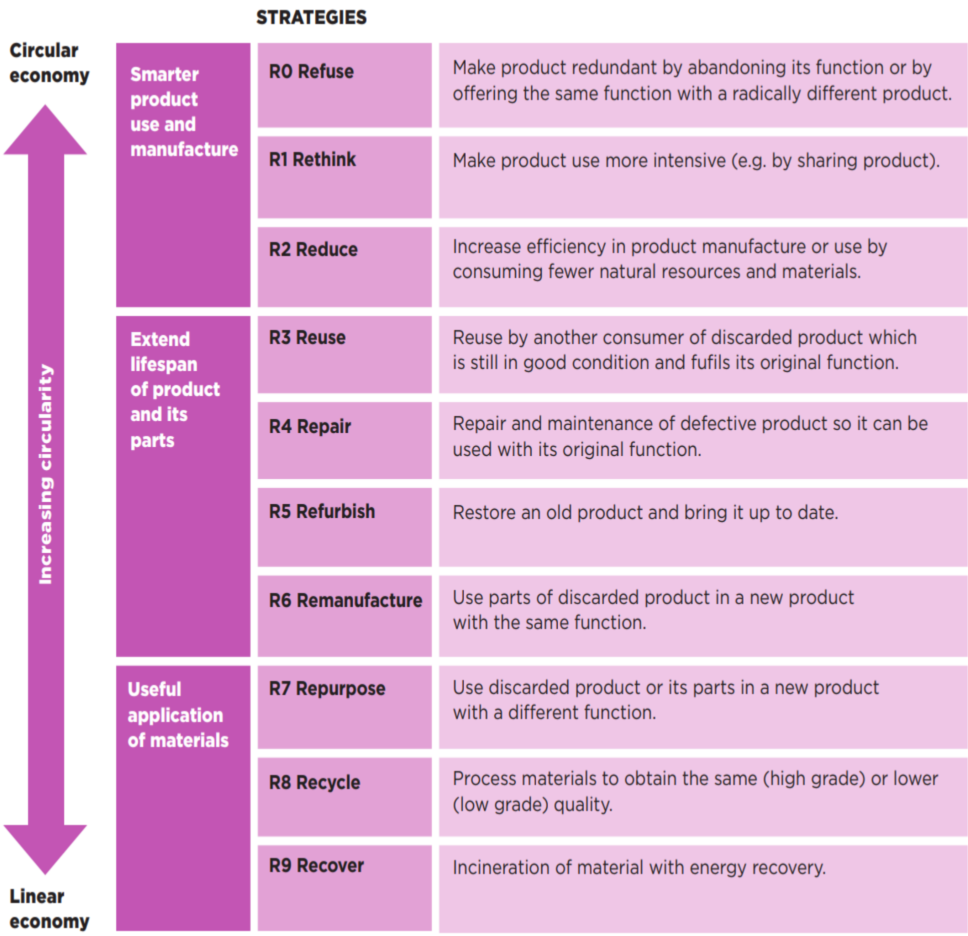

Figure 1. Gradations of circularity, Adapted from Potting et al. [15].

Figure 2 divides the circular strategies into three main categories. Smarter product use and manufacturing (consisting of refuse, rethink, and reduce) is the first category and the most efficient way of keeping the material in the production chain for a long time due to it being used for the same product functionality for a long period and being used by a large number of users (such as product renting/sharing) because this requires fewer natural resources to be extracted to produce the materials needed for manufacturing new products and their subsequent use. The second in order of circularity is the extension of the life span of the product and its parts and includes reuse, repair, refurbishment, remanufacturing, and repurposing. The last level of circularity is the useful application of material through recycling and recovery. Based on the gradations of circularity, reuse is the most circular strategy, whereas recovery is the least circular strategy.

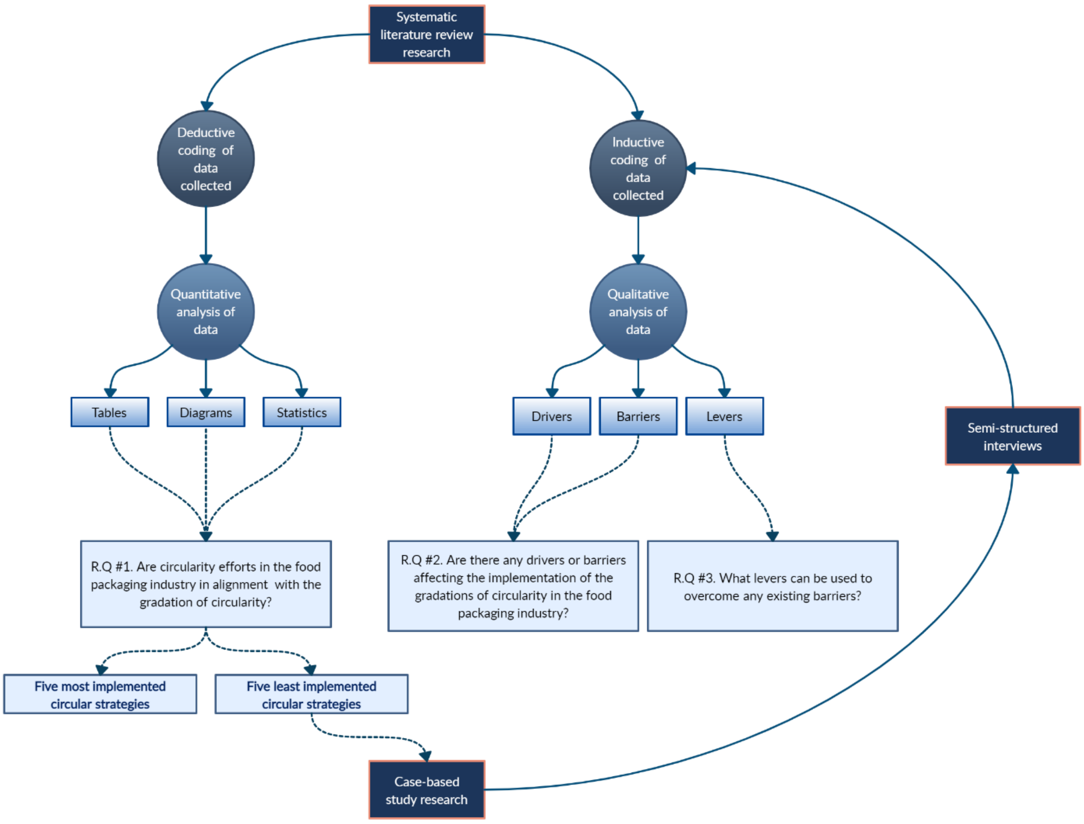

Figure 2. Methodology flowchart I.

The purpose of food packaging is different from the other products because it does not add value to the supply chain [16] instead, it helps the food industry to preserve food quality and reduce food waste. Therefore, the transition of the FPI towards a circular economy requires extra efforts to claim circularity when compared to other businesses [17,18] because the FPI needs to be food safe in addition to being circular. There are many food regulatory requirements that pose additional challenges for the reuse, recycling, and recovery of food packaging due to its chemical contamination [6]. Moreover, food packaging varies based on the nature of the food, which adds additional complexity in terms of the implementation of circular strategies.

Despite the growing popularity of circular strategies for material recovery and the potential for sustainable production, limited work is carried out on the circular efforts supporting food packaging recovery practices across different economies [19]. Given the literary significance attributed to the gradations of circularity as a promising approach for sustainable growth and the complexity of implementing circular strategies in the FPI, this paper aims to identify the current state of the application of the gradations of circularity in the FPI. The research questions addressed are the following:

RQ1. Are circularity efforts in the food packaging industry aligned with the gradations of circularity?

RQ2. Are there any drivers or barriers affecting the implementation of the gradations of circularity in the FPI?

RQ3. Which levers can be used to overcome the existing barriers associated with implementing the gradations of circularity in FPI?

The remaining sections of this paper include Section 2, which critically assesses the relevant literature and outlines the research methodology; Section 3 discusses the research findings and Section 4 concludes, presenting the theoretical and managerial implications, research limitations, and future research directions.

2. Materials and Methods

2.1. Literature Review

The United Nations [3] has reported a population growth of approximately 3.2 billion from 1990 to 2030 and anticipates it to be around 9.7 billion by 2050. Population growth has increased the depletion of natural resources [4]. The depletion of resources is aggravated by technological and scientific advancements that have substantially raised humans' ability to extract, process, and utilise natural resources. High demand for finite resources and the lack of procedural knowledge on reintroducing resources into the biosphere or technosphere are causing waste management issues that endanger the ecosystems [20].

Currently, economic growth relies on high resource consumption and waste production rates based on linear 'take-make-dispose' practices, which threaten economic, environmental, and social stability [21,22]. Given such limitations, academics, policymakers, and practitioners have initiated the transition to circular models that decouple economic growth from environmental deterioration and resource depletion through closed loops [23,24].

The roots of the CE can be traced back to various schools of thought, including the work of Pearce and Turner [25], which introduced the concept of a circular economy model based on Boulding's (1966) [26] view, such as the necessity for Earth's sustainable living. The CE also extends to the industrial ecology ecosystem perspective of industrial systems and environments [25] and the natural capitalism view of overlapping economic and environmental interests [27]. Attempting to refine and develop the CE concept [28], the EMF (2015) [7] has fused these earlier theories with current ones, like regenerative design, biomimicry, blue economy, performance economy, and cradle-to-cradle.

Similar to other concepts that require changing the embedded practices, the literary emphasis of the CE lies in the transition phase. The effects associated with the transition from a linear model to a circular one have been reviewed [7,25,29] and different conceptual frameworks have been developed to help with the transition [28,30,31]. Different drivers, barriers, and practices that influence the implementation of economic circularity have also been described [4,32–35] along with indicators that measure the transition towards circularity principles [31,36]. This growing focus on the transition phase questions whether the appropriate tools exist for measuring circularity progress and if major stakeholders are ready for post-transition phases.

CE principles present firms with long-term competitive advantage opportunities, including reduced material costs, new profit streams and alternatives to resource depletion and price volatility. However, they involve high upfront investments [4] that are associated with supply chain redesign, as circular loops for continuous product and material recovery are required [37]. Such loops expand the scope of supply chain operations [38] thus explaining the literary emphasis on supply chain redesign [20,39] and on supply chain management implications [40]. Given that circular supply chains require greater stakeholder collaboration than linear ones, shared responsibilities and integrated relationships have also been widely explored [41].

Governments have played a key role in operationalising the CE concept through policy and law enactment, as most firms are profit-driven and ignore the long-term benefits of the CE [4]. For instance, in Germany, the CE concept surfaced in 1975 through the Waste Disposal Act and was endorsed at a European level through the Waste Directive 2008/98/EC and ascertained in the EU's Circular Economy Package [42]. Japan initiated their transitioning efforts starting from 1991 with its law for the Effective Utilization of

Recyclables and ascertained it through its Japanese Circular Economy Initiative [40,43]. In 2002, the Chinese government officially endorsed the CE concept (McDowall et al., 2017). Korea's circularity efforts can be traced to their Promotion of Resources Savings and Recycling, Waste Management Act, Extended Producers Responsibility scheme [44] and their Food Waste Reduction policy [42]. Many countries are currently advancing their CE plans to achieve sustainable development in their economies.

The applicability of circular material flows has been analysed for various industries, including the mobile phone industry, and is associated with short product lifecycles [4]. The Chinese steel industry has also been considered due to its increased waste production, resulting from rapid industrialisation and urbanisation [45]. The chemical industry has gained attention due to its rapid growth and potential environmental impact throughout various lifecycle phases. Given the rapid growth of the FPI and food industry, this has led to increased resource consumption and waste production; the FPI warrants priority in the CE agenda but has not received much attention from different stakeholders [1].

As previously mentioned, despite the negative environmental impacts associated with the FPI, food packaging contributes positively to the food industry by reducing food waste, preserving product quality, and preventing chemical contamination and food-borne diseases [46]. Furthermore, it helps to fulfil marketing and logistic goals and provides key consumer information. Hence, the development of food packaging differs from other the development of other products that focus on meeting consumer demands [47] as it aims to enable the product (food) to add value to the supply chain [16]. Thus, designers must consider the varied functionality of food packaging when addressing food packaging issues [48].

The complex sustainability requirements and varied functionality of food packaging make decision-making regarding its development complicated [49], and this explains why sustainable packaging development efforts in the FPI remain fragmented, with some packaging developments focusing on enhancing the packaging's benefits to minimise food waste and other focusing on eliminating food packaging [47,49–51]. In fact, reducing food waste means more rather than less packaging. Therefore, sustainable food packaging studies have focused on improving packaging properties to support lightweight, adequate product protection. However, the future of the FPI should not be based on packaging minimisation but rather on long-term optimisation strategies [48]. Concerns also remain in the idea that the FPI has pursued an oversimplistic approach that favours low-risk strategies over strategies that offer more economical and environmental value [47].

The transition of the FPI towards circularity requires more than minimal adjustments to firms' business-as-usual approach to then claim to be circular [18,28]. The transition calls for a complete redesign of the FPIs supply chain and individual firms' transformation of operations and product designs [6]. It requires a holistic perspective that integrates closed loops of material and component recovery and emphasises the gradations of circularity [13,47,52,53]. The transition recognises that circular strategies like refusing, rethinking, reducing, reusing, repairing, refurbishing, remanufacturing, and repurposing maximise resource utilisation more than strategies like recycling and recovery [13,54–56].

In light of the significance of the gradations of circularity in the FPI to improve resource utilisation and reduce waste issues, this paper aims to increase transparency on the current state of the application of circular gradations in the FPI. Thus, it will explore the circularity efforts of the FPI and identify any drivers and barriers influencing the implementation of such gradations and the potential levers for overcoming the identified barriers.

2.2. Methodology

A mixed-methods, complex methodological approach with a sequential explanatory design following two steps was used for this paper. An overview of the methodological approach pursued is shown in Figure 3.

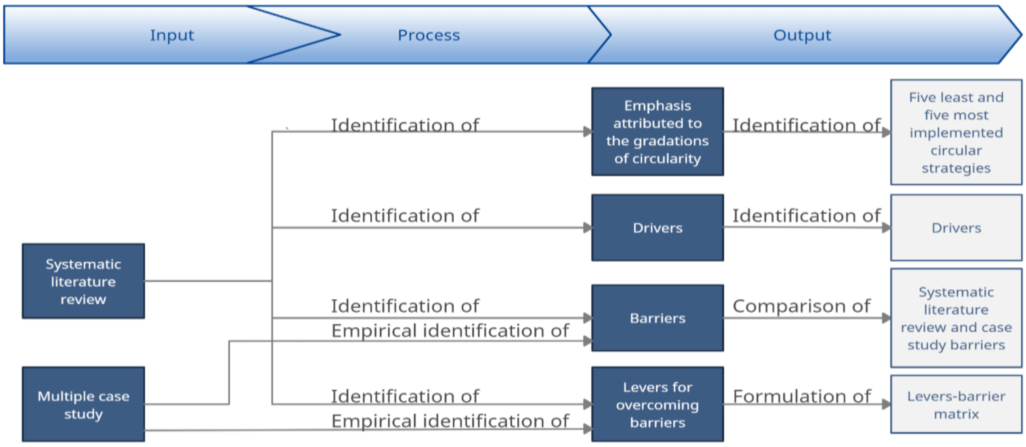

Figure 3. Methodology flowchart II (modified from [55]).

Firstly, a systematic review of the primary studies on the topic of the CE in the FPI was undertaken. Data were extracted and coded utilising NVivo software. Data relating to research question 1 were analysed quantitatively to find the five least and five most commonly used strategies in the CE literature. The findings are displayed using tables. Data relating to research questions 2 and 3 were analysed qualitatively, where the drivers were identified in addition to the barriers and respective levers, which were transformed into a lever–barrier matrix. Secondly, the findings of question 1 of the five least-used CE strategies identified through the SLR were used as a basis to conduct multiple and holistic case-study-based studies to provide insights into the empirical barriers faced by companies transitioning (or already transitioned) to the CE and the levers for overcoming such barriers. The empirical barriers and levers identified through the case studies were analysed thematically and synthesised into a lever–barrier matrix, along with the literary findings. A visual overview of the previously described research approach with the research outcomes is depicted in Figure 4.

2.3. Methodology Pursued for SLR

A systematic literature review was performed (as the first step) to identify, select, assess, and integrate all the primary studies that meet the predefined data selection criteria for answering the three research questions of the paper.

The literature search was conducted using four databases, including Business Resource Complete, EconLit, Scopus, and Web of Science Core Collection. In addition, Google Scholar, an open-access database containing grey literature, was searched to avoid publication bias. Publication years were limited to 2013–2020, a period during which the CE literature grew substantially due to the popularity of the EMFs CE principles (EMF, 2013). Initially, broader keywords like "circular economy", "CE", "circular", "circularity", "gradations of circularity", "circular strategies", "9R framework", "9Rs", "waste hierarchies", "reverse supply chain", "reverse logistics", "circular loops", "closed loop" AND "food packaging" OR "food packaging industry" were used to search for literature in each database. Subsequently, keywords and search strategies were refined, as shown in Table 1. Primary studies' relevance was preliminary assessed based on their title, after which their full reference was obtained if they appeared relevant to the research and merited further evaluation [57].

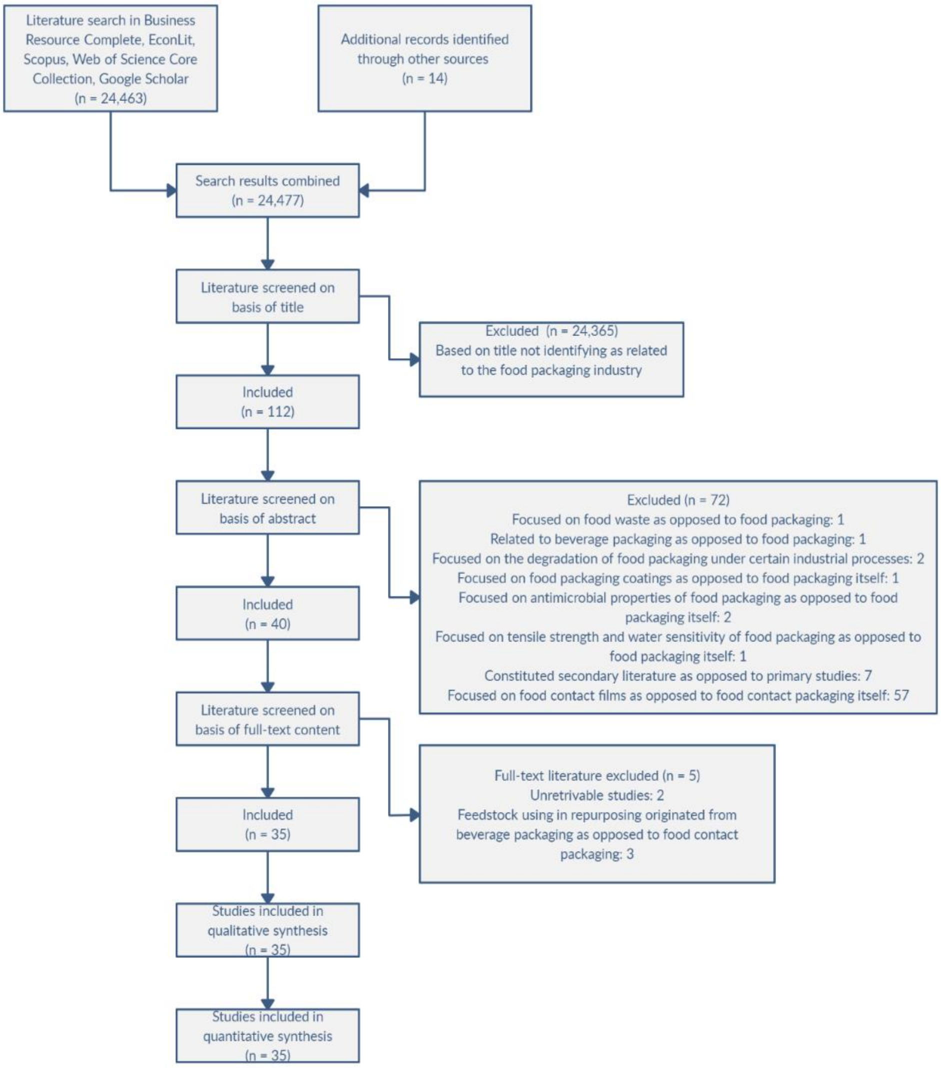

Figure 4. Flow diagram synthesising the findings from the literature search, screening, and quality assessment processes.

Table 1. Refined keywords and search strategies.

Main Search Keywords and Strategies		
refus* OR redesign OR re-design OR eco-design OR ecodesign	AND	food packaging industry OR food package*
rethink* OR shar* OR sharing product OR sharing platform OR service	AND	food packaging industry OR food package*
reduce OR reduc*	AND	food packaging industry OR food package*
reus* O R re-use OR re-us*	AND	food packaging industry OR food package*
repair* OR maintenance	AND	food packaging industry OR food package*

Table 1. *Cont.*

Main Search Keywords and Strategies		
refurbish* OR re-furbish* OR revamp*	AND	food packaging industry OR food package*
remanufacture* OR re-manufactur* OR rediscover* OR re-discover*	AND	food packaging industry OR food package*
repurpose* OR re-purpos* OR repurpose	AND	food packaging industry OR food package*
recyc* OR re-cyc*	AND	food packaging industry OR food package*
recover* OR energy recovery	AND	food packaging industry OR food package*

* Represents the variation in the term.

The literature search was first conducted in Business Resource Complete, which yielded 20 studies with relevant titles, followed by a search in EconLit, which yielded a redundant result. Next, the search was conducted in Scopus, which yielded 20 relevant studies, followed by a search in Web of Science Core Collection limited using the first 500 pages and relevant journals, yielding 47 studies. Next, a search was conducted in Google Scholar, limited to the first 10 pages, yielding 47 studies, followed by a backward search that identified 3 studies. All sources identified a total of 112 studies with relevant titles.

To determine if all 112 studies were relevant to the research topic and met the predefined criteria, their abstracts were read. It was found that 40 studies were relevant and subsequent attempts to retrieve their full-text versions for in-depth quality assessments was undertaken.

Articles, theses, and dissertations from reputable publishers were deemed high quality and included as data sources. Due to a lack of sufficient information, most case study publications were not included in the review. After a detailed review, 3 studies pertained to food packaging repurposing (utilising beverage packaging) that did not meet the inclusion criteria. Moreover, the full-text versions of two of the studies were not retrievable. Thus, only 35 studies were included in this paper's research. Figure 4 shows a flow diagram summarising the findings from the literature search, screening, and quality assessment processes.

Studies were manually extracted and imported into NVivo software for inductive and deductive coding and respective qualitative and quantitative analyses. For the inductive coding approach (qualitative analysis), the drivers, barriers, and levers for overcoming the respective circular strategy implementation barriers were identified and coded, whereas for the deductive approach (quantitative analysis), the studies were analysed, coded, and thematically classified into 1 of 10 circular strategies, as described in Figure 1. Table 2 displays the classification results from the deductive coding process, which formed the basis for the case study research (Table S1 provides details on the articles coded per each circular strategy). The table indicates that the five commonly implemented circular strategies in the context of the FPI are refuse (10), reuse (6), recycle (6), recover (4), and reduce (3), and the five least commonly implemented strategies are repair (0), remanufacture (0), refurbish (1), rethink (1), and repurpose (2). The details of the quantitative and qualitative findings are explained in Section 3.

Table 2. Deductive coding classification of the studies.

Inductive Coding Classification	Sources
Refuse	10
Rethink	1
Reduce	3
Reuse	6
Repair	0
Refurbish	1
Remanufacture	0
Repurpose	2
Recycle	6
Recover	4
Food packaging and CE	2
Total	35

2.4. Methodology for Case Study Research

This section introduces the five case studies selected through the purposive/judgemental sampling approach in the context of the implementation of 1 of the 5 least implemented circular strategies in the FPI. Table 3 provides a summary of the companies' background and their circular strategy initiatives. A representative from each of the 5 companies selected was interviewed. The semi-structured interviews were transcribed and coded using NVivo Transcription and NVivo software, respectively. The barriers encountered by each company during the implementation of the respective circular strategy are described in Section 3.2.2, and the levers used to overcome such barriers are provided in Section 3.2.3 and Table 6, along with levers identified from the SLR.

Table 3. Background information of case study companies.

Company Name	Legal Nature	Year Established	Geographical Location	Circular Strategy	Tranformation Undertaken	Transformational Means	Transformational Methods
Company 1	Private Company Limited by Guarantee	2017	Durham, North Carolina, United States	Rethink	Transforming single-use food takeout packaging approach.	Intensive use of takeout packaging through reusable food takeout packaging service	Digital technology (digital application) for locating participating restaurants and return stations and QR codes for renting and dropping-off reusable assets.
Company 2	Public Limited Company (PLC)	1946	New South Wales, Australia	Repair	Transforming unsustainable pallet utilisation for goods' transportation and handling	Providing pooling services based on a circular business model (leasing and repairing of sharable and reusable pallets)	Advanced reverse logistics, high- capacity infeed lines, digital inspection technology (high definition cameras and laser sensors) and robotic repair.
Company 3	Private Company Limited by Shares (Ltd)	1951	Lund, Sweden and Lausanne, Switzerland	Refurbish/Revamp	Providing a wide range of highly innovative and sustainable packaging solutions for various food packaging needs.	Increase primary packaging's renewable material content and recyclability within existing waste streams as well as introducing cutting edge retort able cartoon packaging as alternative to steel cans and glass jars.	In-house team of engineers, technology teams as well as customers and consumers engagement.
Company 4	Public Limited Company (PLC)	1932	Luxembourg, Luxembourg	Remanufacture	Transforming glass manufacturing processes' resource consumption, waste production and carbon footprint.	Utilising discarded glass cullet as feedstock for remanufacturing glass bottles.	Closed-loop manufacturing process and glass cullet colour sorting lines.
Company 5	Private Company Limited by Guarantee	1996	Madrid, Spain	Repurpose	Providing a sustainable solution for managing a difficult waste flow (EPS fish boxes) and reducing PS resource consumption for food-contact packaging	Utilising discarded EPS fish boxes to convert them into PS sheets combined with virgin material to produce food -contact packaging with different functionality.	Collecting, sorting and pre-treating (briquetting, hot caustic washing, rinsing, drying), decontamination (volatilization with vacuum and temperature) and extrusion processes.

3. Results

3.1. Quantitative Findings through SLR

After undertaking an SLR, 35 relevant studies were identified. These were coded deductively and analysed quantitatively (Table S1 provides details on the articles coded from each circular strategy) to answer research question 1: are circularity efforts in the food packaging industry in alignment with the gradations of circularity?

The SLR of the FPI demonstrated that the most commonly used five circular strategies include refuse (10), reuse (6), recycle (6), recover (4), and reduce (3), whereas the five least commonly used strategies are repurpose (2), rethink (1), refurbish (1), repair (0), and remanufacturing (0), as demonstrated in Table 2. It is evident from the SLR that the FPI currently does not adequately emphasise the gradations of circularity. Although primary studies have emphasised the implementation of the circular strategy with high circularity for refuse (10 studies through eco-designs and zero-waste packaging business models [49,58–60], reuse (3), and reduce (6), studies continue to focus on the two least circular strategies of recycling (6) and recovery (4).

The number of studies on recycling, reuse, and reduce as circular strategies were influenced by their formation as the main strategies of the original 3R framework (reduce, reuse, and recycle) and subsequent R-frameworks (6). Despite being a well-established industry, recycling is associated with inevitable material degradation [61] which means it is not the most circular strategy. Regarding reduce, despite being one of the main strategies of the 3R framework [18], it yielded only three studies which can be attributed to consumers' concerns regarding increasing light-weight packaging trends due to food product safety [62].

The studies on the circular strategy of recovery have resulted from the widespread use of energy recovery technology in Denmark, Sweden, the Netherlands, and Germany as an alternative to waste landfilling [63]. However, it is the least circular strategy, given that it chemically treats or combusts waste for energy recovery as opposed to maximizing the use of resources in closed loops [64,65].

Among the five least commonly used strategies, rethink, which incorporates technology into the reuse strategy to intensify the use of products through sharing [66], saw a low study yield (1 study).

The circular strategies of repurpose, remanufacture, and repair are highly regulated to safeguard consumers' health and safety [67,68]. The repurpose strategy yielded two studies, while repair and remanufacture yielded none. This can be explained by the increasing interest in maximizing resource efficiency but a lack of feasibility regarding the manufacturing of products with the same functionality after being used for food packaging (remanufacturing), thus deferring to alternative product functionality through repurposing [67,69]. Repair, which is a strategy that is more applicable to tertiary packaging (e.g., wooden pallets) over secondary or primary packaging that is usually made of resilient, hard repair plastics [61], limits its application in the FPI.

3.2. Qualitative Findings

After deductively coding and quantitatively analysing the 35 studies identified from the SLR, we subsequently inductively coded the results and qualitatively analysed them, along with the interview transcripts from the five case studies, to answer question 2 (are there any drivers or barriers affecting the implementation of the gradations of circularity in the food packaging industry?) and question 3 (which levers can be used to overcome any of the existing barriers associated with implementing the gradations of circularity in the FPI?).

Circular strategy-specific drivers, barriers, and respective levers for overcoming such barriers were identified through SLR. For those circular strategies that yielded no studies through the SLR, brief information on them was identified in the yielded studies, which helped identify the associated drivers, barriers, and levers. Given that refurbishing is a circular strategy that is more applicable in high technology industries rather than low and medium technological industries like the FPI, we used "revamping" and "innovating" as alternative meanings.

Tables 4 and 5 summarise the SLR-identified drivers and barriers, respectively. The SLR findings on the barriers pertaining to the five least implemented circular strategies were reinforced with the CSR findings, as presented in Section 3.2.2 and Table 5. Table 6 summarises both the SLR- and CSR-identified levers.

Table 4. Summary of the drivers identified through SLR.

S.No	Circular Strategy	No of Studies	Product Characteristics	Environmental	Health and Saftey	User's Behaviour	Scale	Stakeholders' Behaviour	Technological	Opeational	Economic-Financial	Political	Product Availablility	Market Uncertainty	Feedstockilability	Circularbound	Total
1	Refuse	10	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**						9
2	Rethink	1			**C**	**C**				**L + C**	**C**						4
3	Reduce	3	**L**			**L**		**L**				**L**					4
4	Reuse	6	**L**			**L**	**L**	**L**		**L**	**L**		**L**				7
5	Repair	0						**L**		**C**	**L**	**L**	**C**	**L**			6
6	Refurbish/Revamp	1	**C**		**L**	**L**	**C**	**L**	**L**		**L**	**L + C**				**C**	9
7	Remanufacture	0			**L**			**L + C**		**L + C**		**L**		**L**	**C**		6
8	Repurpose	2	**L**		**L + C**			**L**	**L**	**L + C**	**C**	**L + C**		**L + C**			8
9	Recycle	6	**L**	**L**	**L**	**L**		**L**	**L**	**L**	**L**	**L**		**L**			10
10	Recover	4	**L**	**L**				**L**	**L**	**L**	**L**						6
	Total		7	3	6	6	3	9	5	8	8	6	2	4	1	1	
L = From SLR, **C** = From Case Study, **L + C** = From both SLR and Case Study																	

Table 5. Summary of the barriers identified through SLR and case studies.

S.No	Circular Strategy	No of Studies	Product Characteristics	Environmental	Health and Saftey	User's Behaviour	Scale	Stakeholders' Behaviour	Technological	Opeational	Economic-Financial	Political	Product Availablility	Market Uncertainty	Feedstock Availability	Circular Rebound	Total
1	Refuse	10	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**						9
2	Rethink	1			**C**	**C**				**L + C**	**C**						4
3	Reduce	3	**L**			**L**		**L**				**L**					4
4	Reuse	6	**L**			**L**	**L**	**L**		**L**	**L**		**L**				7
5	Repair	0						**L**		**C**	**L**	**L**	**C**	**L**			6
6	Refurbish/Revamp	1	**C**		**L**	**L**	**C**	**L**	**L**		**L**	**L + C**				**C**	9
7	Remanufacture	0			**L**			**L + C**		**L + C**		**L**		**L**	**C**		6
8	Repurpose	2	**L**		**L + C**			**L**	**L**	**L + C**	**C**	**L + C**		**L + C**			8
9	Recycle	6	**L**	**L**	**L**	**L**		**L**	**L**	**L**	**L**	**L**		**L**			10
10	Recover	4	**L**	**L**				**L**	**L**	**L**	**L**						6
	Total		7	3	6	6	3	9	5	8	8	6	2	4	1	1	
L = From SLR, **C** = From Case Study, **L + C** = From both SLR and Case Study																	

Table 6. A summary of the levers identified through the SLR and case studies.

S.No	Circular Strategy	Value added Proposition	Partnership/Collaboration	Improved Design	Alternative Financing	Communication and Awareness Generation	Changing Business Practices	Supply Chain Integration	Technology Employment	Skills and Competence	Legislation, Regulation and Guidelines	Total
1	Refuse	**L**	**L**	**L**	**L**	**L**	**L**		**L**	**L**	**L**	10
2	Rethink	**L + C**	**C**	**C**	**L + C**	**C**	**C**	-	**L + C**	**C**	**C**	9
3	Reduce	**L**	-	**L**	-	**L**	**L**	-	**L**	**L**	**L**	7
4	Reuse	**L**	**L**	**L**	-	**L**	**L**	-	**L**	**L**	**L**	8
5	Repair	**L**	**C**	**C**	-	-	**C**	-	**C**	**C**	**L**	7
6	Refurbish/Revamp	**C**	**C**	-	-	-	-	**C**	**L + C**	**L + C**	**C**	6
7	Remanufacture	**L + C**	**L + C**	**C**	-	**C**	**L + C**	-	-	**L + C**	**L**	7
8	Repurpose	**C**	**L + C**	-	**C**	**C**	**L + C**	-	**L + C**	**L + C**	**L + C**	8
9	Recycle	-	**L**	**L**	**L**	**L**	**L**	-	**L**	**L**	**L**	8
10	Recover	**L**	-	-	-	-	**L**	-	**L**	**L**	-	6
	Total	9	8	7	4	7	9	1	9	10	9	

L = From SLR, **C** = From Case Study, **L + C** = From both SLR and Case Study

3.2.1. Drivers

The SLR identified 12 main drivers (shown in Table 4). The two prominent drivers across all of the 10 circular strategies were political and environmental drivers, followed by users' behaviour, stakeholders' behaviour, technological, and economic-financial drivers. The least recurrent drivers included operational, business strategy, product differentiation, product characteristics, and infrastructure.

It is evident from Table 4 that the political and environmental drivers are the main drivers for the five most commonly used circular strategies (refuse, reduce, reuse, recycle, and recover), indicating the considerable role played by regulation, legislation, and the guidelines implemented at the economy level (such as energy recovery from food packaging waste as an alternative to waste landfill in Denmark, Sweden, Netherlands, and Germany) as well as at the regional level (such as the Directive on Packaging and Packaging Waste [68], the EUs Circular Economy Action Plan (2020), the Waste Framework Directive [70], and the European Strategy for Plastics in a Circular Economy [71] for promoting the implementation of CE strategies.

The Users' and stakeholders' behaviour drivers are second, which are associated with an increased awareness of environmentally friendly, sustainable, and reusable packaging, zero-packaging shopping models [49] and the overemphasis on recycling and energy recovery technologies and their employment [72]. Thirdly (in order) are the economic-financial and technological drivers. Economic-financial is associated with the popularity of zero-packaging business models worldwide [58], reducing transportation costs and increasing transportation efficiencies through increasing the use of innovative and light-weight packaging [73,74] and offering clients value propositions with lower resource consumption and production costs [75]. The technological drivers, which are prevalent in the circular strategies of rethink, repurpose, remanufacture, and recovery, entail the emerging chemical recycling technology for recovering polymers' petrochemical constituents [76], and experimentation with catalysts and feedstock to improve energy recovery processes in oil yields [67], employing EREMA technology for repurposing after-use PET food containers and increasing the optimization of reusable packaging logistics through digital technology [77].

These facts indicate that increasing the awareness of consumers [78] and other industry stakeholders will play an essential role towards the implementation of circular strategies and can lead to the development of more circular business models in the FPI in combination with the political, environmental, technological and economical-financial drivers.

3.2.2. Barriers

Initially, the barriers were identified through the SLR of the FPI for all 10 of the circular strategies. Then, five case-study companies were selected that were implementing one of the least-applied circular strategies (identified through SLR). The interviews with the representatives from the case study companies highlighted the barriers that were applicable to their businesses. This practice not only highlighted more of the barriers from the existing set previously identified through SLR but also identified some new barriers not observed in the FPI literature.

The SLR identified 12 distinct barriers in the FPI, whereas two more barriers: feedstock availability and circular rebound, were identified through the case studies of remanufacture and refurbish/revamp, respectively. The four dominant barriers across all of the 10 circular strategies are stakeholders' behaviour; operational, economic-financial, and product characteristics; user behaviour, health, and safety; and political and technological barriers. The least recurrent barriers were environmental, scale, product availability, market uncertainty, feedstock availability, and circular rebound. A summary of the barriers identified through the SLR and case studies is provided in Table 5. The recycle circular strategy had the highest number of barriers (10 out of 14), followed by refuse and refurbish (9 out of 14), whereas the lowest number of barriers were identified within the rethink and reduce strategies (4 out of 14). These facts indicated that all circular strategies face barriers in their implementation irrespective of being the most or least circular in nature.

As the prime purpose of food packaging is food safety and preservation for consumers, therefore, the stakeholders' behaviour, operational, economic-financial, and product characteristics, health and safety, and user behaviour, as the main barriers to the implementation of circular strategies are justifiable because the safety of the food and its consumers is of prime importance compared to the circularity of packaging.

An interesting fact to note in this study is that 9 out of 12 drivers were also the most occurring barriers to the circular strategies, which means the same factors are pushing companies in the FPI to adopt circular strategies, and the same factors are preventing them from doing so. The factors that served as both the drivers and barriers include political, environmental, operational, technological, economic-financial, user behaviour, stakeholder behaviour, product characteristics, and health and safety. If we look more closely, the nature of these common factors is external, except for operational and product characteristics, indicating that the country's economic, regulatory, and technological landscape and the awareness of its users and stakeholders play a very important role in paving/hindering the way for the adoption of circular strategies, alongside the innovative product development and operational capabilities of food packaging companies.

3.2.3. Levers

A detailed analysis was carried out on the levers for removing the barriers for all the circular strategies identified through the SLR and case studies. The total number of levers identified was 159, out of which 97 were derived from the literature, 54 were derived from the case studies (repair (10), refurbish (9), remanufacture (5), and repurpose (13)), and eight were found to be common in the literature and case studies (Table S2). These 159 levers were aggregated into 10 lever categories (shown in Table S2) for all the circular strategies and are summarised in Table 6. All the FPI levers that emerged from the literature were confirmed by the case studies except for supply chain integration, which was identified in the refurbish case study. Supply chain integration is not emphasised with reference to the FPI despite the fact that it is considered an important factor for the adoption of circular strategies in SMEs and requires an integrated approach for proper communication across all the players in the supply chain to maximise the use of resources [79].

The table indicates that refuse and rethink are the circular strategies that require the most levers (9 out of 10) for overcoming the related barriers. The case studies of the companies for the five least used strategies highlighted some more levers which were not identified in the SLR for those circular strategies, such as value-added proposition, alternative financing, and communication and awareness, which were identified in the repurpose strategy, and value-added proposition, partnership/collaboration, supply chain integration and legislation, and regulation and guidelines, which were found for the refurbish strategy.

Among the 10 categories, the five most occurring levers were skills and competence, changing business practices, value-added proposition, technology employment, and legislation, regulation, and guidelines, followed by partnership/collaboration, improved design and communication, and awareness. Alternative financing and supply chain integration are less recurrent levers, despite the fact that these two levers are very much important for developing innovative packaging and reducing food packaging waste (after use) due to complexity of the materials currently used for packaging.

A lever–barrier matrix (LB Matrix onwards) based on case studies and literature review findings was devised to improve managerial understanding of the barriers and levers associated with the implementation of the gradations of circularity in the FPI. The LB matrix, shown in Table 7 (derivation is detailed in Table S3), links the major barriers with the respective levers for overcoming those barriers.

It is evident from the LB Matrix that, among the 10 levers, five levers were identified that could overcome most of the FPI-related barriers (to circular strategy implementation), and these include changing business practices, legislation regulations and guidelines, technology employment, partnership/collaboration, and improved design. A comparison between the prominent levers of all circular strategies (presented in Table 6) and the LB Matrix (presented in Table 7) suggests four common levers that include changing business practices, legislation regulations and guidelines, technology employment, and partnership/collaboration. The two prominent levers of circular strategies, i.e., value-added proposition and skills and competence, are ranked lower in the LB Matrix, whereas improved design has emerged as an important lever for overcoming 9 out of 14 of the barriers. This finding indicates that the implementation of circular strategies needs to design a sophisticated system through the co-operation of FPI stakeholders, regulatory authorities, and companies, providing technology solutions to design innovative packaging that can maximize the use of resources to keep those in circulation for a longer time period.

According to LB Matrix, operational, economic-financial, and stakeholders' behaviour are the multifaceted and complex barriers that need large numbers of levers to implement circular strategies. However, the levers identified for overcoming the operational-, economic-financial-, and stakeholders' behaviour-related barriers can indirectly contribute to overcoming the other 11 barriers observed in the FPI and can stimulate the implementation of circular strategies that are aligned with the gradations of circularity. This lever–barrier matrix might prove to be a useful toolkit or guide for the management of the FPI, particularly for SMEs planning to transform their business practices from linear to circular or are in the early stages of transition to the CE.

Table 7. A Lever-barrier Matrix linking the barriers to circular strategies and the levers for overcoming the barriers.

Levers / Barrlers	Changing Business Practices	Legislatin, Regulation and Guidelines	Technology Employment	Iparthershipl/Collaboration	Improved Design	Communication and Awareness Generation	Value added Proposition	Skills and Competence	Supply Chain Intergration	Alternative Financing	Total
Opeational	L + C	L + C	L + C	L + C	L + C	L + C	L + C	L + C	C	L	10
Economic-financial	L	L	L + C	L + C	L + C	L	L + C	L + C	-	L + C	9
Stakeholders' behaviour	L	L	-	L	L + C	L	L + C	-	L	-	7
Product characteristics	L	L + C	L + C	C	L + C	-	L + C	-	-	-	6
Health and Saftey	L	L + C	L + C	C	L	L	-	-	-	-	6
User's behaviour	L + C	L	-	-	L	L + C	L + C	-	-	C	6
Technological	L	L + C	L + C	L	-	L + C	-	L + C	-	-	6
Market uncertainty	L	L	-	-	-	L	L + C	-	L	-	5
Political	L + C	L + C	L + C	L + C	-	-	-	-	-	-	4
Environmental	C	L + C	C	-	L + C	-	-	-	-	-	4
Scale	L	-	-	L + C	-	-	-	-	L	-	3
Product availablility	-	-	L + C	-	C	-	-	C	-	-	3
Circular Rebound	-	-	C	-	C	-	-	C	-	-	3
Feedstock availability	-	-		C	-	-	-	-	-	-	1
Total	11	10	9	9	9	7	6	5	4	3	

L = FromSLR, C = From Case study, L + C = From both SLR and Case Study

4. Conclusions

Although the CE concept is not entirely new, given that it builds on schools of thought dating back to 1966, it remains a topic that has not been widely explored in the FPI due to it being a technology-oriented sector [45,80]. The unsustainable resource consumption and exacerbated waste production of the FPI calls for prioritizing the industry within the CE agenda [1]. While significant efforts towards the transition from the linear to the circular economy have been initiated, they appear to have been subverted into "a bit of twisting of the status quo" [18] by favouring recycling strategies that retain less of the product and raw material value [13,47]. However, the literature recognizes the importance of implementing the gradations of circularity, which focuses on the hierarchical implementation of circular strategies that retain materials longer in the supply chain [7]. In order to increase the understanding of the current state of the gradations of circularity in the FPI, this paper sought to answer three main research questions:

1. Are efforts towards the circularity of the food packaging industry in alignment with the gradations of circularity?;
2. Are there any drivers or barriers affecting the implementation of the gradations of circularity in the food packaging industry?;
3. Which levers can be used to overcome any of the existing barriers associated with implementing the gradations of circularity in the FPI?

This research paper pursued a complex, mixed-method approach through the systematic research of the primary literature and a case study-based research. Studies were coded deductively and were classified (based on their content) into the corresponding 10 circular strategies based on their degree of circularity, and the five most and five least commonly used circular strategies were identified. The results of this practice (presented in Table 1) demonstrated that, currently, the primary literature associated with the FPI does not attribute adequate attention to the gradations of circularity. The SLR recognised the importance of eco-designs and zero-waste packaging business models, which appeared in the highest number of studies regarding the refuse strategy for greater circularity in the FPI. However, the literature exhibits high reliance on circular strategies like recycling and energy recovery, which are the two least circular strategies. It identified that reuse and recycle, which are the main strategies of the original 3R framework, have been implemented into the industry more, relatively speaking. Despite being one of the main strategies of the original 3R framework, reduce has not been implemented much due to consumers' concerns regarding the effect it has on the safety of food products [62].

Repurposing was identified to have been less implemented than reducing but more implemented than rethinking, repairing, remanufacturing and refurbishing. This can be explained by the increasing interest in maximising product and material utilisation but the low feasibility of using discarded products and parts to remanufacture new products with the same function [67,69] and the limited application of the strategy of repairing tertiary packaging over secondary or primary packaging made primarily of resilient and hard to repair plastics [61]. Rethinking was less implemented than repurposing but more implemented than repairing, remanufacturing and refurbishing. By building on the principles of reuse, rethinking simply incorporates technology into an already established concept [66], thus explaining why it has not been as widely explored by the literature. Conclusively, the efforts of the FPI are not in alignment with the gradations of circularity. This warrants the attention of all major stakeholders in the industry, who should work together to adopt circular strategies that maximise resource efficiency to ensure the industry's sustainable growth.

Having identified (through the quantitative analysis in SLR) the representatives from the five companies deemed to be representative examples of the successful application of the five least implemented strategies (repair, remanufacture, refurbish, repurpose, rethink, and repurpose), these representatives were interviewed as part of a case-based study research. Interview transcripts, along with systematically identified studies, were coded inductively using NVivo software to identify the drivers and barriers associated with the practical implementation of the 10 circular strategies and to identify the levers that can be used to overcome such barriers. The political and environmental drivers were the two most dominant drivers identified, followed by the users' behaviour and stakeholders' behaviour drivers, and then the further technological and economic-financial drivers. The drivers associated with operational, business strategy, product differentiation, product characteristics, and infrastructure were among the least frequent drivers identified.

The total number of barriers identified in the FPI was 14; the SLR identified 12 barriers, whereas two subsequent barriers, i.e., feedstock availability and circular rebound, were identified through the remanufacture and refurbish case studies, respectively. The four most dominant barriers identified among the 10 circular strategies were the stakeholders' behaviour, operational, economic-financial, and product characteristics barriers, followed by the technological, political, users' behaviour, health and safety, market uncertainty, environmental, and scale-associated barriers. The barriers associated with feedstock availability, product availability, and circular rebound are among the least recurring barriers identified. A comparison between the drivers and barriers highlighted that 9 out of 12 of the drivers were also the most frequently occurring barriers to the circular strategies, namely political, environmental, operational, technological, economic-financial, user behaviour, stakeholder behaviour, product characteristics, and health and safety. The dual behaviour of these factors indicates their vital importance for the implementation of circular strategies in the FPI.

Among the 10 identified levers for the FPI, nine were identified in the literature, whereas the tenth lever (supply chain integration) was identified through the refurbish case study. The main levers identified for overcoming such barriers included devising value propositions, partnering and collaborating, improving the design, seeking alternative financing, communicating and generating awareness, changing business practices, supply chain integration, utilising technology, employing skills, and competence, as well as legislation, regulation, and guidelines.

A lever–barrier matrix was devised for linking the barriers to those levers (both identified through the literature and case studies) that might be used to overcome the barriers. The LB matrix can be used as a toolkit by managers attempting to redesign their operations towards greater circularity or by the managers of companies that have already started the transition towards the CE. Thus, managers can identify the barriers their companies could potentially face or are facing and utilise the LB matrix to select the appropriate levers to overcome them efficiently and effectively. Conclusively, maximising those drivers that favour the implementation of the gradations of circularity in the FPI, as well as identifying the barriers preventing such implementations, and further identifying the relevant levers to overcome the faced barriers, can contribute towards aligning the future of the industry with the gradations of circularity.

4.1. Theoretical Implications

This research provides academia with a pioneering study on the unexplored topic of the gradations of circularity and its associated drivers, barriers, and levers to overcome the barriers in the FPI, which can be extended within the explored industry and could extend to other industrial sectors. The identification of factors with a dual nature (for the barriers and drivers) and the LB Matrix can help researchers to develop targeted solutions and strategies for the companies in the FPI to overcome the challenges faced when implementing circular strategies.

4.2. Managerial Implications

This paper also has managerial implications, as it increases the understanding of the current state of the implementation of the gradations of circularity within the FPI. Companies in the FPI can use the findings of this research to anticipate any barriers they might face when attempting to redesign their operations for implementing circularity. The lever–barrier matrix provides an insightful starting point for managers pursuing such a transition, as it links the potential barriers with those levers that can be used to overcome such barriers. In addition, the LB matrix can be used as a guide for finding the most optimal levers to overcome the maximum barriers in companies that have already transitioned but continue to experience barriers. More specifically, the LB matrix highlights the main barriers that need to be overcome to align the future of the industry with the principles of the CE and the levers that can be used to achieve such a goal.

4.3. Limitations and Future Research

This study has its limitations. Firstly, the research was conducted at a global scale (given that the FPI operates at a global scale); thus, the studies originating from different countries were included in the literature-based research and companies from different countries were chosen for the case-based research. However, limiting the research to a specific country or region, like one comprised of the EU member states, could provide insights on the level of circularity in the FPI achieved by each country or region independently, providing a promising avenue for further research. Secondly, this research project excluded studies related to food contact films manufactured from radically different materials to avoid the over-representation of the refuse strategy compared to other strategies. Extending the research to include such studies also provides an opportunity for future research and the quantification of such studies. Thirdly, the research can be extended to include the beverage industry, which is an industry that, upon conducting this research, was identified to have high circularity, possibly even more than the FPI. Fourthly, the findings from the case-based research under a particular circular strategy cannot be generalised to all cases of that circular strategy (despite the fact that the case-based research findings are supported by the literature findings), as only one case for each strategy was chosen for this paper, considering the fact that a smaller number of a representatives from companies with circular strategy implementation were willing to participate in our research during the challenging time of the COVID-19 pandemic. However, this research can be extended to more case studies under each circular strategy to add to the findings of the current paper.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15043007/s1. Table S1. Studies coded per circular strategy. Table S2. Categorical representation of levers identified through SLR and case studies. Table S3. Lever-Barrier Matrix derivation by linking levers and barriers identified through SLR and case studies.

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