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New business models in the Circular Economy

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Abstract. *Circular Economy is becoming an important part of the trend on global business development. Companies and public organizations are facing new challenges and strive to integrate fresh concepts and instruments within their value chains. Strategic environmental goals are based upon reused resources and reintegrated materials, reduced carbon emissions, renewable energy, innovation, and overall optimization of models and processes. Governmental agencies are also preoccupied to enact specific regulations, to favor the economic and social integration of the circular economy. The advantages of the 6 R's integration (recycle, reuse, reduce, repair, remanufacture, redesign) for businesses are straightforward, from cost optimizations, price volatility control, to increased automation and innovation.*

This paper is the first step of a more complex research endeavor, aiming to assess the feasibility of various fine tunings on specific business models that integrate circular economy principles. We have based our current assessment on six industries, with a major impact on the environment, and that can provide impacting solutions for environmental preservation. For each analyzed industry, a specific original diagram was provided, integrating the main industrial processes, outcomes, and reuse opportunities, derived from circularity principles. The literature review was intended to support each industry's development pattern, highlighting different types of solutions for waste recycling, and business reorganization redesign.

Keywords: Circular economy, Business models, Value chain, Recycling, Reuse, Reintegration, Innovation

Introduction

The main principles of the circular economy (CE) have been laid out by the Ellen MacArthur Foundation, in relation to the textile industry. These principles are the elimination of pollution and waste, the recirculation of products and materials, and the regeneration of nature (Ellen MacArthur Foundation, 2022). The circular economy focuses on the Reuse principle which refers to 'any operation by which products or components that are not waste are used again for the same purpose for which they were conceived' (Directive 2008/98/EC). This principle has clear environmental benefits (fewer resources used, less energy and labor for the extraction of virgin raw materials), but also economic benefits in relation to the rising prices of materials (Ghisellini et al., 2016). The Reuse principle is coupled with the demand for reused or remanufactured products, durable design, and multiple cycles of use (Geissdoerfer et al., 2017). Companies have also started to advertise product take-back programs and remanufactured products if the recycling systems can support these initiatives (Kant Hvass & Pedersen, 2019).

Circular business models represent strategic decisions to preserve environmental and economic value by reusing resources and reintegrating materials into other systems and new products (Centobelli et al., 2020). In the circular economy, value creation is associated with the maintenance of products and processes, the recombination, recycling and upcycling of materials,

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and on-demand production processes. Value creation is linked to eco-design and product innovation for reuse, disassembly, remanufacturing, or recycling (Geissdoerfer et al., 2017). The purpose of circular business models is for materials to be returned safely to the environment without compromising the biosphere. Closed-loop or circular systems are implemented across the entire value chain and take advantage of life cycle analyses (LCAs) and eco-efficiency improvements. The concept of circular economy has been extended to include renewable resources such as green energy – wind, solar, or biomass (Bórawski et al., 2020).

Objective and method

The purpose of this paper is to analyze several business models which have definite characteristics of the circular economy. From the literature, we selected six industries for which recent contributions on circularity have been published. These industries are oil and gas, electronics, furniture, textiles, leather, and agri-food. These industries have a major impact on the environment and solutions are sought to reduce the impact of different types of waste. For each industry, original diagrams have been designed to highlight the circular aspects. These models of the circular economy indicate the industrial processes, outcomes, and reintegration opportunities by applying circularity principles. The literature review that accompanies each circular business model seeks to pinpoint the types of waste generated by the respective industries and the solutions for 'closing the loop.'

Industry analysis on circularity principles

Oil and gas

The energy industry is mainly based on oil and gas, still the largest market worldwide. Nevertheless, the individual markets on different categories of fuel are having a specific behavior, depending on the operating pattern and characteristics. Under the label of "oil and gas," the business value chain is based on the *upstream segment*, where exploration and extraction of crude oil and gas are included, and the *downstream segment*, with crude oil refining, storage, pipeline transportation, marketing, and sales. In the same value chain, there are integrated various support activities, such as engineering services, acquisition of the refining equipment, decommissioning, and restoration (OMV Petrom, 2021).

Some authors are discussing the explicit value and the potential value of the energy sector. The explicit value is driven by their operations and products or services. The potential value is achievable from the potential of innovation and process optimization. China is considering enforcing its own CE system, based on recycling and expansion of the engineering service in the oil industry (Kun & Jian, 2011). Some actions are emphasized to sustain the CE: performant, solid exploration systems, efficient use of resources, enforcing specific legislation and taxation, preserving the environment (Kun & Jian, 2011)

In the last decades, energy companies have been constantly focusing on protecting the environment and preparing to integrate the circular economy's objectives. Oversight regulators have updated the legal requirements to accommodate and promote new challenges within the business environment. For example, the specific European regulations, transposed locally by each member state, require that the renewable energy content in transportation fuels to increase from 10% in 2020 to 14% in 2030 (EU Directive 2018/2001 – RED II). Green electricity is another milestone for the main actors in oil and gas. In 2020 OMV Petrom, the largest oil and gas company from South-Eastern Europe, reported that it had installed photovoltaic panels in its Romanian gas

stations and, as a consequence, more than 10% of the electricity consumed is provided by solar power (OMV Petrom, 2021).

From complying with regulations on reducing carbon emissions, increasing energy efficiency, using renewable energy, to innovation and optimizing the resources' exploitation there is a worldwide preoccupation to become more environmentally friendly and "green". The major outcomes that oil and gas companies have developed, in connection to CE, are summarized in the following paragraphs.

The upstream part, mainly the extraction segment, is based on drilling, an operation that produces a substantial quantity of wastes, i.e., drilling fluids, heavy metals. In Europe the CE (circular economy) impact had increased in the last years, correlated with some ongoing projects in the area. One of these was the successful implementation of the *Thermomechanical Cuttings Cleaning* (TCC) process for drilling fluids, in the Cyprus Oil and Gas Exploration Program (Kazamias & Zorpas, 2021). This technique is promoting a valuable solution on CE, because it generates heat that helps the water evaporate, alongside the hydrocarbons from waste, that are then separated and recycled, as recovered wastewater, recovered oily waste, and cement components (Kazamias & Zorpas, 2021).

The following diagram in Figure 1 summarizes the circular processes in the oil and gas industry:

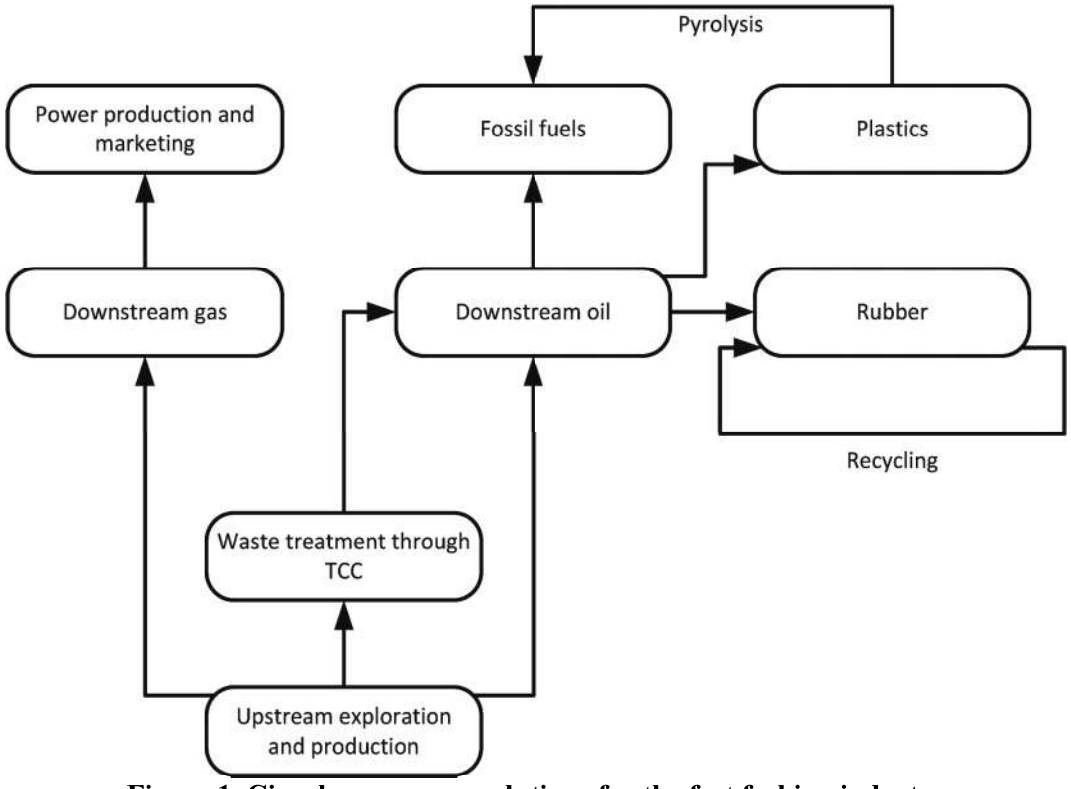


Figure 1. Circular economy solutions for the fast fashion industry

Source: Authors' design.

Other upstream opportunities for CE are related to the equipment used in the process of exploration. When the decommissioning step is fulfilled (i.e., for offshore platform, pipeline etc.)

most of these companies are recycling different components, as a result of this activity, reintegrating the outcome in other business models (Alnuaim, 2019)

In the downstream segment, the CE opportunities are in connection to water and chemicals and their recycling. Additionally, increasing energy efficiency through conservation should also be considered and included in this process, as some researchers are highlighting (Alnuaim, 2019). An important issue is related to the environmental aspects of plastics, a non-biodegradable material with a very long life-cycle, and the efforts that are made through different R&D projects to solve various consequences of its use. ExxonMobile has recently announced that they have completed the first step of a project that is recycling plastic waste into raw materials to produce high-value polymers. This Baytown (Texas) project is intended to be scale-up globally, as a circular solution for plastic (ExxonMobil, 2021).

Another opportunity for recycling is related to tires that are annually disposed of in impressive quantities, 50% being burned or abandoned (Alnuaim, 2019). Some companies are promoting projects to extract the synthetic rubber, steel, silica and other components within modern tires and recycle them for various purposes. Concerning the management of the energy infrastructure, there are projects aiming to integrate modularization of facilities and logistics, that could provide good results in disassembly, maintainability, upgradability, reusability, and recyclability. Modularization is based on the standardized components used in the same infrastructure facility that can be easily dismantled and recycled. Additionally, modularization can reduce demolition waste and material consumption while increasing efficiency (Mignacca et al., 2020).

Electronics

The problem of electronic waste (e-waste) is one of the most pressing matters for the circular economy (Islam et al., 2021). The end-of-life of electrical and electronic equipment presents severe challenges to the environment and to human health due to the presence of toxic substances. In the European Union, e-waste is categorized into six segments (Directive 2012/19/EU): temperature exchange equipment (such as freezers and air conditioners), screens and monitors, lamps, large equipment (such as washing machines), small equipment (such as vacuum cleaners), and small IT and telecommunications equipment (mobile phones and laptops). In most cases, product use manuals do not provide sufficient information to consumers on repairing electronics or recycling them. A circular business model would create a market for refurbished or remanufactured products, as well as for recycled raw materials (Parajuly et al., 2020). A visualization of circular economy options related to e-waste is provided in Figure 2.

Reverse logistics (i.e., collection systems) are a critical component of the circular economy in the case of e-waste, especially for large appliances (Isernia et al., 2019). Many countries and companies offer different types of incentives to customers to dispose of e-waste within the system. Appropriate disposal behavior depends on the consumer's awareness of recycling options, convenience being one of the determining factors of correct disposal (Xavier et al., 2021). On the other hand, stockpiling small e-waste is common and unwanted consumer behavior. Some items can be reclaimed, repaired, refurbished and resold, or transferred to other users. Other equipment can be dismantled into components that are still usable. Finally, valuable raw materials can be recovered from deprecated e-waste, but only in specialized recycling centers. Governments may support the creation of these recycling facilities, which are considered a necessary infrastructure development. Post-manufacturing recovery is labor-intensive and profit margins are very small in the absence of government subsidies (Awasthi et al., 2019).

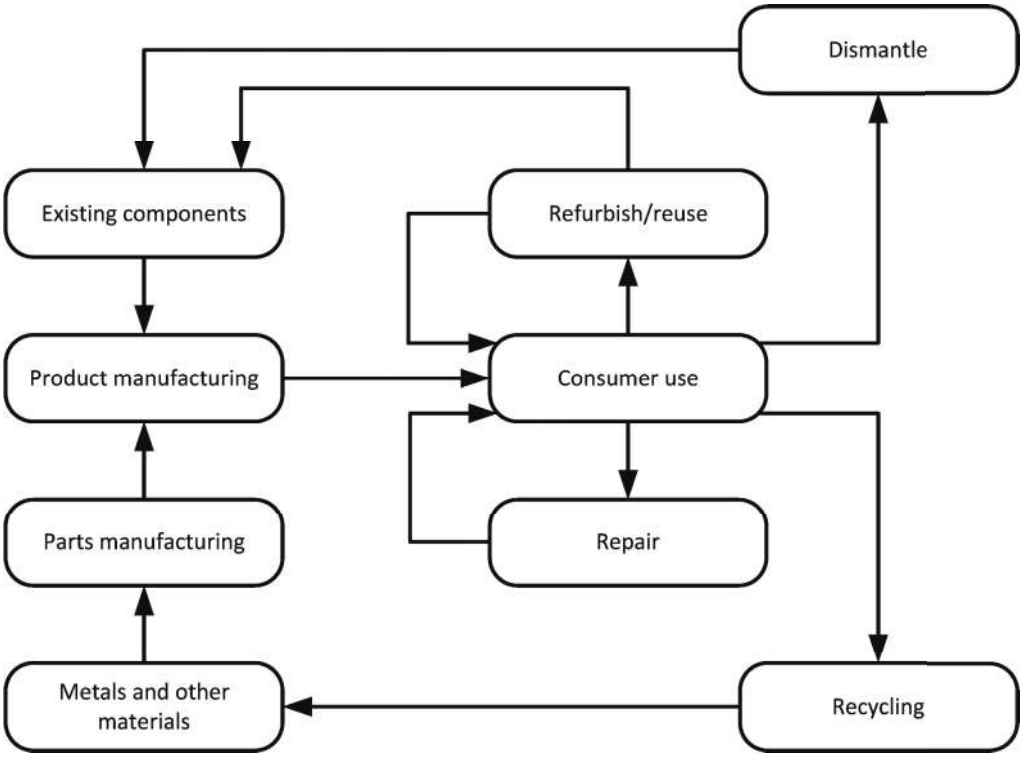


Figure 2. Circular economy options concerning e-waste

Source: Authors' design.

Product design should provide information related to the circular economy, such as material source (virgin or recycled), product lifespan, years of service guarantee, e-waste logos, and product identification to help recycling centers. However, most electronic products are not designed for repair or reuse (Dindarian et al., 2012). Cell phones are the e-waste with the most convenient collection systems, but the recoverability of materials depends on the end-processing technologies available in each country (Cordova-Pizarro et al., 2019). In this respect, the extended producer responsibility is a very important tool that provides incentives for producers to improve product design that facilitates treatment, reuse, and recycling (Parajuly et al., 2020). Material flow analysis is a complementary decision-making tool that establishes the route of materials and components through different processes until their destination. In the circular economy, value chain actors should strive for the complete recovery of materials such as glass, steel, copper, aluminum, lithium, plastic, rare earths, and precious metals. Extended producer responsibility would incentivize manufacturers to re-draw their product designs to increase the useful life of the equipment and reduce end-of-life costs (Parajuly et al., 2020).

Furniture

The furniture sector is characterized by intensive use of virgin raw materials such as wood, metal, glass and leather. Additionally, manufacturers use adhesives, dyes and coatings that generate volatile organic compounds and additional waste. While each type of material gets a different end-of-life treatment, the furniture industry as a whole should move to more sustainable and circular practices (Barbaritano et al., 2019). In this industry, eco-design is one of the answers to the circularity challenge. Eco-design is involved in creating furnishing objects with components that are easily separable at the time of their disposal (Susanty et al., 2020). Similarly, eco-design would

favor the use of recyclable raw materials (aluminum and glass, rather than wood) and the use of water-based paints and non-toxic glues. Finally, the storage and distribution of goods in the pre-consumer phases should aim for optimization and energy efficiency. A model of circularity in the furniture industry is presented in Figure 3.

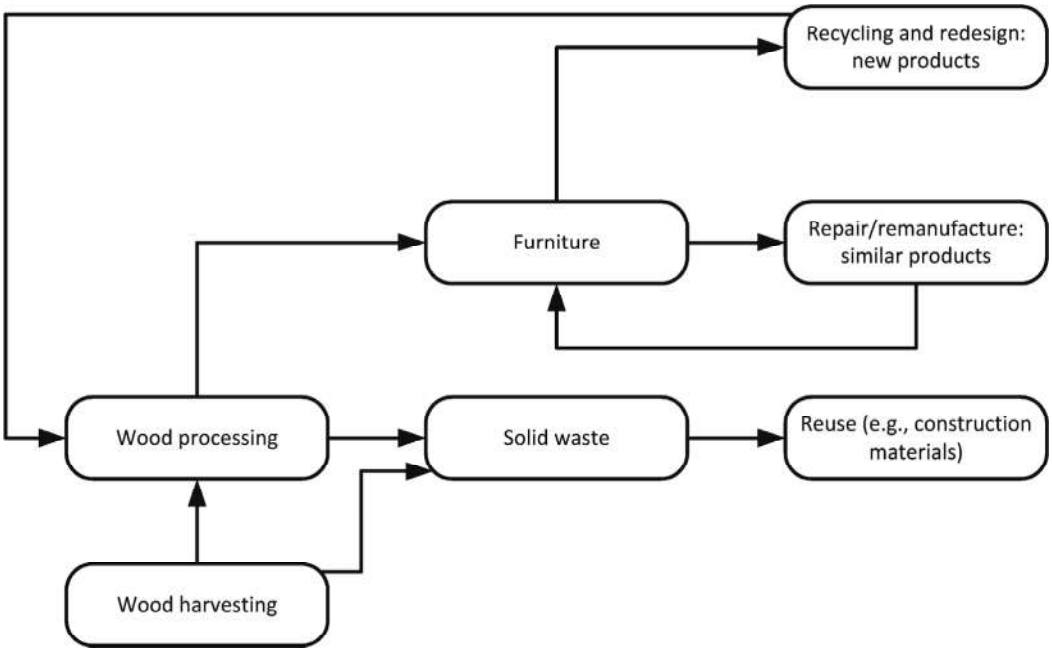


Figure 3. Circular economy applications in the furniture industry

Source: Authors' design.

One of the most important certification instruments in this industry is the Forest Stewardship Council (FSC) certification for sustainable wood (Susanty et al., 2020). At this moment, the FSC label refers to the sourcing of virgin wood products. However, external certification could extend to reusing and recycling wood products, as these circular practices are considered more sustainable than wood harvesting (Barbaritano et al., 2019). An assessment of durability of the finished product is essential for estimating the useful life of furniture, which is another crucial component of the circular economy. Reuse-or-recycle practices need to be reinforced by providing customers with incentives to donate or give back the furniture items they want to discard (De los Rios and Charnley, 2017). The reverse logistics system deals with waste and product leftovers, allowing the return of such material to the market, in a downcycled form. The goal is to divert the furniture from becoming municipal waste and being sent to landfills or incinerated.

Wood waste can occur at any stage in the production process, and also in the post-consumer phases of a product's life cycle. In the production phases, there are several types of wood waste (Hartini et al., 2021): timber harvesting waste, processing waste (sawmill dust, log cuts, veneer waste, peeled residues, and wood edge cutting). In the post-consumer phase, any broken or worn-out piece of furniture can be considered wood waste that can be recycled into a myriad of products (Oliveira et al., 2018). Wood waste is one of the most suitable examples of applying the 6R methodology (Bradley et al., 2018): reduce, reuse, recycle, recovery, redesign, and remanufacture or repair. For example, redesign activities involve including scrapped components into new products from the same line or of another type (like children's toys). Remanufacturing involves

reprocessing products or components for recovery of the product's original state or form without loss of functionality (De los Rios & Charnley, 2017). The furniture industry should avoid incineration of wood waste because this contributes to carbon emissions.

Textiles

The circular economy model encourages the input of recycled fibers instead of virgin fiber, in the production of textiles (Centobelli et al., 2020). For companies which choose to include a proportion of virgin fibers in their products, these raw materials may be independently certified regarding their provenance. Bio-cultivation of cotton and cellulose fibers from responsible forestry are the most common certifications. Fibers are used by textile and garment manufacturers, which are usually not part of the retail group. Fashion companies control the following activities: designing, packaging, distribution, and retail. Fashion retailers seek to collaborate with non-governmental organizations (NGOs) and governmental agencies to reduce resource consumption (Provin et al., 2021). They advertise their collaborations on websites, social media, and product labels.

At each stage of the value chain in Figure 4, circular economy solutions are focused on material and waste reduction, reuse, resell, repair, recycle, redistribute, in addition to source certification, and longer product life (Colucci and Vecchi, 2021; Jia et al., 2020). The downstream segment of the value chain includes customer use, product reuse, and fiber recovery. Large retailers or other organizations collect post-consumer garments and accessories so that the recovery phase can begin (Kant Hvass and Pedersen, 2019). Fibers and materials are reprocessed and integrated into other products from the same industry or transferred to other sectors. Detailed labeling and website disclosures ensure greater transparency for the customer and recycling agents in later stages of the product's life cycle (Mishra et al., 2021). Sustainability report disclosures (the main source of data for the present research) are also part of the value chain's transparency output (de Aguiar Hugo et al., 2021).

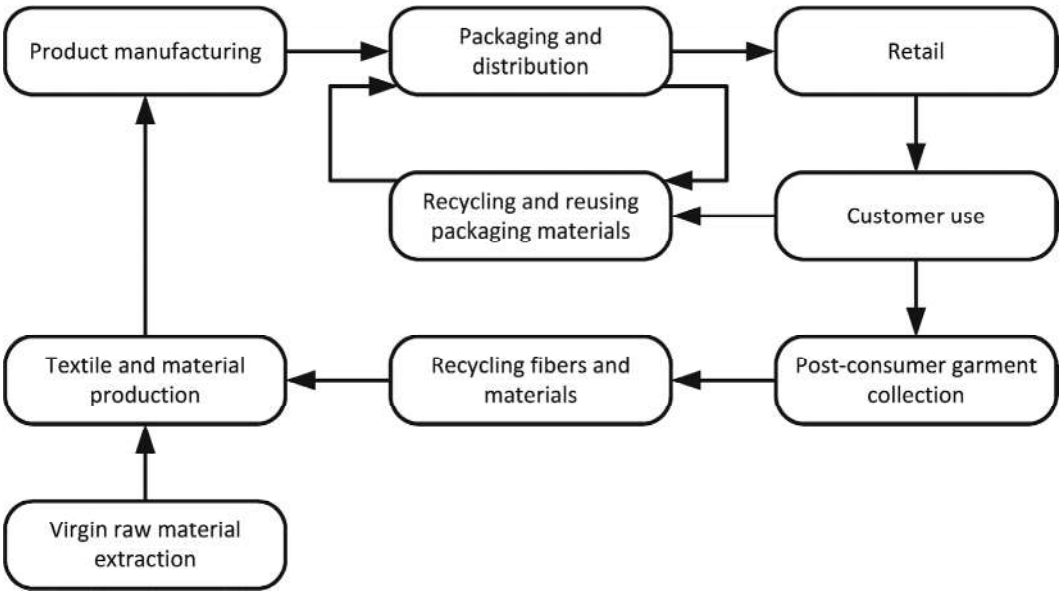


Figure 4. Circular economy solutions for the fast fashion industry

Source: Authors' design.

Leather

The leather industry presents a significant challenge to the circular economy. It is one of the most polluting industries, producing a large amount of byproducts for a relatively low proportion of usable products (Chojnacka et al., 2021). Being an ancient industry, the amount of chemicals emitted depends on the type of treatments and technologies in the tanning process. The waste is composed predominantly of solid materials such as tannery sludge, waste leather, lining, shavings, hair, and scraps (Moktadir et al., 2018). Therefore, tannery waste management traditionally consists of landfill transfers and incineration. As in other applications of the CE, the transformation and use of valuable substances will reduce the costs of waste management and will abate harmful emissions. The diagram in Figure 5 describes the application of CE principles in the leather industry.

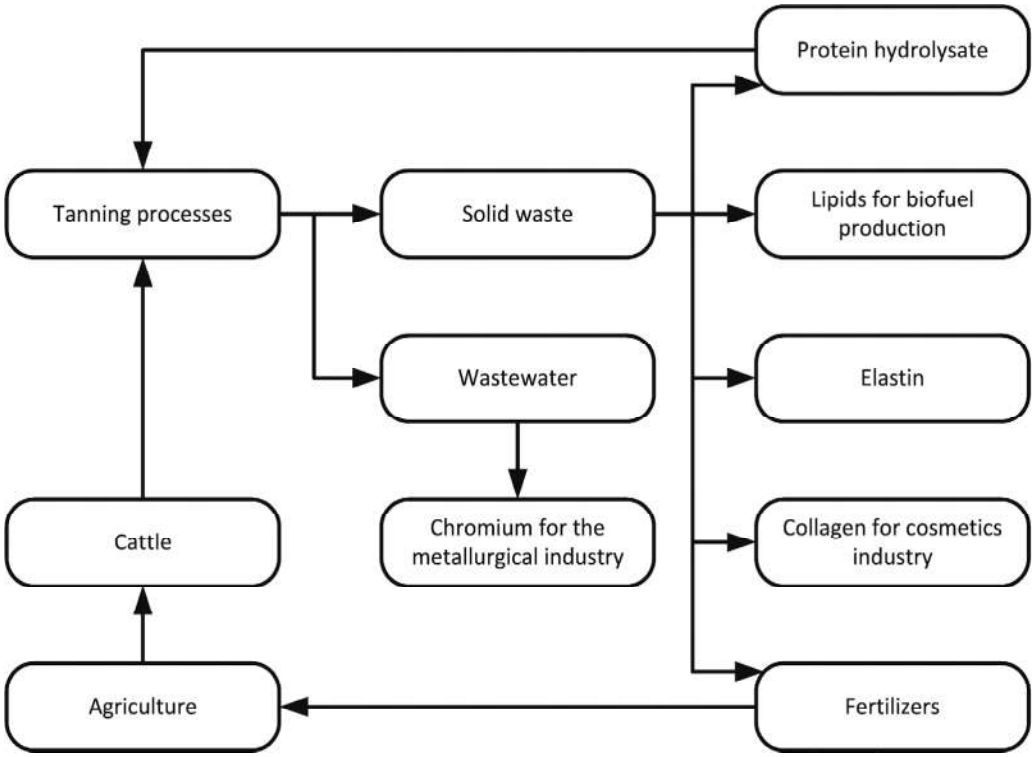


Figure 5. Circular economy applications in the leather industry

Source: Authors' design.

The byproducts of the tanning process can be reused in a number of ways (Moktadir et al., 2018). The protein-rich waste can be hydrolyzed to obtain collagen or gelatin for the pharmaceutical and cosmetic industries. Other tannery residues can be used for extracting fats and oils and for the production of biofuels. At the same time, leather wastes can be used to obtain activated carbon for biogas refining or the production of biopolymers from bovine hides. Organic fertilizers and surfactants from the protein fraction are other industrial applications of tanning waste. Biodegradable retanning agents can be obtained from process waste (Chojnacka et al., 2021).

One of the most important challenges in the leather industry is the reduction of chromium contamination. Chrome-tanned solid waste and chromium-contaminated wastewater can be a threat to human health. By applying CE principles, other non-toxic tanning solutions can be utilized such

as organic chelates and mineral acids, with a similar efficiency. Chromium can be recovered from tannery waste to be later used in the metallurgical industry. The byproducts and emissions of the tanning industry are contingent on local regulations. Therefore, fashion retailers in developed countries do not want to get involved in the production of leather goods or deal with the waste management of this industry. Leather suppliers are mostly located in countries with very little environmental protection or government support (Moktadir et al., 2018). In conclusion, the leather industry is not yet close to introducing zero-waste technologies, where each waste stream can be recycled (Karuppiah et al., 2021).

Agri-food

Food waste is specific to the distribution and consumption stages, associated with overstocking and consumer behavior (Parfitt et al., 2010). Regardless of the stage where it occurs, food waste has significant economic, social, and environmental effects. The environmental impact of food loss and waste is primarily linked to landfilling and the production of methane and carbon dioxide as part of the natural decomposition process (Amicarelli et al., 2021). Other environmental impacts associated with food waste are the depletion of natural resources and nutrients in the soil and water, energy waste, and the interruption of biogenic cycles due to intensive agricultural activities (Lipton and Saghai, 2017). Food waste that is still safe for human consumption (items close to the expiration date) can be donated to charities, while other types of waste can be reused for different purposes such as generating energy from biomass, reprocessing (i.e., fermentation), or as fertilizers. A visual representation of the circular economy in the food industry is displayed in Figure 6.

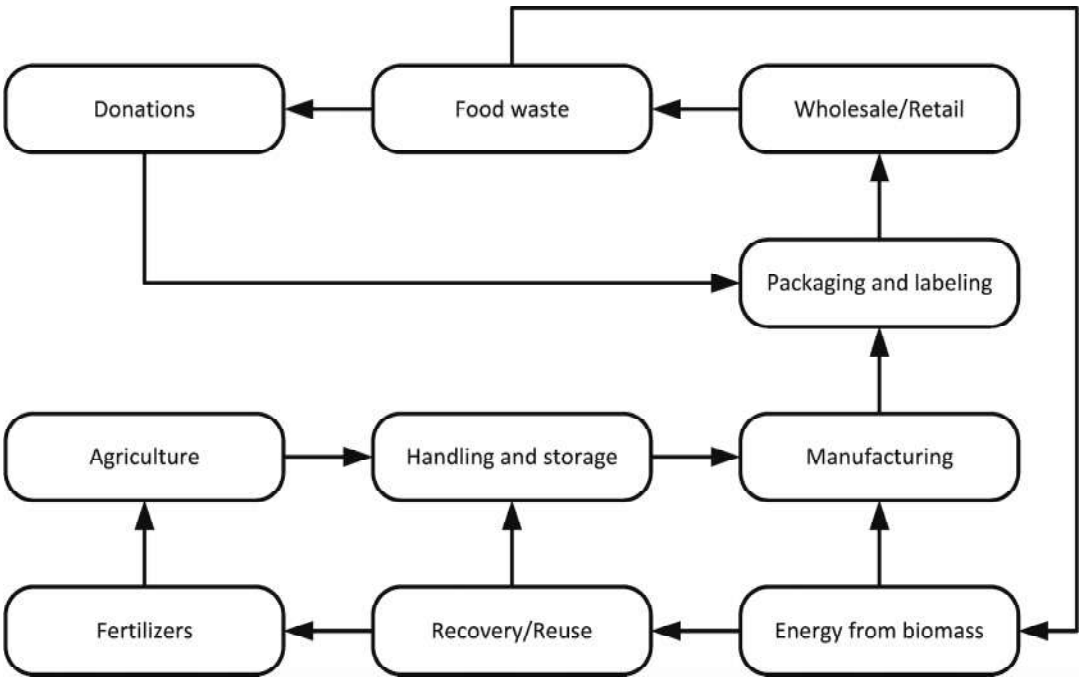


Figure 6. Circular economy solutions in the food supply chains

Source: Authors' design.

The European Federation of Food Banks (FEBA) plays an important role in encouraging food donations (Beretta et al., 2013), especially from supermarket inventories. According to the annual report published on the FEBA website, at the European level, 860,000 tons of food were

collected and distributed through 335 food banks in 2020. The main objective was to reduce food insecurity in Europe by preventing food waste (including the recovery of surplus food for human consumption). Food companies can contribute to the circular economy, fighting hunger and malnutrition by donating food surplus that met food security standards in all countries where the group operates (Thyberg and Tonjes, 2016).

Food distribution companies focus on the supply process and systematically collect, monitor, and analyze data to determine the types of food waste in stores and the reason for their occurrence (Teigiserova et al., 2020). Companies are investing in new storage and packaging technologies that extend the shelf life of fruits and vegetables, saving a large amount of raw materials (Gharfalkar et al., 2015). Processes are constantly reviewed, and packaging is used for food waste prevention. Clarification of label data is a major concern for companies, as the guidelines on how to store food and when to use it are not always clear. Another direction of action is better management of inventories, e.g., store areas dedicated to products with a short shelf life. The effect is tighter control of the shelf life within the supply chain, maintaining the quality and freshness of products for customers (Papargyropoulou et al., 2014). Another way to reduce waste is to create special packages for products close to expiration and all companies in this industry resort to discounts before expiration or for products with minor defects.

Companies have found innovative solutions to reuse food waste: obtaining gin by distilling beer that could have been otherwise wasted; transformation of rejected fruits into by-products such as apple juice, cakes, or sorbet; creation of vegetable products that were to become waste; using the surplus cheese, yogurt, beer and apple juice as ingredients in cakes and bread. Recycling usually refers to the transformation of food waste into energy. Some examples are the use of new equipment for the separation of packaging for recycling, fruit and vegetable waste being transformed into energy; collecting used coffee grounds to produce electricity at biogas stations; biomethane production; soaps, detergents, and compost/fertilizer production.

Conclusion

The importance of the CE had exponentially increased in the last decades, becoming a milestone on both the government's agendas and companies' strategic planning. Not only that CE provides a more sustainable model based upon the idea of restoration or regeneration by intention and design (Ellen MacArthur Foundation, 2022) but it also enables a more fair, healthier, and effective society (Barbaritano et al., 2019). The CE contribution to business efficiency is mainly driven by cost optimization, reduced materials consumption, decreased price volatility (Murray et al., 2017). The impact of new technologies and processes automation tools have an important role in the open economic systems, favoring the 6 R's (recycle, reuse, reduce, repair, remanufacture, redesign).

This paper is aiming to provide a brief guideline on how CE can reshape companies' business models in various industries. New business models, tailored to achieve sustainable development and a fair society (Ghisellini et al., 2016; Mathews and Tan, 2011) that better integrate economic, social, and environmental issues, are required in different industries. Products that are used to their maximum potential and on an extended lifespan, environmentally friendly technologies, eco-designs and innovation, higher long-term sustainability are some of the advantages of the CE integration. We have focused on six industries, with a material impact on the environment, that may become successful milestones of CE. Specific diagrams were designed for entities within oil and gas, electronics, furniture, textiles, leather, and agri-food, to highlight their operations, results, and reintegration opportunities, if circularity principles would apply. This

endeavor is the first part of a larger research project that intends to assess the feasibility of various fine-tunings on specific business models that integrate CE.

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