The Role of Product Design in Circular Economy Business Model

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Abstract: Circular economy business models have undoubtedly become a hot topic nowadays both in academia and among industrial practitioners and companies. In this paper, we focus on the product design practices that can be conceived in circular economy business models along two major dimensions: (i) the value network, i.e. the ways through which companies interact with suppliers and reorganize their own internal activities, and (ii) the customer value proposition and interface, i.e. the implementation of the circularity concept in proposing value to customers. Therefore, a theoretical framework of product design practices for circular economy business models is proposed and tested on a case study of an Italian manufacturing company.

Keywords: circular economy, circular economy business model, product design, product design practise, value creation, value capture.

1 Introduction
The transition to a more circular economy requires companies to change and innovate their business model, transforming its existing structural and organizational conditions (Lieder & Rashid, 2015; Bocken, et al., 2014; Moreno, et al., 2016). A circular economy business model represents the rationale of how a company creates, delivers and captures value with and within closed material loops (Mentink, 2014). Linder & Willander (2015) define “circular” a business model in which the conceptual logic for value creation is based on utilizing the economic value retained in products after use in the production of new offerings. Accordingly, the product design plays an important role both in the value
network of companies, to create value along the supply chain and in the customer value proposition and interface, as well as to transfer and capture value by producing new offerings (Urbinati et al., 2017). In particular, the product design practices can allow improving the material selection, standardizing product design and modularizing components, purer material flows, and design for easier disassembly (Ellen MacArthur Foundation, 2012). In addition, product design practices (i) elevate design to a systems level, (ii) strive to maintain product integrity, (iii) are about cycling at a different pace, (iv) explore new relationships and experiences with products, and (v) are driven by different business models (Bakker et al., 2014). Starting from these premises, the paper aims at understanding the role of product design practices in circular economy business models that are conceived along the dimensions of value network and customer value proposition and interface. We do so, by having in mind the following research question: “What are (and how are they implemented) the product design practices that companies adopt along the dimensions of the value network and the customer value proposition and interface of a circular economy business model?”

After the Introduction, the paper presents, in Section 2, the State-of-the-art of the product design practices for circular economy business models and then maps them along the dimensions of value network and customer value proposition and interface of the proposed theoretical framework. Section 3 highlights the rational of the methodology and presents the case study used for empirical analysis. In Section 4, the paper presents and discusses the results to finally summarize, in Section 5, the conclusions of our study and point out some avenues for further research.

2 State-of-the-art

2.1 Product design practices at value network dimension

Design for Reused materials or resources is under the categorization of the long-life products by reusing materials for the primary phase of the production that is obtained from recycled materials. Accordingly, by using the recycled materials from the last phase of the production process the loop will be closed, which economically and environmentally is profitable and lead to slowdown of resources flow (Moreno et al., 2016; Sihvonen & Ritola, 2015; Bocken et al., 2016; Allwood et al., 2011).

Design for Repair and Maintenance is referred to the prolonged use of products and corresponds to all aspects of performance delivering through the use phase (van den Berg & Bakker, 2015). Whereas maintenance is concentrated on assessing the performance and services of products to retain the functionality of the serviced parts, repairing is about restoring a product or component to a good condition after a decay or damage where assurance is basically covering the part that is repaired (Linton & Jayaraman, 2005; den Hollander et al., 2017).
Design for Redistribute or Reuse is referred to the distribution or use of discarded goods that are still in a good condition to fulfil the initial requirements (Potting, et al., 2017). Thus, this practice is aimed to extend and stretch out the lifespan of goods beyond the first lifecycle.

Design for Refurbish concerns the modularity and reconditioning of parts but the same functionality under the manufacturing and industries registration (Go, et al., 2015). Refurbishing is a practice that is less than remanufacturing but more than repair. Comparing to repair, the quality becomes more valuable by partly substitute broken components to reach the technologically updated modules (Sihvonen & Ritola, 2015).

Design for Remanufacture is the return of a used product to at least its original performance with a warranty that is equivalent or better than the newly manufactured products. The practice is perceived as a comprehensive process of restoring activities (mainly under the test, inspection, full disassembly, refurbishment, part replacement, clean and reassembly), which affect the related reverse flow strategies (Bakker, et al., 2014; Linton & Jayaraman, 2005).

Design for Disassembly and Reassembly ensures that the products and their parts can be separated andreassembled perfectly, also for separating materials that are specified for different cycles in circular economy (biological or technological) (Bocken, et al., 2016).

Design for Recycling allows recycling of materials simply showing the possibility of closing the loop between post-use wastes and production which resulting in a circular flow of resources (Bocken, et al., 2016). Recycling is any recovery operations by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.

2.2. Product design practices at customer value proposition and interface dimension

Design for durability is an important practice that has been investigated among scientific literature as the conservation of products properties (Ardente & Mathieux, 2014). In the manufacturing industries, the concept of design for durability is more concerned on the design of products to extend their lifetime. Possibilities to enhance the longevity of a product not only to consider likelihoods to functionally extend the lifespan but also how to design emotional attachments to a product to make users unwilling to discard it is a point of design strategy (Bocken, et al., 2016; Chapman, 2009).

Design for Quality is what makes a product valuable in terms of robustness and performance that apparently appear under the time consumption. Quality has a wider meaning beyond the word description for customer perspective, however, it has been developed by many authors and manufacturing practitioners. The quality of a product is associated with the target and the variability of functional requirements based on product features and performances (Goel & Singh, 2007; Holt & Barnes, 2010).
Design for Reliability represents the probability of a failure and is related to the possibility of meeting the functional requirements at a certain point of time (Goel & Singh, 2007). Also, it refers to designing for a high likelihood that a product will be operated throughout a specified period without experiencing a chargeable failure when maintained in accordance with the manufacturer’s instructions (Moss, 1985; Goel & Singh, 2007).

Design for Esthetical-longevity means that the longevity of a product is compromised for the long-time of product lifecycle, which is particularly designed for reducing the environmental impact. However, the appearance of a product in terms of esthetical-longevity is something that gives the good impression to the users so that users will not be willing to change a product even if it is not physically destructed. This fact is particularly related to the emotional durability of a product during its perfect life-time (Cramer, 2011).

Design for Customization concerns the products that offer a high level of personalization and customization create deeper emotional satisfactions between the users and the products. By customization, the users could be able to create personal meaning, where mas-customization concept offers a range of choices in style and colours to create a personal look (Chapman, 2009; Niinimaki, 2011).

Design for Customers’ attachments means that when customers are active players in the design of manufacturing and sometimes in the assembly phase itself, this gives the opportunity to increase the uniqueness and personalization of the products. Customers’ attachment is somehow in the way of customization; however, it does not coincide with the production design characteristics (Niinimaki, 2011).

2.3 Theoretical Framework

We propose hereafter the theoretical framework that will be also used as a guide for the following empirical analysis (Figure 1).
**Value Network**

<table>
<thead>
<tr>
<th>Product Design Practices</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Df Reused material</strong></td>
<td>Second-handed material consumption in production process to reduce cost and virgin materials</td>
<td><em>Den Hollander, et al., 2017; Potting, et al., 2017; Moreno, et al., 2016; Bocken, et al., 2016; Van den Berg &amp; Bakker, 2015; Go, et al., 2015; Balkenende &amp; Bakker, 2015; Planing, 2015; Tukker, 2015; Sihvonen &amp; Ritola, 2015; Bakker, et al., 2014; Allwood, et al., 2011; Holt &amp; Barnes, 2010; Braungart, et al., 2007; Tukker &amp; Ursula, 2006; Linton &amp; Jayaraman, 2005</em></td>
</tr>
<tr>
<td><strong>Df Redistribute or Reused</strong></td>
<td>It reaches when a product enters the end of need phase, but can capitalize on finding customers with different needs</td>
<td><em>Bocken, et al., 2016; Waddilove &amp; Charnley, 2015; Go, et al., 2015; Sung, et al., 2015; Tukker, 2015; Tukker, 2015; Ardente &amp; Mathieux, 2014; Downes, et al., 2011; Cramer, 2011; Niininmaki, 2011; Holt &amp; Barnes, 2010; Chapman, 2009; Goel &amp; Singh, 2007; Tukker &amp; Ursula, 2006; Moss, 1985</em></td>
</tr>
<tr>
<td><strong>Df Refurbish</strong></td>
<td>Include collection activities, testing, redistribution and remarketing also includes replacements of modules</td>
<td><em>Sihvonen &amp; Ritola, 2015; Bakker, et al., 2014; Allwood, et al., 2011</em></td>
</tr>
<tr>
<td><strong>Df Repair and Maintenance</strong></td>
<td>Restoring a product to a good condition after decay or damage</td>
<td><em>Bocken, et al., 2016; Waddilove &amp; Charnley, 2015; Go, et al., 2015; Sung, et al., 2015; Tukker, 2015; Ardente &amp; Mathieux, 2014; Downes, et al., 2011; Cramer, 2011; Niininmaki, 2011; Holt &amp; Barnes, 2010; Chapman, 2009; Goel &amp; Singh, 2007; Tukker &amp; Ursula, 2006; Moss, 1985</em></td>
</tr>
<tr>
<td><strong>Df Remanufacture</strong></td>
<td>Remanufacturing is the process of restoring the product or part functionality to “as-new” quality</td>
<td><em>Bocken, et al., 2016; Waddilove &amp; Charnley, 2015; Go, et al., 2015; Sung, et al., 2015; Tukker, 2015; Ardente &amp; Mathieux, 2014; Downes, et al., 2011; Cramer, 2011; Niininmaki, 2011; Holt &amp; Barnes, 2010; Chapman, 2009; Goel &amp; Singh, 2007; Tukker &amp; Ursula, 2006; Moss, 1985</em></td>
</tr>
<tr>
<td><strong>Df Reassembly</strong></td>
<td>Being sure that products and parts could be assembled and separated quickly and easily</td>
<td><em>Goel &amp; Singh, 2007; Tukker &amp; Ursula, 2006; Moss, 1985</em></td>
</tr>
<tr>
<td><strong>Df Disassembly</strong></td>
<td>Give this possibility to easily embed components and parts</td>
<td><em>Goel &amp; Singh, 2007; Tukker &amp; Ursula, 2006; Moss, 1985</em></td>
</tr>
<tr>
<td><strong>Df Recycle</strong></td>
<td>Backing based materials from used products but loses much of the added value the managerial desire to perfectly close the loop.</td>
<td><em>Goel &amp; Singh, 2007; Tukker &amp; Ursula, 2006; Moss, 1985</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Customer Value Proposition</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product Design Practices</strong></td>
<td><strong>Df Durability</strong></td>
<td>Based on physical durability for instance; the development of products that can take wear and tear without breaking down</td>
</tr>
<tr>
<td><strong>Df Quality</strong></td>
<td>Products that are meaningful to the user over a long period of time and thus they are not easily disposable</td>
<td></td>
</tr>
<tr>
<td><strong>Df Reliability</strong></td>
<td>Design of the product that highly operated for a specified period without any deficit and failure</td>
<td></td>
</tr>
<tr>
<td><strong>Df Esthetical-longevity</strong></td>
<td>The design lasts over time as styles and colours are classical, and the materials age well</td>
<td></td>
</tr>
<tr>
<td><strong>Df Customization</strong></td>
<td>Products that are easily personalized or customizable offer an opportunity to create a deeper emotional bonding between the user and the product</td>
<td></td>
</tr>
<tr>
<td><strong>Df Customer’s attachment</strong></td>
<td>Involving customers into design process by digital technologies that enable adopt customer’s need to increase likelihood of a long product life due to unique and personalized products</td>
<td></td>
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</table>

**Figure 1.** Theoretical framework.
3 Methodology and Empirical Analysis

3.1 Leveraging on a single case study analysis

The paper leverages on a single case study methodology to gain a better understanding of the role of product design practices in circular economy business models. The choice of a single case study is favoured when addressing complex organizational and managerial issues through a qualitative approach. According to Bromley (1990, p. 302), a case study is a “systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest”. Case studies are rich, empirical descriptions of peculiar instances of a phenomenon that are typically based on a variety of data sources (Yin, 1994). It is believed by Siggelkow (2007) that case studies can help sharpen existing theory by pointing to gaps and beginning to fill them. According to Yin (1994), the case study design must have five components: the research question(s), its propositions, its unit(s) of analysis, a determination of how the data are linked to the propositions and the criteria to interpret the findings. In addition, single case study is an appropriated design under these circumstances where the case represents: (i) a critical test of the existing theory, (ii) a rare or unique circumstance, (iii) a representative or typical case, (iv) where the case serves a revelatory, and (v) a longitudinal purpose. By a study from Pettigrew (1988), it is noted that given the limited number of cases which can usually be studied, it makes sense to choose cases such as extreme situations and polar types in which the process of interest is “transparently observable”. Thus, it is essential to choose cases that are likely to replicate or extend the proposed theory.

Accordingly, to selected case should fit within the context of the study, i.e., the circular economy business model adoption, and the theoretical aspects defined in the State-of-the-art. The selected company should be fit exactly in the circular economy and business model principles. Therefore, the case should provide an example of mutual types and allow for theoretical comparisons. Our unit of analysis is the product, and our main reason to select the company is that it is focused on a circular design of its product. We collected insights about the way the company adopts circular economy in its business model and how it is being implemented.

For this study, we have established a semi-structured questionnaire with open-ended questions regarding the information ensuing from the State-of-the-art to and used as interview protocol to make the interviewees with the key respondents of the company. The interview protocol was built around a set of 13 questions, as listed in the Appendix. Each question contained several sub-questions as guidelines to conduct effectively the interviews. The first round of interviews was followed by a second and, in some cases, a third round to consolidate the information collected, cross-check relevant data and clarify important issues. In some cases, interviews were also followed-up by emails with questions of clarification over the period of the study. First-round interviews lasted from 1 hour to 1 hour and a half, while second and third rounds lasted from 45 minutes to 1 hour, for over 10 hours. Then, the interviews were completely recorded and
transcribed. The list of the interviewed managers and the rounds of interviews are reported in Table 1.

**Table 1.** List of the interviewed managers and the rounds of interviews.

<table>
<thead>
<tr>
<th>Interviewed Managers</th>
<th>First round</th>
<th>Second round</th>
<th>Third round</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head of Business Innovation &amp; Development</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Research Development &amp; Innovation Director</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Commercial &amp; Sales</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Total no. of interviews</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition, the Company provided access to internal confidential information related to its circular economy strategies and business initiatives. We also leveraged on – and triangulated the primary sources of information with – secondary sources of information to avoid post-hoc rationalizations (Chiesa & Frattini, 2011).

### 3.2 Presentation of the case

The company chosen for performing the case study is EuroSintex, which since 1996 is in the business of producing and selling plastic containers for waste collection.

EuroSintex was selected from the Atlas of Italian Circular Economy Champion, which is one of the well-known leaders of adopting the Circular Economy Business Model for producing plastic containers under the name of “Plastica Seconda Vita (PSV or Second Life Plastic)”. In particular, EuroSintex is the first Italian company to produce and sell their own products based on THIS “Plastica Seconda Vita” (“PSV or Second Life Plastic”), which is plastic coming from the post-consumer waste collection. Company’s products have been certified by the Institution for Promotion of Recycled Plastic (IPPR). Since 2009, EuroSintex has been producing and selling more than 12 million recycling containers and 300,000 home compost bins. Where both post-consumer recycled material, coming from the collection of the plastics as well as reusing scrap plastic coming from their own internal production. Thus, both post-consumer material and recycled material coming from the industrial production, which means materials that are both recyclable and recycled, are used for the production processes. Second-hand plastic materials purchased by EuroSintex are reprocessed internally and technically tested to achieve the required standard that is needed for producing final products (i.e., the bins). This makes the use of second-hand material more expensive than the virgin ones due to the colour and the market price fluctuation of the materials. Furthermore, second-hand materials require performing specific and ad-hoc technical tests before final production process start. EuroSintex manufactures and distributes containers for separate waste collection and systems for ecology, ranging from domestic containers and composting to street furniture and underground systems. The EuroSintex product range is one of the most complete: from the 5-litre bin to the 1,100-litre bin, to the composter and to the street furniture elements, all made of recyclable plastic.
The mission of the Company is to make waste a resource, developing containers and collection systems that favour its differentiation and recycling. Table 2 shows some general information regarding the EuroSintex position in the financial market and the size of the company in 2015 and 2016.

Table 2. EuroSintex financial market overview.

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>€ 17,237,040.00</td>
<td>€ 19,710,118.00</td>
</tr>
<tr>
<td>Profit/loss of the year</td>
<td>€ 564,779.00</td>
<td>€ 702,171.00</td>
</tr>
<tr>
<td>Net assets</td>
<td>€ 2,117,561.00</td>
<td>€ 2,719,728.00</td>
</tr>
<tr>
<td>ROI</td>
<td>6.40%</td>
<td>15.06%</td>
</tr>
<tr>
<td>Number of employees</td>
<td>22</td>
<td>24</td>
</tr>
</tbody>
</table>

Suppliers’ network
Several worldwide suppliers (mainly located in China and South-America) are providing raw materials to EuroSintex, whereas the second-handed materials are provided mainly by European suppliers. Therefore, second-hand materials need to be checked by the Project Managers of the Company before the final purchasing. Since EuroSintex needs to be sure that the quality of the second-hand plastics purchase meets the technical and colour requirements for the bin’s production process. However, by the managers of the Company, there will be an estimation regarding the percentage of the virgin and recycled materials used. It mainly depended on the colour and the quality of the plastic procured, but on average it can be said that approximately 60% of the plastics procured by EuroSintex are second-hand plastics. EuroSintex then tries to build a long-term relationship with suppliers, selecting the most reliable vendors and fixing in advance the price and the terms and conditions of the purchase orders. They have also occasional partners, even though they prefer to close the long-term agreements with suppliers at the beginning of each year.

Materials qualification standards and expectations
The main issue for the Company concerns the standard of the colour used for their production and by those contracted suppliers who can maintain the same colour during the entire duration of the purchase order agreements. It is approved by the Company that their main activities to perform and evaluate the quality of the raw materials are based on presented technical safety sheet. The technical safety sheet should be provided by the suppliers to guarantee that the products are tested and certified by different laboratories. Since the safety test is approved, they make production test before starting the final production to be sure that what their providers complied is under their requirement conditions. Generally, they purchase the raw materials when they are cheaper, although, this is a seasonal fluctuated price and not frequently predictable. The materials that have been purchased are internally stocked by the Company to try to prevent any price variation.

EuroSintex customers are mainly formed by public companies or private collectors that deal with public companies. This means that a Business to Business (B2B) model is adopted by them. In the last 10 years, customers’
attitude is changing towards using recycled materials. The customer appreciation indeed increased towards the recycled plastics in the last years, due to the high awareness that they have had regarding the sustainable products and PSV term. In this scenario, EuroSintex did not increase the cost of the products due to working and supporting the customers that are part of the public sectors. Furthermore, according to the regulation (D.M. 203/2003, Green Public Procurement (GPP)), the public bodies are now obliged to buy their final products that contained recycled materials at least by 30%. However, the end users are more concerned and sensitive rather than the public buyers.

**Points of market differentiation**

One of the critical points of EuroSintex success is mainly related to the production of a large array of recycle containers in terms of colour and appearances, with only minor differences from the virgin materials. This represents a source of the Company competitive advantage, i.e. to be able to produce recycled products with the same quality and performance of the new ones. One of the biggest achievements by EuroSintex is that they are collecting plastics from real collection points, bringing back the PSV products into the production phase. It is too early to say that all the used products will come back to the company and put again into the production phase in the short term. Indeed, when the bins are distributed among the end-users it takes time to bring them back to the production process, due to the facts that residentially located bins stay for a longer time like in 10 or 20 years in an apartment. This currently happens also for bigger containers that are public and externally used.

**Circular Economy Business Model adoption**

Those products that are produced from PSV have a sign that shows the certification that they contain 70% second-hand materials. Moreover, every single producer has a specific license number for the products to guarantee the verification of PSV standards. All the people in EuroSintex are aware of the products and PSV due to transparency via meetings to get them familiar with every aspect of the CE terms that are applied to the products. There is a very informal environment due to the characteristics of the Company, being a family business where no formal procedures are implemented. EuroSintex with a team of 5 commercial managers and 30 sales agents all over the Italy has planned to spread their sales agents across the Europe in Portugal, Greece, and the UK. Regarding their regional competitors, in Italy 5 to 6 smaller companies, there is a high competitors entrance potential into the market even from other countries who are able to supply Italian customers as well.

Since EuroSintex has started to adopt recycled plastics into the production, they have changed their production systems regarding new processes, new quality, and new tests to check the materials coming from external. Considering these issues, the production process has been improving constantly thanks to the high quality of new colours and products that are also reached by suppliers. By increasing the quality of technical testing and changing some proper equipment due to constant checking of new technologies they could produce PSV in blues, different tones or green and even white. Comparing to the past where they had
only green, brown and grey range of colours, now reaching the white PSV that was not easy due to performing lots of new material experimentations time by time, based on the daily updating technological improvements to attain the final stage.

Moreover, EuroSintex production process is managed both externally and internally. There are around 100 people working in external companies that are exclusively allocated for EuroSintex to internally control and check the standard qualification of Company’s product requirements. All the external suppliers are 20 to 30 kilometres geographically located. On the other hand, about 5 to 7 people are internally working for the moulding phase of the final products. There is a high level of customization in terms of product design that is mainly provided according to the customers’ need for specific design alignments, such as capacity and shape. It is specified that there are no structured processes or procedures for product design, it is simply based on the top managers’ contribution to improve product specifications and characteristics prior to satisfying customer’s requests.

4 Results and Discussion

This case-based analysis allows us to reflect on the role of product design practices into the circular economy business model dimensions of the theoretical framework to clarify how they are implemented in practice. Considering both the theoretical framework and the case study, we are going to emphasize the theory that is implemented from the industry side by elaborating the design practices to the business model strategies that EuroSintex has been adopted. Considering the definition of the circular business model strategy that implies a return flow to the producer from users where there are intermediaries in between (Linder & Willander, 2015), EuroSintex circular business model is built on this strategy.

Value Network design practices adoption

The vital aspect that has been widely developed by EuroSintex towards the circular business model is using lower virgin materials, which account for only 30 to 40 percent, and the rest is embedded of “Plastica Seconda Vita” (PSV), which is the second-hand plastics. It is important to consider that the use of second-hand plastic is first of all compulsory by the government to push the public municipalities for purchasing the plastic goods, with at least 30% contained recycling materials. Furthermore, another important factor in circular economy practices for EuroSintex is minimizing the virgin materials to reduce as much as possible the production of waste and energy consumption (Allwood, et al., 2011; Bakker, et al., 2014; Bocken, et al., 2014; Lieder & Rashid, 2015). By this fact, EuroSintex not only reached the regulated PSV limits but also have gained the higher amount, with almost 70% due to the managerial commitment to accelerate more circular strategy.

What makes this company circular is the customer’s engagement and leveraging on long-term global agreements for providing recycled materials not only for their final customers, which are mainly public authorities, but also for the plastic
suppliers. Many authors argue that reforming the supply chain and partner relationships of companies could make a significant difference in the overall efficiency (Bakker, et al., 2014; Go, et al., 2015). Then, considering that suppliers have been chosen based on the technical qualification sheet, this is not caused that they do not internally check and test before the final production in order to reconfigure and remanufacture the products to be prepared for the final stage.

The other practices effectively adopted by EuroSintex are remanufacturing of polymers that bought from the external suppliers, who by separating polypropylene from papers, cans and different types of plastics, give the possibility to reconfigure polypropylene for the production process. Other practices such as Design for Refurbish, or Repair are often performing under Remanufacturing practices in manufacturing process to collect and use the scratch components during the production and reuse them. In other ways, it is also useful for composites with specific design order that detect the different types of waste collection by signed tags (RFID) to be perfectly connected with the tag readers of municipalities or collectors. In this case, they operate and interact with their public customers to repair and maintain the components in case of any failures and parts break.

On the other hand, EuroSintex does not specifically register some circular design practices that can be considered as a source of comparison for the circular business model adoption. However, the practices of Design for Redistribute or the Design for Dis- or Re-assembly do not have specific places in the Company’s value network. This issue could arise from the characteristics of their products that have been designed with 100% recycled polypropylene components, and this could be considered as a source of advantage for them to cut the cost of de-manufacturing and dis-assembling of different kinds of material characteristics by adopting different technologies. Although they are using the second-hand materials for their production process, they did not implement collecting and recycling of their products (with the end of useful life) from customers that have bought the products before. From the interviews, in the future they will have a specified plan that aims to perfectly close the loops by collecting the products that have been purchased and will not be used further by customers to bring them back again to the production process.

**Customer value proposition & interfaces for design practices**

Different kinds of qualification and technical tests EuroSintex performed to remanufacture polypropylene, optimize the performance and quality of end components produced. However, these tests are mainly performed to obtain a certificate from the regulatory authority and government, brought them a good reputation among the customers due to considering their needs and requirements in different shapes of the design. This is the consequences of reliability to the product design practices regarding the quality and durability configuration which have postponed the obsolescence period and maximized the esthetical longevity where customers are desired to keep the products for a longer period.

EuroSintex has been always efforted on customer value by concentrating on their preferences for product design and caring that what is the most desirable
characteristics that customers ordered. Indeed, managers of EuroSintex have a direct interaction with their customers (public authorities) to know their specific needs and requirements to always be up-to-date for any modifications or adding a new feature to reach to the best solutions. They have a high level of customization based on the customers’ orders, which they change as much as possible to shape and size the containers based on the customer orders.

According to the observations above, we mapped in Figure 2 the adopted circular economy business model of EuroSintex along the theoretical framework dimensions to show which product design practices have been implemented by different levels of availability, such as: perfectly implemented, moderate implemented, rarely implemented, not-implemented and to be implemented (future target). In so doing, we aimed at showing that implementation of each product design practice in the circular business model is due to managerial decisions (technology improvements and market positioning) and influence by external contextual factors (regulation authorities or law factors, environmental impact). For instance, practices such as Reused material, Remanufacturing and Quality-durability-reliability depend by both managerial decisions and regulatory frameworks. Others seem to depend only by peculiar managerial decisions, such as customization, esthetical longevity, internally and externally quality acceptance, and production of components. Finally, practices like Dis- or Re-assembly are not implemented by the Company.
Figure 2. EuroSintex product design practices mapped along the theoretical framework dimensions.

<table>
<thead>
<tr>
<th>Value Network</th>
<th>Customer Value Proposition</th>
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</thead>
<tbody>
<tr>
<td><strong>Product Design Practices</strong></td>
<td><strong>Level of implementation</strong></td>
</tr>
<tr>
<td><strong>Df Reused material</strong></td>
<td>Perfectly implemented; regarding managerial decision to make it stronger (higher than limitation 30%) and regulation authorities</td>
</tr>
<tr>
<td><strong>Df Distribute or Reused</strong></td>
<td>Not-implemented; all the containers are resistance for a longer time of usage</td>
</tr>
<tr>
<td><strong>Df Refurbish</strong></td>
<td>Implementing based on managerial decision that enforces somehow by regulation to reduce the waste gathered from product waste during production and reuse them</td>
</tr>
<tr>
<td><strong>Df Repair and Maintenance</strong></td>
<td>Implementing in terms of selecting preferred type of plastics (tag holders), also using scratched products during the production. Managerial level of decision</td>
</tr>
<tr>
<td><strong>Df Remanufacture</strong></td>
<td>Implementing before starting the final production process by granulating of plastic</td>
</tr>
<tr>
<td><strong>Df Reassembly</strong></td>
<td>Not fitted for the company business model</td>
</tr>
<tr>
<td><strong>Df Disassembly</strong></td>
<td>Not fitted for the company business model</td>
</tr>
<tr>
<td><strong>Df Recycle</strong></td>
<td>To be implemented in the future regarding the managerial desire to perfectly close the loop.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Product Design Practices</strong></th>
<th><strong>Level of implementation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Df Reused material</strong></td>
<td>Perfectly implemented regarding the characteristics of containers that are hard resistance especially the ones for public consumption</td>
</tr>
<tr>
<td><strong>Df Quality</strong></td>
<td>One of the managerial decisions priority based on their market position to be prior in using PSV with minor differences with virgin materials</td>
</tr>
<tr>
<td><strong>Df Reliability</strong></td>
<td>It is perfectly adopted by managerial and technical configuration which containers used for a longer period even in the apartments</td>
</tr>
<tr>
<td><strong>Df Esthetical-longevity</strong></td>
<td>Perfectly implemented based on the different shades of colour from PSV materials since 2009 regarding the managerial and technical improvement</td>
</tr>
<tr>
<td><strong>Df Customization</strong></td>
<td>Perfectly implemented according to the tight relation with customers and their preferences</td>
</tr>
<tr>
<td><strong>Df Customer’s attachment</strong></td>
<td>Not directly specified by customer’s hand, but it effects the design of containers</td>
</tr>
</tbody>
</table>
5. Conclusions

This case study has allowed us to reflect on the role of product design practices into the circular economy business model dimensions of the theoretical framework to clarify how they are implemented in practice. Even though this study aims to propose a good understanding of companies’ positioning in developing circular economy business model in the production phase, there are some limitations due to companies’ managerial and practical awareness, as well as different customer’s attitude and preferences. The case here analysed was not sufficient to clarify the influence of management commitment in adoption of circular economy business model and product design practices by companies. More manufacturing involvement is indeed required for further analysis. We argue therefore that the present case could be a good point to start more empirical analysis to improve the product design practices proposed by the framework in order to understand the internal reasons that push companies to move towards a circular economy business model implementation through these practices.
References


Appendix

Interview Protocol

Company Profile
- Sector of activity
- Dimension (Revenues, EBITDA, etc.)
- Level of investments for sustainability-oriented activities
- The role of contextual factors, such as regulatory frameworks, market concentration and level of competition, in influencing the company’s activities

Circular Economy Business Model
1. About the CE and the benefits that could be arisen for the economy and environment, how are you concerned about it in terms of the policy and target goals of your company?
2. In what sense, you are ambitious to include CE principles into your company strategy? Or have you ever fully considered the CE vision into your business model?
3. What is the main critical point of your Business Model strategy? Have you ever included any innovative aspect into your production chain to be more sustainable in terms of less use of raw materials?
4. What are (or were) the trends of improvement and consequences of using less raw materials in the production phase?
5. What is your point of decision regarding the product design to be more circular and sustainable for the supply manufacturers and customers?
6. What is your vision about optimizing product’s features for a better functionality, reparability and recyclability?
7. What is your strategy about the life cycle planning of products from different categories of products?
8. Since 1996, how many times have you changed any type of products design strategies that are mainly concerned with the environment to create a lower amount of waste? What were the main consequences that you have potentially understood for the innovative changes into your company?
9. Have you ever taken any strategic decision regarding these product design and business model strategies?
   a. Product design strategy for closing resource loops or, in other words, a product design strategy for complete and technical cycles and to support the design for dis- and re-assembly?
   b. Product design strategy for slowing resource loops or, in other words, a product design strategy for longer product life cycle and to support the design for attachment, trust, reliability and durability.
   c. Product design strategy to support the design for product-life extension by maintaining, repairing, refurbishing, reusing, redistributing and remanufacturing.
10. How much do you pay attention towards the design strategy of your product that could bring customers-hand into the use and attaching the products to create higher
level of integrity and emotionality to a longer use of product? Do you think that this would be an effective point of view for a circular product design strategy?

11. Regarding your company commitment, how would you be able to develop products with less impact to the environment in terms of any specific technology that you have been adopted?

12. What is your strategy for end of life of each product that is distributed by your company? Do you have any collection point to bring them back into your manufacturing chain? (Explaining more about the process of recycling of those boxes with different components, i.e., how are they extracting and how are they reusing again?)

13. What are the facilities and supports that you provide to your customers after sales of your products in terms of value delivering and value capturing from the design strategy of product?