Chapter 2
Circular Economy Analysis Applying Ellen MacArthur Model: Spanish Glass Sector Case

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Abstract Circular economy (CE) has reached a quite relevant position on academic research studies nowadays, and it has been considered a key driver for long-term organization supply chains sustainability and competitiveness increase. Some theoretical models have been developed trying to identify the most relevant key parameters and conditions that allow to define a specific supply chain, or a sector or organization, as "circular economy practice". Between the models, one of them was developed and established by the well-known Ellen MacArthur Foundation (EMF). This research tries to analyze the applicability and fulfillment of EMF model to the Spanish glass sector, through a deep analysis of real practices already applied in this industrial sector. After the analysis, it is possible to infer that this sector meets almost all the EMF model characteristics. Nevertheless, there is still some run for circularity improvement in the sector, since still renewable energy application is below current demanding standards.

Keywords Circular economy · Spanish glass sector · Sustainability · Circular economy case study

2.1 Introduction

Since the beginning of the First Industrial Revolution, companies have been focused on exploiting resources to create cheap and massive products, and as consequence of that has been created a society with a large capacity of waste generation. Final result has been a high consumption of new additional resources to produce massive consumer products and a large amount of waste [1, 2]. The increasing interest forced the development of the well-known Brundtland report [3].

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This report detailed the environment deterioration and the need to take care of the ecosystem through a better use of raw material and product´s consumption, in order to achieve a sustainable economic growth [3–5].

The concept of sustainable development was defined based on the three main sustainability pillars: environmental, economic and social [3]. According to [6], a high qualified economic system is able to meet the sustainable characteristics of taking care for the environment, achieving competitive economic objectives and improving social parameters. Following [7], the sustainability and the ecosystem have become a top priority integral issue being able to combine social, environmental and economic angles. Considering the environmental angle, circular economy (CE) is based on using resources in a very efficient way, but always seeking to reduce waste and emissions [8].

Natural resources are finite, and the demand is increasing daily due to the exponential population growth (from a total population of 2.6 billion people in 1950 to more than 7 billion people in 2020). It worries many collectives, who have developed different CE concepts over last decades. A summary of its evolution is shown in Table 2.1.

Most recent studies [17, 18] on CE propose a design adaptation in the supply chain, increasing quality and speed of manufacturing using resources efficiently. This leads to higher supply chain performance in terms of reused ability maintaining its technical properties [19].

In order to promote a social, economic and environmental balance, Unites Nations (UN) sponsored The Kyoto Protocol (1997), aiming to reduce greenhouse gases, improving the worldwide quality of life and reducing environment issues [20, 21]. After some initial trials, the so-called 2030 Agenda aims to achieve sustainable planet development in a medium-long term and implementing a friendly environmental

Table 2.1 Circular economy concept evolution. Source: author´s elaboration

Industrial ecology [9]	It proposes to study the materials inflows and outflows, using a sustainable system applying renewable energy and an efficient resources use
Regenerative design [10]	The supply chain is a self-supply closed system. Balance social and environmental needs in highly promoted
Performance economy [11, 12]	It proposes an economy working in loops, with a longer useful life of the product, and a reconditioning products for its new use
Cradle to cradle [13]	It bases the supply chain on the environment, where all organisms can be connected to each other generating zero waste
Blue economy [14]	The waste of one system becomes part of the input of another, without waste generation, and always, using the cascade concept
Ellen MacArthur model [15, 16]	Expose the feasibility and profitability of applying a circular economy. Model increase its relevancy since there is a high interest on finding real application on business environment

global circular economy, where the use of renewable energy is encouraged and all products must increase their capability to be reused [22–24].

To achieve stablished objective, 169 goals were defined based on the seventeen UN Sustainable Development Goals, which are interrelated and connected to three different angles: (i) social, such as the end of poverty or hunger, (ii) environmental, like ecosystem care; and (iii) economical, where entities must generate added value through business innovation on circular products and higher renewable energy use [22, 23, 25, 26].

Ellen MacArthur Foundation (EMF) has developed a circular economy model concept embedded into UN Sustainable Development Goals. Following EMF companies and governments must jointly work to improve the transformation processes toward a more efficient system.

In this research, authors conduct a research to apply EFM to a sector practices, and glass sector has been chosen as study field. Main study objective will be related to the EMF application feasibly to this particular industry.

2.2 A Reference Circular Economy Model

The CE aims to give maximum utility and reuse to resources [1, 27] by manufacturing products able to be reused, recycled and/or repaired [15, 28]. As consequence, balance could be achieved in the system in order to mitigate the supply risk [29, 30]. To create a product that fulfills the circular characteristics, it must be considered that in the last phase of the product life circle, the raw material must be recovered as much as possible [15, 31]. To get the most out of resources, [32] created some theories in order to avoid waste in the transformation process. This also entails a lower use of energy, trying to use renewable as much as possible because of the current situation of environmental risk [16, 17].

On top of that, Ellen MacArthur proposes to interconnect different systems in such a way that waste materials from a system are useful as new raw material for others [15]. For that reason, [15] has developed during last decade a conceptual model that tries to integrate certain characteristics that should be fulfilled by any organization that it could be considered a “circular economy organization” (see Table 2.2).

This EMF circular model tries to keep inside all the raw material waste generated by different systems as a loop. This means that scraps from one of the system could be a manufacturing input for other [15]. It means less externalized traditional environmental costs and other associated risks related to waste management [8]. Organizations should achieve the highest level of resource self-recovery to reduce the generation of non-reusable waste [33].

Table 2.2 Circular economy characteristics based on Ellen MacArthur Foundation model Source: author´s elaboration based on EMF 2014

	Characteristic 1: The inner circle When the end user considers the product is a waste, product has the possibility of being reused, recycled, remanufactured or shared within its own system
	Characteristic 2: Infinite loop The product considered waste can reproduce an inner circle in an infinite way. Becoming input of the same system without losing the quality it had at the beginning
	Characteristic 3: Cascade manufacturing The raw material can be part of several interconnected systems among themselves. For example, a garment can be part of its own system by reusing it, or it can be part of another subsequent system (e.g., cotton fiber)
	Characteristic 4: There are no losses An essential characteristic of the circular economy is that the raw material remains within the value chain, without the existence of toxic waste or emissions

2.3 Objective and Study Methodology

This study is part of a global research line that aims to deepen the understanding of circular economy practices and also to make specific proposals for improving management practices, potentially applicable to other sectors. The objective of this particular study was to check if EC practices at Spanish glass sector fit, or not, with a specific EC model characteristics proposed by Ellen McArthur Foundation.

In an initial step of the study, an extensive search of published data (basically through web searching in several web pages from Spanish sector entities) regarding the glass industry has been performed, and due to the specific nature and novelty of this issue, it was decided to carry out a case study.

Case study method, according to Eisenhardt [34], Rialp [35] and Voss et al. [36], is a very suitable tool for issues related to strategic management decisions. Yin [37] suggests using case study analysis when boundaries between the context and the phenomenon to observe are not obvious. Case studies have been gradually recognized, despite some criticism, as a very correct way “to address contemporary organizational problems and established credibility” [38].

2.4 Circular Economy in Spanish Glass Sector. Case Study

2.4.1 Circular Economy at the Sector

Spanish glass manufacturers and bottling companies are organized in large sectorial associations divided by products (flat glass, bottles, …) to carry out specific technical practices. The most important associations are ANFEVI (manufacturers of glass bottles), which produces 66.4% of total Spanish glass consumption and has a turnover over 1,000 million euros; and FAVIPLA (manufacturers of flat glass) with a share of 26.4% of total Spanish glass consumption and 700 million euros in turnover [39].

Glass is a non-biodegradable material, so if it was not recycled, it would mean a serious environmental problem [40]. The history of glass recycling in Spain begins in 1980 when recycling it was applied to a production methodology to recycle the entire bottle without generating non-biodegradable waste [41]. At that time, glass recycling started to be promoted as a fundamental element to obtain energy savings in smelting furnaces, getting the possibility of raw materials recovering to reuse in new bottle manufacturing. In this regard, hollow glass companies were the first Spanish industrial sector to launch a comprehensive recycling system in collaboration with local entities and citizens [42]. Recycling in this industry achieved following indicators level by 2018:

- 230,950 glass "collection containers", which facilitates the empty bottle collection and recycling, reach 896,450 tons in 2019 [41].
- 51% of bottle manufacturing raw materials are sourced within a radius of less than 300 km [39], what optimizes supply chains resources use.
- A ton of recycled glass saves 1.2 tons of raw materials, 30% of energy and the emission of 670 kg of CO_2 [43]. In Spain, 84% of people recycle glass which means that 24.4 million MW of energy and 13.2 million tons of raw materials have been saved in the last 20 years. Also, 7 million tons of CO_2 have been reduced as pollution emissions to the atmosphere [39].
- A recycling rate of 76.5% is obtained in Spain (calculated as a ratio between recycle and sold bottles). This ratio is higher than the European Union environmental objectives within the 2030 Agenda. It implies a saving of more than 1 million tons of raw material, which means avoiding more than 500,000 tons of CO_2 into the atmosphere [40].

The Spanish legal normative process took several years. These recycling activities were regulated by EU Directive 94/62/CE [44] and its transposition into Ley Orgánica 11/1997 [45] regarding containers management and waste within their supply chain. This was intended to prevent and reduce the impact on the environment, recovering waste throughout bottle life cycle [45]. Given this regulation, glass manufacturers created an integrated management system (SIG) called ECOVIDRIO, which is a non-profit association responsible for the glass collection and recovery [41].

In 2011, a new legal regulation (Decreto ley 22/2011) [46] regarding contaminated soils and waste recovering established full responsibility on the producer. In this case, glass companies must recover empty bottles at the end of the supply chain and from soils [46]. SIG was passed to be called as SCRAP (expanded collective responsibility producer system).

Spanish companies have introduced new techniques which reduce energy consumption and therefore CO_2 emissions. For instance, they are preheating the furnace incoming air because energy saving is always a priority objective for manufacturers. More than 70% of total energy consumption corresponds to furnace heating, and they consume a high amount of energy, between 20 and 30% of the production cost [43]. As consequence of all these efforts, it has achieved a reduction of 50,000 CO_2 tons of emissions per year.

2.4.2 Circular Economy Model (EMF) Applied to Glass Sector

In order to understand the Spanish glass bottle supply chain, the study puts attention on the area of the SC that includes the processes from bottles manufacturing to their recovery and reuse as raw material into manufacturing process. The filled bottles follow alternative channels within the supply chain. On the one hand, the filled bottles can be distributed in retail establishments (restaurants, retail shops, etc.) which are responsible for returning the bottles already used to the bottler company (such as a returnable bottle) to be cleaned and refilled. And, on the other hand, at the consumer level, the bottle is recovered through the "igloo" containers, which are collected by the SCRAP collection systems and returned to the bottler company through the own SCRAP. Thus, the raw material always remains within the system itself, there is no residue or waste, and there is a positive impact on energy saving and materials on the whole production system. To analyze whether the glass industry contains in its supply chain practices of CE, its practices are analyzed through the glass life cycle in relation to the model developed by Ellen MacArthur Foundation [15] as described in Table 2.3.

2.5 Conclusions

From the analysis that has been managed, when the EMF circular model is applied to the Spanish glass sector, it could be possible to infer with respect to characteristics 1 (inner circle) and 2 (infinite loop) that the glass sector widely complies with both characteristics due to the fact that being a material that can practically be reincorporated into the productive process as raw material many times and in many different products. So, both characteristics are fully found and clearly verified in the practices of the Spanish glass sector.

Table 2.3 Summary of EMF model application to Spanish glass sector

Characteristic 1: The inner circle The glass container is recyclable and becomes another bottle similar to the previous one, without losing its value, since from one container there is another of identical characteristics; therefore, it can be said that it meets this requirement at 100%
Characteristic 2: Infinite loop In the case of glass containers, there are two options: the returnable bottle and the non-returnable one (one way). In the case of one way products, the packaging is recycled. In the case of refillable containers, the container becomes packaging plant to be reused for an indefinite number of cycles
Characteristic 3: Cascade production Due to its inert material capacity, it can be used in infinite applications. For example, 69% of glass wool comes from recycled glass
Characteristic 4: There are no losses All collected bottles are reused or recycled

Source: author´s own elaboration

On top of that, being the glass a material that also constitutes a relevant input for other sectors manufacturing, such as decoration and construction, it can feed other sectors supply chains as an important raw material. That fact totally fulfills the specific requirements that the used reference model (EMF) establishes as "cascade production".

Respect to the last characteristic of the EMF model described as "there are no losses". The recycling and reuse levels managed by companies operating within the Spanish glass sector have achieved a degree of efficiency that the waste in terms of materials and pollution generated by those companies is really a very low percentage of used resources. However, even though this sector nearly approaches to the total fulfillment of this characteristic in the way in which every returned glass bottle is reincorporated as a raw material to the production process, it does not fully comply with EMF model because still it does not use exclusively renewable energies along their supply chain.

From the analysis carried out, it could be possible to infer that the Spanish glass sector complies with most of the characteristics established by the circular economy EMF model, since the recycling and reuse of bottles in a continuous way have been internalized as part of its sector transformation process, without losing its properties and quality of use. Still there is a possibility of improving the sector's circularity performance by expanding the use of renewable energy in its manufacturing process and increasing the level of consumer recycling awareness.

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