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Enhancing Circular Economy Practices in the Furniture Industry through Circular Design Strategies

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Abstract: The furniture industry represents a substantial segment of Europe's economy, with the European Union producing approximately 25% of the world's furniture. This sector is currently transitioning towards a circular economy. This study aims to thoroughly examine the circular initiatives undertaken by European furniture companies, emphasising the role of design in fostering innovative solutions. By employing a multiple case study methodology, the research demonstrates that existing circular solutions predominantly focus on materials and products, with significant adoption of circular design strategies. The majority of furniture companies are implementing these strategies to enhance resource efficiency and prolong product lifespans. Additionally, some companies are developing complementary service systems to improve product performance and longevity further. However, only a few have successfully implemented circular business models alongside circular product design strategies. This study also highlights that increasing user engagement and adopting a systemic perspective that includes various stakeholders in creating mutually beneficial solutions are areas that are still underdeveloped. Finally, we propose a framework to effectively guide furniture companies in implementing design strategies from a systemic perspective, aiming to generate comprehensive circular solutions within the European furniture sector.

Keywords: circular economy; circular design; design strategy; furniture sector; case study

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1. Introduction

The furniture industry plays a crucial role in Europe's economy, with the European Union accounting for approximately one-quarter of the world's furniture production. According to research by the EU Joint Research Center [1], furniture represents Europe's second-largest product market, valued at EUR 140 billion in 2021. The environmental impact of this sector is substantial due to the extensive use of virgin materials, adhesives, dyes, and coatings, which contribute to significant waste generation and the release of volatile organic compounds [2]. Despite its economic significance, the sector faces increasing pressure to transition towards a circular economy (CE). The traditional linear model of 'take-make-dispose' is no longer sustainable, leading to a growing recognition of the need for circular practices that promote resource efficiency, waste reduction, and sustainable development. The CE proposes a closed-loop system for material flow as an alternative solution [3], offering a theoretical framework, tools, and methods to integrate sustainability into business and society, thereby reducing environmental impact and improving the surrounding environment. However, the furniture manufacturing industry has slowly adopted CE practices, particularly those related to reuse, which still need to be prioritised over recycling, incineration, and landfill [4,5].

Over the past decade, CE has attracted significant attention from academics, practitioners, and governments. As a creative activity aimed at establishing the multi-faceted qualities of objects, processes, services, and systems, design can be pivotal in supporting companies to achieve sustainability objectives and circular strategies. The strategic role of

design has evolved from product design to ecosystem design [6], enabling the development of sustainable product-service systems [7] and circular business models [8,9]. As the literature highlights, design can facilitate circularity at various levels by implementing multiple strategies and applying principles and guidelines to achieve specific goals. The main barriers to adopting and implementing CE practices include economic–financial, managerial and organisational, relational, consumer-related, design and technical, institutional and legislative, and socio-cultural challenges. Scholars are developing practical tools, methods, and guidelines to help the EU manufacturing industry overcome these barriers. However, many of these solutions have yet to be specifically tailored to the furniture industry.

Therefore, this research explores how furniture companies implement design strategies to transition towards a circular economy. Using a multiple case study method, this study aims to observe current initiatives, understand different strategies, correlate them with existing literature, and assess their potential impact on companies. Our analysis reveals that while many circular solutions in the furniture sector are primarily material or product-focused, there is a notable emphasis on developing complementary service systems to enhance product performance. However, implementing circular business models alongside circular product design strategies still needs to be improved. There needs to be more variety and competitiveness in service systems and circular business offerings within the sector. Moreover, the development of user experience and engagement in circular initiatives is still in its nascent stages.

2. Motivations

The research findings indicate that although many circular solutions in the furniture sector focus primarily on materials and products, there is a significant need to enhance complementary service systems to improve product performance. However, implementing circular business models alongside circular product design strategies remains limited. The sector lacks variety and competitiveness in service systems and circular business offerings, and user experience and engagement in circular initiatives are still in the early development stages.

This research aims to address existing gaps by investigating the practical applications of circular design strategies that have facilitated furniture companies in conceptualising and implementing circular economy projects and products. The sector possesses substantial potential for further advancing and integrating more profound circular practices. Firstly, there is a scientific motivation to understand better design for circular behaviour and consumption, which have yet to be largely overlooked. Companies have focused on material-selection and manufacturing processes but have devoted minimal effort to understanding consumer perceptions and fostering consumer engagement in circular practices. Secondly, this study aims to investigate the potential of new technologies in applying circular design strategies. Furniture companies should adapt products for easy assembly and disassembly, fostering component reuse. Technology like generative AI and parametric software can enhance the design process and impact business models by leveraging product and user data. Thirdly, the predominant focus on materials and products limits the development of sustainable solutions considering design contributions at the product service system (PSS), business model, and ecosystem levels. The research aims to integrate systemic and strategic design approaches to enhance circularity across the entire value chain. For instance, renting and leasing models require maintenance and refurbishment services, necessitating design considerations at the service system level.

Recognising the importance of an ecosystem perspective, we propose a framework integrating material, product, service, and business model design to achieve a circular economy. This framework delineates three levels for design: materials, product and product-oriented services, and use- and result-oriented services and business models. It is an analytical tool to guide furniture companies in developing circular initiatives and planning circular design strategies, presenting an ecosystemic perspective that extends beyond material and product improvements. This holistic approach can distinguish companies from competitors

by incorporating a comprehensive view of circularity. In conclusion, by leveraging the potential of design from a systemic approach, the furniture sector can overcome challenges and move towards the objective of achieving a circular economy. This research aims to provide valuable insights and practical guidelines to facilitate this transition, ultimately contributing to sustainable development in the industry.

3. Background

3.1. Circular Economy in the Furniture Sector: Challenges and Opportunities

At the European level, the furniture industry predominantly comprises SMEs and employs approximately one million workers and manufacturers [10]. Currently, this industry is facing several economic, regulatory, and environmental challenges: e.g., the increasingly growing competition worldwide, such as low-cost manufacturers, technology-led logistics players, and the significant environmental and economic impact [1,10]. The environmental impact of this sector is substantial, mainly due to the fact that furniture uses a large volume of virgin material, adhesives, dyes and coating, which can lead to a large amount of waste and volatile organic compounds [2]. In Europe, furniture waste in 2017 was 10.78 million tonnes, about 4% of the total municipal solid waste (MSW), of which between 80% and 90% is incinerated or sent to landfill [5]. The furniture manufacturing industries need to catch up on sustainability and circular transition. Definitions of a circular economy (CE) can be found in the literature, focusing on different aspects—among others on eco-industrial development, the 3R Principle, or economic aspects—however, within this article, CE is interpreted as 'an industrial economy that is restorative or regenerative by intention and design' [3]. Among the various definitions, this is the most comprehensive, including environmental and economic benefits, and, at the same time, including the idea of regeneration, leading to a positive contribution towards these systems. In the last decade, studies and analyses have been developed to help industries and companies understand the importance and theories of sustainability and CE and, more importantly, to provide them with different perspectives, indications, and guidelines to start their sustainability and CE transformation journeys. On the one hand, scholars [11–17] have identified the barriers and difficulties that companies perceive and face when adopting and implementing CE practices [18]. Among the barriers detected in the literature, it is possible to mention a few main categories, such as economic–financial, managerial and organisational, relational, consumer-related, design and technical, institutional and legislative, and socio-cultural barriers. Within these categories, it is possible to find various articulations and differences depending on the product sector, the national context, and the individual companies.

To foster a sustainable and circular transition, research is being conducted to introduce different sustainable innovations and approaches towards CE in manufacturing industries and the furniture sector [19,20]. Furniture companies are currently exploring various approaches to carry out CE practices, particularly related to product life extension and reuse, which are still not prioritised over recycling, incineration, and landfill [4,5]. The EU Joint Research Center [1]—in line with other previous research [5,21]—has pointed out that improvements towards CE in the furniture sector should focus on overcoming challenges like low quality of material and product design, weak demand and poor knowledge from the consumers' side, high cost of repair and refurbishment, waste generation and management, lifetime extension, and regulation establishment. In the furniture sector, all of the above-mentioned barriers to implementing a circular economy can be detected, particularly in the economic-financial, design, and technical aspects [20,22,23]. More specifically, for furniture companies, implementing circular practices and business models based on refurbishment and repair is more complex due to the operational difficulty of automating; in fact, it is labour-intensive and creates a high demand for storage space, resulting in higher costs [22,23]. From a financial point of view, this implies a large initial investment and risk for furniture companies, especially when considering strategies such as the resale of used furniture and leasing/renting that implies uncertainty about the quantities of products available [22,24]. These practices can be fostered by national or EU policies, which are

absent to date [22,25]. The management of the value chain and relationships with partners must also be facilitated to implement sustainability and circularity practices, particularly by facilitating the flow of information towards transparency [22–24]. Finally, socio-cultural aspects related to user perceptions are also challenging for furniture companies. In this regard, users are increasingly subject to fashion-driven choices, prefer to possess furniture, and are sceptical about the economic benefits of leasing/renting [22,23,26–28]. Indeed, Silvius et al. [20] mention the lack of creativity and planning among the barriers to the implementation of CE in the furniture sector. On the other hand, scholars are testing practical tools, methods, and guidelines that provide diverse potential aspects to improve, like the management of the supply chain in the EU furniture industry [20], circular product design [29–31], benefiting from advanced digital technology [32,33], CE services, and business model exploration and exploitation [34–36]. However, many of them have not been explicitly developed for the furniture industry.

3.2. Design Strategies for Circular Economy

Research increasingly addresses the crucial role that design can play in providing innovative solutions to the problems targeted by circularity. By its nature, design presents a rational and structured process to create something new for solving sustainability-related problems [37,38]. Design, as a creative activity aiming to establish the multi-faceted qualities of objects, processes, services, and systems in whole life cycles [39], can actively support companies in achieving sustainable and circular objectives. Circularity is a promising issue for designers to apply their creativity to generate economic, environmental, and societal impacts. Therefore, design can act as a creative means for value creation, delivery, and capture [19,40] for companies to combine economic growth with environmental development needs. The EU Joint Research Center's report [1] has emphasised how design should extend product durability and facilitate non-destructive disassembly, reuse, repair, and recycling. According to Charter [41], designing for the CE implies facilitating product circularity from the early creative stages of the process.

The literature has acknowledged design's role as a catalyst in fostering the transition from the linear process to one that is more regenerative and circular. One of the most cited works in this research field was the study by Bocken and colleagues [42]. They identified a framework of strategies for product design and business models aimed at moving from a linear to a circular economy. Building on Stahel's theory [43], they suggest eight product-design strategies to narrow, slow, and close the resource loop. These design strategies are highly linked to the physical product design and engineering process, for which design deals with the problem of goods, structure, components, and materials used, such as design for attachment and trust, design for maintenance and repair, or design for dis- and reassembly. The framework addresses the need for companies to implement design and business model strategies in conjunction.

Moreno et al. [44] also worked on creating a conceptual framework for circular design, exploiting and cross-referencing the approaches and strategies already established by Design for X (DfX) with the circular design strategy. They conducted a systematic literature review on the state of the art of circular design principles, examining the evolution process from green design, eco-design, cradle-to-cradle design, to DfX, and then a full transition to circular design. The categorisation is defined as a design for resource conservation, a design for slowing resource loops, and whole systems design. The circular design strategies developed replace end-of-life with the concept of recovery and eliminating waste and using renewable resources, seeking to consider closed-loop strategies within biological and technological cycles [30]. In this way, the circular design strategies propose a systemic and inclusive process that aims to develop solutions to minimise negative and maximise positive impacts by circulating resources and preserving the intrinsic value of the materials [45,46].

Den Hollander et al. [47], through a literature review, developed their taxonomy based on the terms of design for circularity, starting from the concept of obsolescence, thus

dividing it into Design for Product Integrity (macro-approaches to resisting, postponing or reversing obsolescence) and Design for Recycling [48].

Van Dam et al. [49] examined the contributions of industrial design research to circular economy knowledge by reviewing design journals. They clustered four main types of contributions: design for the circular production process [50,51], design for circular consumption, design to support policy for circularity [52–54], and design education for the circular economy. In the design for circular production, scholars have addressed design approaches to innovate the production process towards circularity: design and designers promote the systemic perspective with the concepts of distributed manufacturing and open design [55,56] to enable collaborative local productions. Moreover, design has the capacity to recover the product values from working with materials to retain the values to adopt strategies for extending the product's lifecycle [57–59]. Design can also motivate consumers to create and maintain certain behavioural routines for facilitating the adoption and implementation of circular initiatives [60–62].

It is necessary to emphasise that many authors highlight the need to align the product with the purposes of the business model (BM), trying to cross-reference the different types of BMs through their frameworks [9,42,44]. This is also where the strategic role of design evolves, from product design to business model design and then to ecosystem design [6]. The studies intersecting design strategies, BM, and circularity are growing in the literature. For example, Linder and Williander [63] stated that creativity and design are key elements for building a circular economy business model because they allow revising inputs, transforming processes and outputs, providing innovative solutions that enable the continuous cycling of materials, and reducing or eliminating waste. Saphira et al. [64] and Santa-Maria et al. [65,66] developed an operational framework that integrates the DT process steps in developing circular business innovation activities.

In summary, design can play a strategic role in achieving circularity at various levels by defining and implementing diverse principles and strategies. Table 1 provides an overview of the primary clusters of circular design strategies discussed in the literature. In the furniture sector, the implementation and application of these strategies remain suboptimal due to the industry's unique characteristics. This is evident even in applying the most developed strategies, such as product design strategies [67].

Table 1. A summary of circular design strategies for circular economy development from literature (elaborated by authors).

Circular Design Strategies	Main Concepts	Authors
Design for narrowing resource loop/resource conservation and efficiency	Design for optimising the resources and processes used in the production process. The design strategies could be applied on both material level and product level.	Bocken et al. (2016) [42]; Moreno et al. (2016) [44]
Design for extending the product life/(value recovery)	Design methods and solutions are used to facilitate value recovery of the product via reuse, repair, refurbishment, and remanufacturing. The design strategies can be applied through different approaches. They can intervene on how the materials are used to produce the products, how the products are designed and structured, and how the use phase of the product is extended through offering access to use or service systems.	Bocken et al. (2016) [42]; Moreno et al. (2016) [44]; Go et al. (2015) [29]

Table 1. *Cont.*

Circular Design Strategies	Main Concepts	Authors
Design for closing resource loop/Design for Recycling	The design strategies focus on fitting for the technological and biological cycles and systems to make the materials completely recycled. The products are designed to continuously be recycled into new materials or products, with safe and healthy materials, and to be easily dis-/reassembled.	Bocken et al. (2016) [42]; De Aguiar et al. (2017) [48]
Design for Cleaner Production and Transportation	Design is applied to generating solutions that reduce the negative environmental impacts that are caused due to the delivery of products and production. The design strategies support the creation of solutions that focus on promoting a local-based production system and reducing the weight and spaces during the transportation.	Mullagh et al. (2019) [51]; Markou et al. (2017) [50]; Van Dam et al. (2020) [49]
Design for Product Service System that deliver functions rather than ownership	Design for transforming from selling products to delivering functions, intervening on the holistic system of value proposition, creation, and delivery. The design strategies aim to extend the use phase of products and maximise the recourses and values contained in the products.	Manzini & Vezzoli (2003) [7]; McAloone and Pigosso (2018) [68]
Design for fostering circular behaviour and consumption models	Design to support consumers to form and implement behaviour supporting circular economy. This is usually achieved through motivation, acceptance, education, and communication.	Ackermann (2018) [60]; Mugge et al. (2018) [62]; Bhamra et al. (2011) [61]; Van Dam et al. (2020) [49]
Design for collective engagement of stakeholders/whole system design	A systemic perspective and systemic design approach to enable stakeholders and the network to collaborate towards sustainability and circularity.	Moreno et al. (2017) [30]; Nohra and Barbero (2019) [56]; Goldsworthy and Ellams (2019) [55]
Design for supporting policy towards circular economy	The design approach can foster more inclusive governance processes towards circularity through engagement. At the same time, some key components of broad infrastructures related to circularity could also impact the design process and results (e.g., product).	Cooper (1999) [52]; Reitsma et al. (2017) [54]; Munthe-Kaas and Hoffmann (2017) [53];

4. Materials and Method

The methodology has been designed to answer the following research question: what design strategies are adopted and implemented by furniture companies to guide their transition initiatives towards a circular economy, and how do they employ them to achieve this transition? The investigation opted for qualitative methods with an exploratory approach to reduce uncertainties around the topic and, simultaneously, better understand the phenomenon [69]. In particular, we have conducted a multiple case studies method [70] to generate a general understanding of the topic by analysing a critical mass of examples and understanding the effects of changes [71–73]. In other words, by observing current initiatives, it is possible to understand the different strategies, associate them with those already present in the literature, and consider how the changes could impact companies. Furthermore, the choice of this method also lies in the fact that it addresses the analysis of a complex phenomenon derived from the context of real life, with unclear boundaries [72,74], e.g., how the furniture sector is changing its offerings and BMs towards circularity.

4.1. Research Design

The research process (Figure 1) followed three macro-phases in line with Gray [72] and Yin [74], namely, a first definition phase to understand existing theories and perspectives

on the phenomenon; a second phase of design, preparation, and collection, where criteria were defined, and data were collected from multiple sources; lastly, the final phase of analysis, where case data were examined and compared to draw the results. Each step is presented below to ensure understanding and improve the clarity and reproducibility of the research process.

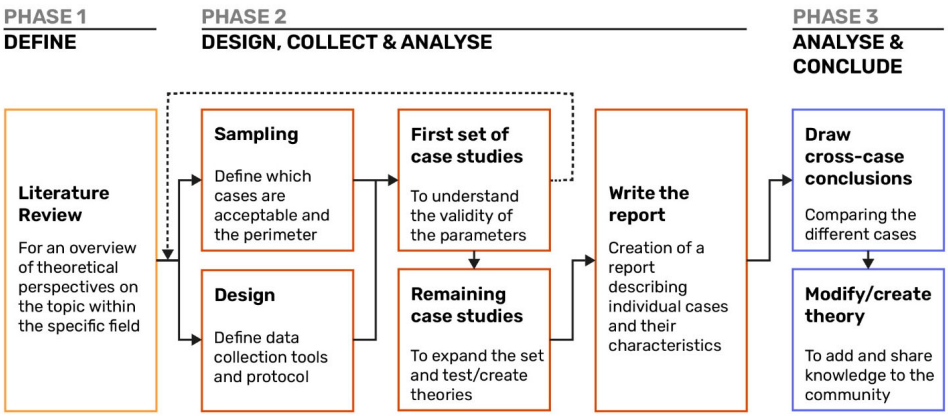

Figure 1. The research process adopted for the multiple case studies (elaborated by the authors and adapted from Gray, 2004 [72], and Yin, 1994 [74])).

4.2. Phase 1—Define

Following a deductive approach in accordance with Yin [74], the research process started with an initial literature review that could provide an overview [75] of theoretical perspectives on the necessity of developing a circular economy within the furniture sector, as well as the potential of circular design strategies to achieve this goal. This analysis would have subsequently allowed the results to be selected, analysed, and interpreted consistently with the theories and interpretations already in the field [72]. For this reason, the literature review conducted in this research did not aim to map a topic comprehensively but had an exploratory scope, allowing researchers to familiarise themselves with the frameworks and findings of other scholars [76]. Firstly, we analysed the most important studies and authors in circular economy and circular design. Subsequently, the research focused on the furniture sector and related circular design strategies. This involved a boolean search with terms such as 'Furniture sector, Circular Economy, Circular Design, Design Strategies' in major databases, including Scopus and Google Scholar, without any time filter from which journal articles, conference papers, books, and book chapters written in English were extrapolated. In the thematic literature review, it was possible to identify the main design strategies, approaches, methods, and possibilities in the furniture sector, as reported in Section 3 of this article.

4.3. Phase 2—Sampling Strategy, Data Collection, and First Analysis

The next phase involved data collection and an initial analysis to understand the circular design strategies implemented in the furniture sector. Given the particular importance of the unit of analysis and sampling in research based on qualitative methods [77] and the risk of having investigations too broad [76], it was decided to opt for a non-random sampling [78] by focusing the unit of analysis on offerings (products and services) or business models developed by furniture companies with the objective of achieving the circular economy. Given this unit, the sampling of cases was defined in geographical and temporal terms. The first parameter, geographical limits, was selected to include cases from Europe, where the authors are based. This choice was dictated for several reasons. As stated in Section 3, the European Union accounts for approximately 25% of global furniture production. Moreover, the European Commission has launched policies to push the adoption and implementation of CE practices, and, finally, the authors have a long history working with the European furniture sector, which enables them to reduce the

cultural barriers in understanding and interpreting data from the cases. For the second parameter—temporal limits—we opted for initiatives that emerged in the last ten years because, in this period, the CE and its principles have had the opportunity to spread and develop beyond academic boundaries. Furthermore, to focus on the article's objective, we included circular initiatives that have adopted at least one of the previously mentioned circular design strategies (Table 1). We selected cases that indicated the circular design strategies adopted by using keywords and terms related to design, sustainability, and circularity in their offering description. Furthermore, the cases were selected by observing the companies' inclination to use design, focusing more on design-intensive brands [79]. To obtain a holistic perspective on the complexity of the change taking place, the case studies focused on products or services that revolve around furniture products, understood as objects such as chairs, tables, beds, kitchens, etc., that are placed inside a home or other building to make it suitable and comfortable to live or work in [80].

Two case study collection protocols were designed to enable multiple perspectives: desk and field research. For desk research data collection, cases were identified, mapped, and constructed using second-hand data such as grey and company literature (including agency or European project reports), company websites, media reports (including newspaper, magazine, and webzine articles), and scientific literature (including single case study research). Since the data are second-hand and may be inaccurate or biased, an investigative approach was adopted, comparing different sources to verify the truthfulness of the arguments and consolidate each case study. The data collection followed an iterative process to allow for the readjustment and verification of the sampling strategy and analysis parameters, cross-referencing with the literature that emerged in the previous phase. To facilitate this process, the cases' links and parameters were mapped using different spreadsheets shared between the authors. Further case studies were analysed once the sample was defined and validated to expand the sampling and obtain a broader overview. For each of them, the offer was analysed, indicating the design strategy [42], the type of service offered [81], and the characteristics of the business model [9]. The frameworks and taxonomies used for the analysis were chosen for their comprehensiveness, scientific validity, and popularity. For each case study, qualitative contextual information was collected, such as the partnerships and relationships developed to implement the offer, the national context, the design contribution, and the drivers that started the initiative.

The second protocol involved data collection from the field through observation guided by a digital worksheet [73]. The worksheet was based on the three previously defined levels, e.g., materials and products, services, and business models. The data were collected through the participation of the first two authors of this article in sector events and trade fairs, in particular, the Salone del Mobile and Fuorisalone during the Milan Design Week in the years 2023 and 2024. To facilitate the analysis and collection of data in the field, the focus was placed on leading furniture companies, namely, large design-intensive companies (e.g., companies declaring the adoption of design within the case study or the entire company). While attending the events, data were collected through the worksheet by observing and analysing the products on display, information materials (e.g., brochures, stand signs, videos, etc.), and asking stand personnel for information. To obtain a complete overview and supplement the information, if necessary, grey and company literature such as articles in trade magazines or company websites were used. Once the observations were completed, the data were collected and catalogued within the same spreadsheets described in the previous protocol. A total of 58 cases were collected through the desk and field protocols. The full list of case studies, with a brief description, can be found in Appendix A.

4.4. Phase 3—Data Analysis

Each of the selected cases was analysed to understand the different design strategies applied in the furniture manufacturing companies for developing and implementing circular economy initiatives. The previous literature review provided a strong structure to support the coding activity. The analysis tool is composed of two main elements. The first

element looks at the applied circular design strategy(ies) summarised in Table 1 in Section 3 of the literature review, taking into consideration the offerings (both products and services). This allowed us to understand the main outcomes of the applied circular design strategies in the furniture sector. The second element aims to analyse from the perspective of the business model [40]. As anticipated before, the analysis of each case is divided into value proposition (the offering as a product or service), the circular design strategies adopted, value creation, and value delivery [9,40,81,82]. An example of the analysis generated for each case study is presented in Table 2. For each case study, qualitative contextual information regarding the required analysis elements was used. Other specific information to increase the case's context includes companies' key activities, partnerships, and other firms involved in developing the offerings, delivery channels, and applied technologies.

Table 2. An example of case study analysis (elaborated by the authors).

Case Name	Offerings/Outcomes	(Principle) Circular Design Strategies
Lyght Living (https://lyght-living.com/en/ accessed on 6 May 2024.)	A furniture-renting service system that offers consumers (both individuals and other businesses) to rent top-quality furniture packages for a certain period, with an open option to own at the end of the renting period	- Design for extending the product life: reuse furniture products by renting to different uses) - Design for circular product service system solutions: the service allows users to pay for use and then choose to return or own them
How does the service work	1. Explore eco-friendly furniture collections; 2. Select a rental period; 3. Get furniture delivered at the place; 4. Extend or shorten the rental period or purchase the furniture (at the end of the renting, consumers could pay for owning the products, or the company takes back the products)	
How does the CEBM work	Value Creation and Delivery - Renting services with a rich catalogue of furniture packages (home and office) and flexible rental period (be able to change the product during the service period) - Furniture product delivery, installation, and maintenance (partnership with logistic companies)	Value Capture - Main revenue: subscription service, prices are defined based on the rental period (e.g., a package for a lounge area costs EUR 65/month for a rental period of 24 months) + furniture purchase (optional) - Furniture delivery and maintenance - Platform management
How does this change the product design	Implementing circular product design strategies could facilitate furniture product transport, maintenance, repair, and reassembling	

The coding and analysis process was performed independently by the first two authors on all cases; for those where the coding was different, the sources were re-analysed, and a collective comparison was made between the two analysts. A cross-case analysis was carried out, searching for regularities and patterns to highlight the correlations between the offering (through circular design strategies and the type of service offered) and Business Model Innovation. Firstly, as already mentioned, using spreadsheets and classifying the case studies according to the highlighted parameters, it was possible to identify a series of quantitative data, such as the most common strategies and correlations. This enabled clustering of the initiatives and strategies adopted, identifying more used ones. From this, it was possible to analyse the results and the clusters critically, iteratively comparing the considerations with individual cases, to define the conclusions, e.g., to clarify the state of the art in the furniture sector of circular initiatives, design strategies adoption and, consequently, how the sustainable transition is proceeding.

5. Results

The analysis results provide an overview of the current circular economy initiatives in the furniture sector. The circular economy initiatives have been clustered according to the circular design strategies that they have applied and the scope and subject of the design

actions and intervention. In this section, we present these categories by illustrating them with concrete and detailed examples from the collected case studies. Following the most acknowledged design for sustainability frameworks [6,83,84], the revolution of design for facilitating companies' sustainable and circular development has impacts from the material, product, and product service system to the business model and the whole ecosystem. This corresponds to what Buchanan [85] has named the four orders of design. If we examine the circular design strategies applied in the furniture sector, we can see that the design actions are implemented at all these levels. In this section, we will illustrate how circular design strategies are applied at different levels and what outcomes they create. Table 3 summarises the implementation of different circular design strategies in the furniture sectors, supported by practical cases.

Table 3. Circular design strategies and their implementation in the furniture sector (elaborated by authors). The reported case studies are selected as the most representative ones.

Circular Design Strategies	Principle Scope of Design	Circular Design Initiatives in the Furniture Sector	Representative Case Studies
Design for narrowing resource loop/resource conservation and efficiency	Product level	The design of furniture products helps to preserve the resources used during production or increase the resource efficiency of the product performance (the contribution of advanced technology)	• Couch in an Envelope (Space 10) • Bell Chair (Magis) • OTO chair • Velda Resleep (Veldeman Bedding)
Design for closing resource loop/Design for Recycling	Material level	Substitute traditional materials with biological and natural ones as input for product design and output at the end of the product lifecycle	• Catifa Carta (Arper) • Re-Chair (Kartell and Illycaffe) • Q/WOOD (Kartell) • Herso Wood Furniture (Herso) • Re-Airchair (Magis) • Bell Chair (Magis)
		Use wastes and recycled materials as input resources for furniture product design and production	
	Product level	Product design facilitates the recycling of part of the product or the whole products	• OTO chair • REVIVED Service (Gispen) • Velda Resleep (Veldeman Bedding)
	Service and business model level	Develop a partnership for the collection, recycling, and use of materials in new furniture products	• Kungsbacka (Ikea) • Bell chair (Ikea)
Design for extending the use phase/(value recovery)	Product level	Product-design strategies are applied to extend the use phase by providing the possibilities to maintain, repair, refurbish, and remanufacture. Furniture products are designed: • In high quality for long duration; • In modular and standard; • To facilitate dis- and reassemble.	• OVO collection (Benchmark) • Stykka Kitchen (Stykka) • OTO chair • Eco's Services (Steelcase) • Invitrum (Valcucine) • Costume Sofa (Magis) • August (Fischer Lighting) • Couch in an Envelope (Space 10) • EASYDIA and EASYolo (Arcadia Design) • Velda Resleep (Veldeman Bedding) • Tripp Trapp (Stokke) • Nova C (Green Furniture Company) • ZA:ZA (Zanotta)

Table 3. *Cont.*

Circular Design Strategies	Principle Scope of Design	Circular Design Initiatives in the Furniture Sector	Representative Case Studies
Design for extending the use phase/(value recovery)	Service and business model level	Complementary service for maintenance and repair furniture products	• OVO collection (Benchmark) • Stykka Kitchen (Stykka) • Eco's Services (Steelcase)
		Collect and resell the used furniture to another consumers or business	• 2nd Cycle (Artek) • Circle Store (Vitra) • Circular Hub (Ikea)
		Refurbishment and remanufacturing based on the reused furniture products	• REVIVED Service (Gispen) • Sajkla • August (Fischer Lighting)
Design for Cleaner Production and Transportation	Product level	The product design helps to reduce the spaces during furniture transportation	• Bell Chair (Magis) • Couch in an Envelope (Space 10) • OTO chair
Design for Cleaner Production and Transportation and Design for collective engagement of stakeholders	Ecosystem level	Reduce environmental impact by bridging production and transportation	• Opendesk • PET Lamp • OTO chair
Design for Product Service System that deliver functions rather than ownership	Service and business model level	Apply furniture as a service logic to sell the access of use to consumers or businesses, instead of the ownership	• Lyght Living • Circular Offices (Desko) • Live-Light • FAAS (Ahrend)
Design for fostering circular behaviour and consumption models	Service and Business model level	Engage consumers to take part in bringing back used products	• Circular Hub (Ikea) • Circle Store (Vitra)

5.1. Material-Orienting Furniture Product Design towards Circularity

The case studies have presented a large number of circular design strategies implemented at the material level by furniture companies. Replacing negative-impact materials with high-performance ones has become a common circular practice, and furniture companies adopt it to adapt their products to new regulations, user demands, and market trends [86,87]. These material-orienting circular design strategies mainly focus on two types of approaches. The first one has explored the possibility of making the best use of waste and recycled materials as input for designing furniture products. For example, the leading Italian furniture brand Kartell launched a collaboration with IllyCaffe' in 2023 with the notion of the circular economy in mind, developing *Re-chair*. The chair is designed by transforming the flawed coffee capsules into a new type of material to replace the traditionally used plastics while maintaining the elegance of the original design of Antonio Citterio. Though with certain limitations, the outcome shows an exploration of a furniture company that uses the wastes as input to shape its practices towards a circular economy by strengthening the materials used in product design and production models. This strategic partnership between the two brands also launched new collections under the same notion and objective in the Salone del Mobile in 2024. Another inspiring case from our case studies is *Herso*, a wood furniture company in the Netherlands that reuses the wood from old products, such as old furniture, window frames, and doors, to design and produce wooden furniture. Another circular design strategy that we have observed is the substitution of traditional materials used in furniture products and productions with environmentally friendly ones. The recycling business model [9,42] aims to close the loop and overcome the insufficiency in the linear production lines. Recycling is often needed at the material level,

and it requires knowledge of both product design and material science. In the furniture sector, we have witnessed a significant case this year. The Italian furniture company Arper has presented its *Catifa Carta* (Figure 2) chair, which represents a new era of material evolution in furniture. The main body (the seat and the back) is made of a new material derived from used paper. At the end of its life cycle, *Catifa Carta* can be transformed into biochar that could be used to regenerate biodiversity. This circular initiative aims at closing the loop by considering the whole lifecycle of furniture products, from innovating the input material to the recycling of the materials at the end-of-life of the product as part of the mature (design for biological recycling).

Figure 2. Catifa Carta by Arper® (Monastier di Treviso (TV), Italy). Photos taken by the authors inside the company stand during the Salone del Mobile 2024.

These two circular design strategies try to achieve a circular economy using different approaches, though both focus on material intervention. Material substitution in the furniture sector requires changes in the production process, the acquisition of new skills, and the establishment of relationships and collaboration models with the materials' suppliers. It is a systemic change rather than a material revolution, and it could be exploited by applying systemic thinking and design [88], which could stimulate a reflection on the industrial symbiosis processes with more actors involved and resources presented beyond the current supply chain in the whole territory. Replacing a material by considering the entire system (in an industrial symbiosis perspective) would allow, as in natural ecosystems and the cradle-to-cradle approach, to cultivate and foster (new) material flows and reuse the waste from one company (or other types of organisations) as value and input for another one [31,42,44]. From consumers' perspective, it is not easy to fully perceive the added value since most do not have a deep knowledge of materials. In this direction, creativity and design could bring new perspectives on material selection—an activity associated with technical figures but recently becoming increasingly grounded in the design field [89]. From the perspectives of systemic design and strategic design for sustainability, this activity could and should also impact the company's business model, for example, proposing and establishing unconventional partnerships and creating new relationships with diverse actors to avoid waste and provide economic and environmental benefits to all stakeholders [7,90].

5.2. Designing Products and Systems for Clean Production and Transportation

The second typical circular strategy in proposing circular initiatives in the furniture sector is to reflect and redesign the production and transportation systems with the objective of reducing the resources used in production and logistics.

From the collected cases, we have observed that several companies have developed new furniture products that aim to preserve the resources used in production—using less material and causing less energy consumption during production. The design of the product combines function, aesthetic, and circularity goals, selecting the form, structure, and connection model to make the most efficient use of raw materials, both from quantitative and qualitative perspectives. Due to these design decisions, in most cases, the weight of furniture products has also been reduced, connecting to the narrowing strategy. Moreover, the circular design strategies extend beyond the product itself. For example, Magis' Bell chair has implemented a logistics concept to conserve additional resources. This concept includes a custom-designed, reusable delivery pallet capable of stacking up to 24 chairs. Consequently, the vertical stacking configuration reduces the transportation footprint. Additionally, the pallet serves as a store display for retail partners and is constructed from the same recycled plastic as the chair. Another case, *Couch in an Envelope* by Panter&Tourron and Space 10, has experimented with the same circular design strategy, reducing the environmental impact, personal efforts, and economic costs when transporting their sofa. Thanks to the contribution of Generative AI, the shape of the sofa is designed as the best choice that has balanced the functions and aesthetics. Additionally, it is also designed to facilitate transportation and offers the possibility to re-arrange and adapt to new contexts and needs.

Mitigating the environmental impact of reverse logistics systems can be effectively addressed through a systemic design approach. One promising way is the implementation of a localised production system that significantly reduces the distance required for transportation. This proximity not only diminishes the associated carbon emissions and fuel consumption but also enhances the overall efficiency of the logistics network. This concept enables furniture companies to contribute to the reduction in the adverse environmental effects traditionally associated with long-distance transportation in reverse logistics systems. The *Opendesk* case exemplifies the potential of localised production systems. It operates as a global platform that facilitates local manufacturing. It connects customers with a pool of designs and nearby craftsmen, creating a new supply chain that produces furniture on demand. This approach is not only sustainable and affordable but also aligns with the circular economy in several ways. Firstly, Opendesk's on-demand production model prevents overproduction, ensuring that furniture is made only when there is a confirmed need. Secondly, sourcing production locally minimises transportation distances, significantly reducing associated carbon emissions and fuel usage. This model also alleviates the need for lengthy and costly shipping processes, benefiting both consumers and the company. Furthermore, it eliminates the necessity for extensive showroom spaces and large storage facilities, thus reducing operational costs. Overall, Opendesk's innovative system demonstrates how localised, on-demand production can enhance sustainability and efficiency in the furniture industry.

5.3. Extending the Furniture Products' Lifetime by Designing Products, Service Systems, and Business Models

The most commonly applied circular design strategy in the furniture sector is to extend the furniture products' life, which is achieved through two different design approaches. A number of cases have designed their products to enable maintenance, repair, and upgrade in order to extend the duration of the furniture, such as design for modularity and design for dis- and reassembly. On the other hand, new business models and systems are also designed to achieve this goal by offering renting and exchange services.

At the product level, Design for X strategies [29,44] are widely applied. For example, design for the dis- and reassembling of single furniture products or product collections

could be observed in a series of cases. The product and product systems are mainly designed with simple structures and fewer components that: (1) are easy for consumers to dis- and reassemble by themselves whenever they need to move and deliver the furniture elsewhere; (2) save space and cost for logistics, storage, and distribution; (3) provide the possibilities to remove, modify, replace, and fix some parts of the furniture that will have a shorter life and duration; (4) involve consumers/users to dis- and reassemble the furniture products by themselves for recycling. For example, cases like *couch in an envelope, OTO chair (Figure 3), Costume Sofa,* and *August* have all simplified and well-balanced product functions and forms to make furniture pieces easy to dis- and reassemble. The design for standardisation and compatibility is often associated and linked to design for dis- and reassembling. Design for upgradability and adaptability is another way to extend the product usage and duration observed from the case studies.

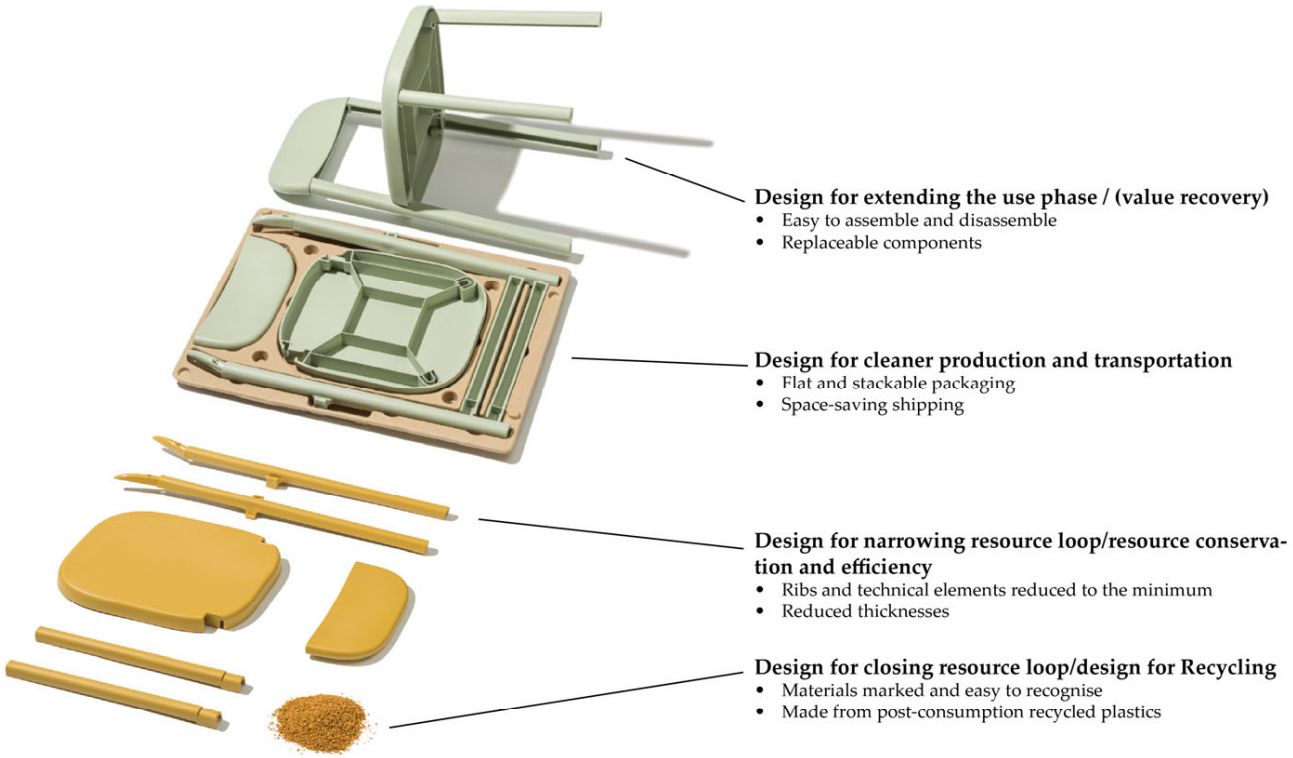

Figure 3. OTO chair main circular design strategies, elaborated by the authors based on the original images of ONE TO ONE.

The circular design strategies for extending the product life are also applied by implementing new business logic and not selling furniture products but the access of use to the consumers or other businesses. Adopting the servitisation logic [91] in the furniture sector is still in the early stages, as shown by the analysis results. The most common service system typology is the product-oriented one [92], focusing on the furniture (enhancing function, forms, performance, and interactions), which is still considered as the crucial value of companies' offerings. Most services are designed to extend the use of the furniture pieces to the same owners who have bought the furniture, and different related services are provided to the product owners: maintenance, repair, updating, and reconfiguration. Another type of service, use-oriented service, applies the furniture as a service (FAAS) logic to provide customers with the possibility of paying for the use and function instead of the ownership. Cases such as *Ahrend*, *Lyght Living,* and *Desko are significant examples* of furniture companies providing a FAAS. It is notable to mention that companies such as *Ahrend* have reshaped their business model to realise the life extension based on the previous change in

product design and manufacturing process. The products are designed to enable effective maintenance, partial replacement and repair, as well as upgrading with new components.

5.4. Designing for Engaging Consumers in Co-Creating the Values towards a Circular Economy

In addition to circular production, the concept of circular consumption is one important part of achieving a circular economy. Circular design strategies can influence consumers' behaviour and perceptions towards adopting the circular economy. However, the research results show that this circular design strategy is less present among all the collected cases. In the cases in the furniture sector, circular initiatives have paid relatively less attention to the consumers' perspective. The *Circular Hub* proposed by Ikea is one good practice that has implemented this circular design strategy. This initiative focuses on involving consumers to actively participate in bringing back used furniture products, which allows the company to repair, refurb, resale, and recycle. At the same time, consumers are awarded a discount for their future purchases. The design strategy guides consumers to participate in promoting and facilitating a circular economy actively and eventually educates them to form a circular behaviour that takes care of the furniture during its whole lifecycle, especially in the take-back phase. Another similar case is the *Vitra Circular stores*, launched by Vitra in some European cities to resell used accessories and furniture (such as samples and display pieces), enabling the products to extend their lifecycle. This circular initiative selects the physical store as a new touchpoint to promote its circular initiatives, where consumers have opportunities to closely understand the brand's practical actions towards its ecological missions. The physical store is also part of its new circular business model for implementing a circular economy.

6. Discussion

6.1. The Under-Developed Areas for Applying Circular Design Strategies in the Furniture Sector

The research findings elucidate the practical applications of various design strategies that have enabled furniture companies to conceptualise and implement circular projects and products. However, a comprehensive analysis of the literature and case studies indicates that the furniture sector still possesses substantial potential for advancing and integrating more profound circular practices.

Firstly, design for circular behaviour and consumption remains a peripheral consideration for furniture companies when developing circular solutions. In various case studies, furniture companies have invested substantial resources and efforts into adopting circular approaches in material selection, manufacturing processes, and extending product lifecycles. However, they should devote more effort to understanding how consumers perceive, understand, and accept these circular choices and the role consumers could play in amplifying and fostering such practices. For instance, while many furniture companies have replaced traditional materials with recycled and recyclable alternatives, few have implemented take-back services that facilitate the return of products to the manufacturers. The absence of such take-back services could fail to recycle used products at the end of their lifecycle, undermining the effectiveness of these circular initiatives. In other words, it could be interesting for furniture companies, on the one hand, to communicate the choices and backstage of a product, service, or system by making them understand the circularity aspects, and on the other hand, to explore and design the relationship between user and product through purchase activity, maintenance, dis-assembly, and other strategies. In this way, it might be possible to make users understand the value of a product and the economic and environmental benefits of choices, overcoming barriers [22,23].

Secondly, there is a need to explore how new technologies can be used in applying circular design strategies. For instance, the *Stykka Kitchen* case illustrates how a digital twin can provide comprehensive information about a product's materials, components, and structures, simplifying and optimising maintenance operations. This approach enables continuous updates to the product or its parts and allows customers to order individual replacement and repair parts. Furniture companies must adapt their products to facilitate

assembly and disassembly and, through modularity, enable component reuse in other products. Thus, it might be possible to reduce costs, labour, storage, and transport time. This integration fosters creativity in product design, service experiences, and digital service touchpoints. Moreover, technology should complement both product and service design. This can enhance the design and creative process by providing powerful tools during concept generation through generative AI and product development through parametric software, improving optimisation and durability. Utilising such technologies can also impact business models by leveraging data from products, users, and value chain partners. Technology-driven design for ease of maintenance and repair can build customer loyalty, foster long-term relationships, and use aggregated data to enhance product durability by targeting weaker components and materials. Additionally, historical data allow customers to monitor product health and plan maintenance and repairs, even after ownership changes, ensuring sustained product performance and longevity. Alternatively, through data collected by local partners, it might be possible for furniture companies to manage logistics for remanufacturing and repair or for end-of-life resource management in an area distant from the production site.

Thirdly, the case studies demonstrate that the predominant focus of design within the furniture sector remains at the material and product levels. The circular initiatives are still predominantly product-centric, and this fragmented approach hinders the development of truly sustainable and circular solutions that consider design contributions at the product service system (PSS), business model (BM), and ecosystem levels [18]. There is a huge opportunity for integrating systemic and strategic design approaches to enhance circularity across the different design scopes and involve the entire value chain. In some cases, we have observed a significant interconnection between materials, products, service systems, and business models. For instance, the management of renting and leasing furniture products encompasses services such as maintenance, repair, and refurbishment. This necessitates that the design of furniture products facilitates these activities. Consequently, during the product design process, design decisions should consider their implications at the service system level.

6.2. A Framework for Applying Circular Design Strategies from an Ecosystem Perspective

Recognising the importance of adopting an ecosystem perspective, we propose a framework (Figure 4) that integrates three principal elements of the offerings provided by furniture companies—material, product, service, and business model—designed to achieve a circular economy. The framework delineates three primary levels that are subject to design and redesign in accordance with the circular design strategies discussed in previous sections, e.g., (1) materials; (2) product and product-oriented services; and (3) use-, result-oriented services and business model. PSSs are intended to bridge the product and the BM. Indeed, by working on product-oriented services, extending the product's life and facilitating its repair or take-back for recycling is possible. However, the company's BM would not be affected, allowing it to experiment beyond the product. Through use- and result-oriented PSS instead, it would be possible to implement new services capable of innovating the BM and drastically reducing the environmental impact, such as second-hand sales or lease/rental. The objective is to illustrate that circular design strategies can be applied across different domains to achieve varied outcomes, as evidenced by the selected case studies. Furthermore, this framework serves as a guide to assess and ensure the comprehensive application of circular design strategies by considering the interconnections and interdependencies among different elements and the resultant impacts at various levels. Through the strategies indicated at each level, it is possible to link the case studies identified in this article and obtain a clearer idea of how the sustainable transition has been addressed and of future explorations and experiments in the furniture sector towards circularity. The three levels (and thus the strategies) are subject to the contextual situation and ecosystem of the individual furniture company. Because of this, during the

application and definition of the strategies, the stakeholders (primary and secondary) must be considered and preferably involved.

The framework is developed with three primary objectives. First, it serves as an analytical tool to guide both furniture companies and designers in expanding their approaches to developing circular initiatives and planning the implementation of circular design strategies. Second, it can be used to present and illustrate an ecosystemic perspective for defining circular solutions in the furniture sector, extending beyond material- and product-level improvements, where most companies currently focus their efforts. Third, from a strategic design perspective, the framework offers additional elements and considerations for furniture companies to chart their unique path towards achieving circularity. This approach distinguishes them from competitors by incorporating a more holistic perspective.

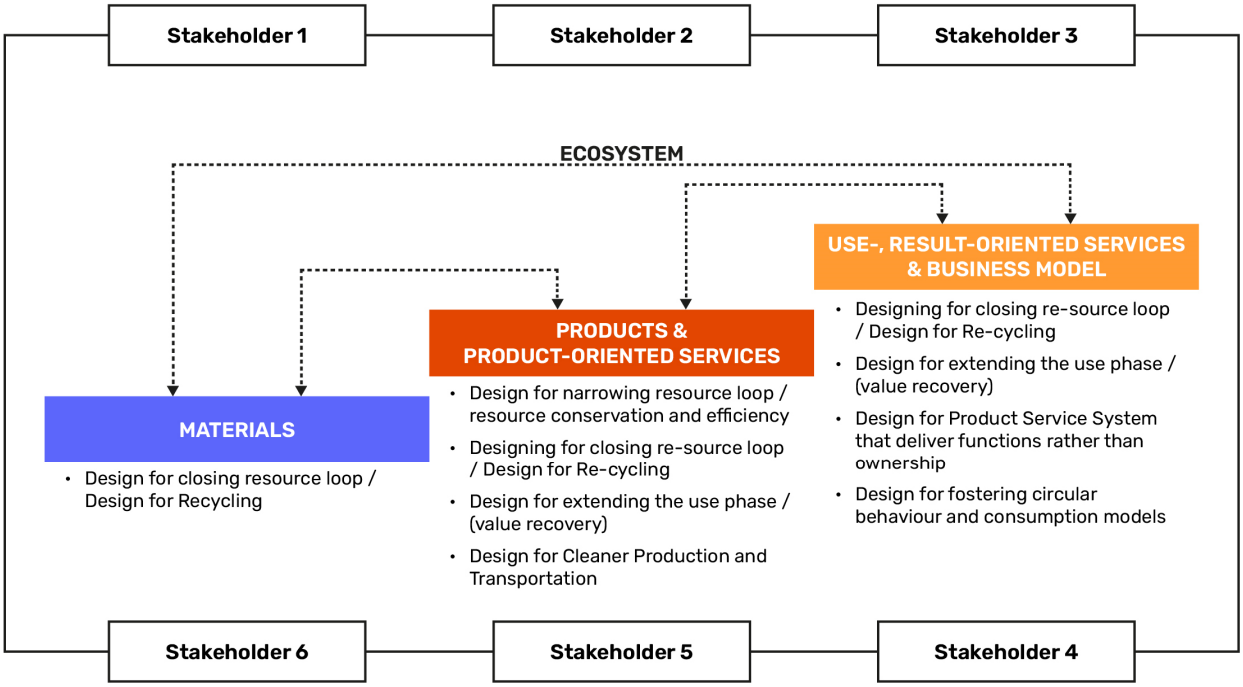

Figure 4. Framework for applying circular design strategies in the furniture sector from an ecosystem perspective (designed by the authors).

7. Conclusions

This article conducted a multiple case studies analysis to understand how the furniture sector is implementing circular design strategies, changing and reshaping its products, service systems, and BMs towards achieving a circular economy. The results show how the actions taken to date by the furniture sector retrace the levels cited by the most recognised frameworks in the field of design for sustainability [6,83,84], as well as in the four orders of design [85]. In particular, it is possible to highlight interventions at the material level; a reduction in the interventions aimed at reducing the environmental impact during production and transportation processes; and the extension of the lifetime through appropriate product design, PSS, or BM. Strategies that involve users and encourage sustainable behaviour emerge marginally, so the role that consumers can play in driving and amplifying circular practices remains to be explored. Furthermore, the role of technology in the application and exploitation of circular design strategies still needs to be investigated, leaving room for future research. The results show that the furniture sector is still product-centric, focusing on material and product-level interventions. The contribution of design to the PSS, BM, and ecosystem levels still needs to be explored, leaving opportunities to integrate systemic and strategic design into practical applications in the furniture sector. Based on these considerations, this study proposes a framework for applying circular design strategies in the furniture sector with an ecosystem perspective, connecting the different

levels. These research findings and the proposed framework have the potential to benefit both the academic community engaged in similar topics and practitioners and companies in the furniture sector. Specifically, they can assist those seeking to integrate circular design strategies in their efforts to transition towards a circular economy.

8. Limitations

As indicated in Section 4, the research applied two protocols, one desk and one field. In both cases, the data collected mirror the situatedness of the researchers. These are filtered by the particular position covered in the relational and manufacturing fabric of the Italian and European territories. By changing the location and thus the context of the researchers, the case collection and analysis could be carried out differently, leading to different conclusions. Furthermore, the research uses qualitative methods that require the authors' interpretation. Although strategies have been adopted (i.e., two authors interpreted the data independently), using a different epistemological approach (e.g., objectivist) could result in different outcomes. Finally, this study does not include a historical perspective on the social, cultural, economic, and technological changes necessary for generating a revolutionary understanding of the transition process in the furniture industry. Future work may cross-reference the results of this article with in-depth narratives on the transition of the furniture sector.

Looking to future developments, this research has shed light on circular design strategies in the furniture sector. Researchers and practitioners could take inspiration from these to develop projects, offers, approaches, and tools to facilitate implementation in this sector. This research was exploratory and did not aim to be an ending point but rather to provide a practical insight to be supplemented and supported with further data to progress the sustainable transition in the furniture sector.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. The complete list of cases and brief description.

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
1	Couch in an Envelope (Space 10) (https://www.designboom.com/design/carry-sofa-ikea-10kg-couch-envelope-space10-06-15-2023/ accessed on 6 May 2024)	Sweden and Switzerland	Recyclable sofa that weighs 10 kg designed to fit into an envelope for effortless portability. The designers challenge design archetypes with artificial intelligence, reimagining a couch as a lightweight, versatile, and sustainable item. The tool-less and screw-less design makes this concept couch easy to assemble, disassemble, and recycle if necessary while remaining lightweight, facilitating easier transportation.	a, b, d
2	Kungsbacka (Ikea) (https://www.formuswithlove.se/work/kungsbacka/ accessed on 6 May 2024)	Sweden	Kitchen fronts line made entirely from recycled plastic bottles and reclaimed industrial wood. With twenty-five plastic bottles used per unit, Kungsbacka proves a viable alternative as well as a statement to the world. Eliminating virgin plastics in large-volume productions is the way ahead.	c
3	Odger Chair (Ikea) (https://www.ikea.com/it/it/p/odger-sedia-bianco-beige-60359996/?msockid=08129192939668ce23de80c1924b6918 accessed on 6 May 2024)	Sweden	The chair is made with a wood fibre/plastic composite material, giving the chair a distinctive matte finish that is soft and pleasant to the touch.	c
4	Circular Hub (Ikea) (https://www.ikea.com/ch/it/campaigns/circular-hub-pubb0b4ba10 accessed on 6 May 2024)	Sweden	Second Chances Corner at IKEA stores, with old collections, second-hand products, or products with some defects ready for a second life at affordable prices.	b, f
5	OTO Chair (https://www.dezeen.com/2023/04/26/oto-chair-alessandro-stabile-martinelli-venezia-one-to-one-dezeen-showroom/ accessed on 6 May 2024)	Italy	Recycled plastic chair with the goal of achieving full sustainability, not just in material choices (using plastic recovered from the sea) but in the supply chain. It systematises the entire sustainable supply chain, from production to logistics, distribution, and assembly, to stimulate the public with a product capable of activating a new awareness. The chair is produced using a single mould, and it is sold online and delivered directly to consumers flat-packed.	a, b, c, d

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
6	Tripp Trapp (Stokke) (https://www.stokke.com/ITA/it-it/100140.html accessed on 6 May 2024)	Norway	Chair that grows with the child and allows a baby to sit at the table with the family from birth. The chair has an adjustable seat and footrest heights and depths for optimal ergonomics for different ages. With available accessories to personalise it in different use cases, the chair can be used from birth through adulthood.	b
7	Lyght Living (https://lyght-living.com/en/ accessed on 6 May 2024)	Europe	A furniture-renting service system that offers consumers (both individuals and other businesses) to rent top-quality furniture packages for a certain period, leaving open the option to buy and own at the end of the renting period	b, e
8	Opus Incertum (Laboratorio Linfa) (https://laboratoriolinfa.com/it/progetto/progettazione/297-tavolo-pranzo-opus-incertum accessed on 6 May 2024)	Italy	A sturdy, extendable table made of only wax–waterproofed reclaimed wood. The extension system allows the table to extend from 6/8 seats to 12 seats.	a, c
9	Velda Resleep (Veldeman Bedding) (https://ecodesign.vlaanderen-circulair.be/en/cases/cases-detail/velda-resleep accessed on 6 May 2024)	Belgium	The mattress and topper were developed according to the cradle-to-cradle principle without staples, glue, or PU foam. Parts are also 100% recyclable or reusable. The different components or materials are assembled using the company's own patented connecting techniques. This ensures easy transportability. The materials used have been reduced to a minimum, and they all have a low environmental impact.	a, b, c
10	Mirra 2 Chair (HemanMiller) (https://www.hermanmiller.com/it_it/products/seating/office-chairs/mirra-2-chairs/design-story/ accessed on 6 May 2024)	UK	Building on its tradition as the first office chair developed entirely on the principles of design for the environment, Mirra 2 is made to use and reuse of materials. In redesigning Mirra, Studio 7.5 took careful consideration of each element, which is essential to use the least amount of materials possible while not sacrificing more advanced performance.	a, b, c
11	Sett Ce Sofa (Gispen) (https://www.gispen.com/en/collection/seats/sett-ce-sofa/ accessed on 6 May 2024)	The Netherlands	This sofa is made out of no less than 95% recycled materials. The shell of the sofa was created by 3D printing plastic waste. The foam of the seat and backrest, the polyester lining, and the upholstery are also made of recycled materials. Moreover, all the materials this sofa consists of are separable; every single component can be reprocessed into a new product.	a, b, c

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
12	Furniture as a Service (Gispen) (https://www.gispen.com/en/services/furniture-as-a-service/ accessed on 6 May 2024)	The Netherlands	The service allows the client to pay a fixed monthly amount for the needed furniture. Gispen keeps ownership of the furniture. The furniture-management system will allow users to easily submit repair and request service. Gispen will also take care of transportation.	b, e
13	REVIVED Service (Gispen) (https://www.gispen.com/en/circular-interior-design/refurbishment/Revived/ accessed on 6 May 2024)	The Netherlands	The user can buy products with the label revived at a favourable price. This is because used pieces of furniture are refurbished to be as good as new again and are sold. Through the web portal, it is possible to trade furniture.	b, d, f
14	Herso Wood Furniture (Herso) (https://herso.nl/ accessed on 6 May 2024)	The Netherlands	Custom-made furniture produced with reclaimed wood harvested through urban mining. The company also produces floors and wall covers with the same material.	c
15	OVO Collection (Benchamrk) (https://benchmarkfurniture.com/collections/ovo-collection/ accessed on 6 May 2024)	UK	The products are made from Red List Free Declare Labelling-certified materials. In addition, the entire collection is designed with simple shapes specifically for long-lasting, durable, and reliable design.	b, c
16	Repair and Take Back (Benchmark) (https://benchmarkfurniture.com/lifetime-repair-take-back-scheme/ accessed on 6 May 2024)	UK	The company offers a Lifetime Repair Service to encourage refurbishment rather than replacement. When the furniture is no longer wanted or needed, the company offers a Take Back Scheme so that furniture can be returned to be refurbished or repurposed and given a new life.	b
17	Bell chair (Magis) (https://www.magisdesign.com/it/product/bell-chair/ accessed on 6 May 2024)	Italy	Made of recycled polypropylene obtained from production waste of Magis products and that of the local automotive industry. The patented material almost completely excludes 'virgin or new' materials and can be 100% recycled again after use.	a, c, d
18	Re Airchair (Magis) (https://www.magisdesign.com/product/re-air-chair/ accessed on 6 May 2024)	Italy	Chair made of recycled polyolefins obtained from the recycling of polylaminates and single-use food packaging. It is 100% recyclable.	a, c, d

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
19	Costume Sofa (Magis) (https://www.magisdesign.com/product/costume/ accessed on 6 May 2024)	Italy	Modular sofa with a 4 mm thin structure made from recycled and recyclable polyethene. The cover is fully removable thanks to the elastic loops hooked into the bottom. The sofa can be easily dressed and undressed for cleaning and replacement. The modular system consists of on single unit, which can be interlocked in various constellations or extended with armrests.	a, b, c, d
20	Re-Chair (Kartell and Illycaffe) (https://www.kartell.com/it/it/ktit/shop/product/re-chair-powered-by-illy-2-sedie/kar05803il accessed on 6 May 2024)	Italy	Chair made of recycled coffee capsules and produced with respect for sustainability. Re-Chair's stylistic feature allows it to fit into different environments in the home, from the dining area to the study.	c, d
21	Q/WOOD (Kartell) (https://www.kartell.com/it/it/ktit/shop/product/q-wood/117-789 accessed on 6 May 2024)	Italy	An armchair that is part of a family of products produced with an innovative material made from wood fibres and then processed by bending the wood to its curvature limit.	c
22	EASYDIA and EASY-olo (Arcadia Design) (https://www.progettoarcadia.net/it/design/economia-circolare/easy-system accessed on 6 May 2024)	Italy	Modular children's furniture made of solid wood, without chemicals and adhesives. Water-based paint and non-toxic varnish make remodelling and disposal safe. Modular design allows furniture to extend its useful life and adapt to children's growing needs. Easy disassembly allows pieces to be redesigned into other interior design elements.	b
23	Stykka Kitchen (Stykka) (https://www.stykka.com/inventar accessed on 6 May 2024)	Denmark	Long-lasting furniture with a digital operating platform. The furniture system allows users to build freely in height, width, and depth. Long-lasting furniture with a digital operating platform. The platform contains information on the life cycle of the product and allows its condition to be checked via a digital twin, facilitating repair.	a, b, f
24	Ahrend FAAS (https://www.ahrend.com/en/Solutions/Furniture-as-a-service/ accessed on 6 May 2024)	The Netherlands	Ahrend furniture as a service (FAAS) delivers workspaces that can easily be adapted to changing needs. Sharing platform on which there's an exchange of furniture based on supply and demand between organisations. Marketplace for furniture, on which it is possible to return used products as a customer. The company refurbishes the clients' old furniture and re-use with another customer to prevent waste.	b, e

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
25	2nd Cycle (Artek) (https://www.artek.fi/2ndcycle/en/ accessed on 6 May 2024)	Finland	A platform where the company buys and sells rediscovered furniture, lighting, and other everyday objects, giving them a second cycle in their lives.	b
26	Circle Store (Vitra) (https://www.vitra.com/it-it/about-vitra/sustainability/vitra-circle-stores accessed on 6 May 2024)	Switzerland, Belgium	Vitra Circle Stores sell used accessories and furniture from Vitra and Artek, such as samples, trade fair items, and display pieces. The sale takes place on-site, and the prices are based on the condition of the products. The functionality of all items is checked and repaired if necessary so that the warranty can be renewed.	b, f
27	Eco's Services (Steelcase) (https://www.steelcase.com/eu-en/research/articles/topics/people-planet/ecoservices-circular-steelcase-new-economic-model/ accessed on 6 May 2024)	France	Service that offers a second life to office equipment no longer needed by customers. Eco's Services is a turn-key building-clearance and furniture-recovery service dedicated to making workstation updates by incorporating end-of-life products into new cycles.	b
28	Live Light (https://www.live-light.com/ accessed on 6 May 2024)	Belgium	Rental furniture subscription that can be swapped, added, or returned at any time. The furniture can be bought out if the client decides to keep it by paying the difference between the actual retail price, minus the amount already paid over the course of the subscription.	b, e
29	August (Fischer Lighting) (https://www.fischer-lighting.com/knowledge/august/ accessed on 6 May 2024)	Denmark	August is designed according to circular principles and materials; its patented reflector provides the basis for multiple design options. The outer ring is made from recycled fishing nets—a residual product from the fishing industry. The company is based on the concept of repair and reuse of products.	a, b, c
30	Circular Offices (Desko) (https://www.desko.nl/circulaire-kantoorinrichting accessed on 6 May 2024)	The Netherlands	Sustainable and circular office furniture as a service. The company provides second-hand furniture from different brands with which it collaborates. Desko helps companies through a value scan to determine the value of the current office inventory. The furniture makers refurbish everything that can still be used.	b, e, g

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
31	Nova C (Green Furniture Company) (https://greenfc.com/product-series/nova-c-seating/ accessed on 6 May 2024)	Sweden	Modular and customisable seating system designed and developed to prioritise a long use cycle. Maintenance and replacement of parts can be performed by the client. The series is made of several building blocks that can be put together into thousands of different configurations to make it possible to renew an area by reconfiguration. The choice of materials, chemicals, and the design itself has been guided by the principles of circularity.	a, b, c
32	Opendesk (https://www.opendesk.cc/lean/studio-desk/#get-it-made accessed on 6 May 2024)	UK	Flat-pack furniture designed by independent designer through Opendesk, an online marketplace that connects its customers to local makers around the world. Rather than mass manufacturing and shipping worldwide, the company is building a distributed and ethical supply chain through a global maker network.	d, g
33	Invitrum (Valcucine) (https://www.valcucine.com/elementi-speciali/basi-invitrum/ accessed on 6 May 2024)	Italy	With the Invitrum base system, Valcucine creates the first kitchen in the world completely in aluminium and glass that respects the main rules of circular and eco-sustainable design—dematerialisation, recyclability, reduction in toxic emissions, and long life—generating zero waste at the end of its life.	b, c
34	Lilla Åland (Stolab) (https://www.stolab.se/sv/om-stolab/hallbarhet accessed on 6 May 2024)	Sweden	The company produces durable solid wood furniture, putting quality, design, and function at the centre and prolonging the psychological and absolute obsolescence. The furniture pieces are designed to be timeless classics.	a
35	Restore Service (Stolab) (https://www.stolab.se/sv/aterforsaljare/stolab-restore accessed on 6 May 2024)	Sweden	The company created a growing group of dealers who can also repair furniture that has been worn or broken during its lifetime to give damaged furniture new life and offer the service to customers.	b, f, g
36	Stolab Reuse (Stolab) (https://www.stolab.se/en/about-stolab/sustainability accessed on 6 May 2024)	Sweden	The aim is to associate skilled furniture repairers with Stolab to repair furniture that has been worn or broken during its lifetime. Damaged or discarded furniture gets fixed and sold with the label Stolab Reuse.	b, f, g
37	High Profile (Delta Light) (https://deltalight.com/en/products/high-profile accessed on 6 May 2024)	Belgium	A range of luminaires inspired by leftover aluminium profiles. The design takes a critical look at the manufacturing process, finding both opportunity and beauty in residual elements that would normally be cast aside.	a, b, c

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
38	A.I. (Kartell) (https://www.kartell.com/it/it/ktit/shop/product/a-i-2-sedie/kar05886bi accessed on 6 May 2024)	Italy	A.I. is a chair made using recycled material using generative design. The added value of the A.I. chair consists of being the first family of products conceived by artificial intelligence that responds to the inputs received from the designer, generating a collaboration between man and machine to reduce waste.	a, b, c, d
39	Snowpouf Collection (Caimi Brevetti) (https://www.caimi.com/en/products/snowpouf-sound-absorbing-pouf/?gad_source=1&gclid=CjwKCAjwyJqzBhBaEiwAWDRJVL92jGTfrf_d9Rlx0431WiDcisq_r4KazVBwD9T9rHAYZhnHQeaMsRoCS6AQAvD_BwE accessed on 6 May 2024)	Italy	Comfortable, sound-absorbing pouffe covered with Snowsound Fiber, consisting of technopolymer sound-absorbing padding and wood. The collection includes pouffes of various sizes and a coffee table with a light oak wood top. Recently, it has also been released with Snowsound Fiber 12 ECONYL fabrics.	c
40	Conscious Chair 3162 (Mater) (https://materdesign.com/products/conscious-chair-bm3162-coffee-waste-black-by-borge-mogensen-esben-klint accessed on 6 May 2024)	Denmark	The chair is made of FSC wood and Matek, where an innovative technology allows the company to recycle fibre-based waste materials with recycled plastic waste. The Matek materials are designed to be recycled again and again using the company technology and made into new furniture.	a, c, d
41	Berlin Collection (Ekomia) (https://ekomia.de/ accessed on 6 May 2024)	Germany	Organic furniture made with solid wood from trusted sources and without materials that could harm the environment. The Berlin collection is made from hand-selected solid wild oak.	a, b
42	Repair Kits and Upcycling Instructions (Ekomia) (https://ekomia.de/en/products/moebeloel-samt?_pos=1&_sid=ca9a77f11&_ss=r accessed on 6 May 2024)	Germany	The company offer both repair kits to repair every product's parts and upcycling instructions to help avoid waste.	b
43	Cosima series (Bolia) (https://www.bolia.com/it-it/divani/tutti-i-disegni-di-divani/?family=cosima&lastfacet=family accessed on 6 May 2024)	Denmark	Modular sofa, which is made of FSC-certified wood with soft feather and down filling sewn into channels to prolong its durability and maintain its shape. Cosima can be customised to the clients' needs, with seating in two depths, removing or adding modules as needed.	b
44	Gleim (Geyersbach) (https://geyersbach.com/ accessed on 6 May 2024)	Germany	The company gives old wood a second life as a unique piece of furniture. The company developed an environmental grading system for its wood furniture to provide transparency to its customers.	a, b

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
45	Le Petit Boudoir (Lensvelt) (https://www.lensvelt.nl/en/lensvelt-teun-zwets-le-petit-boudoir/a8681 accessed on 6 May 2024)	The Netherlands	Series of cabinets made from scrap materials derived from leftover metal elements from Lensvelt's production. The collection includes 10 models, all similar yet all different.	a, c
46	Rememberme (Casamania) (https://www.casamania.it/en/design-furniture/rememberme-chair/ accessed on 6 May 2024)	Italy	A collection (chair, bistrot table, and coffee table) that gives new life to clothes, which are unconscious memory capsules. Rememberme is made of jeans and cotton T-shirts mixed with a special resin.	c,
47	Tellus (Vestre) (https://vestre.com/tellus/meet-the-worlds-first-bench-made-from-fossil-free-steel-designed-with-tellus-in-mind accessed on 6 May 2024)	Norway	The bench is made from 100% fossil-free steel from SSAB. As a bench for public spaces, wear and tear resistance strategies were used, minimising materials without affecting durability.	b, c
48	606 Universal Shelving System (Vitsœ) (https://www.vitsoe.com/us/606 accessed on 6 May 2024)	UK	The company uses recyclable aluminium, steel, and compostable wood. Products can 'evolve'—they are designed in modules that can easily fit together and produce different functionalities. The furniture is assembled with mechanical joints and is not welded, making it easy to repair and dismantle at the end of furniture life. The company also prioritises reuse over recycling.	b, c
49	Reuse and Recycling Old Furniture (Kinnarps) (https://www.kinnarps.com/add-on-services/ accessed on 6 May 2024)	Sweden	Kinnarps offers an entire range of furniture-related services. When refurnishing a workspace, there are always previous items that need to be removed. If the customers are unable to sell or reuse what they already have, the company can handle it to recycle it properly.	b, f
50	Store your Furniture (Kinnarps) (https://www.kinnarps.com/add-on-services/ accessed on 6 May 2024)	Sweden	The company stores the customers' excess furniture in one of the warehouses, where there is space for anything from single products to entire office interiors. The company also handles transportation to and from the warehouse.	b
51	Furniture Washing (Kinnarps) (https://www.kinnarps.com/add-on-services/ accessed on 6 May 2024)	Sweden	The panel of services offered by Kinnarps also includes the possibility of washing furniture within the home itself, avoiding additional travel.	b

Table A1. *Cont.*

N.	Cases Name (Company)	Country	Brief Description	Adopted Circular Design Strategies [1]
52	Digital Ecocystem for Reuse of Existing Products and Furniture (Off2Off) (https://www.off2off.se/en/portalen/ accessed on 6 May 2024)	Sweden	The company implements, operates, and develops digital ecosystems for reuse of functional surpluses based on organisations' own operations. The platform is developed and provides a cloud-based communications service specifically designed for structured reuse, which visualises and matches user needs and functional surplus with each other and peripheral services.	b
53	Furniture Subscription (Beleco) (https://beleco.com/sv-SE accessed on 6 May 2024)	Sweden	The company does not own furniture but instead creates customised packages of furniture by bringing together the products of its partners (e.g., furniture producers and retailers) and users. The service is available for events, offices, and to equip employees for smart working. Revenue comes from a 'pay-per-use' model.	b
54	Sajkla (https://sajkla.se accessed on 6 May 2024)	Europe	A platform that enables the creation of an inventory of available furniture so that companies can make the most of what they already have and not buy additional furniture. The furniture in the library are bookable.	b
55	Catifa Carta (Arper) (https://www.arper.com/it_IT/catifa-carta?gad_source=1&gclid=CjwKCAjwyJqzBhBaEiwAWDRJVJvltOqZpO2ewsbOutWGAzHNU6a-bn0QWfTGx8NhP3KQyUQ5klz1vxoCgicQAvD_BwE accessed on 6 May 2024)	Italy	Catifa Carta's shell is made of PaperShell, a revolutionary new material derived from wood waste, which provides essential strength and comfort.	a, c
56	Upholstery Service (Albin) (https://www.albinihyssna.se/en/ accessed on 6 May 2024)	Sweden	To help prolong furniture life, the company offers upholstery services to its customers, both for products that are still in production, as well as for older products. To facilitate repair, the company offers furniture for rent during the time that consumer furniture is being repaired or refurbished.	b
57	ZA:ZA (Zanotta) (https://www.zanotta.com/it/prodotti/divani/za-za accessed on 6 May 2024)	Italy	Seat, back, and armrest cushions of regenerated and regenerable polyurethane/polyester spheres. Glue-free upholstery assembly. Removable fabric cover. Steel support structure. In addition, the shapes are designed for durability.	b
58	PET Lamp (https://www.petlamp.org accessed on 6 May 2024)	Spain	Combining the local communities' handcraft skills with modern design to make lamps by giving a second life of the used plastic bottles. The project empowers the local community development. The lamps are mainly sold to restaurant, retail shops, exhibition spaces, and many other businesses.	d, g

[1] a. Design for narrowing resource loop/resource conservation and efficiency. b. Design for extending the use phase/(value recovery). c. Design for closing resource loop/design for recycling. d. Design for cleaner production and transportation. e. Design for product service system that delivers functions rather than ownership. f. Design for fostering circular behaviour and consumption models. g. Design for collective engagement of stakeholders.

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