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CIRCULAR ECONOMY PATHWAYS IN THE AGRI-FOOD SYSTEM

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Manal

Summary

1. Introduction and conceptual framework

A circular economy enables a positive and continuous cycle of development that preserves and enhances natural capital, optimizes resource returns, and reduces system risks by managing finite stocks and renewable flows. The 21st century faces challenges that are more significant and complex than ever before.

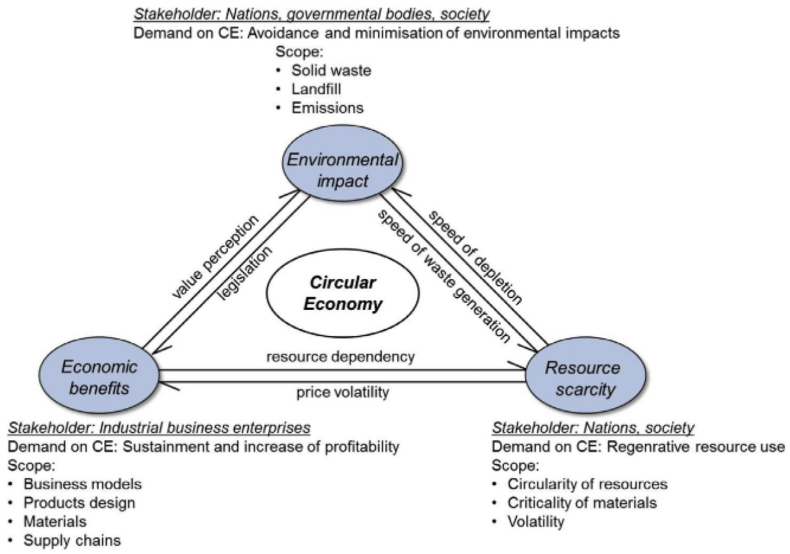
The circular economy has been defined as a “restorative or regenerative industrial system by intention and design” (Ellen MacArthur Foundation, 2015), which implies pursuing and creating opportunities that involve moving from a “end-of-life” concept to a “cradle-to-cradle” concept, from using nonrenewable resources to using renewable ones. It is considered an alternative model to the linear “take-make-dispose” economy to help slow, close, and shrink resource cycles (Bocken et al., 2016). The goal of a closed-loop system is to increase resource efficiency with a focus on urban and industrial waste in order to achieve a better balance and harmony between the economy, environment, and society. A closed-loop system supports sustainable development and consumption through technology and innovation (Ghisellini et al., 2016).

Circular economies have developed through a variety of schools of thought, including Cradle to Cradle (McDonough and Braungart, 2002), Laws of Ecology (Commoner, 1971), Looped and Performance Economy (Stahel, 2010), Regenerative Design (Lyle, 1994), Industrial Ecology (Graedel and Allenby, 1995), Biomimicry (Benyus, 2002), and the Blue Economy (Pauli, 2010), all of which acknowledge nature as an (Sakai et al., 2011; Preston, 2012; Reh, 2013; Su et al., 2013; Lett, 2014).

However, CE is still an emerging concept (Velenturf et al., 2019), and there is still no agreed-upon theoretical framework or definition (Kirchherr et al., 2017), despite the fact that the academic literature shows that over the past ten years, the number of scientific publications has increased by more than ten times (Geissdoerfer et al., 2017). The benefits of investigating these ideas and encouraging the use of circular systems can be linked to decreased environmental impact through waste minimization, increased economic benefits through redesign of products, supply chains, and material selection (Figure 1. 1), as well as material cost savings, decreased price volatility and supply risks, significant job growth, and other benefits (Lieder and Rashid, 2016).

The circular economy must be implemented with support from innovation planners and intermediaries who offer services and projects that enable radical changes to policies and decision-making tools because it, like all other sustainable models, requires both innovative concepts and innovative actors (Golinska et al., 2015; Küçüksayraç et al., 2015; Friant et al., 2021; Donner et al., 2021).

Figure 1.1 – Circular economy structure.



Source: Lieder and Rashid (2016).

1.1 Circular economy in the agri-food sector

Given that the population is predicted to reach 9 billion in 2050 and that food production will need to increase by 70% to meet nutritional needs, the agribusiness sector today aims to meet the growing demand for food, feed, fiber, fuel, and industrial products while attempting to use fewer resources (FAO, 2016).

In this context, the sector has recently given significant attention to concerns including food safety, production traceability, product quality, and environmental and human friendliness, led by legislation, nonprofit groups, and academia (Anastasiadis et al., 2022; Atanasovska et al., 2022; Zhang et al., 2022; McDougall et al., 2022; Agnusdei et al., 2022).

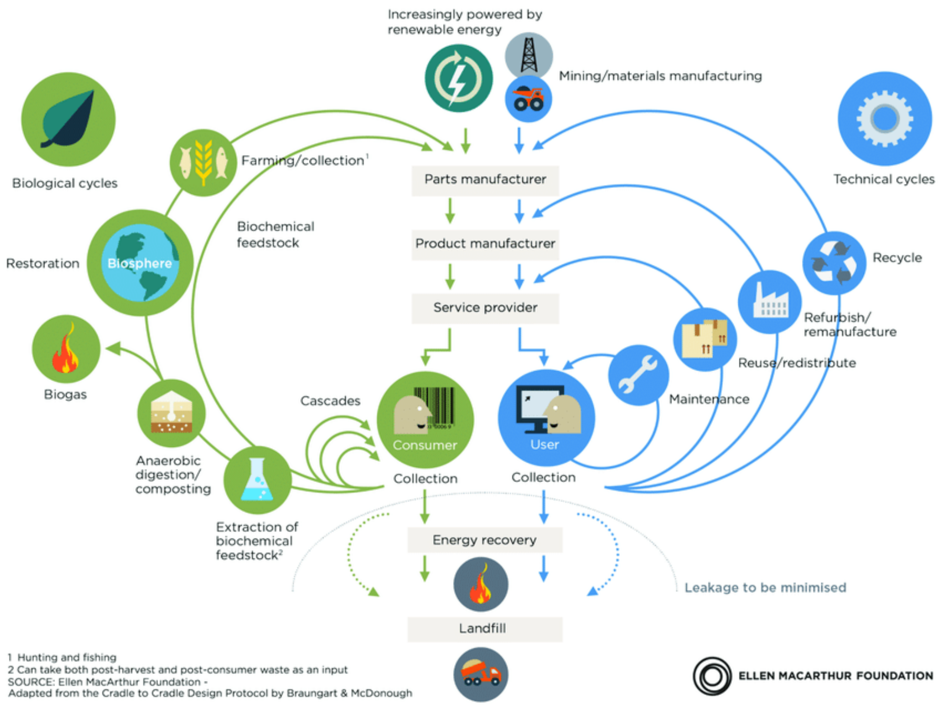
This has caused manufacturing systems to adopt greener practices.

Contrary to popular belief, the challenge facing preventive and regenerative eco-industrial development (Cembalo et al., 2020) does not call for a greater adoption of "green" technologies, but rather a broader and much more thorough vision in the design of alternative solutions. These solutions should, in the context of an agribusiness system, cover the entire life cycle of the process, giving importance to the interaction between the process, the environment, and the economy.

Although several academics believe that biomass will play a significant role in achieving the global climate goals set forth by the Paris Agreement (Creutzig et al., 2015; Daioglou et al., 2019), little attention has, to date, been paid to the circular product design, recycling, and cascading, of bio-based products. This is surprising given that biomass represents one of the few options to replace fossil raw materials with a renewable resource, thereby reducing emissions.

The "butterfly diagram" (Figure 1.2), developed by the Ellen MacArthur Foundation (EMF, 2012), illustrates how the economic system may experience both "technical" and "biological" cycles. The management of completed materials used in closed-loop systems and intended to return to the technosphere is referred to as the technological cycle. On the other hand, the biological cycle refers to the flows of organic and inorganic renewable materials that are intended to return to the biosphere and are arranged in an open-loop system of "cascading" resources through successive stages of extraction, production of bio-based materials, and energy recovery to feed the next cycle of primary products.

Figure 1.2 - Butterfly diagram.



Source: Ellen MacArthur Foundation (2012).

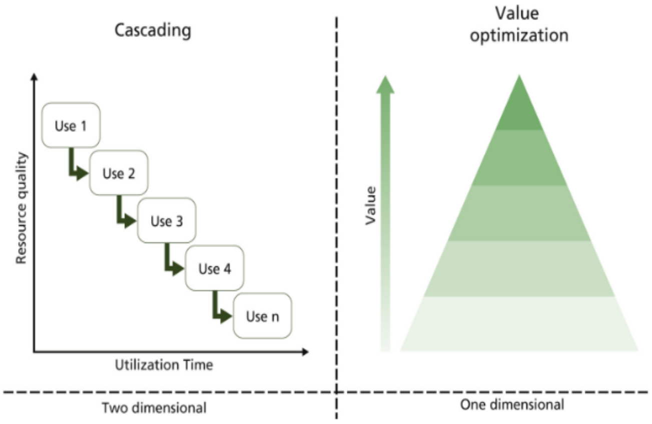
In particular, biological metabolism is designed as a mechanism for recovering food loss, food waste that happens throughout all stages of processing in the agribusiness chain, and food waste that is instead attributable to waste inherent in consumer behavior (Pinto et al., 2022; Kassim et al., 2022; Howard et al., 2022; Dora et al., 2021; Ciccullo et al., 2021; Kusumowardani et al., 2022). In fact, the agricultural industry generated around 1.3 billion tons of trash in 2019 as a result of inadequate resource and process management and unsustainable customer consumption habits (Proto et al., 2008; Taghikhah et al., 2019; Liu et al., 2021).

The cascading use of biomass (Figure 1.3), or the sequential use of resources for different purposes, is undoubtedly one way to add value to agri-food by-products. According to Olsson et al. (2018), this system supports the circularity of the industry and maximizes the intrinsic and extrinsic value of the products.

The phases of the cycle aim to maintain the quality of resources throughout time, moving from the production of high-value biomaterials to the production of low-value biomaterials, in order to lower the piramide of the value of biomass and the hierarchy of rifiuts (Walsh, 2010) (Figura 1.4). Through these cascading processes, bioraffineries enable upcycling, a technique used in biological metabolisms as a primary method of resource recovery for products and materials that are no longer in use or are destined for disposal. Upcycling enables the creation of products with equivalent or superior properties, such as pharmaceuticals, food products, beverages, chemicals, biocombustibles, compost, and energy (Chodkowska-Miszczuk et al., 2021; Berbel and Posadillo, 2018).

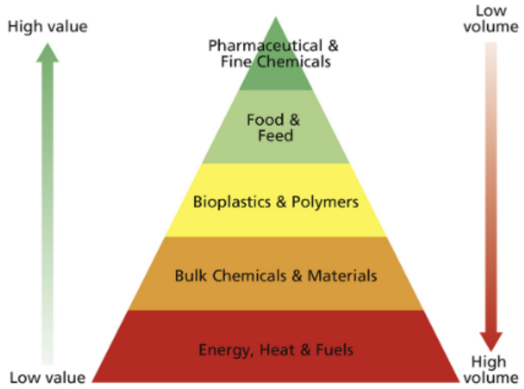
The study by Fehrenbach et al. (2017) regarding cascading pathways of bioplastics, textiles, paper, and wood, or the study by Bais-Moleman et al. (2018) who showed significant reductions in GHG emissions for cascading wood, show that cascading biomass use has led to environmental benefits in light of the foregoing. The use of biomass to generate electricity has the greatest potential to reduce greenhouse gas emissions, according to research by Daioglou et al. (2019).

Figure 1.3 – Cascading.



Source: Stegmann et al. (2020).

Figure 1.4 - Biomass value pyramid.



Source: Stegmann et al. (2020).

The production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bioproducts, and bioenergy, are described as the bioeconomy (BE - Bioeconomy), which was proposed by the European Union in this regard (European Commission, 2012).

The European Commission said in 2018 that "the European bioeconomy must include sustainability and circularity at its heart", indicating the need for a clearer and more comprehensive strategy.

The meeting of these concepts led to the creation of the term, "Circular Bio-Economy" (CBE), which already appeared around 2015 and has been increasingly used in scientific publications since 2016, as an application of the concept of CE to biological resources, products and materials. Stegmann et al. (2020, p. 5, original English quotation mark) suggest the following definition of CBE: "Circular bio-economy focuses on the sustainable and efficient valorization of biomass in integrated, multi-output production chains (biorefineries), also using residues and wastes and optimizing the value of biomass over time through cascading. Such optimization can focus on economic, environmental or social aspects and ideally consider all three pillars of sustainability. Cascading steps aim to maintain resource quality by adhering to the biobased value pyramid and waste hierarchy where possible and appropriate".

1.2 Sustainable Business Models (SBMs)

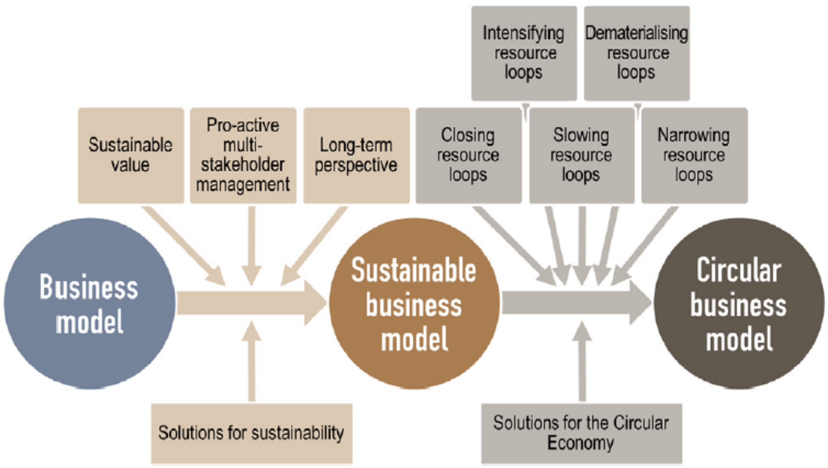
Driving a production system toward the circular economy entails the need for a new way of doing business.

A conventional business model describes "the way business is done" (Magretta, 2002) and illustrates how a business proposes, creates, delivers, and captures value (Richardson, 2008) for the customer and the business (Osterwalder et al., 2005).

A sustainable business model (SBM), on the other hand, requires a broader understanding of value and stakeholders and is defined as "a business model that creates competitive advantage through superior customer value and contributes to the sustainability development of the company and society" (Lüdeke-Freund, 2010, p. 23). While providing and capturing value like a traditional business model, a sustainable business model simultaneously recognizes the importance of integrating the economic, environmental, and social aspects of sustainability into an organization's purpose, at the corporate and network level (Gioia et al., 2012), utilizing a triple bottom line (people, profit, planet) approach (triple bottom line) (De Koning, 2019). Not only technological, product, or service innovation, but also business model innovation, is required for sustainability (Girotra and Netessine, 2013; Yang et al., 2017).

Sustainable business models are developed to reduce the negative impacts of business activities on the environment and society (Charles et al., 2017) and can be categorized based on their level of sustainability. Closed-loop models (Johannsdottir, 2014), industrial symbiosis (Chertow, 2007), social inclusion models (Nelson et al., 2009), demand management models (Behrangrad, 2015), and product-service systems (PSS) are among the most sustainable business models (Reim et al., 2015). Especially, circular business models (CBMs), which have become important for achieving greater levels of sustainability (Ghisellini et al., 2016; Bocken et al., 2016; Ritala et al., 2018; Breuer et al., 2018; Yip et al., 2018; Geissdoerfer et al., 2018; Lüdeke-Freund et al., 2018), they can be considered an important subcategory of Sustainable Business Models (Figure 1.5), as they contribute both to addressing the increasingly pressing impacts of climate change and to business competitiveness and broader socioeconomic issues (Ghisellini et al,. 2016), through slowing resource cycles, extending the life cycle and reusing products (Velte et al., 2016), closing cycles by capturing residual value from by-products or "waste" through business model innovation (Bocken et al., 2016; Geissdoerfer et al., 2017).

Figure 1.5 - Traditional, sustainable and circular business model.



Source: Geissdoerfer et al. (2018).

1.3 Circular Business Models (CBMs)

Although the concept of circular business models has been around for decades, the term has only recently been used in academic research (Lewandowski, 2016; Nußholz, 2017). A CBM is a type of sustainable business model (Adams et al., 2016; Bocken et al., 2014) that integrates environmental and economic value creation through profit generation from a continuous flow of materials and products reused over time (Bakker et al., 2014) by capitalizing on the value embedded in used products (Bocken et al., 2016; Linder and Williander, 2017). Mentink (2014, page 24) defined it as "the logic of how an organization creates, delivers, and captures value within closed material cycles". On the basis of this definition, Linder and Williander (2015, p. 183) assert that "the conceptual logic for value creation is based on the use of the economic value retained in products after use to produce new offerings".

Providing that "100% circular business models do not exist (yet). It is difficult to achieve zero waste for physical and practical reasons" (Van Renswoude et al., 2015, p. 2); the objectives of CBMs are not limited to reducing environmental impacts (Lewandowski, 2016), but also to generating economic value by saving both customers and the company money by extending the life cycle of materials, components, and products and by reusing, repairing, and remarketing (Mentink, 2014) in a manner that preserves their intrinsic value at the highest level of utilitarian Circular business model assumptions include circular supply of renewable energy, fuels, and bioproducts, waste as a resource from which useful resources and energy can be recovered, industrial symbiosis, increasing the utilization rate of products by increasing the number of users, obtaining greater benefits from the same volume of goods by eliminating downtime, the product as a service (dematerialization of products), and providing access to products while minimizing waste.

On the other hand, social goals involve the sharing and reusing of resources among members of society, primarily businesses. As companies do not create value on their own (Beattie et al., 2013), it is necessary to improve their interactions with suppliers, partners, and customers in order to enhance the quality of life (Bocken et al., 2018; Stubbs and Cocklin, 2008). To achieve these objectives, businesses must be guided through the Circular Business Model Innovation process (CBMI). Therefore, a variety of methods and tools have been developed to assist business developers in overcoming the obstacles they face when designing and innovating circular business models (Whalen et al., 2018; Mont et al., 2017; Antikainen and Valkokari, 2016; Nußholz, 2017; Leising et al., 2018; Linder et al., 2017; Nußholz, 2018).

Lewandoski (2016), for instance, presented more than twenty-five business models that correspond to the Ellen MacArthur Foundation's (2015) ReSOLVE (regenerate, share, optimize, loop, virtualize, and exchange) framework. In 2016, the same group advanced a conceptual circular business model framework based on Osterwalder and Pigneur's (2010) "Business Model Canvas", one of the most widely used tools today, to highlight both the ways in which circularity is applied to each dimension of the business model and the additional elements that are crucial to the implementation of the circular economy, namely the recovery systems and adoption factors. Nonetheless, the process of developing a circular business model is an innovative component of a business strategy that requires industrial design.

1.4 Circular design strategies

Design is a discipline shaped by industry to be time-bound and is recognized as one of the key factors in the transition to a circular economy (Ellen MacArthur Foundation, 2012; RSA Action and Research Center, 2016), as it involves the adoption of sustainability strategies that are based on eco-efficiency, which, unlike the concept of eco-efficiency, aims to redesign ex-ante products, whose materials flow continuously (Figure 1.6).

Figure 1.6 - Eco-efficiency and Eco-effectiveness.

Source: (EPEA GmbH, 2013).

Circular design goes beyond the linear take-make-dispose model, as designers, inspired by McDonough and Braungart's (2002) Cradle to Cradle philosophy, think about the system as a whole and consider outputs, i.e., waste, both as biological nutrients for a subsequent generation of living organisms (Benyus, 2002) and as technological nutrients, thanks to dematerialization processes, which ensure easy separation and reassembly, an essential component of circular.

Several circular design strategies that focus on both "technical cycles" and "biological cycles" have been identified in the literature, such as design for resource conservation, in which products are designed with minimal resources (Bocken et al., 2016), design for multiple cycles, which allows for longer circulation of materials and resources across multiple cycles (Bocken et al., 2016; Bakker et al., 2014), and design for systems change, which refers to design thinking for systemic change (Charnley et al., 2011).

Design for long-lasting use of products, on the other hand, focuses solely on the "technical cycle" and aims to extend the use of a product by extending its lifespan and offering services for reuse, repair, maintenance, and upgrading (Bakker et al., 2014), or by improving longer-lasting relationships between products and users through "enduring emotional design" (Chapman, 2005), in order to resist obsolescence. Finally, design for circular supplies, which focuses primarily on "biological cycles" and believes that "waste equals food", whereby resources are captured and returned to the environment without causing harm (Benyus, 2002) through biodegradation (Vert et al., 2012) processes such as compositing, in which organic matter is biologically decomposed by microorganisms, such as bacteria and fungi (Vert et al., 2012).

Additional design approaches discussed by academics can be traced back to ecodesign (Ceschin and Gaziulusoy, 2016) and green design, which McDonough and Braungart (2002) criticized for their otherwise linear approach, nature-inspired design (de Pauw, 2015), design for social innovation (Manzini and Coad, 2010), and transitional design (Irwin, 2015). However, business model innovation and strategic design present a company with both an opportunity and a challenge (Koen et al., 2011) because of barriers that slow CBM adoption (Blomsma and Brennan, 2017; Bocken et al., 2017).

The purpose of this study was to investigate how research, consumers, and enterprises are responding to the transition from a linear to a circular economy in the agri-food sector, as well as the present hurdles and possibilities that may be utilized soon.

The three articles in this research examine the circular economy from several angles.

In the first article (Chapter 2), the academic literature is reviewed with a view to comprehending its key tenets and points of view as well as summarizing and debating the literature in this area. It offers a better comprehension of the possibilities provided by the circular economy as a response to the present need to lessen the environmental effects of business-as-usual economic systems and the condition of the circular economy in the academic discussion.

The results demonstrate the necessity for the adoption of cleaner production models and corresponding improvements in stakeholder responsibilities and knowledge, on the part of both producers and consumers, as well as the deployment of appropriate legislation and mechanisms.

The variables influencing millennials' attitudes and behaviour with respect to lowering their use of plastic are examined in the second article (Chapter 3). As a conceptual framework, an expanded theory of planned behavior was created that explicitly evaluates the function of previous and stated actions as they are assessed using a projective approach.

According to the study's findings, plastic-free behavior is a unidimensional construct. In addition, the significance of socio-demographic and psychological characteristics, as well as behaviors, in predicting the desire of millennials to minimize their usage of plastic beverage containers was emphasized. The research concluded by demonstrating that the introduction of projective methods to TPB components might assist lessen the social desirability bias of these measures.

Contrarily, the third article (Chapter 4) tries to emphasize the variables driving innovation in agriculture systems and to chronicle the number of inventions released by enterprises in the European Union over the three-year period 2012-2014.

The paper identifies a striking disparity between how enterprises and end users perceive obstacles. It exemplified how a lack of financial and political support hinders product and process innovation.

In conclusion, some discussion points on the ideas discussed in this chapter and the results obtained are quickly summarized, before illustrating some potential solutions that could be used in the future.

2. Circular Economy Models in Agro-Food Systems: A Review

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Abstract

Around the world, interest is growing in the circular economy in response to the current unsustainable model of production and consumption based on increased use and depletion of resources. This paper provides a review of the academic literature on the circular economy in agri-food systems, with the aims of understanding its main characteristics and perspectives, and summarizing and discussing the literature in this field. This review provides a deeper understanding of the opportunities provided by the circular economy as a solution to the current need to reduce the environmental impacts of business-as-usual economic systems and the state of the art of the circular economy in the academic debate. The results are discussed based on the chosen topiccore investigated in this review: business model and organization management, food loss and waste along the supply chain, analytical tools for the circular economy, stakeholder acceptance of the circular economy, and mitigation strategies and political approach. The findings show the need for the implementation of cleaner production models and consequent increases in stakeholder responsibilities and awareness, from both producers and consumers, as well as the need for the implementation of suitable policies and tools.

Keywords: circular economy; business model; sustainability; agro-food; sustainable; food waste; supply chain

2.1 Introduction

During the last decade, the circular economy (CE) has received increasing consider ation around the world as a method to overcome the present model of production and consumption, which is characterized by increased use and depletion of resources.

The CE is defined as "a production and consumption model, which involves sharing, renting, reusing, repairing, renovating and recycling existing materials and products for as long as possible (European Parliament, 2015) and reducing to the minimum of waste" (European Commission, 2015), offering a better alternative to the current model of economic development, the "take, do and dispose" of model (Ness, 2008) with a view to economic, environmental, and social sustainability (Ghisellini et al., 2016).

It was estimated that by 2050, the population will reach 9 billion, and our natural resources are limited. Following demographic and economic development and change in consumption patterns, the use of global resources has considerably increased (UNEP, 2016); in this context, the extractive industries are responsible for the main global carbon emissions, resource extraction, consequent loss of biodiversity, and water scarcity, having negative impacts on climate and natural systems (International Resource Panel, 2019).

The 21st century is facing increasingly important and complex challenges such as biodiversity loss, climate change, resource depletion, water scarcity, population growth, and economic issues. A circular economy makes it possible to overcome these challenges through economic and environmental development that preserves and enhances natural resources and renewable flows (Lewandowski, 2016). The advantages of CE systems are attributable to the reduction in the environmental impact through the minimization of waste, the increase in economic benefits, the redesign of products, the choice of materials (Lieder and Rashid, 2016), the reduction in price volatility, and increased job growth (EMF, 2013; Jabłonski, 2015). The EC therefore aims to reshape global industrial systems following the ideal goal of a zero-waste economy (Stahel, 2016).

Nowadays, 8.6% of the world's economy is defined as circular (Circle Economy, 2020). The current goal is to move toward a circular, sustainable, and regenerative bioeconomy, which should consider direct and medium- and long-term factors that affect the environment.

The issues of agri-food industry by-products and the resulting generation of waste have pushed the European Union (EU) to promote a zero-waste economy by 2025, attracting the interest of researchers, regulators, industry, and consumers. The initiative promoted in December 2019 by the European Commission (European Commission, 2020) for a Green Deal aims to make the climate challenge and the ecological transition an opportunity for a new development model, providing the EU with the opportunity to play a leadership role at the global level. The

Green Deal constitutes an important framework for accelerating the transition to a CE, moving toward a more sustainable bio-economy. The European goal is to become the first climate-neutral continent by 2050, strengthening the competitiveness of European industry and ensuring a transition that is not only sustainable for the environment and the economy but also for society as a whole.

The discussion of the CE has also grown rapidly at the policy level and in the academic literature. Several academic authors have conducted studies on the theory and conceptualization of CE, the development of innovative CE models in the agri-food sector (Esposito et al., 2020), definitions of food waste (Corrado et al., 2017), strategies for the avoidance of food losses and waste (FLW) along the agro-food supply chain (Dora et al., 2020), strategies for the valorization of food waste, and emerging conversion tools through the analysis of the functionality of technologies and the management of agri-food waste in the context of the CE (Kyriakopoulos et al., 2019). In the academic debate, the number of papers on CE has grown more than ten-fold in the last years (Geissdoerfer et al., 2017), as many different CE studies have been published around the world (Yap, 2005; Andersen, 2007; Feng and Yan, 2007; Charonis and Degrowth, 2012; EMF, 2012; Preston, 2012; Su et al., 2013; Lett, 2014; Naustdalslid, 2013; Prendeville et al., 2014; Chinnici et al., 2019).

Several scholars have evaluated the progress of CE strategies aimed to decrease the carbon footprint of the agri-food supply chain through the development of methodologies that assess both the upstream and downstream, such as material flow analysis (MFA), considered by Hamilton et al. (2015), which is a methodology that translates into increased energy savings, food waste recycling strategies, and a cleaner production model. The results of our study showed the need to implement cleaner production models and a consequent increase in the responsibility and awareness of stakeholders, both producers and consumers, as well as the need to implement appropriate policies and tools. A cleaner production model is defined as the continuous application of an integrated preventive environmental strategy to processes, products, and services in order to increase overall efficiency and reduce risks to humans and the environment (Hamilton et al., 2015).

This paper provides a review of the academic literature with the aim of describing its main characteristics and perspectives. The objective is to understand if the CE could help reduce the environmental impacts of current agri-food economic systems.

The novel character of the paper is to present possible ways to implement CE principles in the agri-food sector, with a strong emphasis not only on technical and organizational aspects but also on political and social dimensions. The findings can help further transform the current economy into the CE model.

The topics investigated in the selected papers chosen for this study are discussed in five categories: business model and organization management, food loss and waste in the agro-food supply chain, analytical tools for the CE, stakeholder acceptance of the CE, and mitigation strategies and political approach.

The remainder of this paper is organized as follows: Section 2 describes the conceptual framework and Section 3 presents the materials and methods. Section 4 discusses the main findings of the literature review. The concluding remarks and limitations of this study are presented in Section 5.

2.2 Conceptual Framework: The Circular Economy in Agro-Food Systems

CE is defined as a "restorative or regenerative industrial system by intention and design, which implies the creation of opportunities that involve the transition from an 'end of life' concept to a 'cradle-to-cradle concept'", from the use of non-renewable energy to the use of renewable energy, from the use of toxic chemicals to their elimination, and from the production of large amounts of waste to its elimination, through the superior design of materials, products, systems, and even business models (EMF, 2015). The CE is a model that offers several value creation tools that are disconnected from the consumption of limited resources (EMF, 2015). The CE is defined as a regenerative scheme in which resource inputs, waste, by-products, energy losses, and emissions are reduced by slowing down, closing, and limiting material and energy circuits through better and more efficient design, maintenance, repair, reuse, durable regeneration, renovation, and recycling (Geissdoerfer et al., 2017).

Kirchherr et al. (2018) defined the circular system as an economic system based on business models that replace the concept of "end of life" with the reduction, alternative reuse, recycling and recovery of materials in the production, distribution and consumption processes, with the purpose of achieving sustainable development, which involves the creation of an environment of better quality and greater economic and social equity, to the advantage of current and future generations.

In practice, the CE can be encouraged and maintained through the establishment of innovative business models (Lewandowski, 2016; Stahel, 2010; Bakker, 2014; Bocken et al., 2016), which incorporate the principles of CE and their value propositions along value chains (CE business models). However, it is challenging for the CE to contribute to sustainability as a whole and doubt remains about the possible environmental impact of innovative circular business models (Mont, 2022; Mont, 2004; Tukker, 2015).

The CE is seen as an engine of sustainability in the literature. The CE and sustainability are closely connected words (Antikainen and Valkokari, 2016). However, CE focuses on environmental and economic benefits, including merely the implicit social aspects

(Geissdoerfer, 2017), whereas sustainability aims to benefit the environment, economy, and society. The CE improves traditional sustainability approaches based on eco-efficiency by combining economic gains, reducing input costs, mitigating supply risks, and reducing externalities (EMF, 2012) to achieve a greener economy through the promotion of a more appropriate and ecological use of resources and innovative business models (Stahel, 2016; EMF, 2012). As stated by Pavitt (1984), innovation in the agri-food sector is mainly aimed at cost decreases. Several industries and companies have used the concept of sustainable business models to simultaneously achieve their economic, environmental, and social objectives.

The agri-food sector, in recent years, has paid considerable attention to issues such as food safety, traceability of production, product quality, and respect for the environment. This has led manufacturing systems to move toward more sustainable approaches. Waste generation along the world supply chain in 2019 totaled approximately 1.3 billion tonnes (FAO, 2019) due to mismanagement of resources and processes (Proto et al., 2008) and unsustainable consumer consumption patterns (Taghikhah et al., 2019). As such, promoting the development of new technologies to encourage a change toward waste recycling is of paramount importance (Homrich et al., 2018).

In 2013, the Ellen MacArthur Foundation (2013) presented the butterfly paper, which shows how two different cycles, technical and biological, can flow in the economic system. The biological cycle covers the flows of renewable materials, designed to re-enter the biosphere and organized in an open-cycle system of cascade resources, through successive phases of extraction, production of bio-based materials, energy recovery, and nutrient restitution to the biosphere in order to fuel the next cycle of primary products. This cascade phases aim to maintain the quality of resources over time by adhering to the bio-based value pyramid and the waste hierarchy. Biological nutrients can be organic or inorganic and are described as materials or products "designed to return to the biological cycle, being consumed by microorganisms in the soil and other animals" (Braungart and McDonough, 2009). It is desirable for processes of this type to be increasingly applied to agri-food systems, but this remains conceptually distant from current realities. To date, some agri-food chains have aroused greater interest in implementing circular systems than others.

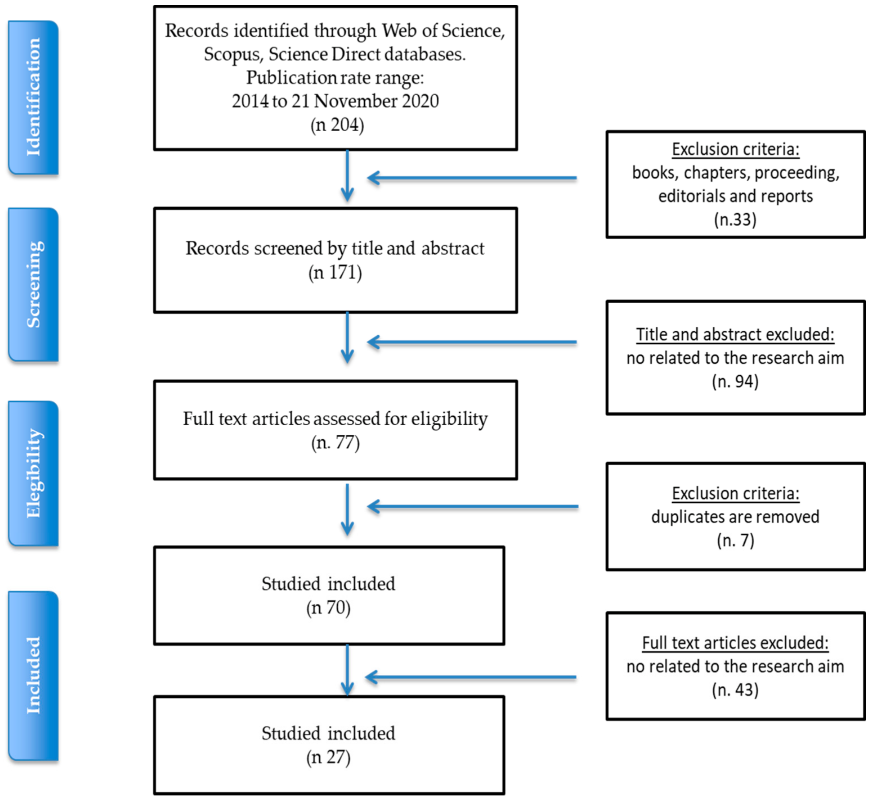
In their literature review, Esposito et al. (2020) analyzed the circular economy in the agricultural supply chain, the state of the art, and the most commonly investigated products in the literature. In the scientific debate, the success of the circular economy concept is expressed in quantitative terms in the number of articles published on this topic. In recent years, the amount of CE documents has grown more than ten-fold and many different CE studies have been published around the world.

2.3 Materials and Methods

2.3.1 Literature Search Method

The review of the literature was conducted to select studies from the academic literature and to summarize the main findings on the CE in agri-food systems. The review was performed following the Preferred Reporting Items for Systematic Review and Meta- Analysis (PRISMA) method (González-Rubio et al., 2020). Figure 2.1 shows a flowchart in which the selection criteria are identified in a systematic and replicable technique with the intention of identifying the papers that explored the topic of the CE in the agri-food sector (Giacomarra et al., 2016; Leonidou et al., 2020; Golbabaei et al., 2020). Scopus, Web of Science, and Science Direct databases were used to search for relevant literature on the topic under investigation. The research was carried out in November 2020 and was restricted to the years post-2013, which was considered appropriate to identify recent trends in the field. The search for the articles ended on 21 November 2020.

Figure 2.1 - Flow chart diagram of the database literature search procedure. Exclusion criteria are indicated.



Source: authors.

The literature search criteria involved a combination of keywords in the databases. The keywords "circular economy" and "agri-food", or "agri-food" and "sustainable" and "food" and "waste" and "supply chain" were used.

First, the papers were selected based on the information contained in the title and abstract; then, duplicate articles extracted from different databases were subsequently excluded. Each of the remaining articles was further reviewed according to the information contained in the full text. The inspection of the full text was directed at the elimination of papers not dedicated to the CE or that did not deal with the agricultural economy. The identification phase was conducted to include relevant studies in different databases.

The process of the selection of the relevant literature occurred in two stages: screening and eligibility (Giacomarra et al., 2016; Leonidou et al., 2020; Golbabaei et al., 2020). In the screening stage, the studies were selected and then subsequently reduced to 171 through the application of the primary exclusion criterion: only academic articles published in indexed journals were included in this review.

Subsequently, in the next phase, the papers were chosen based on the information in the title and then in the abstract. During this stage, the number of articles was reduced to 77, applying the exclusion criterion: only papers related to the research aims were included. In this stage, the analysis of the abstracts led to the deletion of 94 papers not dedicated to the circular economy or not in the field of agricultural economics.

In the next step, seven duplicate documents from different databases were removed; thus, only 70 documents were included in this phase. Each article was also further reviewed based on the information contained in the full text, and we chose whether the study met the eligibility criteria for review. In conclusion, after excluding the irrelevant documents for the study, a sample of 27 documents was selected to address our research question.

2.3.2 Overview of Selected Papers

Information regarding the author(s), title, year of publication, and journal of the papers chosen for this review are presented in Table S1. The papers chosen were categorized based on the core topic investigated:

- Business model and organization management (*n* = 6);
- Food loss and waste along the agro-food supply chain (*n* = 9);
- Analytical tools for the circular economy (*n* = 5);
- Stakeholder acceptance of the CE (*n* = 4);
- Mitigation strategies and political approach (*n* = 6).

The topics investigated are presented in Table 1.1. Several articles investigated more than one topic; therefore, the sum is greater than 27.

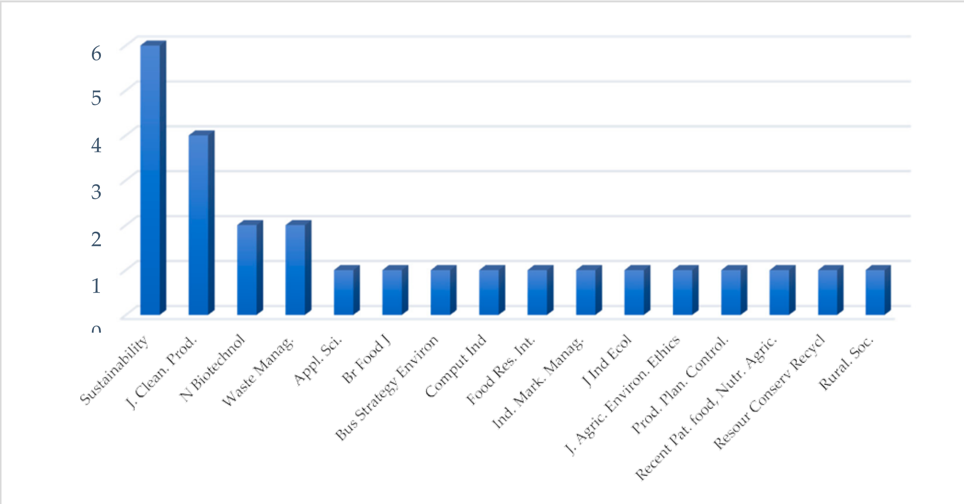
Table 1.1 - Topics investigated in the review.

Topic	Reference
Business model and organization management	Barth et al., 2017; Evans et al., 2017; Franceschelli et al., 2018; Nosratabadi et al., 2019; Sehnem et al., 2019; Donner et al., 2020.
Food loss and waste in thesupply chain	Naziri et al., 2014; Girotto et al., 2015; Corrado and Sala 2018; Boccia et al., 2019; Kyriakopoulos et al., 2019; Principato et al., 2019; Esposito et al., 2020; Bas-Bellver et al., 2020; Dora et al., 2020.
Analytical tools for the CE	Pagotto and Halog, 2016; Corrado et al., 2017; Muradin et al., 2018; Belaud et al., 2019; Esposito et al., 2020.
Stakeholder acceptance of the CE	Borrello et al., 2016; McCarthy et al., 2019; Atinkut et al., 2020;
Mitigation strategies and political approach	Kristensen et al., 2016; Evans et al., 2017; Corrado and Sala, 2018; Lainez et al., 2018; Fava et al., 2021; Muscio and Sisto, 2020.

As can be seen from Table 1.1, the topics most investigated in the literature and analyzed in this study refer to food loss and waste in the supply chain and the business model and organization management. This demonstrates the growing interest of agri-food enterprises in a circular transition. However, only a limited number of studies investigated the analytical tool, mitigation strategies and political approach, and the stakeholder's acceptance of CE still needs further investigation. In this context, consumer acceptance of food products with ingredients previously wasted in the agri-food supply chain is crucial for the success of the products on the market. In addition, the small number of articles demonstrates the need for further research on specific issues faced by the CE in the agro-food sector.

Figure 2.2 shows the journals in which articles were published. The most influential journal was Sustainability, in which six papers were published, representing approximately 23% of all published articles.

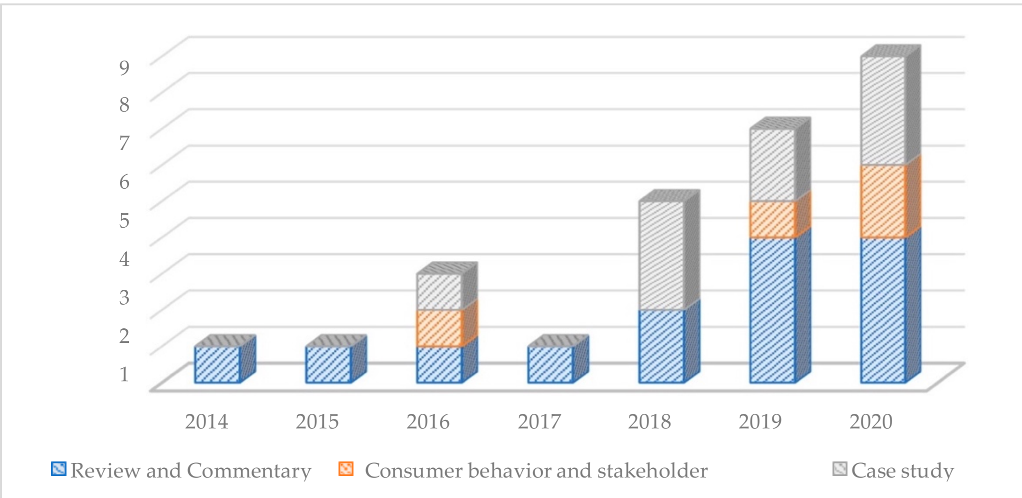
Figure 2.2 - Journals in which selected papers were published.



Source: authors.

The number of selected papers on the topic under investigation per year from 2014 to 2020 is shown in Figure 2.3. Although the total number of articles was limited, there was an increasing trend in papers published in the later years. This attests to the growing attention paid to the topic under investigation.

Figure 2.3 - Type of article per year.

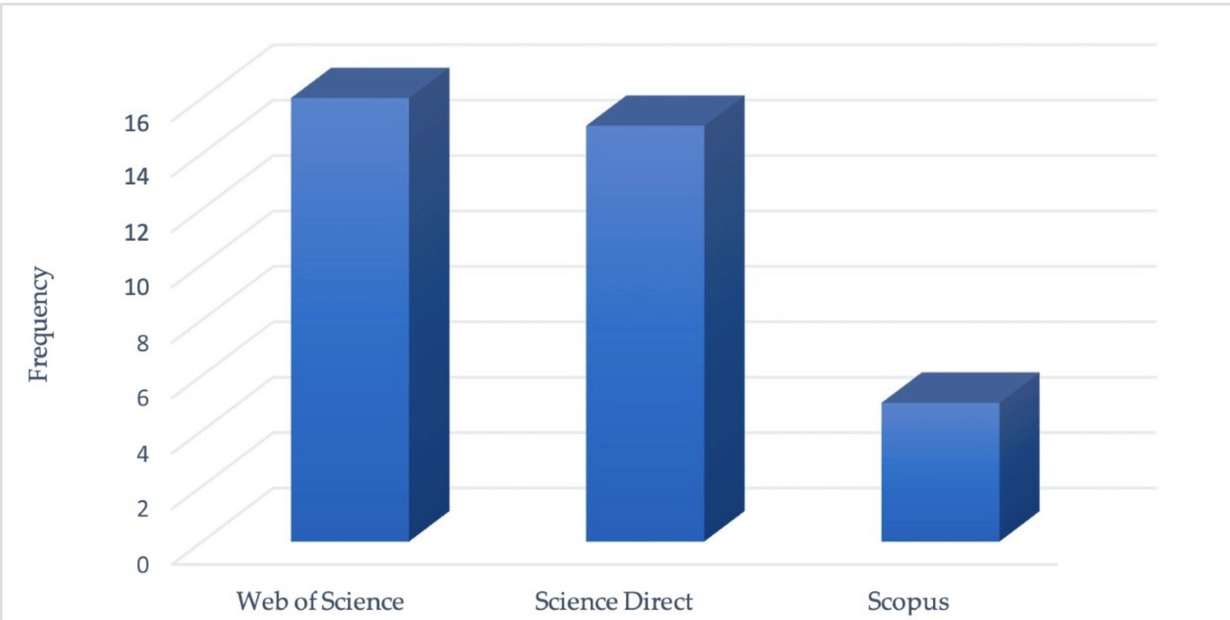


Source: authors.

Regarding the type of article, the majority of the selected papers were reviews and commentary articles (n. 14), followed by case studies (n. 9) and consumer behavior and stakeholder preference analyses (n. 4). In detail, as shown in Figure 2.3, in 2014 and 2015, theselected papers were review and commentary papers; in 2016, the papers were a review and commentary (n. 1), consumer behavior and stakeholder analysis (n. 1), and a case study (n. 1); in 2017, the papers were reviews and commentaries (n. 3); in 2018, the papers were reviews and commentaries (n. 2) and a case study (n. 1); in 2019, the papers were review and commentary (n. 4), a consumer behavior and stakeholder analysis (n. 1), andcase studies (n. 2); finally, in 2020, the papers were reviews and commentaries (n. 4), consumer behavior and stakeholder analyses (n. 2), and case studies (n. 3).

Concerning the databases from which the selected papers were obtained, as shown in Figure 2.4, the majority of selected papers were found in the Web of Science database (n. 16) and Science Direct (n. 15), and the rest in Scopus (n. 6). Several articles were identified in more than one database; therefore, the sum of the figures is greater than 27.

Figure 2.4 - Number of articles selected in each searched database.



Source: authors.

2.4 Results

2.4.1 Business Model and Organization Management

The realization, acceptance, and advancement of sustainable business models in diverse application fields are still not fully understood (Nosratabadi et al., 2019).

Franceschelli et al. (2018) investigated how a food start-up improved innovations in the business model, considering the significance of social and environmental questions. The authors stated that the expansion of sustainable business model innovation in the agro-food sector is essential since the business is connected with the environmental and social dimension. Barth et al. (2017), in a literature review, suggested a theoretical framework for sustainable business model innovation in the agro-food industry to address the challenges from a sustainable perspective. Evans et al. (2017) developed a combined theoretical view to understand business model innovations that lead to improvements in the economic, environmental, and social performance of an organization. According to the authors, planning a sustainable business model requires the organization of sustainable value flows between various stakeholders. The authors concluded that considering the interests and responsibilities of stakeholders for the creation of mutual value is imperative to achieve a sustainable business model. Nosratabadi et al. (2019) discussed sustainable business models in different sectors, considering the process of building a sustainable business model as an innovative part of a business strategy, to provide beneficial solutions to all stakeholders and meet the requirements of the environment and society. The outcomes revealed how the use of sustainable business models can be grouped into fourteen categories, four of which are the main methods used to design a sustainable business model: designing a sustainable value proposition, designing sustainable value creation, designing the offer of sustainable value, and the generation of sustainable partnership networks for the creation and delivery of sustainable value capable of providing social, environmental, and economic benefits.

The authors concluded that the realization of sustainable business models through all application fields increases with the growing usage of innovative technologies.

Donner et al. (2020) highlighted the characteristics of circular business models for the valorization of agricultural waste and by-products, concluding that the cascading use of biomass to generate products with high added value plays a key role in the development of a CE. The authors analyzed 39 cases that translated agricultural waste and by-products into products with added value through a CE approach. The authors identified six types of circular business models: biogas plant, upcycling entrepreneurship, environmental biorefinery, agricultural cooperative, agro park, and support structure. The results of this study revealed the interconnectedness of the six different types of business model, highlighting the potential of using biomass first for higher value-added products before exploiting it as an energy source, according to the upcycling principle.

Sehnem et al. (2019) analyzed how the maturity stages of the implementation of CE practices relate to the business models of the CE within an association that included twenty-eight wine producers. The results showed that the implementation of these business models satisfies the

ReSOLVE model proposed by the Ellen MacArthur Foundation (EMF, 2019) and underlined how the principles of the CE are linked to the implemented business models.

2.4.2 Food Loss and Waste in the Supply Chain

In the last decade, FLW in the relationships between quality and quantity has become a main concern from both environmental and social viewpoints (Secondi et al., 2015). Consistent with the United Nations (FAO, 2014), one-third of all food in the world is estimated to be lost or wasted, leaving 800 million people undernourished (Gustavsson et al., 2011). Since the population worldwide continues to grow, increasing food production is not a desirable solution as it involves large costs and places pressure on scarce natural resources. Thus, a system-wide method is needed to add value along the supply chain while preserving nutritional benefits in the context of minimizing food loss and waste in production and consumption (Hawkes and Ruel, 2012).

Several definitions of food loss and food waste are stated in the literature, creating difficulties for comparative studies and limiting the possibility of combining their outcomes in a shared approach to reduce FLW (Williams et al., 2015). The main factors of food loss are the limitations of the infrastructure, climatic and environmental factors, and the classification by quality or safety standards (Dora, 2019). In contrast, food waste arises when food for human feeding is wastefully removed or is not consumed by humans. This comprises food that is wasted prior to its disposal or is still consumable when thrown away (Thyberg and Tonjes, 2016). In addition, food waste occurs mainly in the late phases of the supply chain (retail and final consumer) because of severe conditions for quality or safety principles (Parfitt et al., 2010).

Corrado and Sala (2018) found that current estimates of food loss and waste generation vary between 194 and 389 kg per person per year on a global scale and between 158 and 298 kg per person per year on a European scale. The authors suggested that more efforts are required to promote suitable strategies related to food loss and waste. Options for exploiting food waste (FW) include, for example, the extraction of high-value compounds, using it as animal feed, the production of biomaterials, and the generation of biofuels.

Valorization is generally more appropriate when there is consistency in waste streams (Girotto et al., 2015). So, given the challenges faced by the agri-food chain, it is almost idealistic to define a single CE prototype for the entire sector (Esposito et al., 2020). The solutions supported by Girotto et al. (2015) suggest the interconnection between biotechnological procedures and the co-production of biofuels and bioproducts as a strategic key directed to maximizing the use of food waste and to increasing the income of the production sector.

The improvement in sustainable solutions for food waste management is one of the main challenges for society. In a review, Girotto et al. (2015) provided an overview of the present discussion on the definitions of food waste, reduction strategies, and conversion technologies that have emerged from the concept of biorefinery. The paper highlights several solutions implemented in the management of food waste, such as donating edible fractions to social services or for the production of biofuels or biopolymers, and providing food for nutrient recovery and carbon fixation by composting; less desirable options are incineration and landfilling. The identified solutions should be able to exploit the valuable resources represented by food waste to obtain social, economic, and environmental benefits.

Dora et al. (2020) identified the key causes of FLW in the supply chain of both developed and developing countries. Mitigation strategies were identified by systematically analyzing and synthesizing the existing research in the field of food loss and waste in the supply chain. According to their findings, in high-income countries, most FLWs occur at the distribution and consumption stage, whereas in low-income countries, FLWs are focused in the production and post-harvest stages (Dora et al., 2020).

Principato et al. (2019), through an analysis of global food loss and waste, for the first time quantified the main FLWs and their origins along the food supply chain of pasta production, concluding that these FLWs can be reused in line with the CE. They analyzed the life cycle of pasta production and showed that, along this supply chain, FLW mainly occurs in the cultivation and consumption stages, and that it could be efficiently reused for other purposes. Their outcomes demonstrated that the pasta supply chain is a virtuous model of the CE: the food losses in the field are restricted (less than 2%), while the straw produced during harvesting is usually employed as feed. Consistent with earlier literature, most FLW occurs during cultivation and consumption, indicating that more research is needed to decrease FLW in these two phases of the supply chain.

The tomato industry is another key sector of the food industry, suited to demonstrating the potential of the CE, as it produces enormous quantities of waste. These residues negatively influence the sustainability of the food industry, as their disposal has environmental and economic impacts. However, it represents an economic and renewable biomass that, in the context of the biorefinery model, can be exploited for the production of chemical and energy products, thus contributing to the sustainability of this supply chain. Boccia et al. (2019) also investigated the potential of tomato waste biorefinery in Italy regarding possible reuse tactics and existing cases of converting tomato waste into merchandisable products. The analysis of the tomato sector in Italy showed that the recycling of tomato waste in is limited. According to the authors, some key aspects are required: improvement in innovative technologies and processes, the identification of renewable raw materials that do not compete with other production chains, the establishment of innovative markets and enhancing of competitiveness, and driving the policy makers and stakeholders.

Food by-products and waste valorization practices have recently gained attention as a means of sustainable management, which can simultaneously increase profits for local economies. To highlight new trends and show the potential of regional economies, Naziri et al. (2014) focused on a Greek region that generates large amounts of diverse kinds of by-products and waste from the production of olive oil, wine, and rice. According to the authors, the transition to a CE should aim to involve stakeholders, who should take greater notice of the know-how developed by academia and research institutes in terms of tools for the recovery of by-products to contribute to the objective of a zero-waste society. To implement the principles of the CE in the agri-food sector, some authors have proposed methods of valorization and management of biomass. Bas-Bellver et al. (2020) proposed a method for enhancing vegetable waste, such as carrots, leeks, celery, and cabbage, from fresh and ready-to-eat lines, aimed at the production of functional powders as functional food ingredients. Plant residues are effectively converted into functional ingredients by hot-air-drying or freeze-drying, and variables such as storage environments and grinding intensity prior to drying were measured. According to the authors, vegetable waste powders might be used in the food industry as coloring and flavoring ingredients or natural preservatives, or they can be used to reformulate processed foods to improve their nutritional properties. Kyriakopoulos et al. (2019) provided an update on existing technological advances and their implementation. The authors conducted a multi-parameter approach to study the functionality of technologies in wastewater treatment, organic waste management, agricultural development, and food waste in the context of the CE. Through a critical approach, environmental, marketing, economic, governmental, and procedural points of view were assimilated. The authors noted the complexity of the implementation of the CE norm and the necessity for a specific forecast in each case. The proposed approaches were formulated from the perspective of socio-environmental impact.

2.4.3 Analytical Tools for the Circular Economy

The adoption of models and tools when considering CE is fundamental to overcoming the difficulties posed by food waste and loss and to achieve sustainable development objectives. From this viewpoint, the life cycle assessment (LCA) methodology represents the most commonly used instrument to estimate “the potential environmental impacts associated with all phases of a product, process, or service” (Zhang et al., 2012). LCA is an adaptable tool that can be used to assess environmental impacts to improve production, to optimize resource management, and to support intervention managers in order to identify drivers toward reducing the environmental burden of agriculture and food systems (Gava et al., 2019). In this sense, LCA is a tool that allows a more accurate assessment of the balance between efforts and benefits in the implementation of CE solutions at the micro level (Haupt and Zschokke, 2017).

LCA has been widely useful in measuring the environmental impact of food and in finding diverse opportunities for improving food systems management, including the recovery of potential long-lasting waste. However, in LCA case studies, suitable accounting for food losses is still lacking. A divergence was observed in both the definition of food loss and the approaches adopted towards the environmental burden of food loss. These features can lead to misleading and, at times, contradictory outcomes, limiting the reliability of LCA as a decision support tool for the evaluation of food production systems. Within published studies on food LCA, the assessment of food loss along the supply chain is frequently only partially or inconsistently achieved (Cerutti et al., 2014), limiting the effectiveness of LCA as a process to support instrument decision-making.

Esposito et al. (2020) examined the state-of-the-art research related to the implementation of CE models and tools along the agri-food chain. The paper highlights that, due to the complexity of the agri-food chain, it is utopian to define a single CE model for the entire sector. They called upon academics to increase the quantity and reproducibility of LCA data to guide the sustainable development of products and services. Belaud et al. (2019) assessed environmental impacts by combining the concepts of Industry 4.0, sustainability, and agri-food to choose which pre-treatment to apply to the lignin cellulosic biomass in the rice supply chain. They used the LCA method to support scholars in selecting a sustainable procedure to improve the pre-treatment of rice straw.

Corrado et al. (2017) provided a preliminary analysis to highlight which models in the LCA studies of food loss have been evaluated in the literature. They suggested considering possibly avoidable and inevitable food loss separately, and, through a discussion of the strengths and weaknesses of the diverse methods, they provided recommendations on how to manage food loss. They proposed the development of a shared methodological framework to increase the robustness and comparability of LCA studies. The most important recommendations concerned the systematic accounting of food losses produced along the food chain, the modeling of waste management based on the specific features of food, sensitivity analysis of the modeling methods adopted to model multifunctionality, and the need for transparency in the description of the patterns of the generation and management of food loss.

Muradin et al. (2018) conducted a comparative assessment of the eco-efficiency of biogas production from the food industry for waste-to-energy in biogas plants depending on the type of raw material used, its transport, and the possibility of using the heat generated. The environmental impact of the plants was assessed by applying LCA and the impact on costs was determined using the leveled cost of electricity (LCOE) method. The results showed that high eco-efficiency can be achieved by installing a biogas plant near a food processing plant.

Pagotto and Halog (2016) assessed the eco-efficiency performance of various subsectors in Australian agri-food systems using input–output-oriented approaches to data envelope analysis and material flow analysis. They analyzed the required (desirable and undesirable) inputs and outputs for the entire food supply chain in Australia using material flow analysis (MFA). The environmental impacts produced by the food chain were evaluated, and the economic and environmental efficiency performance of various subsectors in the Australian food system was calculated using data envelope analysis (DEA). The authors also discussed inefficiencies during the life cycle of food production, and how the application of the principles of industrial ecology could increase efficiency through the reductions in negative impacts and non-renewable sources.

2.4.4 Stakeholder Acceptance of the Circular Economy

The integration of sustainability into business models needs a systemic vision that contemplates n overall viewpoint of the diverse features of the system and their inter-relationships (Stubbs and Cocklin, 2008). Value network analysis provides this information and can determine changes in a company's business model (Kothandaraman and Wilson, 2001; Allee et al., 2015). To achieve a balanced system, deliberate interaction, partnership, networking, and learning from multiple and diverse stakeholders are essential (Winn and Kirchgeorg, 2005). Greater stakeholder engagement, coupled with better confidence and innovation in their business models, is among the major changes that companies must undertake to pursue a long-term sustainability goal (Jeffery, 2009; Krantz, 2010; Bolton and Landells, 2015).

The analysis of value flows within the network shows how different choices influence the mutual satisfaction of the stakeholders and, therefore, the sustainability of the net- work (Shaw, 2010). Furthermore, the creation of mutual value requires the systemic consideration of a large group of stakeholders who have an interest and a responsibility in the value creation system. The literature on consumer acceptance of foods resulting from by-products is limited because this area of research is fairly new and there are few products already developed that can be tested (Bhatt et al., 2017; Aschemann-Witzel and Peschel, 2019; Perito et al., 2019).

Coderoni and Perito (2020) assessed the relative importance of all factors influencing consumers' purchasing intentions for value-added foods (waste to value (WTV)). The authors assessed how socio-demographic and psychological characteristics influence the extent to which consumers engage in the CE by purchasing WTV foods enriched with ingredients otherwise wasted in the supply chain. Through the use of two different purchase intentions, the results showed that more than half of the interviewees declared their willingness to buy food based on environmental sustainability issues to reduce the environmental impact of production, assigning importance to the origin and nutritional values of the products. They also found that the likelihood of declaring positive purchase intention decreased with food neophobia and food technology neophobia. An important aspect that can influence the acceptance of novel food products, especially if enriched with by-products, is trust in the food system. Consumers are not always capable of deciding if novel foods produced by new technologies are associated with possible risks, as they have limited knowledge of new technologies (Vega-Zamora et al., 2019).

Atinkut et al. (2020) assessed the current status of agricultural waste management (AWM), farmer availability willingness to pay (WTP), and factors influencing WTP for AWM in a region of Ethiopia. The authors found that the most influential WTP factors were age, education, family size, income, land, livestock, and perception. The outcomes showed that the value of supply in working days, environmental perception, state sub- sidies, the shortage of farms, economic conditions, living in harmony with nature, and knowledge of the AW strongly influenced the degree of the amount paid by farmers. The findings are useful for understanding farmers' attitudes toward rural quality and WTP for environmentally friendly AWMs, as well as the need for public and private tools in AWM for policy development and for turning waste into a resource.

Borrello et al. (2016) illustrated through six circular interactions involving seven actors (grain farmers, bread producers, retailers, compostable packaging producers, insect farmers, cattle breeders, and consumers) an alternative to the traditional bread chain based on principles of the CE considering two innovations: insects used as animal feed and compostable packaging with polylactic acid. The results highlight the main challenges faced in the implementation of the new supply chain and patents related to the production of sustainable bread. Based on the results, consumers are expected to change their habits regarding the end of the product's life cycle, for example, by collecting leftover bread and used packaging and returning them to retailers. Some studies have evaluated consumer behavior toward approaches related to sustainability and the CE. McCarthy et al. (2019) assessed the willingness of Australian households to purchase foods derived from underutilized biomass. According to their results, half of the sample was willing to buy value-added food. The awareness of the problem of food waste is important in distinguishing consumers who are willing to buy value-added food from those who are not.

2.4.5 Mitigation Strategies and Political Approach

The goal to move to a CE has been particularly strong in Europe. The European Union (EU) has embraced the CE as a social and political goal by stating that in "a world with increasing pressures on resources and the environment, the EU has no choice but to make the transition to a CE efficient in terms of resources and, ultimately, regenerative" (European Commission, 2012).

The European Commission considered action on the FLW issue by introducing its new CE package to inspire Europe's transition to a CE, which will increase global competitiveness, encourage sustainable growth, and generate new opportunities. However, the existing business models for the CE are not very dynamic and inclusive and seem unable to support any type of company in the design of a circular business model (Lewandowski, 2016).

Policy makers need to better comprehend which business model features lead to true sustainability, and which operational, behavioral, and policy interventions might be needed to facilitate such innovations. Policy can create effects at the individual firm level as well as at the broader industrial system level, consequently transforming stakeholder behavior through appropriate policy interventions such as regulation, legislation, taxation, education, and incentives (Evans et al., 2017).

Corrado and Sala (2018) analyzed existing studies on the generation of food waste at the global and European scales, and described and compared the approaches adopted, and then analyzed their potential in supporting European interventions and policies related to food waste. The authors analyzed the potential of the approaches adopted to support food waste, highlighting that although the available data provide an overall picture of the generation of food waste at the global and European levels, in reality only two of the ten studies provided information on interventions related to the consumption phase in Europe. Lainez et al. (2018) presented a review of the bioeconomy in Spain, considering its characteristics and the strategy that needs to be implemented through annual action plans. They also described the indicators used to assess the implementation of the strategy.

Fava et al. (2021) provided an overview of the implementation of bioeconomy strategies in Italy, introducing the strengths and weaknesses of the sectors involved and the measures, regulatory initiatives, and monitoring actions undertaken. The authors concluded that the bioeconomy is a central pillar of the Italian economy and an enabling element of the new Italian Green Deal. Research and innovation (R&I) play an important role; therefore, the European Commission (EC) has recently promoted dedicated research activity tools in this area. Muscio and Sisto (2020) discussed current public R&I regulations in support of the transition to the CE model, opening a critical debate on the actual relevance of the EC in current R&I policy regarding its main research policy frameworks in the 2007–2013 and 2014–2020 program periods. The results showed that the desire to favor a socio-technical transition toward circularity in support of agri-food sustainability appears evident but is not yet particularly relevant.

Kristensen et al. (2016) outlined the current interrelated challenges faced by the agri-food system in relation to environmental degradation, economic crises, and social problems, considering how these challenges are addressed in agri-food studies. The authors highlighted examples from the literature of rethinking the future of the agri-food system, concluding that the eco-economy and the integrated territorial agri-food paradigm share a common goal, but the CE stands out from the actors who are emphasizing collaborations and partnerships with existing agri-food companies.

2.5 Conclusions

Within the current context of resource scarcity, global climate change, environmental degradation, and increased food demand, the CE represents a promising strategy to support sustainable, restorative, and regenerative agriculture. The problem created by agri- food industry by-products and waste generation has garnered the attention of academics, regulators, industry, and consumers.

The reduction in food waste requires an integrated approach in the management of the food supply chain (Priefer et al., 2016), highlighting the need for strong cooperation between the various stakeholders (Lipinski et al., 2013). Furthermore, waste prevention requires changes in people's behavior, both at the corporate and individual levels (Thyberg and Tonjes, 2016). National circumstances and cultural diversities have also been linked to food waste patterns (Dora, 2020), which can differ from region to region and from country to country. This indicates that effective approaches to food waste prevention may also differ (Buzby et al., 2011).

Prior to 2015, there was no political applicability of the CE concept to the entire EU agri-food system. In 2015, the European Commission (2015) launched an important initiative to support the transition to a more CE in European countries. It is therefore essential to maintain momentum at all levels, collaborating with multiple stakeholders and understanding the barriers and drivers to facilitate that transition, as well as the role of industries, professionals, and academics to help reach the full potential of the CE model (Dora, 2020). Dissemination of CE implementation good practices can help academics and companies to gain knowledge about sustainable circular economy business models (Kirchherr et al., 2017) as well as sustainable consumption and production patterns. Furthermore, scholars should contribute by publishing relevant results obtained by applying the CE principles (Reike et al., 2018), thus helping producers to reduce food losses and waste.

In the food sector, new frontiers of research aim at the production of innovative WTV products to reduce resource depletion and facilitate waste management.

From a political point of view, two synergistic directions of action have emerged: the information provided by the producers, and the set of individual beliefs. Policy makers and producers should focus their efforts on realizing more desirable and shorter cycle conservation options, such as regeneration, refurbishment, and reuse, considering overall system feasibility and effects (Reike et al., 2018).

In this context, the acceptance by consumers of new food products with ingredients previously wasted in the supply chain is fundamental for the final absorption of all products on the market (Coderoni and Perito, 2020). One of the main challenges in this evaluation is trying to elicit consumer preferences for such products considering their food neophobia, food technology neophobia, or their possible general distrust, because all these elements could influence the acceptance of the specific food product.

The circular economy, like all other sustainable models, not only requires innovative concepts but also innovative actors; often, its implementation must be supported by stake- holders who allow changes in policies and decision-making tools (Golinska et al., 2015; Kücüksayra et al., 2015). The adoption of strategies by companies to improve the circularity of the production system also requires collaboration with other companies along the entire supply chain to achieve a circular model that is as effective as possible (EMF, 2015; Winkler, 2011). The implementation of a circular economy is not always easy to undertake, as it often encounters biophysical limits, including the high-energy requirement for resource recovery and loss in the quality of resources (Brown and Buranakarn, 2003; Castro et al., 2007)

Kirchherr et al. (2017) recently found that in Europe the lack of interest and awareness on the part of consumers is a “main obstacle to the transition to CE”, as previously pointed out by Rizos et al. (2016), who noted the same complaint from small- and medium-sized enterprises trying to move to business models and circular solutions. Kirchherr et al. (2017) found that the scientific literature in this area is insufficient, reporting that only 19% of documents defining the circular economy consider consumption and there is no evidence as to why consumers choose to participate or not in the circular economy. Conversely, Ghisellini et al. (2016), found that the existing literature views consumers as passive and rational recipients, influenced by labels and other signals from the production side in making decisions. Therefore, it is essential to involve consumers since, as suggested by Hobson et al. (2016), the circular economy could result in a significant change in the whole of society (Hopkinson et al., 2018).

The scientific community should consider the growth in the bioeconomy in its research goals. Enterprises could increase added value by innovating and developing technology to develop business projects, bringing products and services to market with efficiency and sustainability as guiding principles. Society must be conscious that the bioeconomy, in the context of the CE, suggests the application of sustainability and efficiency principles and needs innovative technologies that should be recognized and integrated into buying choices when goods enter the market. The CE offers the opportunity to reinvent the economy, thus making it more sustainable and competitive. The use of new and innovative products, processes, and business models can produce increased incomes for producers by maintaining affordable consumer prices and improving environmental and social benefits. Ghisellini and Ulgiati (2020) discussed that legislative and government support is essential in the early stage of implementing a CE. Furthermore, the lack of government support is one of the main obstacles that companies, especially small- and medium-sized ones, must overcome to adopt a circular approach (Preziosi et al., 2016). In this direction, given the sustainable economic, social, and environmental dimensions of the CE, circular agriculture should become a pillar of the economy, rather than a subsidized sector, guaranteeing economic sustainability, the conservation of biodiversity, and productivity over time in its own agro- ecosystems, environmental sustainability and, in general, helping to ensure food security, while also improving social sustainability.

With regard to the limitations of this study, we highlight that, due to the limited number of studies examined, the results should be generalized with caution. In addition, the relatively small number of articles demonstrates the need for further research on specific issues faced by the CE in the agro-food sector.

Future researchers could address the applicability of a CE model through a holistic, interdisciplinary, and integrated approach to the full use of FLW in waste reduction and recovery of valuable by-products, thus moving toward total cleaning (zero waste).

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3. Plastic-free behavior of millennials: An application of the theory of planned behavior on drinking choices

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Abstract

This study explores the factors that influence millennials' intentions and behavior regarding reduced plastic consumption. An extended theory of planned behavior was established as a conceptual model that explicitly analyzed both the role of past and stated behaviors. The stated behavior was measured using a projective technique. The data obtained from a survey of 741 Italian respondents were analyzed through multiple correspondence analysis and partial least squares structural equation modeling. The results of the projective technique characterized "plastic-free" behavior as a unidimensional construct. Structural equation modeling showed that attitudes, subjective norms, and perceived behavioral control influence the intention of millennial consumers to reduce the use of plastic drinking bottles. The perceived behavioral control is the strongest predictor of intention ($ß = 0.304$; $p < 0.001$), followed by social norms ($ß = 0.271$; $p < 0.001$) and attitudes ($ß = 0.130$; $p < 0.001$). The past behavior construct positively and significantly affects attitude ($ß = 0.165$; $p < 0.001$), intention ($ß = 0.231$; $p < 0.001$), and stated behavior ($ß = 0.073$; $p < 0.05$) constructs. The latter is also positively predicted by intention ($ß = 0.151$; $p < 0.001$). Based on the results, actions and incentives for reducing plastic consumption were provided.

Keywords: plastic free; TPB; PLS-SEM; millennials; consumer behavior

3.1 Introduction

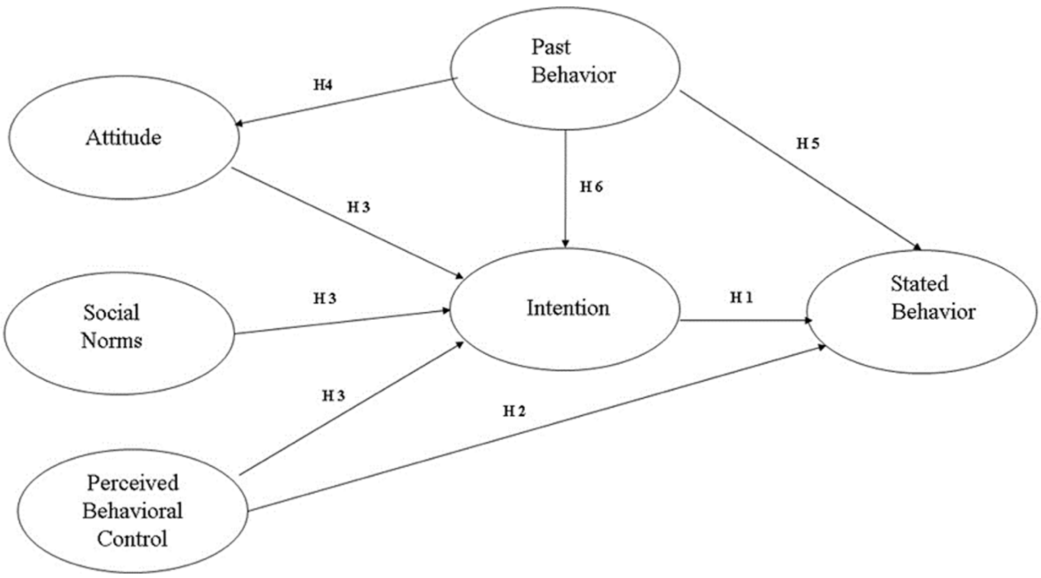
Plastics are extensively used in daily life as food and drink containers and grocery bags (PEMRG, 2020); given its various properties, such as affordability, lightness, versatility, and durability, plastic use and production have increased over the last 60 years (Alam et al., 2018; Sang et al., 2021). For instance, global plastic production reached 368 million tons in 2019, with Europe and Asia contributing 16% and 51%, respectively, while approximately 480 billion plastic drinking bottles were sold worldwide (PEMRG, 2020). On the demand side, 40% of plastics in Europe are used for packaging and 8% as plastic bottles for water, soft drinks, and juices (PEMRG, 2020). According to recent forecasts, the amount of plastic drinking bottles is expected to increase by approximately 15% per year (Laville and Taylor, 2017), reaching 12 billion tons of plastic in 2025. When plastic is not treated using an appropriate waste disposal stream, it may negatively influence natural ecosystems, causing problems for humans, plants, and animals (Orset et al., 2017). If plastic is burned or buried, chemical compounds are toxic to air and soil (Ilyas et al., 2018). Most plastic chemical compounds are also persistent in the environment and are potentially hazardous to the human food chain, posing great concerns for ocean pollution (Laville and Taylor, 2017; Halden, 2010). Therefore, plastic pollution is considered among the main environmental threats by the United Nations, and plastic problems are a major concern for governments and other stakeholders (Paletta et al., 2019). Society acknowledges the negative impact of plastic waste on the environment, and it has been proven that consumers consider contamination of water, air, and food due to plastic pollution as harmful to human health (Kiessling et al., 2017; Joseph et al., 2016). In consumers' perception of food products, plastic packaging leads to a reduction in perceived product quality and an increase in perceived safety risk (Fernqvist et al., 2015; Omari et al., 2018). This would result in an increased likelihood of consumers choosing more sustainable choices (Gifford and Nilsson, 2014) and asking for more eco-friendly packaging solutions aimed at reducing the environmental pressure linked to plastic consumption, in line with the EU Green Deal ambitions (European Commission, 2019). Following this increased interest, scientific literature has focused on consumer perception and behavior related to plastic use and disposal (Zwicker et al., 2020; Rhein and Schmid, 2020). For example, Khan et al. (2019) found that different consumer attitudes lead to different behaviors toward plastic recycling. Although both recycling and reuse practices should be promoted to decrease plastic waste, they do not guarantee a reduction in plastic production or use in general (Heidbreder et al., 2019).

Unexpectedly, according to Heidbreder et al. (2019), recycling might push people to use more plastic than they usually would since recycling may allow consumers to feel exonerated from being responsible for plastic pollution. Therefore, more recently, researchers have focused on how plastic use can be reduced (Heidbreder et al., 2020; Nabila and Nurcahyo, 2020). Some have investigated demographic characteristics - such as gender, age, and education (Madigele et al., 2017; Sharp et al., 2010) - and psychological factors (Sun et al., 2017; Nabila and Nurcahyo, 2020) associated with the use or non-use of plastic items like plastic bags or bottles. Others have analyzed the importance of packaging design (Madria and Tangsoc, 2019), the efficacy of plastic taxes and legislative initiatives (Martinho et al., 2017; Liu et al., 2021), or “plastic-free” promotional campaigns as possible strategies aimed at reducing plastic use (Walker et al., 2020; Heidbreder et al., 2020). However, little attention has been focused on reducing plastic use; quantitative studies are quite scarce (Heidbreder et al., 2019) and do not approach the issue with a well-documented and formalized behavioral model. Therefore, the current study attempts to fill this gap in the literature, aiming to understand how to stimulate the reduction of plastic drinking bottles of future generations (i.e., millennial consumers) by investigating psychological and behavioral factors through an extended model of the theory of planned behavior (TPB; Ajzen, 1991). A projective technique - what are called “completion tasks” (Steinman, 2009) was used to capture the respondents’ stated behavior toward use or non-use of plastic drinking bottles. This was accomplished through a structured survey involving 741 Italian millennials; afterward, behavioral constructs were analyzed through multivariate statistical tools such as multiple correspondence analysis (MCA) and partial least squares structural equation modeling (PLS-SEM).

3.2 The theoretical framework and the research hypotheses

This paper aims at pointing out psychological and behavioral drivers and barriers to the reduction of plastic drinking bottle use. The analysis is theoretically grounded on the theory of planned behavior (TPB). The latter was developed by Ajzen (1991) who considers human behavior as a consequence of intention which in turn is influenced by three constructs: attitudes social norms and perceived behavioral control (PBC) (Armitage and Conner, 1999). While intention captures people’s motivation to adopt a behavior, indicating the probability of executing it (Honkanen and Young, 2015; Dorce et al., 2021), attitudes are based on personal evaluations and opinions about the consequences of the decision. Social norms include what others may think about one's behavior, and finally, PBC represents a subjective evaluation of one's internal and external capabilities and/or limitations that may influence the actual behavior. Owing to its flexibility and high predictive value, the TPB is a theoretical approach largely adopted to examine any form of human behavior including business decisions (Raimondo et al., 2021); TPB has been widely used to study behavioral intentions regarding environmental protection (Despotovi´c et al., 2019), education (Yan and Sin, 2015) and health (Fan et al., 2021) and has also been applied to a wide range of waste related behaviors, including food refusal (Graham-Rowe et al., 2015; Visschers et al., 2016), plastic use (Sun et al., 2017), and recycling behavior (Greaves et al., 2013; Rhodes et al., 2015; Stancu et al., 2016). Many scholars have also extended the TPB framework by incorporating other constructs to improve the overall explanatory capability of the model (Alhassan et al.,2018; Ding et al., 2018; Sun et al., 2017). As discussed by Ding et al. (2018), additional psychological constructs could be added to the TPB to model case or context specific behavior. For instance, Alhassan et al. (2018) included other variables to explain households' solid waste separation intentions; similarly, Sun et al. (2017) extended the TPB framework with convenience, environmental concern and ethical belief for analyzing consumer's intention to use plastic bag. In the current study, an extended theory of planned behavior was applied since the model hypothesized considers an additional predictor: what is called "past behavior." Previous scientific researchers have included past behavior predictors within the TPB (Canova et al., 2020; Hagger et al., 2018), especially if the behavior could be influenced by habits (Canova et al., 2020; Conner and Armitage, 1998). Indeed, according to Conner and McMillan (1999), repeated behavior may convert the behavior from a reasoned to an automatic process. Experience may inform beliefs regarding future performance of the behavior (Ajzen, 2002; Ito and Igano, 2021). For instance, Brown et al. (2020) showed that past behavior may influence the TPB constructs, especially the attitudes; the latter are indeed shaped by past experiences. Stated-behavior was here measured by implementing projective technique - what are called "completion tasks" - (Steinman, 2009) - to capture automatic or non-conscious processes of the decision making process (Steinman, 2009; Bargh, 2002). Projective techniques encourage respondents to reveal unconscious feelings and attitudes by providing responses to verbal or visual stimuli (Will et al., 1996). According to Steinman (2009), "completion tasks" are a kind of projective technique where respondents complete a partial sentence, story, argument, or conversation. This type of projective technique has been widely applied by consumer researchers to reveal consumers' feelings toward a specific product or brand (Sass et al., 2018; Sales et al., 2020). Therefore, in the current study, the "completion task" was used to capture the respondents' stated behavior toward use or non-use of plastic drinking bottles. Based on the literature, the following hypotheses are proposed: Intention has a positive effect on 'stated' behavior to reduce the use of plastic drinking bottles (H1); Perceived behavioral control has a positive effect on the 'stated' behavior to reduce the use of plastic drinking bottles (H2); Consumer attitude, social norms and perceived behavioral control have a positive effect on intention to reduce the use of plastic drinking bottles (H3); Past-behaviour mediates the relationship between Attitude (H4), and Stated-Behaviour (H5) also affecting Intention to reduce the use of plastic drinking bottles (H6). The hypothesized model is illustrated in Fig. 3.1. Each oval corresponds to a latent construct to be measured in this study, while the arrows represent the hypothesized relationships between them. The relationships will be tested through a PLS-SEM.

Figure 3.1 - Extended theory of planned behavior for plastic free consumption: hypothesized model and relations. Note: To avoid overcrowding the picture, indirect hypotheses are not shown in the figure.



3.3 Methodology

3.3.1. Data collection and survey

The convenience sample used in this study was drawn from a population of Italian millennials. There are several definitions of millennials (Form´ankov´a et al., 2019). According to Connell et al. (2012) individuals born in or after 1982 show high sensitivity toward sustainability and they express socially responsible behavior with respect to previous generations. Thus, the current study only includes individual born in or after 1982. Data collection took four months (was from January to May 2020) and involved administering a web-based structured questionnaire. To reach a wider number of participants in the population target, the questionnaire was sent through different messaging and communication platforms (e.g., Facebook, Twitter, WhatsApp, email). Despite the convenience nature of the sampling, the use of different platforms allowed to collect data from respondents with different backgrounds and interests. The sample size was set at 700 to satisfy a level of effect size (correlation between variables) $|\rho|$ equal to 0.15, and a power of 99, according to the a priori power analysis (Faul et al., 2009). Moreover, to account for any potential attrition, allowing for respondent drop-out, the sample size was inflated by 10%, resulting in a sample size of 770 responses. Overall, 29 observations have been deleted due invalid or incomplete responses, resulting in a sample size of 741 participants. The questionnaire was anonymous to avoid social desirability biases. Furthermore, the suitability of the questionnaire language was tested by performing a pilot test with 30 participants belonging to the target population of the study. The pilot test did not detect any misinterpretation of the questions or critical issues, supporting the choice of language used. The survey was created by using Limesurvey®, an Open Source survey tool (http://www.limesurvey.org), in accordance with the principles stated in the Declaration of Helsinki. After clicking the link, respondents who were interested signed the informed consent and then responded to the questionnaire that was organized into three sections; The first attempted to capture the behavioral constructs of millennial consumers to reduce the use of plastic drinking bottles and follow the standard structure of the TPB, while the second section aims to capture the respondents "stated" behavior through the projective technique. The third section collects socio-demographics information. In detail, the first section of the questionnaire included a series of statements used to measure intention (INT), attitude (ATT), subjective norms (SN), perceived behavioral control (PBC) and past behavior (PB). The statements were designed in accordance with guidelines to correctly constructing a TBP questionnaire (Ajzen, 2011).

Overall, 13 items were used to measure the TPB dimensions: three items for each classical construct (intention, attitudes, social norms, and PBC) and one item for the "past behavior" construct. A 7-

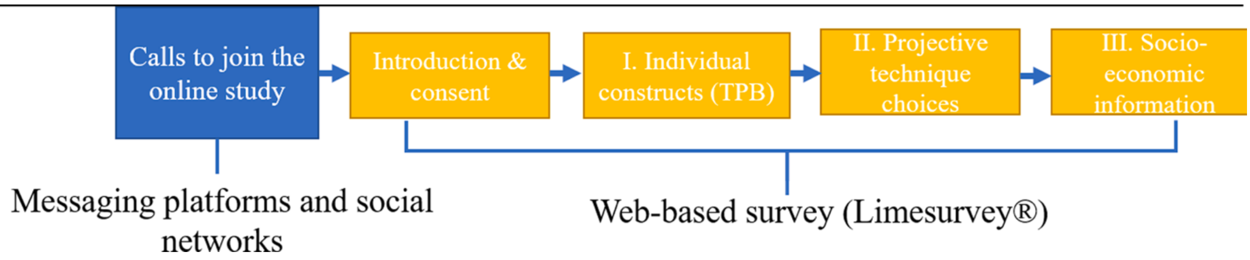
point Likert scale was used to rank each item from 1 ("strongly agree") to 7 ("strongly disagree"), except for the attitude items where the anchors were 1 ("not at all") and 7 ("very much"). The questions were based on the TACT principles (target, action, context, and time elements) (Ajzen, 2011). Since the aim of this study was to examine the reduction of plastic drinking bottles, the word "reduce" was chosen to represent the action, and "plastic bottles" was chosen to represent the target. All the statements were adapted to be relevant to this study and to comply with the principle of construct compatibility (Dorce et al., 2021). The second section of the questionnaire aimed to measure millennials' stated behaviors regarding the use of beverage containers and was developed following the procedure suggested by Steinman (2009) for implementing the projective technique. Three real-life scenarios regarding drinking were proposed to respondents (Table 3.1): i) out with friends, ii) at home, and iii) at university/work. For each scenario, the "completion task" _technique was adopted. Three alternative images of beverage containers (one plastic bottle and two plastic-free beverage containers) were shown as stimuli to each respondent, who was then asked to finalize the scenario that better represented their everyday life. For instance, in the scenario "drinking out with friends", the respondent had to imagine being out with friends in a restaurant/pub and asking for something to drink. Pictures showing a well-known soft drink in three alternative containers were offered to the respondents (Table 3.1).

Table 3.1 - Consumers' stated behavior through projective technique.

Scenario description	Beverage container alternatives
Scenario 1 "out with friends." Imagine you are out with some friends in a restaurant/pub and are going to ask for something to drink. What type of beverage container do you order?	1- Plastic bottle 2- Aluminum can 3- Glass bottle
Scenario 2 "at home." Imagine you are having a daily meal with your family. What beverage container do you find on the table?	1- Reusable jug 2- Glass bottle 3- Plastic bottle
Scenario 3 "at university/work." Imagine you are at university or your working environment and you are going to drink water. What will you use?	1- Plastic bottle 2- Reusable jug 3- Dispenser of water

Finally, the third section of the survey collected traditional socio-demographic characteristics of the respondents: age, gender, education (primary school, secondary school, high school, university degree) and city of residence. The statements were translated into Italian. Completion of the overall survey took an estimated time of five minutes. Fig. 3.2 summarizes the survey protocol.

Figure 3.2 - Outline of the survey protocol.



3.3.2 Empirical analysis

Once the data were collected, two statistical analyses were performed. First, MCA was conducted to analyze millennials' stated behaviors through the projective technique regarding the use of beverage containers. MCA is a quantitative multidimensional statistical technique that processes qualitative data. Furthermore, it is an extension of the correspondence analysis method, allowing for the analysis of relationships between categorical variables (Abdi and Valentin, 2007). MCA can also be seen as principal component or factorial analyses when the variables to be analyzed are categorical (Hoffman and De Leeuw, 1992). This statistical method allows the determination of the internal structure of dependence between frequencies through a graphical representation of a data matrix of qualitative variables and is largely used in the field of marketing, and, in particular, multidimensional mapping (Greenacre and Blasius, 2006). In the current study, the model will be used to analyze millennials' stated behaviors regarding the use of beverage containers in three different scenarios: dining out with friends, at home, and at university/work. Accordingly, the "stated behavior" construct is the output of the MCA. In the second analysis, PLS-SEM was used to investigate the intention of millennial consumers to reduce the use of plastic drinking bottles. PLS-SEM is a multivariate technique widely used for analyzing consumer preferences and buying behavior in both observational and experimental settings (Caracciolo et al., 2020; Pinto et al., 2019; Hair et al., 2019). It consists of two parts: the measurement (or outer) and structural (or inner) models. The former provides relationships between latent constructs (or latent variables) and the items they are defined by, while the structural model shows the relationships between latent constructs themselves (Venturini and Mehmetoglu, 2019). In other words, the structural part is similar to regression analysis, while the measurement part is a type of confirmatory factor analysis. The algorithm used to estimate the PLS-SEM model comprises two steps. First, latent construct scores are estimated by providing the measurement model parameters (weights/loadings). Subsequently, the structural model parameters (path coefficients) were estimated. Once the measurement model was specified, it was confirmed by checking factor loadings > 0.5, Cronbach's alpha > 0.7, and rho A > 0.7 (indicator reliability). Moreover, the convergent and discriminant validity of the constructs were assessed. Convergent validity is achieved when the average variance extracted (AVE) of the construct is equal to or higher than 0.5, while discriminant validity is achieved by the Fornell-Larcker criterion, where the square root of the average variance extracted (AVE) is compared with the correlation of latent constructs (Dorce et al., 2021; Venturini and Mehmetoglu, 2019). Finally, to assess the severity of common method bias, collinearity among the constructs was tested (Kock, 2015) and the Harmon one-factor test was implemented (Podsakoff et al., 2003). The structural model assessment was based on path coefficient values (Venturini and Mehmetoglu, 2019; Hair et al., 2014). The PLS-SEM algorithm has been demonstrated to produce robust estimates even in presence of small sample size and data not normally distributed (Hair et al., 2019). All statistical analyses were performed using Stata 16 (Stata Corp LP, College Station, TX, USA).

3.4 Results

3.4.1 Descriptive statistics

Of the 770 respondents, 29 failed to complete the survey or reported missing information on key statements, giving a final sample of 741 millennials. Socio-demographic information shows that participants (251 male and 490 female) were aged 18–39 years (24.8 ± 4.4 years), living in Southern Italy (89.7%) and in Sicily (46.5%) and in Campania (41.4%) in particular. Half of the sample (50%) had a university degree, while the remainder had a lower level of education. Table 3.2 presents the descriptive statistics (mean, standard deviation, minimum, and maximum) of each item. All the mean scores of items were moderately high, ranging from 4.06 (SN.1) to 6.30 (A.2). In particular, the highest mean values can be seen for items related to millennials' attitudes toward reducing plastic beverage consumption followed by INT.1, INT.3, PBC.1, SN.2 and INT.2 having mean values higher than 5.

Table 3.2 - Items' description and main statistics.

Item	Item description	Mean	Std. dev	Min	Max
ATT.1	Reducing the consumption/waste of plastic drinking bottles in the next month would be satisfying	6.04	1.23	1	7
ATT.2	Reducing the consumption/waste of plastic drinking bottles in the next month would be convenient	6.30	1.08	1	7
ATT.3	Reducing the consumption/waste of plastic drinking bottles in the next month would be positive	6.24	1.05	1	7
SN.1	Most people important to me would like for me to reduce the consumption/waste of plastic drinking bottles	4.06	1.91	1	7
SN.2	Most people I know and appreciate would approve of my choice to reduce the consumption/waste of plastic drinking bottles	5.59	1.55	1	7
SN.3	Most people important to me have reduced the consumption/waste of plastic drinking bottles	4.32	1.63	1	7
PBC.1	If I wanted to, I could reduce the consumption/waste of plastic drinking bottles	5.60	1.57	1	7
PBC.2	I have no difficulty reducing the consumption/waste of plastic drinking bottles	4.74	1.62	1	7
PBC.3	Reducing the consumption/waste of plastic drinking bottles or not is up to me	4.97	1.74	1	7
INT.1	I want to reduce the consumption/waste of plastic drinking bottles in the next month	5.74	1.56	1	7
INT.2	I plan to reduce the consumption/waste of plastic drinking bottles in the next month	5.40	1.54	1	7
INT.3	I will try to reduce the consumption/waste of plastic drinking bottles in the next month	5.64	1.49	1	7
PB	During the last year, I have reduced the consumption/waste of plastic drinking bottles	5.00	1.58	1	7

Note: ATT=attitude; SN= social norms; PBC=perceived behavioral control; INT=intention; PB=past behavior

The output of millennials' stated behavior regarding the use of beverage containers is shown in Table 3.3.

Table 3.3 - Beverage container alternatives: Scenario 1 "out with friends", Scenario 2 "at home", Scenario 3 "at university/work".

Beverage container alternatives		**Total**		**Female**		**Male**		
		Abs. frequency	Perc. frequency	Abs. frequency	Perc. frequency	Abs. frequency	Perc. frequency	Pearson chi-square
Scenario 1	1-Plastic bottle	74	10%	39	8%	35	14%	
	2- Aluminum can	119	16%	70	14%	49	19%	
	3- Glass bottle	548	74%	381	78%	167	67%	
	Total	**741**	**100%**	**490**	**100%**	**251**	**100%**	**11.61****
Scenario 2	1- Reusable jug	265	36%	194	40%	71	28%	
	2-Glass bottle	95	13%	56	11%	39	16%	
	3- Plastic bottle	381	51%	240	49%	141	56%	
	Total	**741**	**100%**	**490**	**100%**	**251**	**100%**	**9.79***
Scenario 3	1-Plastic bottle	236	32%	140	29%	96	38%	
	2-Reusable jug	451	61%	326	66%	125	50%	
	3- Dispenser of water	54	7%	24	5%	30	12%	
	Total	**741**	**100%**	**490**	**100%**	**251**	**100%**	**23.84*****

Note: (*$p < 0.05$; **$p < 0.01$; *** $p < 0.001$) Abs=Absolute; Perc= Percentage

In the first column, there are absolute and percentage frequencies of the total responses; the last two columns distinguish between male and female responses. For *scenario 1* (drinking out with friends), 74% of interviewees preferred the glass bottle option, while 10% chose the plastic bottle. Conversely, the plastic bottle option was the most preferred (51%) in *scenario 2* (drinking at home). Finally, for *scenario 3* (drinking at university/work), 61% of the sample preferred the reusable jug, while 32% preferred the plastic bottle. Meanwhile, Pearson's chi-square test confirmed that differences between females and males were statistically significant in each considered scenario, particularly when respondents were at university or in their working environment (Scenario 3). Therefore, it is possible that females may prefer the plastic bottle option less than males in each scenario. In *scenario 1,* 8% of females chose the plastic bottle versus 14% of males. In *scenario 2*, 49% of females and 56% of males preferred plastic bottles, and 29% and 38% of females and males, respectively, preferred plastic bottles in *scenario 3*.

3.4.2. MCA results

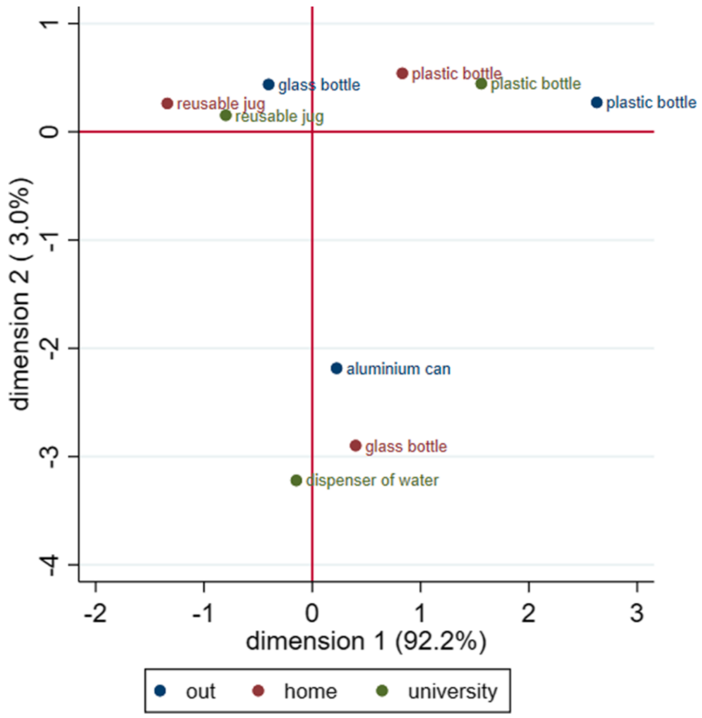
The output of the multiple correspondence analysis is shown in Table 3.4 and graphically represented in Fig. 3.3 as a data matrix with three qualitative variables (drinking out with friends, at home, and at university/work) and nine categories in relation to the x-axis and y-axis, with the x and y axes representing latent dimensions orthogonal to each other. The sum of the inertias of the two dimensions is the total inertia, which represents the total explained variability. The first dimension (x-axis) accounts for most of the inertia (92.2%), while the second dimension (y-axis) accounts for only 3% (Table 3.4).

Table 3.4 - Multiple correspondence analysis output.

	Dimension 1 coordinate (x)	**Dimension 2** coordinate (y)	**% Inertia**
Scenario 1 "out with friends"			
1-Plastic bottle	0.452	0.008	0.200
2-Aluminum can	0.039	-0.068	0.014
3-Glass bottle	-0.069	0.014	0.037
Scenario 2 "at home"			
1-Reusable jug	-0.230	0.008	0.206
2-Glass bottle	0.069	-0.090	0.020
3-Plastic bottle	0.143	0.017	0.118
Scenario 3 "at university/work"			
1-Plastic bottle	0.268	0.014	0.266
2-Reusable jug	-0.137	0.005	0.131
3-Dispenser of water	-0.025	-0.100	0.008

Note: Dimension 1, principal inertia: 0.0295 (92.21%); Dimension 2, principal inertia 0.0009 (2.98%).

Figure 3.3 - MCA Plot.



This indicates that the projective technique reveals "plastic-free" behavior as a unidimensional construct. Both latent dimensions are explained by the nine possible categories regarding the use of beverage containers. This is shown in the third column explaining the contribution of each category to the inertia (variability) of both dimensions. The first two columns report the coordinates of each container's category in the two-dimensional space as emerged from the MCA. They are graphically represented in Fig. 3. The distance between the categories is related to the similarity of their response patterns. By examining the closeness among the categories, the figure makes it possible to identify the associations and disassociations between categories, wherein categories clustered together represented associations (Fig. 3.3). For example, the plastic bottle option of the first scenario is close to the plastic bottle options of the second and third scenarios. Conversely, the alternatives to plastic bottle options are far from the three plastic bottle options but are associated with each other in two different clusters. Therefore, one (stated) dimension is pointed out. A positive value for this dimension indicates the "non plastic-free" behavior, referring to respondents who prefer the plastic drinking bottle option, while a negative value shows the "plastic-free" behavior that selects respondents who prefer alternatives to plastic drinking bottles. Given that the x-axis of the plot catches almost the total variability, the predicted scores of the first dimension were used as a construct (stated behavior) of the TPB model.

3.4.3 PLS-SEM output

3.4.3.1. The measurement model

Table 3.5 illustrates the results of the measurement model, showing strong relationships between the latent constructs and items with factor loadings > 0.5, ranging from 0.6 to 0.9. The results of the final assessment of the model for internal consistency (Cronbach's alpha), indicator reliability (rho A), and convergent validity (AVE) are presented at the bottom of the table. The Cronbach's alpha for Social Normsis below the threshold value of 0.7, but Kline (2015) argues that values between 0.6 and 0.7 may be considered adequate. Moreover, the results could be considered suitable for validating the measurement model because all constructs show indicator reliability (rho A) and convergent validity above 0.7 and 0.5, respectively. The results of the Fornell-Larcker criterion, indicated that discriminant validity of the constructs is established (Table A1, in appendix). Finally, Harmon one-factor test showed that one factor explained most of the covariance, about 34%, which is fairly below the threshold of 50%. Variance inflation factors indicated the absence of pathological collinearity among the constructs (Table A2, in appendix).

Table 3.5 - Factor loadings, Cronbach's α, Rho A and average variance extracted (AVE) of the measurement model.

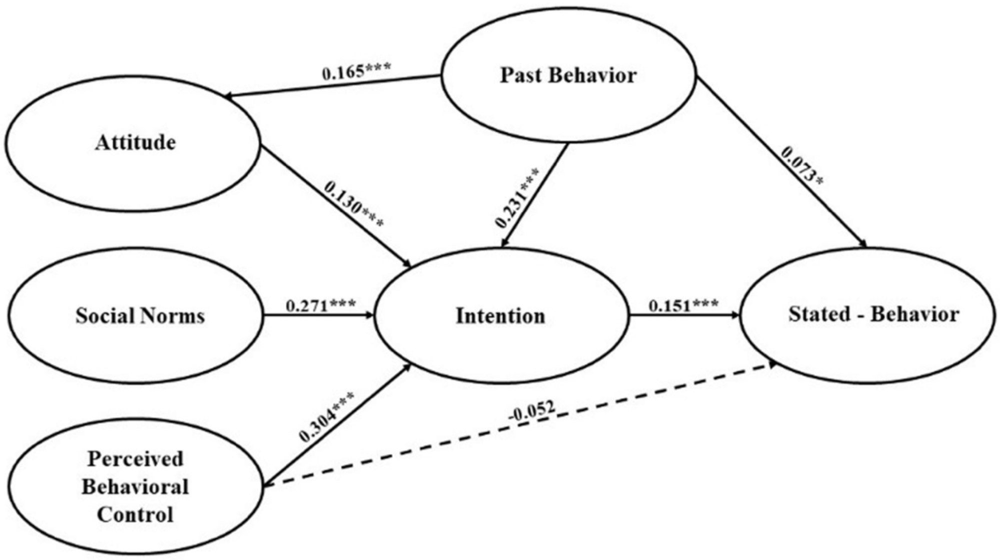
Items	ATT	INT	SN	PBC	PB	ST-BEH
ATT.1	0.845					
ATT.2	0.893					
ATT.3	0.893					
INT.1		0.916				
INT.2		0.921				
INT.3		0.921				
SN.1			0.683			
SN.2			0.858			
SN.3			0.64			
PBC.1				0.878		
PBC.2				0.807		
PBC.3				0.81		
PB					1	
ST-BEH						1
Cronbach's α	0.85	0.908	0.63	0.784	1	1
Rho A	0.909	0.942	0.774	0.871	1	1
AVE	0.853	0.909	0.738	0.835	1	1

**Note: ATT =attitude; INT=intention; SN= social norms; PBC =perceived behavioral control; PB =past behavior; ST-BEH= stated behavior.*

3.4.3.2. The structural model

Once a suitable measurement model was obtained, the research hypotheses of the study have been formally tested with the structural model of the PLS-SEM. Fig. 3.4 presents the direct effects among the considered constructs, showing that all path coefficients are significant and have the expected sign/direction, except for the relationship between the PBC and the stated behavior characterized by a non-statistically significant coefficient ($p > 0.05$). Thus, all hypotheses related to the relations among the constructs are accepted except for H2. Our findings confirmed that all classical TPB predictors (attitudes, social norms, and PBC) influence the intention of millennial consumers to reduce the use of plastic drinking bottles (H3), with PBC being the strongest predictor of intention (ß = 0.304), followed by social norms (ß= 0.271) and attitudes (ß _= 0.130). Moreover, the past behavior construct positively and significantly affects attitude (H4; ß = 0.165), intention (H5; ß = 0.231), and stated behavior (H6, ß = 0.073) constructs. The latter is also positively predicted by intention (H1; ß = 0.151). Indirect effects among the constructs are reported in appendix (Table A.3): Briefly, the indirect effects of attitude (ß = 0.020), social norms (ß = 0.041) and PBC (ß = 0.046) on behavior (stated) are mediated by intention. Moreover, past behavior influences both intention (ß = 0.022) through attitude and stated behavior (ß = 0.038) through intention.

Figure 3.4 - Extended theory of planned behavior for plastic free consumption: Structural model estimate (PLS-SEM). Notes: Significant relationships are marked by bold arrows, and non-significant relationships by dotted line arrows (*p < 0.05; **p < 0.01; *** p < 0.001).



3.5 Discussion

The results regarding stated behavior provided by the projective technique illustrate that respondents prefer plastic beverage containers when they consume their daily meals at home. This outcome may depend on several factors: convenience, lightness, resistance, and versatility of plastic (Sang et al., 2021) as well as consumer's habits (Romero et al., 2018). In addition, 29% of Italian consumers do not drink tap water for health reasons (ISTAT, 2020). Thus, Italy is the country with highest use of bottled mineral water in Europe (Paiano et al., 2021). Otherwise, in the first and third scenarios, they prefer alternatives to plastic bottles. Indeed, in the first scenario, when with friends, millennials prefer to consume soft drinks (i.e., Coca-Cola) in glass bottles and prefer reusable jugs instead of plastic bottles if they are with colleagues at work or at university. This finding is in line with previous studies, which showed that plastic consumption is highly influenced by social desirability, contextual factors, and habits (Nørgaard Olesen and Giacalone, 2018; Romero et al., 2018). For instance, in an extensive literature review on plastic use, Heidbreder et al. (2019) identified several factors affecting plastic consumption behavior, including socio-demographic aspects, environmental attitude, convenience, context factors, habits, and social factors. Moreover, our study also shows that in each considered scenario, male more than female respondents prefer the plastic bottle as beverage container. This result is in line with other studies showing gender-based differences in plastic use behavior. For instance, women are more willing to use alternatives to plastic bags than men (Madigele et al., 2017). The output of the MCA explains the differences among respondents revealing "plastic-free" behavior as a unidimensional construct. The "plastic-free" (stated) behavior refers to millennials who prefer non-plastic drinking containers in each scenario proposed (out with friends, at home and at university/work); conversely, "non-plastic free" includes respondents who prefer plastic drinking bottles.

As for the PLS-SEM output, the results confirmed all direct and indirect relationships proposed in the extended TPB model, except for the direct effect between the PBC and the stated behavior. Therefore, four key findings regarding the use of TPB are discussed here. First, the results confirmed that the three classical TPB predictors (attitudes, social norms, and PBC) influence the intention of millennial consumers to reduce the use of plastic drinking bottles. Furthermore, the strongest predictor of intention was PBC, followed by social norms and attitudes. Although this outcome does not fully reflect Ajzen's hypotheses (1991), which indicates that attitudes are the best predictor of intention, our findings are in line with scientific studies where the TPB has been used to analyze plastic consumption (Hasan et al., 2015; Sun et al., 2017). For example, Hasan et al. (2015) applied the TPB to measure students' behavior to reduce plastic consumption and found that PBC was the strongest predictor of students' intention to reduce plastic consumption, followed by social norms and attitudes. As in the current study, Hasan et al. (2015) judged attitude as the construct with the weakest relationship with intention. Similarly, Sun et al. (2017) analyzed consumers' intention to use plastic bags and found that PBC had the highest impact on intention, followed by subjective norms and attitudes. However, the relative impact of the main TPB predictors on intention varies among studies (Dorce et al., 2021). While some studies confirmed this study's findings, showing the highest impact of PBC on intention (Hasan et al., 2015; Sun et al., 2017), others found the strongest impact of social norms on intention (Hassan et al., 2020) or no impact of attitudes on intention (Nabila and Nurcahyo, 2020). The varying results regarding the influence of the three main TPB predictors on intention are unsurprising. For example, several studies have highlighted the importance of social pressure in influencing the use of plastic (Arı and Yılmaz, 2017; Musa et al., 2013), and social desirability has been considered critical for reducing plastic consumption (Sharp et al., 2010; Yeow et al., 2014). Moreover, the impact of constructs on intention may also vary across populations and time or may depend on the usage of different items to measure TPB constructs, thus influencing the correlations among them (Scalco et al., 2017). The second key finding is that past behavior positively influences attitude, intention, and state behavior. According to some authors, the use of past behavior as a predictor of TPB is of particular interest because it increases the explained variance of intention and behavior as well (McEachan et al., 2011). Conversely, other researchers have shown that past behavior predictors may cloud the effect of intention on behavior and other TPB predictors (Hagger et al., 2018). In this case, our findings are consistent with those of researchers who included these constructs in the TPB (Smith et al., 2008; Hamid and Cheng, 1995). More specifically, Hamid and Cheng (1995) found a direct effect of past behavior in predicting the intention of Chinese students to reduce the use of plastic bags. Furthermore, the direct effect of past behavior on intention and behavior is well known, especially in predicting food consumption (Canova et al., 2020) or when the type of behavior is performed repeatedly (Smith et al., 2008; Bamberg et al., 2003). The current study also pinpoints the positive and significant impact of intention on stated behavior (the third finding).

Although this study measured stated behavior and not actual observed behavior (Ajzen, 1991), the results confirm the importance of intention in predicting behavior, as has been shown by several studies (Canova et al., 2020; Dorce et al., 2021). Finally, for the fourth finding, our results showed a non-significant relationship between the PBC constructs and state behavior. This finding is not new in scientific literature. For example, Canova et al. (2020) revealed the inconsistency of PBC constructs in predicting behavior. Previous studies on healthy eating have also yielded comparable results (Carfora et al., 2016).

As for the indirect effects, our results indicated the existence of indirect effect of attitude, social norms and PBC on stated behavior, mediated by intention (Ajzen, 1991). Moreover, in line with Brown et al. (2020), our findings confirmed the indirect effect of past behavior on intention and on stated behavior, mediated by attitude and intention respectively.

3.6 Conclusions

This study explored the intention of millennial consumers to reduce the use of plastic drinking bottles. An MCA was performed to analyze millennials' stated behaviors regarding the use of beverage containers, and then a PLS-SEM was applied to an extended model of the TPB, including past behavior and the stated behavior constructs. To the researchers' knowledge, this is the first study wherein an extended TPB model was tested for predicting millennials' intention to reduce the consumption of plastic drinking bottles; thus far, few studies have implemented a projective technique to capture consumers' stated behavior. The findings of the study revealed "plastic-free" behavior as a unidimensional construct. Moreover, it also highlighted the importance of socio-demographic (i.e., gender) and psychological factors (i.e., TPB constructs), as well as habits, in predicting the intention of millennials to reduce the use of plastic drinking containers. Finally, the study showed that the application of projective techniques to the TPB constructs could help reduce the social desirability bias of such constructs. Accordingly, future studies may combine TPB with projective techniques. However, the convenience nature of the sample, as well as the non-observed behavior, could be considered the main limitations of the current study that require further investigation. The convenience sample has several advantages compared to other sampling methods (i.e., low costs and low item non-response), but it is potentially affected by selection bias (Acharya et al., 2013) and low statistical representativeness. Based on the study findings, several implications for both research and practice should be highlighted. First, PBC is the strongest predictor of intention to reduce the consumption of plastic drinking bottles. Accordingly, millennials (or individuals in general) must be supported by specific policy measures to facilitate the perception of control over obstacles and barriers. For example, some policy may focus on less expensive and more versatile non-plastic beverage by supporting companies' research and innovation. Moreover, promoting the use of tap water is helpful to reduce the consumption of plastic bottles at home. Specific policy measures should be applied to strengthen the tap water consumption, for example by supporting the diffusion of public and private water purifier systems. Further, to promote the development of intention to reduce the use of plastic drinking bottles, facilitating conditions should be introduced (e. g., providing water dispensers at work or at university), and social pressure may help reduce the use of plastic drinking beverage containers, especially outside the home. The current study also pointed out the importance of past and stated behavior for analyzing the millennial consumption of plastic drinking bottles thus indicating that the use of plastic drinking bottles is almost habitual. Therefore, educational programs aimed at reducing the consumption of plastic drinking bottles may help change the habits of millennials. Future researchers may focus on the determinants of "plastic-free" behaviors for both millennials and other generations. Moreover, future studies could investigate actual behavior instead of the "stated" behavior regarding the consumption of plastics jointly within the TPB and with other projective techniques. Indeed, the projective technique used in this study may also be used to evaluate other lifestyle habits and practices. As the interest in the above issues is rapidly growing, more studies are expected to suggest further effective policy actions to steer citizens towards more sustainable practices.

Appendix.

Table A1. Discriminant validity with Fornell-Larcker criterion.

	ATT	INT	SN	PBC	PB	ST-BEH
ATT	1.000					
INT	0.054	1.000				
SN	0.011	0.291	1.000			
PBC	0.012	0.309	0.274	1.000		
PB	0.027	0.240	0.170	0.170	1.000	
ST-BEH	0.000	0.025	0.001	0.004	0.016	1.000
AVE	**0.769**	**0.845**	**0.538**	**0.693**	**1.000**	**1.000**

Note: ATT =attitude; INT=intention; SN= social norms; PBC =perceived behavioral control; PB =past behavior; ST-BEH= stated behavior; AVE=average variance extracted. The square root of AVE (last row) in every latent construct should be higher than other correlation values among the latent variables.

Table A2. Structural model - Multicollinearity check (Variance Inflated factors -VIFs)

	ATT	INT	ST-BEH
ATT		1.031	
INT			1.642
SN		1.474	
PBC		1.474	1.503
PB	1.000	1.307	1.367

Note: ATT =attitude; INT=intention; SN= social norms; PBC =perceived behavioral control; PB =past behavior; ST-BEH= stated behavior. Values below 3.3 indicate acceptable level of correlation among constructs.

Table A3. PLS-SEM estimates: Direct and indirect effects among constructs.

Hypotheses	Relations	Direct effect	Indirect effect	Total
H3	ATT -> INT	0.130		0.130
	ATT->ST-BEH		0.020	0.020
H1	INT->ST-BEH	0.151		0.151
H3	SN -> INT	0.271		0.271
	SN -> ST-BEH		0.041	0.041
H3	PBC -> INT	0.304		0.304
H2	PBC -> ST-BEH	-0.052	0.046	-0.006
H4	PB -> ATT	0.165		0.165
H6	PB -> INT	0.231	0.022	0.253
H5	PB -> ST-BEH	0.073	0.038	0.112

Note: ATT =attitude; INT=intention; SN= social norms; PBC =perceived behavioral control; PB =past behavior; ST-BEH= stated behavior.

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4. Eco-innovations Transition of Agri-Food Enterprises into a Circular Economy

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Abstract

Eco-innovations that mitigate the environmental consequences of production and consumption are seen as critical components of sustainability transitions and a critical component of a circular economy. Food systems present a significant challenge in the form of food waste, which is recognized as a significant economic, environmental, and social issue. Eco-innovations are critical to changing the food system toward a more circular model based on sustainable agriculture and food processing. The goal of this article was to document the number of innovations launched by enterprises in the European Union during the three-year period 2012-2014 and to highlight the factors affecting innovation in agri-food systems. The results show how enterprises' introduction of innovations is influenced by economic and financial factors.

Keywords: eco-innovation, circular economy, agri-food; enterprises, survey.

4.1 Introduction

By 2030, the UN expects that the world's population will demand at least 40% more water, 35% more food, and 50% more energy. Additionally, it is anticipated that worldwide food consumption will grow by 70% by 2050 (FAO, 2009), global energy consumption will increase by 25% by 2040 and global freshwater demand will increase by about 55% by 2050 (IEA, 2018).

The circular economy (CE) and its principles have developed as a new paradigm in our pursuit of sustainability, presenting new chances for development and progress (Raworth, 2017; Vanham et al., 2019). A circular model, in fact, envisions the long-term use of biomass as products that are processed, reused, and ultimately reintegrated into the biosphere as bioproducts at the end of their useful life.

However, the economy of the European Union remains mostly linear. According to the report (Eurostat, 2017), the EU's circular material consumption rate was just 11.2% in 2017, and only 8.6% of the economy would be circular in 2020 (Circle Economy, 2010). The purpose of transitioning to a circular economy is to obtain environmental benefits (Taranic et al., 2016), which include cost savings and market expansion, both of which result in further economic benefits via employment creation. As numerous scholars have argued (Prieto-Saldoval et al., 2018; Kemp, 2010; Carrillo-Hermosilla et al., 2010; de Jesus et al., 2018), the primary impediment to this transition is the growing need for innovation, which includes not only research on new technologies but also clear guidance on their use, policy support for establishing appropriate regulatory frameworks, and providing the appropriate incentives for technology adoption.

The European Union has been in the forefront of environmental actions since the 1992 Rio de Janeiro Summit, enacting a range of laws and funding research projects. The introduction of a new word, "eco-innovation", has rekindled interest in environmental sustainability. What becomes evident is that eco-innovation is considered as a source of technical progress that helps a business to expand economically and market share, maybe via "green" methods (Andersen, 2004; Berkhout, 2011; Carrillo-Hermosilla et al., 2009; Carrillo-Hermosilla et al., 2010; Hellstrom, 2007).

Recent articles have examined the European framework for member states' innovative responses to the transition to a circular economy. Marino and Pariso (2020), for example, discovered that the 28 EU member states have adopted a diverse variety of solutions, with just a handful judged successful in resolving circular economy concerns across the EU, and Melece (2016) examined the situation and trends in the EU's efforts to achieve green growth and a circular economy.

Agri-business is a big and fast-growing industry. In 2017, the EU bio-based industry earned €2.4 trillion in revenue in the EU-28, a 25% growth over 2008 (Porc et al., 2020). The primary challenges confronting the food industry in producing sustainably need system-wide innovation, including a change in value creation logic and the development of new circular economy-compatible models (Bocken et al., 2014). Transitioning to a circular and resource-efficient economy would need a systematic shift in production and consumption patterns, and eco-innovations will be critical in developing new technologies, processes, commodities, and services, as well as business models (EU). Additionally, the circular economy's technological and organizational innovations would increase

European resource productivity by 3% by 2030, resulting in 1.8 trillion in total benefits across three sectors: mobility, food, and the built environment, including cost savings on primary resources and costs associated with externalities such as the health effects of air pollution (Ellen MacArthur Foundation, 2013). On the other hand, major change, in addition to technological breakthroughs, needs considerable changes in institutional and cultural norms and structures (Prosperi et al., 2020). The goal of this research is to assess the innovation performance of European Union firms throughout the three-year period 2012-2014. The information was gathered using the *Community Innovation Survey* (CIS), which is designed to quantify innovation in enterprises, contains data that can be compared across countries and over time, and is intended to provide information on the innovative capacity of sectors by type of enterprises, the various types of innovation, and various aspects of innovation development, such as goals, sources of information, government funding, and spending on innovation. The study's objective was to ascertain the most significant drivers of circular benefits for product, process, organizational, and marketing innovations, as well as the most significant drivers of circular benefits for enterprises and end users. Moreover, the authors' objective was to demonstrate how the importance of the drivers differs significantly across the food, beverage, and tobacco sectors (FBT) and the whole sample of enterprises. The research questions are as follows:

- *RQ1.* Which factors influence product, process, organizational, and marketing innovations?
- *RQ2.* Which factors influence the circular benefits perceived by enterprises and end users?
- *RQ3.* Are there differences between food enterprises and the total sample of enterprises?

The paper is arranged as follows. To begin, we define eco-innovation and analyze its relationship to the concept of the circular economy. After that, we summarize the scientific literature on empirical examples of food sector eco-innovation. Then, we'll explore the study's methodology and results. Finally, we analyze the data and draw conclusions to offer comprehensive answers to the research's questions.

4.2 Eco-innovation in food sector

4.2.1 Eco-innovation and circular economy (CE)

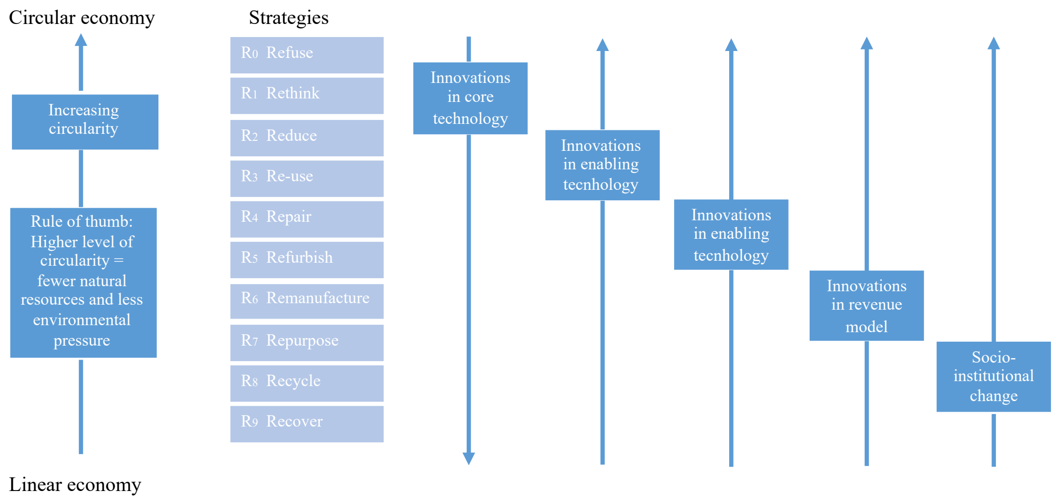
The word "eco-innovation" is a colloquial term that refers to the synthesis of two concepts: sustainability and innovation. According to a widely accepted definition, eco-innovation is "the production, assimilation, or exploitation of a new product, manufacturing process, service, management method, or business method by an organization that results in a reduction of environmental risk, pollution, or other negative impacts on the resources used" (Kemp and Pearson 2008). Furthermore, it contributes to the creation of new solutions that benefit consumers and enterprises (Makara et al. 2016) considering economic, ecological, and social factors (Muscio et al., 2017; Schiederig et al. 2012).

According to Carrillo-Hermosilla et al. (2009), eco-innovation may be tackled in three ways: as add-on solutions, end-of-pipe solutions, or hybrid solutions and is defined as the continuous improvement of technology with the goal of minimizing environmental impact. It may be assessed in terms of eco-efficiency (Franceschini and Pansera, 2015; Hellstrom, 2007; Janicke, 2008; Kemp and Andersen, 2004), regarded a paradigm shift due to the introduction of radical new technology and/or organizational solutions, as well as new production and consumption models, such as closed-loop and cradle-to-cradle systems.

Eco-innovation is predicated, in fact, on a positive attitude toward technology's ability to address environmental problems and on the development of a circular economy centered on increasing production system efficiency (Fig.4.1) through input reduction, eco-design, improved practices, and waste reuse and recycling (Hopwood et al., 2005; Scoones, 2007; Kirchherr et al., 2017; Korhonen et al., 2018; Murray et al., 2017; The Ellen MacArthur Foundation, 2013; Borrello et al., 2020a).

According to this view, innovation has the potential to improve the sustainability and circularity of production processes (Pansera, 2012; Frondel et al., 2007; Freeman and Soete, 2009). For this reason, the complementary between circular economy and innovation can address issues such as environmental degradation and pollution, climate change, soil erosion, and biodiversity loss through continuous improvements in the eco-efficiency of agri-food production systems and resource consumption. However, the relationship between eco-innovation and circular economy remains a mystery (de Jesus et al., 2018; de Jesus and Mendonça, 2018).

Figure 4.1 - Role of innovation in circular economy for production chains.



Source: RLI 2015; edited by PBL Netherlands Environmental Assessment Agency, https://www.pbl.nl/en/publications/circular-economy-measuring-innovation-in-product-chains.

4.2.2 Food industry eco-innovation

The agri-food sector's tremendous losses are a good ground for a of fresh ideas (Chinnici et al., 2019; Hamam et al., 2021). The pursuit of sustainable development objectives demands major changes in the existing economic model, as well as production and consumption systems, where the private sector playing an essential position in this process (El-Chichakli et al., 2016; Lieder and Rashid, 2016).

Eco-innovation has emerged as one of the most significant inventions for sustainable enterprises (Ryszko, 2016; de Jesus Pacheco et al., 2019; Khan and Johl, 2019; Salim et al., 2019; Santos et al., 2017), and its idea has been incorporated into EU rules to encourage eco-solutions (Buttol et al., 2012). Horizon 2020 is the European Union's biggest research and innovation effort, sponsoring projects in waste prevention and management, food waste reduction, creative remanufacturing, sustainable industry, industrial symbiosis, and the bioeconomy (Deselnicu et al., 2018). It ties eco-innovation to the circular economy and underlines the necessity of eco-efficiency. Additionally, it invented the term "systemic", which positioned the circular economy and systemic eco-innovation at the center of European eco-innovation discussions.

Due to the perishability of food, new technologies have evolved that enable the extension of their shelf life and storage (Parfitt et al., 2010) via the use of creative storage techniques (Van Holsteijn and Kemna, 2018). Additionally, new processing techniques have been developed to make a new product from food waste (Galanakis, 2012). This circular economy-based strategy enables goods to keep their worth for as long as possible (Smol et al., 2015).

The development of circular food economic actions has been sparked primarily by the adoption of new technologies and sustainable industrial processes, as well as improved logistics management, as well as increased investment in research and development by enterprises, either individually or in collaboration (Staniskis et al., 2012). Therefore, organizations are implementing innovation into their operations at an increasing rate (Bossink, 2015).

Environmental considerations, which must be incorporated into company culture and business strategy across the design, production, distribution, and disposal processes, started to get more attention, therefore. Numerous technological advancements in agriculture are helped by scientific contributions (Muscio and Nardone, 2012).

Agribusinesses operate in a technological environment that encompasses a broad variety of technologies, including freezing and refrigeration, information and automation technologies, and new breakthroughs in drying, heat treatment, and controlled and modified atmosphere packaging (Welch and Mitchell, 2000).

Indeed, to create effective circular models (Ghisellini et al., 2020), technology is critical in providing innovative tools to support businesses, radical solutions to prevent and manage food surpluses, moving up the food waste hierarchy, and avoiding raw material extraction (Nilsen, 2019), such as information technologies that facilitate food sharing and redistribution via web platforms or apps (Harvey et al., 2019).

The intersection and interaction of the strategic orientations "technology-push", i.e., science and technology (push), and "market-pull", i.e., market recognition (pull), are widely used to characterize technological innovation (Di Stefano et al., 2012).

Food waste management solutions are often associated with both processing technologies, as they include the conversion of excess food into feed, fertilizer, or energy (Arshadi et al., 2016; Laufenberg et al., 2003; Girotto et al., 2015), and the need for a collaboration among all actors in the value chain (Chen et al., 2017). Some examples in the literature (Mercier et al., 2017; Chen and Yada, 2011) portray technological advances as obstacles in building an appropriate collaboration environment (Gellynck and Kühne, 2010).

Proactive eco-innovation has been defined by researchers (Kemp and Pearson, 2007; Garcia-Granero et al., 2018) and research organizations (OECD, 2005) as having three key dimensions: product, process, and technology. According to EIO (2011), product eco-innovation is the introduction of new or significantly improved goods or services through eco-design concepts that contribute to corporate sustainability and the circular economy (Hu et al., 2019; Mazzoni, 2020) by considering the environmental, social, and economic impacts of the entire product life cycle and emphasizing resource efficiency while minimizing environmental impact (Ivascu, 2020).

Eco-innovation in processes is defined as the use of significant variations in methods, equipment, and software to create new or significantly upgraded production or delivery systems. Investing in environmentally friendly equipment and industrial processes are examples of technical eco-innovation. According to Ryszko (2016), technological eco-innovations, while difficult to introduce, are crucial in providing information for inclusive material saving, credentialing, and statistics management initiatives.

Several studies (Przychodzen and Przychodzen, 2015; Marcon et al., 2017; Rodriguez and Wiengarten, 2017; Rodriguez-Garcia et al., 2019; Johl and Toha, 2021) have found that eco-innovation appears to be positively and strongly correlated with enterprises financial success, even of the Santos et al. (2019) study discovered that eco-innovation had a negative association with financial performance.

The eco-innovations are crucial in sustainable transitions at the macro, meso, and micro levels (Kirchherr et al., 2017; Pauliuk, 2018), not all of them contribute equally to the circular economy (Franco, 2017; Carrillo-Hermosilla et al., 2009; Garcia-Granero et al., 2018).

Systemic or eco-efficient eco-innovations (Carrillo-Hermosilla et al., 2010; McDonough and Braungart, 2010) represent a break from established methods and business models and result in significant environmental improvements. They include the introduction of new goods and services, as well as the expansion of markets and clientele (Braungart et al., 2007; Carrillo-Hermosilla et al., 2010). Additionally, they need close collaboration with consumers and intermediaries (de Jesus et al., 2017; Wagner and Llerena, 2011) and make use of open-source trials (Mazzucato, 2018).

Radical eco-innovations seek competitive advantage via technical leadership, disrupt the status quo of corporate operations, and are tied to entrepreneurship (Hall et al., 2010; Hansen and Große-Dunker, 2013). Experimentation has been identified as the most critical radical innovation capability for success since it enables organizations to overcome inertia. According to radical eco-innovation, research, selection, and execution are the three components of all innovation activities (Bessant et al., 2014; Leifer et al., 2000; Seebode et al., 2012; Tidd and Bessant, 2013; Chang et al.,2012). Radical eco-innovations have, also, a negligible compatibility with pre-existing models. Furthermore, due to their extended maturation spans and significant changes inside the company, long-term policies are especially well-suited to systemic and radical eco-innovations (del Rio et al., 2010). They usually demand considerable upfront expenditures that place significant financial strain on businesses, and they frequently need collaboration between the enterprise and important stakeholders. However, O'Connor and McDermott (2004) discovered that it takes at least ten years to market and adapt unconventional ideas. Commercialization of revolutionary innovations with economic, social, and environmental benefits may take up to ten years (Hanna et al., 2015). Environmental stewardship vs. continuous improvement eco-innovations, on the other hand, pursue operational efficiency, cost reduction, input cost reduction, and market leadership. This may include developing or implementing eco-innovations throughout time.

The role of end-users is considered important during the development of enterprise-level innovations (Borrello et al., 2017a; Borrello et al., 2020b). User-driven innovation is a process for creating a new product or service that relies heavily on an integrated analysis and understanding of users' needs, wants, and preferences (Grunert et al., 2008). Research emphasizes the need to include the end user in driving innovation (Sijtsema et al., 2020). Reaching out to diverse groups and networks both inside and outside the enterprise through open innovation and partnerships, improved stage gate processes, new ways to innovate through crowd sourcing, and a deep understanding of business processes are some of the most critical innovations for food product success (Moskowitz and Saguy, 2013). Design thinking (Olsen, 2015), which is an organized way of thinking used in design activities, looks to be useful to food innovation. It utilizes designer techniques to match consumer desires with what is technically feasible and financially viable (Brown, 2008). Lockwood (2010) defines design thinking as "a human-centered innovation process that emphasizes observation, collaboration, fast learning, idea visualization, rapid prototyping, and concurrent business analysis". The tools and methods employed should target not just the rational consumer, but also the irrational motivations for their actions, such as the use of pictures or drawings to stimulate the imagination, and the use of projective techniques has been shown to be beneficial in this respect (Sijtsema et al., 2016). Some authors identified different open innovation models that are connected to the concept of client co-creation (Bigliardi and Galati, 2013). Co-creation is often equated with cooperation. It is a collaborative, open, and creative process in which value is created amongst idea generators, people who have a common interest, end users, and other stakeholders (Ehlen et al., 2017; Filieri, 2013).

4.3 Methodology

4.3.1 Community Innovation Survey (CIS)

The Community Innovation Surveys (CIS) are a series of surveys undertaken by national statistical offices across the European Union that serve as the major data source for measuring innovation in the EU. Standardized surveys, according to the Oslo Manual, are meant to collect data on the innovativeness of different companies and sectors. A NACE code (Nomenclature statistique des activités économiques dans la Communauté européenne) defines the statistical classification of economic activities in the European Union and is used to categorize each sector. The study is conducted on a business-to-business basis and provides data by country, innovator type, and economic activity.

The study covers innovation in products and processes, innovation activity and expenditure, innovation effects, innovation collaboration, public innovation research, and the source of information for innovation patents. Every two years, the EU, and some European Statistical System (ESS) member nations conduct surveys.

The poll is entirely voluntary, and different countries engage in it at different times of the year.

The CIS survey is intended to assess corporate innovation and offers comparable data across nations and across time. Its purpose is to give information on the inventive capability of sectors by company type; the many forms of innovation; and the various factors of innovation development, such as aims, sources of knowledge, public financing, and innovation expenditures. Researchers get access to the resulting microdata via the SAFE Center at Eurostat's headquarters in Luxembourg.

4.3.2 Survey

Eurostat's Safe Centre (SC) in Luxembourg acquired the data using a standardized survey sent to enterprises around the EU. Bulgaria, Cyprus, the Czech Republic, Germany, Estonia, Greece, Spain, Croatia, Hungary, Lithuania, Latvia, Norway, Portugal, Romania, and Slovakia are among the nations that provided information.

The survey version used was 13 dated July 23, 2014, and it was aimed to gather data from companies during a three-year period from 2012 to 2014. It is divided into thirteen sections: general company information; product and service innovation; process innovation; ongoing or abandoned product or process innovation activities; product and process innovation activities and expenses; public financial support for innovation activities; product and process innovation collaboration; non-innovators; environmental innovation; and basic economic information about the enterprises; organizational innovation; marketing innovation; public sector contracts and innovation; intellectual property rights and licensing; non-innovators; environmentally beneficial innovation; and fundamental economic knowledge about the enterprise.

4.3.3 Data analysis

The purpose of this research was to examine the factors that influence the circular benefits of enterprises innovation. The sample included 98,809 observations, all of which were tied to enterprises classified as NACE coded industries. The authors sought to ascertain which factors significantly influenced enterprises and end-users' views of the circular benefits of innovation adoption. The variables used are described in table 4.1:

Table 4.1 - Summary statistics and variable's description

Variables	Description	Item	Mean	Standard Deviation
ecomkt	0=no, 1=yes	Marketing innovations	0.119	0.324
ecoprc	0=no, 1=yes	Process innovations	0.432	0.495
ecoprd	0=no, 1=yes	Product innovations	0.338	0.473
ecorg	0=no, 1=yes	Organizational innovations	0.257	0.437
enagr	0=not significant, 1=low, 2=medium, 3=high	Initiatives to promote good environmental practices	1.371	1.155
encost	0=not significant, 1=low, 2=medium, 3=high	High cost of energy, water, or materials	1.592	1.213
endem	0=not significant, 1=low, 2=medium, 3=high	Current or projected market demand for environmental innovations	1.067	1.091
enereg	0=not significant, 1=low, 2=medium, 3=high	Existing environmental regulations	1.526	1.229
enetx	0=not significant, 1=low, 2=medium, 3=high	Existing environmental taxes, fees, or charges	1.155	1.133
engra	0=not significant, 1=low, 2=medium, 3=high	Government grants, subsidies, or other financial incentives for environmental innovations	0.784	1.021
enregf	0=not significant, 1=low, 2=medium, 3=high	Anticipated future environmental regulations or fees	1.195	1.129
enrep	0=not significant, 1=low, 2=medium, 3=high	Enhancing the enterprises reputation	1.583	1.210
enrequ	0=not significant, 1=low, 2=medium, 3=high	The requirement to comply with public procurement contract requirements	1.034	1.134

Two variables were created: an esent variable that represents the number of circular benefits by the enterprises about: decreased material or water consumption per unit of production, decreased energy consumption or CO2 "footprint", decreased air, water, noise, or soil pollution, substitution of a portion of materials with less polluting or hazardous materials, substitution of a portion of fossil energy with renewable energy sources, and recycling of waste, water, or materials for own use; and esuser variable that represents the number of circular benefits by the end users about: reduced energy use or CO2 'footprint', reduced air, water, noise or soil pollution; and facilitated recycling of product after use.

Using a multivariate model, the drivers of circular benefits for product, process, organizational, and market changes were identified.

$\hat{y} = \beta_0 + \beta_1 x_{enereg} + \beta_2 x_{enetx} + \beta_3 x_{enregf} + \beta_4 x_{engra} + \beta_5 x_{endem} + \beta_6 x_{enrep} + \beta_7 x_{enagr} + \beta_8 x_{encost} + \beta_9 x_{enrequ} + \varepsilon$

A multivariate regression is also performed using esent and esuser as dependent variables. Following that, two ordered logit regressions were calculated to evaluate the relationship between the circular benefits provided by product, process, organizational, and marketing innovations and the benefits felt by enterprises and end users.

The logit regression formula is as follows:

$$\log\left(\frac{p(y)}{1-p(y)}\right) = = \beta_0 + \beta_1 x_{ecoprd} + \beta_2 x_{ecoprc} + \beta_3 x_{ecorg} + \beta_4 x_{ecomkt}$$

where $\frac{p(y)}{1-p(y)}$ is the ratio of the probability that an event will occur (p(x)) to the probability that an event will not occur (1-p(x)). Values >1 indicate an increase in the occurrence of an event while values <1 indicate a decrease in the occurrence of an event.

In the ordered logit regression:

$$y = \begin{cases} 0 & \text{if } y^* \leq \mu_1, \\ 1 & \text{if } \mu_1 < y^* \leq \mu_2, \\ 2 & \text{if } \mu_2 < y^* \leq \mu_3, \\ \vdots & \\ N & \text{if } \mu_N < y^* \end{cases}$$

Additionally, the odds ratio was calculated to determine the strength of the association between the variables. It is as follows:

$$Odds\ ratio = \frac{px/(1-px)}{py/(1-py)}$$

If the odds ratio is equal to 1, the variables are uncorrelated, i.e., regardless of the existence or absence of another variable, the likelihood of an event happening is always the same. When the value is more than 1, the variables are positively associated, and when the value is less than 1, the variables are negatively linked.

The same investigations were conducted on a smaller sample of 6,263 enterprises engaged in the production of food, beverages, and tobacco. It was hypothesized that there is a significant difference between the influence that drivers may have on the circular benefits experienced by enterprises and end users, and so the comparison between the two groups, namely the complete sample of enterprises and food enterprises, is interesting. The table 4.1 summarizes the number of enterprises from which data were obtained by country in food, beverage, and tobacco sectors, and total number of enterprises. All analyses were conducted using Stata 16.

4.4 Results

The results reveal that the whole sample of enterprises and the sector of food, beverage, and tobacco enterprises provide significantly different outcomes. To begin, table 4.2 provide an overview of the variations between countries and between the number of food industries and the overall sample of enterprises.

Table 4.2 - Number of foods, beverages and tobacco enterprises from EU countries that participated in the survey.

	FBT		**ALL**	
	Freq	*%*	*Freq*	*%*
Bulgaria	1,531	24.45	14,255	14.43
Cyprus	0	0.00	1,346	1.36
Czech Republic	261	4.17	5,198	5.26
Germany	295	4.71	6,282	6.36
Estonia	0	0.00	176	1.78
Greece	0	0.00	2,507	2.54
Spain	2,043	32.62	30,333	30.70
Croatia	0	0.00	3,265	3.30
Hungary	704	11.24	6,817	6.90
Lithuania	0	0.00	2,421	2.45
Latvia	0	0.00	1501	1.52
Norway	282	4.50	5,045	5.11
Portugal	428	6.83	7,083	7.17
Romania	586	9.36	8,206	8.30
Slovakia	133	2.12	279	2.82
Total	**6263**	**100.00**	**98,809**	**100.00**

Source: EUROSTAT.

The most striking findings are to Spain and Bulgaria, which had the highest participation rates of 30.70% and 14.43%, respectively, while no food sector enterprises from Cyprus, Estonia, Greece, Croatia, Lithuania, or Latvia participated in the questionnaire. Slovakia, on the other hand, has a relatively low participation rate (2.82%) in comparison to the whole sample of enterprises, although practically all of them (2.12%) are in the food sector.

The table 4.3 summarizes the number of innovations implemented by foods, beverage, and tobacco enterprises. The twelve types of innovation related to product, process, organizational and marketing are: introduction into the market a new or significantly improved good; introduction into the market a new or significantly improved service; introduction a new or significantly improved method of production; introduction a new or significantly improved logistic, delivery or distribution system;

improved supporting activities for process such as maintenance systems or operations for purchasing, accounting, or computing; introduction of new business practices for organizing procedures; introduction of new methods of organizing work responsibilities and decision making; introduction of new methods of organizing external relations; significant changes to the aesthetic design or packaging; introduction of new media or techniques for product promotion; introduction of new methods for product placement or sales channels; and introduction of new methods of pricing goods or services.

The results demonstrate how low the rate of innovation introduction inside enterprises is. Indeed, 57.40% of the total number of enterprises report that they have not implemented any kind of innovation, 12.25% report that they have implemented one, and just 8.06% report that they have implemented two innovations.

Table 4.3 - Innovation frequencies of food, beverage, and tobacco enterprises in EU (2012-2014).

Innovation	Freq.	Percent
0	3,595	57.40
1	782	12.49
2	505	8.06
3	338	5.40
4	304	4.85
5	200	3.19
6	182	2.91
7	124	1.98
8	95	1.52
9	55	0.88
10	41	0.65
11	30	0.48
12	12	0.19
Total	**6,263**	**100.00**

Source: EUROSTAT.

Rather than that, the following tables illustrate the elements that have driven the creation of circular-benefit innovations. Indeed, as seen in Table 4.4, multivariate analysis reveals different results. Almost all factors have a significant effect on the circular benefits of product innovations for the whole sample of enterprises. Only the encost and enrequ variables are proven to be important, i.e., the high cost of electricity, water, or materials, and the obligation to satisfy criteria for public procurement contracts. For food enterprises, the outcome seems to be changing. Indeed, only the variables endem and enrep seem to influence the circular benefits associated with product innovations in food enterprises, i.e., existing or predicted market demand for environmental advances and boosting the enterprise's reputation.

Table 4.4 - Multivariate regression parameters to determine the factors that contribute to the circular benefits of product innovations.

ecoprd		**FBT**	**ALL**
enereg	Existing environmental regulations	0.029	**0.022*** **
enetx	Existing environmental taxes, fees, or charges	-0.038	**-0.058*** **
enregf	Anticipated future environmental regulations or fees	0.025	**0.023*** **
engra	Incentives for environmental innovations	0.027	**-0.020*** **
endem	Market demand for environmental innovations	**0.055** **	**0.115*** **
enrep	Enhancing the enterprises reputation	**0.051* **	**0.056*** **
enagr	Initiatives to promote good environmental practices	-0.016	**-0.022*** **
encost	High cost of energy, water, or materials	0.001	-0.005
enrequ	Procurement contract requirements	-0.036	0.005

*Note ***, **, * indicate significance at 0.01, 0.05, and 0.10 levels, respectively.*

Table 4.5 illustrates a similar case. Indeed, for the whole sample of enterprises, practically all factors have a significant effect on the circular benefits associated with process improvements. Only the variables enregf and engra are not significant, i.e., anticipated future environmental laws or fees, as well as government grants, subsidies, and other financial incentives for environmental advances. In the case of food enterprises, only three variables appear to significantly influence the circular benefits of process innovations: engra, or government grants, subsidies, or other financial incentives for environmental innovations; encost, or the high cost of energy, water, or materials; and enrequ, or the requirement to comply with public procurement contract requirements.

Table 4.5 - Multivariate regression parameters to determine the factors that contribute to the circular benefits of process innovations.

ecoprc		**FBT**	**ALL**
enereg	Existing environmental regulations	0.043	**0.035*** **
enetx	Existing environmental taxes, fees, or charges	-0.036	**-0.021*** **
enregf	Anticipated future environmental regulations or fees	0.000	-0.001
engra	Incentives for environmental innovations	**0.061** **	0.001
endem	Market demand for environmental innovations	-0.008	**-0.018*** **
enrep	Enhancing the enterprises reputation	0.023	**0.071*** **
enagr	Initiatives to promote good environmental practices	0.035	**0.055*** **
encost	High cost of energy, water, or materials	**0.071** **	**0.053*** **
enrequ	Procurement contract requirements	**-0.081*** **	**-0.012** **

*Note ***, ** indicate significance at 0.01 and 0.05 levels, respectively.*

Table 4.6 demonstrates even more atypical outcomes. Indeed, whereas many factors seem to have a significant impact on the circular benefits associated with organizational innovations for the overall sample of enterprises, the circular benefits associated with organizational innovations appear to be unaffected by any factor in the food industry. On the other hand, for the total sample of enterprises, the variables enereg, i.e., existing environmental regulations, enregf, i.e., anticipated future environmental regulations or fees, enrep, i.e., enhancing the enterprise's reputation, enagr, i.e., voluntary actions or initiatives for good environmental practices in the industry, and enrequ, i.e., the requirement to comply with public procurement contract requirements, are significant.

Table 4.6 - Multivariate regression parameters to determine the factors that contribute to the circular benefits of organizational innovations.

ecorg		**FBT**	**ALL**
enereg	Existing environmental regulations	0.019	**0.018*** **
enetx	Existing environmental taxes, fees, or charges	-0.031	-0.005
enregf	Anticipated future environmental regulations or fees	0.008	**0.014** **
engra	Incentives for environmental innovations	0.025	-0.001
endem	Market demand for environmental innovations	-0.014	-0.008
enrep	Enhancing the enterprises reputation	0.020	**0.033*** **
enagr	Initiatives to promote good environmental practices	0.038	**0.044*** **
encost	High cost of energy, water, or materials	0.012	0.001
enrequ	Procurement contract requirements	0.020	**0.015*** **

*Note ***, ** indicate significance at 0.01 and 0.05 levels, respectively.*

The findings in Table 4.7 seem to be comparable as well. The circular benefits of market innovations are highly impacted by most parameters for the complete sample of enterprises. The variables enereg, which refers to present environmental rules, enregf, which refers to anticipated future environmental regulations or fees, and engra, which refers to additional financial incentives for environmental innovation, seem to have no effect. In contrast, the circular benefits of market innovations are greatly impacted in the food industry by factors such as engra, or additional financial incentives for environmental innovation, and enrequ, or the necessity to satisfy standards for public procurement contracts.

Table 4.7 - Multivariate regression parameters to determine the factors that contribute to the circular benefits of market innovations.

ecomkt		**FBT**	**ALL**
enereg	Existing environmental regulations	-0.024	-0.004
enetx	Existing environmental taxes, fees, or charges	0.009	**0.011****
enregf	Anticipated future environmental regulations or fees	0.010	-0.007
engra	Incentives for environmental innovations	**0.062*****	0.001
endem	Market demand for environmental innovations	-0.019	**0.022*****
enrep	Enhancing the enterprises reputation	0.038	**0.026*****
enagr	Initiatives to promote good environmental practices	0.002	**0.009****
encost	High cost of energy, water, or materials	-0.010	**-0.017*****
enrequ	Procurement contract requirements	**0.050****	**0.033*****

*Note ***, ** indicate significance at 0.01 and 0.05 levels, respectively.*

The tables 4.8 and 4.9 shows the aspects enterprises and end consumers regard to be crucial in achieving circular benefits. Specifically, Table 8 reveals that virtually all factors are deemed extremely important by companies for the complete sample of enterprises. Only the variable enetx seems to be insignificant, i.e., current environmental taxes, fees, or levies. For the food sector, on the other hand, the key factors are enereg, or current environmental legislation, enagr, or industry-wide voluntary efforts or initiatives to promote good environmental practices, and encost, or the high cost of energy, water, or materials.

Table 4.8 - Multivariate regression parameters to discover enterprise-specific drivers of circular benefits.

esent		**FBT**	**ALL**
enereg	Existing environmental regulations	**0.248****	**0.204*****
enetx	Existing environmental taxes, fees, or charges	-0.014	-0.010
enregf	Anticipated future environmental regulations or fees	0.108	**0.148*****
engra	Incentives for environmental innovations	0.006	**-0.056*****
endem	Market demand for environmental innovations	-0.024	**0.083*****
enrep	Enhancing the enterprises reputation	-0.113	**0.117*****
enagr	Initiatives to promote good environmental practices	**0.334*****	**0.183*****
encost	High cost of energy, water, or materials	**0.261*****	**0.255*****
enrequ	Procurement contract requirements	-0.015	**0.040****

*Note ***, ** indicate significance at 0.01 and 0.05 levels, respectively.*

Table 4.9 explains which characteristics are deemed significant by end customers when it comes to gaining circular benefits. Indeed, the findings for the whole sample of enterprises are comparable.

Unlike (Table 8), the encost variable is not substantial, i.e., the high cost of energy, water, or materials. For food industries, on the other hand, the variables enereg, or existing environmental regulations, and encost, or the high cost of energy, water, or materials, are insignificant, whereas enrequ, or the requirement to comply with requirements for public procurement contracts, has a significant impact.

Table 4.9 - Multivariate regression parameters to discover end-users-specific drivers of circular benefits.

esuser		**FBT**	**ALL**
enereg	Existing environmental regulations	-0.074	**0.059*** **
enetx	Existing environmental taxes, fees, or charges	0.100	-0.023
enregf	Anticipated future environmental regulations or fees	0.098	**0.101*** **
engra	Incentives for environmental innovations	-0.008	**-0.050*** **
endem	Market demand for environmental innovations	0.041	**0.154*** **
enrep	Enhancing the enterprises reputation	-0.028	**0.085*** **
enagr	Initiatives to promote good environmental practices	**0.157** **	**0.050*** **
encost	High cost of energy, water, or materials	0.019	0.013
enrequ	Procurement contract requirements	**0.125** **	**0.092*** **

*Note ***, ** indicate significance at 0.01 and 0.05 levels, respectively.*

The results of the link between the circular benefits associated with product, process, organizational, and market innovations and the perceived benefits of enterprises and end users are shown. Two ordered regression locations are shown in Tables 4.10 and 4.11.

The table 10 shows that ecorg and ecomkt variables do not seem to have a significant effect on the number of circular benefits gained by the enterprise. All other factors, on the other hand, are positively correlated with the number of circulating benefits generated by enterprises. The odds ratio results indicate that, in the food industry, product and process innovations have a greater influence on the number of circular benefits than organizational and marketing innovations, whereas in the total sample of enterprises, process and organizational innovations have a greater influence on the number of circular benefits. Thus, marketing innovations seem to be those that have the least impact on the quantity of circular benefits.

Table 4.10 - Ordered logit regression analysis of the circular advantages of innovation for enterprises.

esent		**FBT**		**ALL**	
		Coeff.	*odds ratio*	*Coeff.*	*odds ratio*
ecoprd	Product innovations	**0.704*****	2.021041	**0.601*****	1.824345
ecoprc	Process innovations	**1.051*****	2.859831	**1.123*****	3.074816
ecorg	Organizational innovations	0.300	1.349318	**0.876*****	2.40142
ecomkt	Marketing innovations	0.270	1.30996	**0.605*****	1.83186

*Note *** indicate significance at 0.01 levels.*

Table 4.11 shows that all factors are positively linked with the perceived circular benefits by end users. The odds ratio findings indicate that, in comparison to perceived benefits, marketing and organizational innovations have a bigger weight for food industries, but product and marketing innovations have a greater weight for the overall sample of enterprises. In comparison to them, marketing innovations seem to have a stronger influence on the number of circular benefits accruing to end-users.

Table 4.11 - Ordered logit regression parameters of the circular advantages of innovation for end-users

esuser		**FBT**		**ALL**	
		Coeff.	*odds ratio*	*Coeff.*	*odds ratio*
ecoprd	Product innovations	**0.449****	1.566029	**1.034*****	2.81204
ecoprc	Process innovations	**0.417****	1.517333	**0.463*****	1.588725
ecorg	Organizational innovations	**0.611*****	1.842405	**0.683*****	1.980311
ecomkt	Marketing innovations	**0.916*****	2.500176	**0.810*****	2.248971

*Note ***, ** indicate significance at 0.01 and 0.05 levels, respectively.*

Because of the preceding tables, the food enterprises situation is distinct from that of the overall sample of enterprises. We may presume that there are underlying reasons why many of the criteria that are critical for attaining circular benefits in the whole sample of enterprises seem to have little effect on food enterprises pursuit of them. The next part will address possible explanations for why innovation inside a food industry is more difficult, attempting to explain why the move from a linear economy to a circular economy takes longer.

4.5 Discussion

The findings provide a picture of the elements that drive innovation creation and which product, process, organizational, and marketing innovations have the greatest impact on the number of circular benefits seen by enterprises and end users. Market demand for environmental innovations and the aim to enhance the company's image were shown to be variables influencing the development of product innovations in food enterprises. In comparison, environmental innovations and contractual requirements have an impact on the development of marketing and process innovations, the latter of which are also impacted by high energy, water, and material prices. Additionally, it is discovered that process and product innovation have a significant influence on the number of circular benefits seen by enterprises, in comparison to organizational and marketing innovations, which seem to have a higher effect on end users.

Therefore, we may presume that our findings support what has previously been stated in the literature about the difficulties associated with implementing CE practices in the food industry. Indeed, various studies demonstrate that bio-based products continue to face technological and operational impediments (Gatto and King, 2021), making access to product and process innovations inside food enterprises challenging. Several barriers include: high investment costs (Jaeger and Upadhyay, 2020); lack of appropriate technology (Farooque et al., 2019; Sharma et al., 2019; Borrello et al., 2016; Clark et al., 2019; Gedam et al, 2021); lack of financial and government support (Mangla et al., 2018; Rizos et al., 2015; Farooque et al., 2019; Sharma et al., 2019; Urbinati et al., 2017; Ranta el al., 2018; Kirchherr et al., 2018; Farooque et al, 2019; Sharma et al., 2019); administrative burdens (Rizos et al.,2015); inadequate information management systems (Rizos et al., 2015; Romero and Molina, 2011); social barriers related to lack of interest and awareness by businesses and customers (Kirchherr et al., 2018; Singh and Giacosa, 2019; Singh et al., 2021); lack of qualified personnel (de Jesus and Mendonça, 2018; Korhonen et al, 2018; Guldmann and Huulgaard, 2020; Stewart and Niero, 2018); lack of support from top management, lack of circular design (Lahane et al., 2020); lack of network support (Jaeger and Upadhyay, 2020; Jabbour et al., 2020; Chhimwal et al., 2021); lack of know-how (Farooque et al., 2019; Sharma et al., 2019); lack of reverse logistics management (Borrello et al., 2016; Clark et al, 2019; Gedam et al., 2021); lack of cross-sectoral cooperation (Farooque et al., 2019; Sharma et al., 2019; Rizos et al, 2016; Jaeger and Upadhyay, 2020); low investor confidence in high-risk models; processing inefficiencies; and lack of markets to use energy and byproducts (Nghiem et al. 2017; De Clercq et al., 2016; Armington et al., 2018; Hegde et al., 2018; Lahane et al., 2020).

It is important to stress that eco-innovation and transformational innovation both contribute to the reduction of obstacles to the circular economy's implementation (de Jesus and Mendonça, 2018) through the innovativeness of business models (Magretta, 2002; Richardson, 2008; Osterwalder et al., 2005; Borrello et al. 2017; De Cleene and Bora, 2020; Cembalo et al., 2020). Indeed, the literature has already concentrated on the investigation of acceptable approaches and instruments to assist enterprises in innovation in recent years (Bocken et al., 2019; Pieroni et al., 2019; Rosa et al., 2019). However, developing eco-innovations takes a range of timescales, depending on the kind of barrier and the modifications to current manufacturing processes required (Kiefer et al., 2019), as well as the creation of a diverse set of tools adaptable to various sizes and organizations (Pigosso et al., 2018; Whalen, 2017; Werning and Spinler, 2020). The innovation needs "structure and direction to define and concentrate thought" (Eppler et al., 2011) and may take place in one of two modes: the creation of an altogether new business model or the reconfiguration of current business model aspects (Zott and Amit, 2010). This process include testing and assessing several models that are suited for the goal model and involves changes inside the business, facilitated by the engagement of internal and external stakeholders (Bocken et al., 2018). Services are also seen as crucial in assisting with business model innovation, as well as product and process development (Pelli et al., 2017). Despite the growing body of literature on sustainable business model innovation in recent years (Bocken et al., 2014, 2013; Bocken and Short, 2016; Boons and Lüdeke-Freund, 2013; Evans et al., 2017; Schaltegger et al., 2016b, 2016a; Yang et al., 2017), there is still a dearth of studies identifying gaps in current industry practices for slowing and closing material cycles. Additionally, the adoption of novel circular business models involves the establishment of robust networks that are formed by interdependent but autonomous stakeholder cooperation, communication, and coordination (Antikainen et al., 2016; Oghazi et al., 2018). Indeed, developing innovative sustainable business models requires the involvement of inter-organizational networks, which include not only enterprises but also broader social systems, to establish mutually reinforcing dynamics among firms that promote novel value creation methodologies and the ability to overcome significant barriers (Rotmans and Loorbach, 2010; Johnson, 2010; Lovins et al., 2007; Boons and Lüdeke-Freund, 2013).

4.6 Conclusions

Considering what has previously been covered, the article observes a stark distinction between how enterprises and end users perceive challenges. It was demonstrating how a lack of financial and political backing impairs product and process innovation.

The economic and regulatory aspects of transforming the economy from linear to circular are of primary significance. The significant expenses associated with developing a new method or product, as well as regulatory restrictions, are the primary impediments. Policymakers must guarantee that these enterprises get further economic and regulatory support. In terms of suggestions to enterprises, including end users in a co-creation process might be regarded ancillary to designing a product that meets customer expectations. Their interest in organizational and marketing innovations is an important factor to consider when launching new products, as it enables them to create a product that is both effective and efficient.

This case study demonstrates how a food company utilized customer input to create new products and services. Food market possibilities compel enterprise to adapt scientific findings to meet consumer needs, and in many cases, food companies must collaborate with research institutions to achieve breakthroughs. Collaboration between universities and industry in the food sector significantly increases the likelihood of innovation and the success of new food products (D'Alessio and Maietta, 2008; Cabral and Traill, 2001; Stewars-Knox and Mitchell, 2003).

Science and technology research provides the impetus for radical eco-innovations, and thus encouraging science and technology research in universities and public research centers, as well as facilitating science and technology exchanges through public-private partnerships, would be beneficial in encouraging these eco-innovations.

Transitioning to CE will need surmounting innovation obstacles that would be insurmountable in the absence of system-level innovation. This indicates that enterprises had to learn and amass information to improve their operations, get a better understanding of the manufacturing process, and find opportunities for development, ultimately resulting in more circular, sustainable, and efficient processes.

4.7 Limitation

In terms of constraints, the data evaluated in this research are not current. As a result, it is expected that throughout the years following data collection, there have been advancements in the improvement of food sector innovations. For this reason, the analysis must be updated with current data to accurately assess and compare the innovative development of the enterprises throughout the years.

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5.Discussion and conclusion

Food waste, which is acknowledged as a serious economic, environmental, and social issue, continues to pose a substantial challenge to modern food systems.

Due to the indiscriminate use of natural resources, the transition to a circular economy model is now necessary in light of the concerns that have emerged in recent years.

In addition, globalization, in which consumers around the world expand their access to markets and adapt to current consumption patterns, has both positive and negative effects due to the massive consumption of raw materials.

The article proposed in Chapter 2 is based on a categorization of the key issues that have surfaced and covers topics such as business model and organization management, food loss and waste along the supply chain, analytical tools for the circular economy, stakeholder acceptance of the circular economy, mitigation strategies, and policy approach. The results highlight the need for cleaner production models, which will improve stakeholder knowledge and responsibility among both producers and consumers, and, in addition, the need to put the right tools and legislation in place.

However, moving toward circular business models (CBMs) entails a transition that involves a number of internal activities (Grant, 2010) influenced by numerous constraints. For this reason, the transition to a CBM requires to be accompanied by numerous strategies, approaches, methods, and tools that work hand in hand (Bocken et al, 2016) and addressing challenges, both cultural and institutional, that limit its implementation (Oghazi et al., 2018), which refer to organization (Rizos et al., 2016).

Another significant issue is technological know-how, since using the proper information and data management systems to enable materials traceability and reverse logistics is difficult due to a lack of expertise in product design for materials recycling (Kok et al., 2013; Scott, 2015; Laubscher and Marinelli, 2014).

Furthermore, in order for circularity to be possible, all parties must work together (Rizos et al., 2015; Rizos et al., 2016), and a connected system that considers goal achievement is required (Planing, 2015; Barquet et al., 2016; Kok et al., 2013), so it is crucial to have trust between partners, mutual benefits for all partners, and increased dependence on partners. From a marketing standpoint, restrictions on customer type, product categories, fashion vulnerability, cannibalization risk, pricing strategies, branding, and sociocultural issues, including customer habits, public opinion, and consumer acceptance, necessary to predict future product demand, have been identified as challenges (Ghisellini et al., 2016; Genovese et al., 2017).

In this context, the study in Chapter 3 set out to assess intentions and behaviors related to reducing plastic consumption in the food context in order to determine the propensity for sustainable behavior among consumers, particularly millennials.

An extended model of the theory of planned behavior (Ajzen, 1991) was used in the survey to identify psychological and behavioral factors. The results revealed that attitudes, subjective norms, and perceived behavioral control all have an impact on millennial consumers' intention to reduce their use of plastic bottles.

Results from self-reported behavior, however, show that respondents prefer plastic beverage containers while eating daily meals at home, and they convince us that particular policy measures are required to help people feel more in control of hurdles and barriers (Kirchherr et al., 2017).

Several published studies describe food market actors responsible for food waste (Borrello et al., 2017; Borrello et al., 2020).

Indeed, Clark et al. (2019) suggest that customers play a crucial influence in companies' adoption of transformative packaging solutions to improve CE. It is also apparent that their disposition and propensity for a sustainable strategy are influenced by their experiences, education and culture (Pereira et al., 2018; Fogarassy et al., 2020). Therefore for most people to adapt, policy measures must take into account the viability of differentiation systems.

Regarding millennials, Fogarassy et al. (2020) argue that companies should target them through university education regarding circular innovation with appropriate marketing strategies.

Indeed, design and brand elements influence customer sentiment toward items made from innovative materials that promote circularity (Aschemann-Witzel and Peschel, 2019).

Indeed, when organizational and marketing innovations receive more attention from end users, firms can use them to engage consumers in the development of new goods and services.

The food industry, therefore, pushes companies to innovate to meet customer needs, and often, to turn these ideas into reality, food companies must collaborate with research institutions (Kirchherr et al., 2017).

Eco-innovations, in particular, are thought to be crucial for transforming the food system toward a more circular model based on sustainable agriculture and food processing. These innovations help to mitigate the environmental effects of production and consumption, which are important elements of sustainability transitions.

Rabadán et al. (2019) conducted a research emphasizing the crucial role that eco-innovation technology plays in enhancing the sustainability performance of agriculture enterprises.

do Canto et al. (2020) have shown that the presence of a network among supply chain participants is a precondition for sustainability. Particularly, the authors claim that social capital's processes may motivate partners to undertake strategic sustainability efforts, particularly if managers share crucial considerations for the adoption of eco-innovations and the overall sustainability of the supply chain. However, the study results outlined in Chapter 4 show how economic and financial considerations influence how firms introduce innovations and how a lack of government support has hindered the adoption of new products and processes (Jaeger and Upadhyay, 2020).

As they play a critical role in promoting the transition to a circular economy, managers and policymakers must have a thorough understanding of how the circular economy operates in the food business.

In addition, to reduce food waste, today's challenges include persuading various stakeholders in the supply chain to participate in food education and using marketing methods to engage and motivate consumers to participate in food education.

Indeed, the latter would be a significant element influencing customer acceptance of items created from recycled materials, therefore assisting businesses interested in employing recycled resources for their products. They can only help to a circular economy and lessen the effect of our consumption on the environment if they obtain a more prominent position on the market and are embraced by consumers as viable alternatives.

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