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Implementation of Circular Business Models for Olive Oil Waste and By-Product Valorization

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Abstract: Mediterranean olive oil producers have multiple incentives for adopting circular business models and better resource management, facing water scarcity and huge amounts of waste, but also seeing new opportunities for value creation. This article aimed to understand how circular business models valorizing olive oil waste and by-products are implemented. Ten business cases from six Mediterranean countries were studied, mainly based on semi-structured interviews with enterprise managers. Data were analyzed according to the business model canvas elements, success factors, and barriers while considering the institutional context. The results highlight the diversity of activities, types of resources used, and partnerships and products offered in different market segments. The principles of biowaste conversion and circularity, such as cascading, upcycling, recycling, and recovering, are all applied. The key success factors comprise an environmental concern, knowledge about biotechnologies, markets and logistics, a long-term commitment to the sector, local availability of resources, legislation, subsidies, and product acceptance by consumers. The main barriers include a lack of specific public financial support, an insufficient knowledge transfer from research to olive oil producers, and a lack of articulation of needs for research by the enterprises. More public-private collaborations and multi-stakeholder projects are needed for further shifting to a circular economy in the olive oil sector.

Keywords: circular economy; bioeconomy; business models; sustainable production; agricultural waste and by-products; Mediterranean olive oil sector

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1. Introduction

The Mediterranean region is facing specific threats coming from climate change, particularly water availability [1]. A region that is an important biodiversity zone, with an outstanding diversity of up to 25,000 species, 60% of which are indigenous, is now also a major climate change hotspot [2]. Temperatures are rising 20% faster than in the rest of the world, causing diverse environmental [3], but also economic and social, problems [4]. Some of the major challenges are coming from an intensification of agriculture, pressure on water resources, and food losses and waste [5]. In particular, one of the leading Mediterranean sectors, olive oil production, is paradoxically dealing with a double challenge, regarding water as a resource being preciously needed for irrigation [6] and on the other hand water being polluted in the industrial process of olive oil production [7]. Besides wastewater, whose quantities depend on the extraction method, olive oil production generates huge amounts of olive pruning waste (wood, branches, leaves) and other industrial by-products (olive pomace, olive stones) [8]. These residues are not only problematic given the environmental impact, but they also are from an economic perspective, as their management and disposal

are expensive [9]. In terms of amounts, the estimation for European producer countries is at 9.6 million tons/year of waste from the olive mills (whereof olive pomace represents the biggest part, with 8.4 mission tons; the remaining part are stones and leaves) and 11.8 million tons/year of additional residues from the olive tree pruning process (wood, branches and leaves), whereof only 30% can be used, as its recovery is difficult in mountains [10]. Due to this, olive oil producers face multiple incentives to adopt circular business models and better waste management, driven by institutional regulations, especially regarding olive mill wastewater, societal demands, and resource scarcity. However, an increasing number of enterprises are also seeing new opportunities for sustainable value creation based on olive waste and by-products [11].

For acting on challenges related to waste, resource scarcity, and overuse, various global institutions are calling for more sustainable choices. For example, the United Nations, with the Sustainable Development Goal (SDG) 12 Responsible production and consumption [12], are expressing the global ambition for achieving zero waste, with a particular reflection on water, energy, and food. The SDG 12 specifically targets a sustainable and efficient use of resources and a reduction of (food) waste generation through prevention, recycling, and reuse. Furthermore, one of the founding pillars of the European Green Deal, the agenda launched in 2020 by the European Commission, is the Circular Economy Action Plan [13]. Its aim is to become a global leader in the domain by promoting sustainable consumption and ensuring less waste production. The Action Plan also underlines the negative environmental impact of food value chains with regard to losses of resources and it announces a new regulation aiming at water reuse and efficiency, being particularly important for the Mediterranean region [13]. The circular economy is hence proposed as a solution for a more sustainable world. For the concept of the circular economy, however, there is no strict common definition agreed on by the scientific community until now [14]. Kirchherr et al. [15] analyzed 114 circular economy definitions, using the activities of reduction, reuse, and recycling as a foundation, and most of the cases pointing to the system change needed for implementation.

This article aims to understand how circular business models valorizing olive resources, including olive oil waste and by-products (for food and non-food applications), are implemented. Up to date, research has mainly been dedicated to developing olive oil waste treatment solutions and new conversion technologies for adding higher value. Therefore, a new approach from a business perspective is here chosen to identify the key elements, success factors, and barriers of the circular business model implementation for olive oil waste and by-product valorization. The more specific objectives are to understand (i) the particular business model canvas elements and circular strategies applied by enterprises in the olive oil sector, (ii) the success factors and barriers of those circular business models, and (iii) the specific role of the institutional context in circular business activities. Ten business cases valorizing waste and by-product from the olive oil sector are studied. The selected cases are localized in six countries of the Mediterranean area, thus presenting diverse national contexts.

In the next section, the theoretical background-circular business models and the particular challenges of the olive oil sector related to waste and by-products is introduced, and a conceptual framework for the business model analysis is proposed. Afterward, the methodology is presented. The main results from the ten cases of circular business models in the olive oil production sector are outlined, followed by a discussion. Finally, some major conclusions are drawn, with preliminary recommendations and future research ideas for this topic.

2. Background

2.1. Circular Business Models

For business models in general, a basic yet straight-to-the-point definition is that "business models are stories that explain how enterprises work" [16] (p. 4). For Teece [17], a business model represents the logic of a firm to create value for customers while ensuring a

viable economic business structure. For a more detailed understanding of business models, employing the business model canvas developed by Osterwalder and Pigneur [18] a decade ago is the common approach. The main component of the business model canvas is the value proposition, i.e., the value that the enterprise proposes to the customers to solve their problems and satisfy their needs. The main building blocks and elements around the value proposition are: (i) infrastructure/value creation, including key activities, key partners, and key resources; (ii) customer/value delivery, including customer relationships, customer segments, and channels; (iii) financial/value capture, including the cost structure and revenue streams.

More recently, sustainable and circular business models have been explored by researchers [19–23] who adapt the business model canvas by including elements of the circular economy and sustainability. In this article, the canvas model is also used, as it is a well-established, widespread tool for visualizing and analyzing the core elements of a business, and it is applicable to sustainable and circular business models. It is well adapted for analyzing both emerging businesses with new and recent activities, focusing more on value creation elements, as well as for traditional businesses. In the case of olive waste and by-product valorization, both long-lasting practices are present (such as pomace oil or soap production) as well as more innovative recent practices.

Circular business models are models that incorporate circular economy principles as guidelines. Various definitions of circular business models outline, as their core principle, the aim to fully close, slow, or narrow product or material loops [24]. Some authors consider circular business models to be a subcategory of sustainable business models [25,26], with circular business models being more concrete, as they describe the ways to achieve sustainability [27]. Bocken et al. [25] also define circular business models as models that propose value creation from waste or provide functionality instead of products, avoiding linear value creation. Linder and Williander [28] consider a circular business model as one where the logic for value creation is based on the economic value retained in products after use for producing new products. Mentink [29] (p. 35) defines circular business models as those following a logic of closing material loops.

Stål and Corvellec [30] consider that circular business models are generalized templates prescribing how enterprises should organize themselves to be aligned with the circular economy as an emerging institution. They argue that the enterprises' organizational choice is limited to similarities in practice and structure, resulting from rules, norms, and beliefs, which are the outcome of institutional regulative, normative, and cognitive processes. In particular, the influence of regulative processes is interesting in the context of our research, as it was conducted in six Mediterranean countries where a strong advocacy for the circular economy exists, in particular in the North of the Mediterranean. As the study includes the role of external factors, Stål and Corvellec's [30] hypothesis offers an additional frame for an analysis of circular business models.

Lüdeke-Freund et al. [26] provide major circular economy business model patterns: repair and maintenance; reuse and redistribution; refurbishment and remanufacturing; recycling; cascading and repurposing; and organic feedstock. For the context of bioeconomy and agriculture, the last two patterns are pertinent. Cascading and repurposing business models are founded on the eco-principle that 'waste is food', value creation is based on cascading, i.e., taking back the valuable biological nutrients still existing in the product components, used materials, and waste. Finally, the organic feedstock business models come in place after all the cascading is done, and when the remaining biomass can be recovered for the production of energy.

Circular business models, in a bioeconomy context in general, still face numerous barriers or challenges, such as a lack of financial capital, price competitiveness compared to traditional products, a lack of adequate technologies, or a lack of consumer awareness, to name the most important ones [31]. For business models valorizing agricultural waste and by-products, Donner et al. [32] identified critical success factors related to biotechnology

developments, logistics, joint investments and partnerships with research institutes, public regulations, and financial support, as well as local stakeholder involvement.

2.2. Particular Challenges of the Olive Sector in the Context of a Circular Bioeconomy

Olive is a perennial Mediterranean crop, used for the production of oil and table olives. The European Union is the major producer of olive oil, accounting for 69% of the worldwide production. Around two million tons of olive oil are produced in the EU every year, particularly in countries from the Mediterranean region (Spain accounts for 66%, Italy 15%, and Greece 13%) [33]. Olive oil is a major gastronomic pillar in the region and the central point of the Mediterranean diet. Olive oil production is also a key sector for employment in the rural Mediterranean areas, as 20–30% of the population works in the sector [34]. On the other hand, olive pruning and olive oil processing generate huge waste streams, whose quantities and physical–chemical characteristics of the waste and by-products depend on factors related to the fruit (e.g., variety or ripening stage), the year of production, microbial treatments, and the method used for the oil extraction [35,36]. There are three different extraction processes: the traditional hydraulic process, which is sometimes still used due to the high quality of the oil obtained, and two different centrifugal processes, using three-phase or two-phase systems [37]. Continuous centrifugation systems improve the quality of olive oil and reduce waste by 75% [38,39]. For example, while olive mill wastewater is primarily produced in the traditional and three-phase extraction process, with 400–600 kg and 1000–1200 kg wastewater, respectively, for 200 kg of oil, the two-phase system produces only 85–110 kg [40]. Even though olive mill wastewater contains phytotoxic properties, it is sometimes still thrown in the surrounding environment, causing soil, plant, or groundwater contamination [41]. In addition, the wet olive pomace that is produced in higher amounts by the two-phase extraction process has strong odor emissions, and, due to its pasty texture, its transport and management is difficult [42].

In general, treating olive mill effluents is challenging for several reasons, as highlighted by Ergüder et al. [43] and Komnitsas et al. [41]. Olive mill effluents have a high organic loading, they are seasonal (as olive mills are operated only from November to February), and they are also territorially scattered. In addition, the costs for installing a waste treatment facility are high, especially for small- and medium-sized producers, and the organic compounds, such as fatty acids and phenolic compounds, are hardly biodegradable. Finding solutions for olive oil waste and by-products is of the utmost importance to avoid negative environmental externalities and to locally protect and preserve scarce resources such as water, soil, energy, and raw materials. Olive oil waste and by-products can be converted into new ingredients and products with an added value via circular economy and bioeconomy approaches. Different valorization opportunities exist; from lower to higher-added value, they are from bioenergy, biofuels, bio-fertilizers, purified water, bio-based materials, food, and feed to special ingredients for the pharmaceutical or cosmetic sectors, as shown in the biomass value pyramid [11,12]. The valorization is based on circular and bioeconomy principles such as cascading (a consecutive production process in which waste is first used for high-added value products or ingredients before using the remaining biomass for lower added-value), upcycling (converting waste into a higher added-value), recycling, or recovering for bioenergy use. However, despite the high-adding value potential, according to an estimation in the most important olive oil production region Andalucía in Spain [10], most of the biomass is currently used for low or medium-value products. Energy production accounts for 80% (whereof 47% is for electricity and 33% for thermal energy production), composting or direct application in the field for 14.3%, landfill for 0.7%, and 5% is used for animal feed [10].

2.3. Proposition of a Conceptual Framework

With the literature introduced in Section 2.1 and 2.2, the following conceptual framework is proposed for our business case analysis (Figure 1). In includes business model canvas key elements based around value creation, proposition, delivery, and capture [18];

circular strategies (cascading, upcycling, recycling, and recovering); bioeconomic principles (waste conversion from higher to lower value) [11,12,26]; circular bioeconomic business models success factors and barriers [31,32], as well as the role of the institutional context for a circular economy [30].

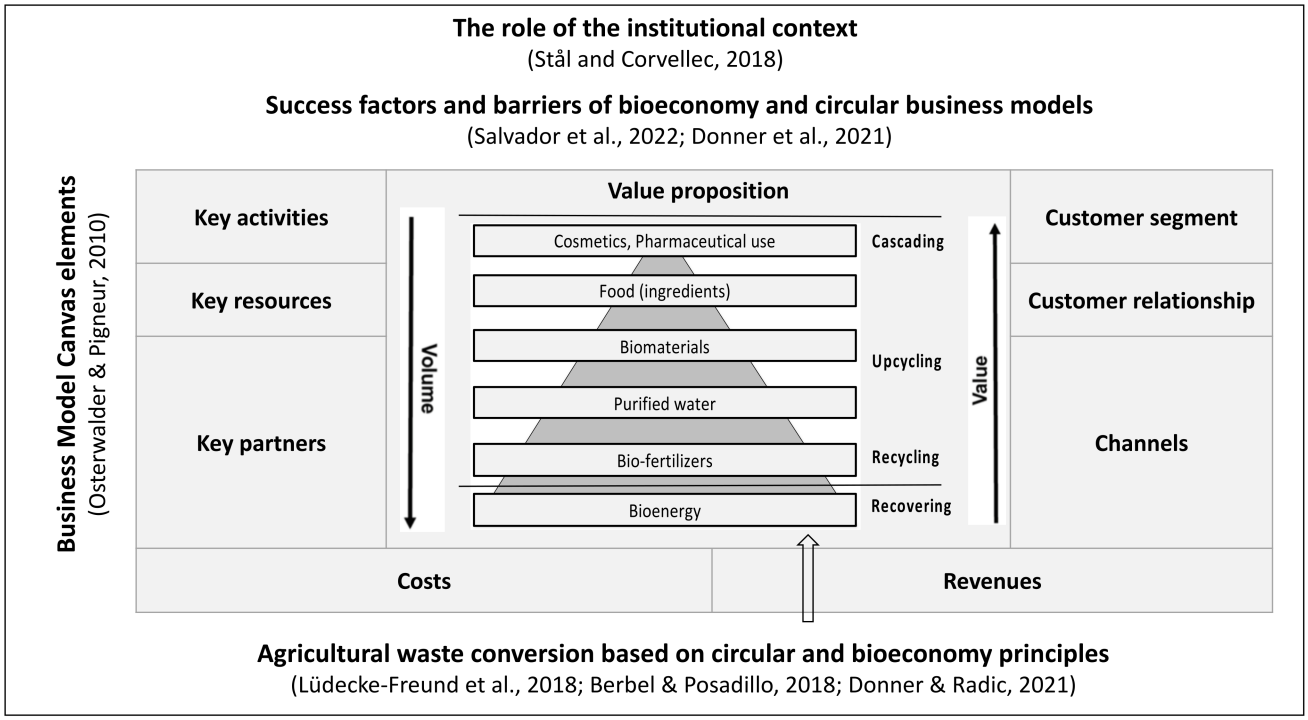

Figure 1. Conceptual framework for the business case analysis (based on [11,12,18,26,30–32]).

3. Methodology

The criteria for selecting the business cases were the diversity (i) of countries and their contexts, (ii) of types of initiatives (e.g., specialized in waste valorization vs. non-specialized, family business vs. cooperative, small vs. large-scale), and (iii) of the business model elements-resources and value propositions. Additionally, snowball sampling was employed for receiving referrals from the project partners and experts in the olive oil sector for getting in contact with the enterprises. The willingness and availability of business managers to conduct interviews was a final factor for proceeding with the case studies.

The search resulted in ten studies of olive oil businesses from the following Mediterranean countries, as illustrated in Figure 2: Spain (1 case), Morocco (1 case), Tunisia (2 cases), Greece (3 cases), Italy (2 cases), and France (1 case).

The natural and climatic conditions in these Mediterranean countries, characterized by hilly landscapes, dry and hot summers, and wet and mild winters, are similar and very favorable for olive trees (https://ec.europa.eu/environment/nature/natura2000/biogeog_regions/mediterranean/index_en.htm, accessed on 8 July 2022), and they are considered one of the most ancient and best-adapted species to the Mediterranean-type climate [44]. Due to the long life of olive trees and also partly a shift from low-density to intensive or even super-intensive cropping systems requiring large areas and irrigation, different varieties exist [44]. The main cultivation characteristics and olive oil production volumes of the six countries studied are shown in Table 1, going from the country with the largest olive oil production volumes (Spain) to the smallest one (France). Table 1 also highlights the similarities and differences between the countries in terms of production mode and the part of irrigated area, which is especially high in Morocco due to the increasing heat and drought (https://www.oliveoiltimes.com/production/heat-and-drought-hamper-olive-harvest-in-morocco/99868, accessed on 8 July 2022).

Figure 2. Location of the ten business cases studied.

Table 1. Main cultivation characteristics and olive oil production volumes in the six countries (based on [45]).

	Spain	Italy	Greece	Tunisia	Morocco	France
Production surface (ha)	2,623,156	1,230,000	1,125,000	1,825,000	1,015,000	60,000
Main varieties	Picual, Picudo, Empeltre, Hojiblanca, Cornicabra, Lechín de Granada, Lechín de Sevilla, Manzanilla Sevillana, Manzanilla Cacerena, Verdial de Badajoz, Arbequina	Carbonella, Coratina, Frantoio, Grappolo, Leccino, Bosana	Agouomanacolia, Corfolia, Koroneiki, Mastoidis, Andramitini, Konservolia	Chamlali, Chétoui, Oestali, Chemchali	Moroccan, Picholine, Haouzia, Maslala, Menara	Araban, Argetal, Bancal, Boutillan, Cailletier
Irrigation (%)	32	19	16	3	83	0
Rainfed (%)	68	81	84	97	17	100
Production Mode:						
Low-density (%)	71.2	80	80	91.2	75	68.4
Intensive (%)	26.3	19	19.5	6.5	20	21
Super-intensive (%)	2.5	1	0.5	2.3	5	10.6
Olive oil production volume (×1000 t)	1342.33	386.77	213.67	183.33	126.67	3.97

For each case, the data available online (websites, videos, articles) were compiled as a preparation. In addition, semi-structured interviews were conducted with the enterprise managers, mainly via skype or telephone. For the two Tunisian cases, on-site visits could still be performed before the COVID pandemic travel restrictions. The semi-structured interview guide for circular business model assessment from Donner et al. [46] was adapted to the specific olive oil sector and the Mediterranean context, including political-legal and market conditions, business objectives and development, and technological, organizational, marketing, and financial aspects (cf. Appendix A). The interviews were conducted in English, French, Italian, and Spanish.

Of the ten cases studied, eight produce olive oil and additionally valorize waste and by-products. Their main value proposition is then the olive oil, and the waste and by-products generated in the process are being handled to use the remaining value. The two businesses that are not directly involved in olive oil production but whose main activity is

waste valorization (cases 1 and 10), are partnering with the olive oil producing companies in order to (i) create energy based on olive biomass (case 1), (ii) extract polyphenols from the olive wastewater for use in the cosmetic or food industry (case 10), or (iii) create innovative materials based on olive kernels, with possible applications in the cosmetics industry, construction industry, and animal feed (case 10). The main type of activity, i.e., whether waste and by-product valorization are a main or side activity, impacts the circular business model implementation. In case of a cooperative or company that is already focused on olive oil production, the knowledge about the olive resources and the proximity to the olive farmers and millers is higher, and the business model innovation then consists of a diversification of activities. In case of a (start-up) company or cooperative specializing in by-product valorization, a completely new business model needs to be developed, or the existing business model has to be significantly modified, new partners searched and cross-sector markets be entered; therefore, the risk of failure is higher.

The key data of each case were first synthesized as the following: name and type of the business, country of origin, main activities, history and key objective of the enterprise, type(s) of resources and technologies used, and products or services offered to the markets, partnerships, and marketing strategies (Table 2). According to our research objectives, the specific focus of the analysis was on the business model canvas elements: the key activities, resources and partnerships, the value proposition (i.e., the products and/or services offered based on bioeconomy and circular principles), the key customers, marketing and distribution channels, and financial structure. Furthermore, for a better understanding of the socio-economic environment for circular economy activities in the olive sector, success factors and barriers for the circular business model adoption, as well as the specific role of the institutional context, were analyzed.

Table 2. Overview of the ten cases studied.

Case Number	Type of Enterprise	Country	Main Activity	Key Driver	Olive Resources	Products and Services	Partnerships	Marketing Strategy
1	Small private enterprise	Morocco	Production of energy (heat, electricity)	Excess of olive pomace and stones in the territory	Olive pomace, olive stones	Heat, electricity, service for heating installations	With olive oil producing companies	Energy sold to national hotels and industry
2	Large family-owned enterprise	Tunisia	Refinery for production of olive pomace oil, biomass collection	Lack of olive waste collection in the territory, business opportunity	Olives, olive pomace	Pomace oil, biomass	Few industrial partners	Export strategy to Europe for oil and biomass
3	Family-owned enterprise	Tunisia	Olive plantation and production of extra virgin olive oil	Environmental concern, water saving	Olives, wastewater, branches, leaves	Olive oil (partly organic)	Animal producers, pomace oil firms, public partners	Local for by-products and export for organic oil
4	Large cooperative	Greece	Olive growing, production of extra virgin olive oil, cheese, animal husbandry	Modernization, shift to more environmentally friendly production	Olives, olive pruning residues, pomace	Olive oil, olive pomace oil, olive kernels, cheese	With regional farmers and research institutes	Local and export for oil
5	Large share-holding private company	Greece	Production of extra virgin olive oil, bottling of oil	Better quality of olive oil, traceability from the field to the bottle	Olives, olive leaves, pomace, wastewater	Olive oil, bottling service	Local olive farmers, olive mills	Worldwide export of olive oil, local use or sales of by-products

Table 2. *Cont.*

Case Number	Type of Enterprise	Country	Main Activity	Key Driver	Olive Resources	Products and Services	Partnerships	Marketing Strategy
6	Cooperative	Greece	Production of olive pomace oil, cosmetics, soap, bottling of oil	Profit of pomace oil higher than for olive oil	Olives, olive pomace, olive pruning biomass	Olive pomace oil, bottling and trading service	Member of a local cluster of companies	Pomace oil exported, olive oil sold in local shops, soaps to hotels
7	Cooperative	Spain	Production of refined pomace oil	Amounts of pomace in the region	Olives, olive pomace, olive pruning biomass	Pomace oil, waste treatment service	Many olive oil mills as providers of olive pomace	Mainly export, but also local sales
8	Cooperative	Italy	Olive growing, production of olive oil and wine	Find a solution for wastewater, strict regional regulations	Olives, leaves, pomace, pruning biomass, wastewater	Olive oil, wine	Public partners	Providing biomass for heating in local public buildings
9	Family enterprise	Italy	Production of olive oil, extraction unit for mills	Water as a scarce resource	Olives	Olive oil, new technology for oil extraction using less water	Local olive oil producers	Mainly local sales
10	Union of cooperatives	France	Valorization of wine, olive, and fruit waste	Environmental problem of olive mill wastewater	Wastewater from olive mills	Diverse products and applications, olive polyphenols	Local olive oil mills	Export of polyphenols mainly to Asia

4. Results

In this section, the results are presented according to the three objectives of this article, namely, to understand the particular business model canvas elements and circular and bioeconomy strategies applied by enterprises in the olive oil sector (Section 4.1), the success factors and barriers of those circular business models (Section 4.2), and the specific role of the institutional context on circular business activities (Section 4.3).

4.1. Circular Business Model Canvas Elements in the Olive Oil Sector

The main elements of the business model canvas by Osterwalder and Pigneur [18] are presented as follows: key activities, key resources, key partnerships, value proposition, customers and customer relationships, marketing and distribution channels, costs, and revenues.

In the analyzed cases, the following key activities in circular business models in the olive oil sector were observed:

- The enterprises that produce olive oil use multiple olive tree resources and employ different valorization pathways. In the olive plantation field, olive branches and leaves usually are used for composting (as in cases 4 and 8); hence, they remain in the same field for fertilization, representing a reuse of resources. Branches and leaves can be used for covering the soil, which to an extent prevents successive transpiration and loss of humidity from the soil (case 4), representing a reduction of resources, as less water is needed for irrigation. Another use for pruning leftovers is feed for animal husbandry (cases 4 and 8), being often a coupled activity with olive growing in the Mediterranean region and representing an upcycling of the resources.
- The processing unit level—the olive oil mill—is where the main product is created: extra virgin olive oil, which represents around 20% only of the olive resources used. The remaining by-products are olive pomace, a solid by-product containing pulp and olive kernels, and wastewater (as water is added for the extraction process). Additional

oil can be extracted from olive pomace, being of lower quality and called olive pomace oil. However, this product has a different usage than the virgin oil, as it is well-adapted for cooking at high temperatures and is hence valuable in the food industry (cases 2, 4, 6, 7, 8). Depending on the technology of the mill, wastewater can be reduced (case 9); however, in this case, the solid part—wet olive pomace—is more humid and needs an additional technological process of evaporation of water, requiring the use of energy. This energy is often generated by the final biomass left.

- After a complete oil extraction process, the remaining biomass is normally used directly in situ for energy, but in some cases, it is also exported to remote countries. Then, the logistics and transport costs play a discriminating role (cases 2 and 7).

The key resources are above all the biological resources such as the olive, the pruning waste (branches, leaves, wood), and the by-products (olive cake, olive mill wastewater) from the olive oil extraction process. Firstly, these are fully biological materials, which can provide several value propositions through cascading until the final utilization of the remaining biomass. Usually, the waste generated in the olive mill is a resource for the refinery, or a company producing soap, and even polyphenols. The energy resources used for the functioning of the mill or refinery often come from olive oil production itself (remaining biomass). Apart from the biological resources, another key resource is the infrastructure needed for valorizing waste and by-products. For example, the refinery for the treatment of pomace is needed for the cascading valorization of olive pomace, namely the extraction of all the available oil until the leftover biomass (cases 1, 2, 6, 7, 8). Furthermore, patents issued from R&D activities allow the protected use of innovative technologies, e.g., for the extraction of polyphenols (case 10), or for oil extraction (case 9). Finally, the importance of human resources is essential, as the implementation of a circular economy approach requires highly skilled teams, as confirmed by case 4 where the cooperative was transformed by a young proactive management, or case 5 where the collaboration with sustainability consultants was one of the key factors for a successful circular economy approach.

Key partnerships are one of the crucial elements for the adoption of circular business models in the olive oil sector. In certain cases, the partnership is traditional via agricultural cooperatives as in case 7, with around 2000 small farmers providing olive pomace, thus representing a collective effort of waste valorization. In case 4, the cooperative is also serving for collective marketing, as olive oil issued from the olive production of numerous small farms is collectively branded under the cooperative mark. Cooperatives in general seem to be ideal structures regarding the critical waste quantities needed for a profitable collection and valorization, including investments in technologies. Partnerships can also appear in the form of a business cluster, gathering enterprises from the same region, as in case 6. A shareholding enterprise can also form strong ties with farmers providing the primary matter (olives) in the form of partnerships in which farmers comply with the quality requirements, and the company then provides input used for production and advisory service (case 5). Partnerships with R&D centers, in particular universities and public research institutes, exist but were, in the cases studied, considered rather problematic and not easy to implement, despite the strong need for this kind of collaboration. In case 8, there was a collaboration with universities in the past; however, the interviewed person described the university research process as “never giving final results”. When asked about partnerships with research centers or universities, another interviewee (case 1) responded: “Enterprises and universities are two separate worlds”.

Several possibilities for value propositions based on circular and bioeconomy principles were found. One of the value propositions is the olive oil, issued from a production site applying circular principles (cases 3, 4, 5, 6, 8) and in particular, the active management of waste. These enterprises valorize waste and by-products themselves (cases 4, 5, 6, 8) and/or by creating partnerships (cases 3, 5). Another value proposition is the bioenergy offered in the form of heating or electricity (cases 1, 2, 5, 8). Next, cosmetics and soap are sold as very traditional products (cases 2, 6). In addition, ingredients for animal feed are

proposed (cases 4, 5, 8), which represent upcycled products from the solid waste of the olive oil production, as they have an additional value and contain high-quality components/supplements for animal feed. Another type of value proposition is the extracted molecules of polyphenols, which can be used in the cosmetic, pharmaceutical, and fortified foods sectors (cases 8, 10). Innovative technological solutions for olive oil production using less water are one of the newest value propositions allowing the fulfilment of the reduction principle of the circular economy (case 9). Finally, treating wastewater or recuperating wet pomace are service types of value propositions in circular business models (cases 7, 8, 10).

For the final products or outputs issued from the olive waste and by-product conversion, the majority of cases (1, 2, 6, 7, 8, 9, 10) have a B2B (business-to-business) approach to the customers. For example, the energy produced from biomass (heat, electricity) is used by industrial customers such as hotels, the food industry (case 1), or public facilities (case 8). Pomace oil is sold to the food industry (case 6, 7). Customers for animal feed are the farms involved in animal husbandry, mainly cattle production (case 8) or ruminant production (case 4). The polyphenols issued from olive wastewater are offered to the pharmaceutical and fortified food industry (case 10). Strong customer relationships mainly are created based on territorial proximity, in which case the circularity principles truly are important, as the customers are in the same territory as producers and, all together as a community, are working on a circular economy transition. In certain cases, with olive oil as the main product sold, there is a B2C (business-to-consumer) approach (cases 3, 4, 5, 8). The relationships with consumers aligned with the circular economy principles; in these cases, they take place through direct visits of the farm or enterprise and practical experience of tasting the final products (olive oil) in the farm where it is produced.

Marketing and distribution channels for olive oil vary, and it can be sold both directly on-site or indirectly via the firms' website (cases 3, 4, 5, 6, 8) to restaurants (cases 4, 5) or using a network of international distributors (case 5). The oil is branded with its own enterprise mark (cases 3, 4, 5, 6, 8) under a private label (cases 5, 6) and with collective marketing brands, such as geographical indications (cases 4, 5, 8). Pomace oil is usually distributed to the food industry (case 6, 7). For polyphenols, the marketing and distribution are rather complicated, the offer is very high, and the demands are very dispersed; hence, the distribution must happen via specialized distributors (case 10). Biomass is sold to facilities for heating or electricity production directly (cases 2, 7, 8) or through international platforms (case 7).

For the revenue streams, it was not easy to extract detailed information; however, some insights were available. Extra virgin olive oil is often a niche and rather highly-priced product. For illustration, a price of organic extra virgin olive oil from Greece issued from a company aligned to circular economy principles is EUR 12/liter, while in the supermarket one can buy extra virgin olive oil for less than EUR 2/liter. The involvement in circular business models thus seems to have a positive effect on the prices of the main products (olive oil) and also on the revenue streams, but it can also lead to a reduction of costs of production, as in case 5 where the complete olive oil production facilities use their own biomass for heating and electricity, or in case 4 where the biomass after pruning is used instead of purchasing fertilizers. Furthermore, the profitability of by-product valorization is, in most of the cases studied, rather positive, as it provides (additional) income; however, by-product valorization activities in general do not always lead to important economic advantages. The profitability also seems to depend on the value propositions and target markets: in case 1, for example, the bioenergy production is profitable if it is sold at a local scale; in case 2, the raw biomass is lucrative as exported from Tunisia to Europe; for case 6, exporting raw pomace oil provides good margins, as it is refined at low costs in other European countries; however, in case 7, the refined olive pomace oil is only profitable, as the mills do not charge for the pomace; in case 8, providing pellets for heating is profitable, as the local market demand is high; and in case 10, the olive by-product valorization is not profitable due to the strong market competition for polyphenols.

4.2. Success Factors and Barriers

Using waste and by-products of olive oil production are long-standing practices (as soap and pomace oil have been produced for centuries already), and the pioneers in the field are now well-established companies with successful business models (cases 1, 2, 6, 7). For example, an interviewee (case 2) stated about the enterprises' pioneer status in the sector: "I am the only person in Tunisia to be involved in biomass, we can make a lot of money with the by-products!" Although this statement seems to be exaggerated, this enterprise owner was already starting to seize the business opportunity based on olive by-products in the 1990s by investing in a soap factory.

The sustainable image of an enterprise is often a driver for implementing sustainable and circular practices as a way of keeping the promise to clients for an engagement in environmental sustainability. In case 5, e.g., the company vouched to become 'zero waste' in the next 3 years; they consider it achievable, and they want to give a second use to everything used in their company "From the pen, to the printing paper, tasting cups, everything!".

Concerning circular business model success factors, the following internal and external factors were observed.

4.2.1. Internal Success Factors

- Environmental concern: enterprise managers are aware of the potential negative impact of their activities on the environment, especially concerning toxic wastewater and water scarcity. They realize that, to continue their activities, more sustainable practices are needed. "We are proud to carry out the project which responds to the calls for environmental care, water saving, circular economy, biomass, and also nutrition" (case 9).
- Knowledge: in case 4, the educational level and knowledge about modern technologies, as well as knowledge about marketing strategies, was stated as one of the key success factors.
- Logistics/proximity: this concerns the organization for the waste and by-product collection from olive plantations and often many different small mills dispersed in the territory. As indicated by case 7, the activity is viable only for resources coming from a radius of 120 km. In addition, the logistics for selling the products need to be organized. Here, the proximity of ports in case of export is an advantage (cases 2, 6, 7).
- Partnerships: stable and trustful partnerships are crucial, especially with local olive producers as waste suppliers and in the case of cooperatives (cases 4, 5, 7, 8, 10).

4.2.2. External Success Factors

- Subsidies/participation in development projects: case 3 participates in a larger Mediterranean circular economy and development project (SwitchMed), which serves as financial support for the development of its activities, for new collaborations, and as promotion.
- Civil society and consumer requirements: in case 1, the demand for heating with olive biomass came from the food industry, where more sustainable practices were introduced only after consumers wanted a cleaner and more sustainable production.
- Availability of resources: biomass from olive oil production is available in very high quantities in the Mediterranean. Relying on locally issued resources means not relying on imports; this is also cheaper and already available (cases 1, 4, 5, 8).

4.2.3. Barriers or Risk Factors

There were four important barriers or risk factors of circular business models, the first two being external and the other two internal factors.

- External financial support: financial support would be needed by the enterprises, but from the cases studied, only case 3 is profiting from public subsidies for its waste valorization activities.

- Competition and changing market conditions: competition, especially at an international level, and potentially changing market demands with fluctuating prices, is a risk factor for pomace oil (case 7) and polyphenols (case 10)
- Investments: to implement (new) technologies required for the valorization of waste and by-products, often, large investments are needed.
- Partnerships with research institutes: as mentioned earlier in 4.1., creating partnerships for joint R&D activities is important but sometimes difficult (cases 1, 5, 8).

4.3. The Specific Role of the Institional Context

Legal obligations, especially for treating wastewater, but also regional norms for the preservation of landscapes push enterprises to adopt circular economy principles, as confirmed by the case examples. In the European Union, the reuse of wastewater is strictly regulated by the legislation [47]. Some examples for circular economy inclusion in the legislative framework in Morocco are the framework law no. 99-12 as the national charter for the environment and sustainable development [48] or for law no. 28-00 for waste management and disposal [49]. In Tunisia, decree no. 2013-1308 defines the conditions and management methods for olive wastewater from oil mills for rational use in agriculture [50].

An example of the impact of regional norms on agricultural production modes is lake Garda in Italy. It is one of the most important places for ecological and sports tourism, and the image of the region requires local agricultural producers to orient towards organic, eco-friendly production, and circular economy activities are in line with this requirement (case 8). An important aspect for the implementation of circular activities by the enterprises is also the belief that the enterprise is contributing to environmental preservation and sustainability. In case 5, the enterprise is committed to agriculture, which contributes to environmental improvement. In case 9, the reasoning behind the creation of an enterprise was the belief that the Mediterranean region needs help due to water scarcity and excessive water use in olive oil production.

5. Discussion

The key results from the analysis of the ten business cases are summarized in Figure 3.

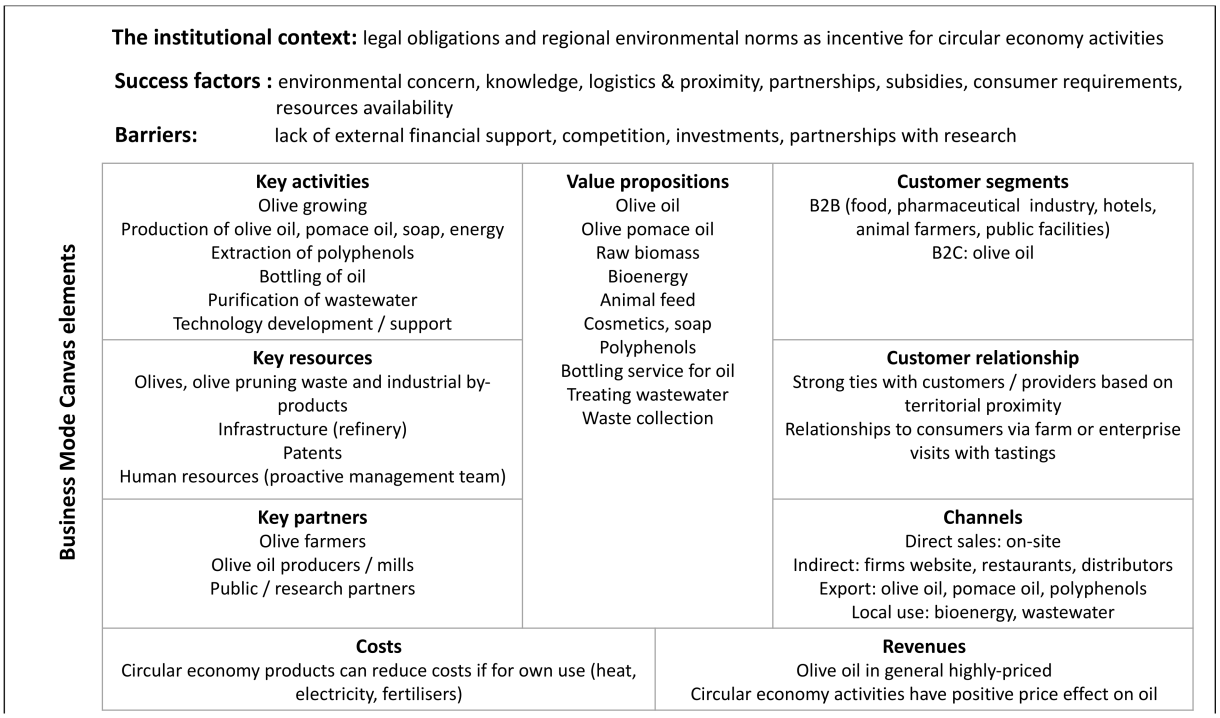

Figure 3. Summary of the main results.

Overall, the results from the business model canvas analysis highlight the diversity of activities in the olive oil sector, the types of resources used, the partnerships, as well as the products and services offered in different market segments. The principles of biowaste conversion and circularity such as cascading, upcycling, recycling, and recovering are all applied by the cases studied, mostly within a local or regional geographical context. Many and diverse product and service value propositions exist such as olive oil, pomace oil, soap and cosmetics, bioenergy/heating/electricity, animal feed, and even high-added value polyphenols; services include waste collection and the bottling of oil. However, despite the diversity, not all potential valorization pathways are exploited by the cases studied. For example, the production of renewable biofuels for combustion engines based on olive mill wastewater is missing [51]. The value propositions are based on the various resources from the olive tree and side-streams from olive oil production, and going from low (bioenergy) to high (food and feed, specialty molecules) added value. Hence, implementing circular business models allows for thinking about multiple resources, products, and markets instead of linear, single resource chains. There seems to be a real business potential for circular value creation in the olive oil sector, either by specializing in waste valorization or by diversifying activities next to the main olive oil production.

However, a number of factors influence a successful value creation by businesses. The results show that both internal factors, such as environmental values of business managers or capacity development, as well as external factors, such as geographical, social, and political factors, play a crucial role in implementing circular business models in the olive oil sector. As a common feature observed across all the cases, the territorial embeddedness of actors with a nearby availability of olive resources are important both as the driver to implement circular activities and as a factor for success. The most significant discrepancy among the cases concern external support and types of partnerships, ranging from strong ties with public actors, to close collaborations with olive producers mainly in cooperatives, and finally to mere private business partnerships. Particularly, these two potentially risky barriers for enterprises, external support and partnerships, require both managerial implication and the reaction from authorities and decision-makers. First, even though the olive oil sector is meriting subsidies, the enterprises involved in waste management do not have any specific measures of support. Waste management activities are recognized, but in practice, they are not supported. Without access to external financial support, firms need to carry the investments themselves while facing the competition of large multinational enterprises and challenges related to research and development. Second, it is sometimes complicated for enterprises to collaborate with research centers or universities. Apparently, the transfer of knowledge from the research level to the field, as well as the articulation of enterprise needs for research, are challenging for further applying circular economy principles. This implies that accelerating the shift to a circular economy would require more collaborations among public and private sectors or multistakeholder projects. These insights on financial and collaborative barriers correspond to earlier findings from the literature [31,32]. However, the price competitiveness of biobased compared to fossil-based products as a barrier could not be confirmed in this study for all products; for example, dry biomass export, local bioenergy production, and pomace oil were profitable in the cases studied.

Finally, the insights from the specific role of the institutional context confirm our hypothesis that legislative obligations, norms, and beliefs as incentives significantly impact circular business activities, both in the North and in the South of the Mediterranean. This is aligned with the argument put forward by Stål and Corvellec [30] that enterprises engage with circular business model templates in order to be perceived appropriate in front of the external environment. However, once enterprises are on the way towards transitioning and already implementing circular business models, they also become the advocates of circular economy transition on local, regional, or national levels.

The representativeness of the cases is, however, somewhat limited, as the study included ten business cases from six different countries. Among these cases, there was

only one from Spain, which is by far the largest olive oil producer in the world. Other important Mediterranean olive oil producing countries such as Turkey, Portugal, or Algeria were missing. The success factors and barriers were approached in a way such as general issues emerged; however, specific local or national contexts were less addressed. Therefore, common insights from this study for the Mediterranean olive oil sector were gained, but they may vary from cases to case and from country to country.

6. Conclusions

The aim of this article was to understand how circular business models are implemented by enterprises valorizing olive oil waste and by-products for food and non-food applications in the Mediterranean region. The main focus was on the circular business model canvas elements, the success factors, and barriers as well as the role of the institutional context. Ten cases of business models for waste and by-product valorization in the olive oil sector from six different Mediterranean countries were analyzed. The results showed the diversity of all the elements of the business model, in particular in terms of the types of biological resources used, issued as waste and by-products from the pruning and olive oil extraction process. The results also put forward the circular and bioeconomy principles applied to olive oil waste and by-product valorization and the variety of products or services offered. Another insight from this study was that the application of circular principles by enterprises can also offer an added value for branded olive oil, either with an enterprise brand or a collective marketing label, such as geographical indication.

Furthermore, the most important success factors for olive oil businesses involved in a circular economy on an internal level were their own concern for the environment, their knowledge of technologies, potential markets and logistics, and their long-term commitment to the sector. The access to resources and subsidies and the consumer requirements constituted external factors. It could be noted that, despite the mainstream narratives of governments about supporting the circular bioeconomy, in reality, there is still little direct financial support for enterprises carrying out waste valorization activities. Public subsidies, though available for the production of olives and olive oil, do not exist for particular activities involving value-adding waste valorization. In addition, the current price increases for gas and oil make processing and logistic activities more expensive, negatively impacting the cost structure of businesses. On the other hand, virgin olive oil and pomace oil prices themselves have in general substantially increased over the past 2 years [52], and the demand for olive pomace oil as a substitute for sunflower oil has also grown. Moreover, alternative biobased energy may become more important as a substitute for fossil-based energies in the future. All these factors and market developments might impact the implementation of circular practices in business models and especially their costs and revenues' structure, and they should be taken into account.

The main conclusion from this study is that a transition to a circular economy in the Mediterranean olive oil sector requires strong entrepreneurial efforts and multiple skills, but it must also be supported by national governments and regional policymakers via subsidies and public-private collaborations or multi-stakeholder projects. For further research on the topic of circular business models in the olive oil domain, we suggest focusing more on the enterprise marketing and communication strategies and on the value distribution among the key value chain actors involved.

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Appendix A. Interview Guide for Analyzing Circular Business Models in the Olive Oil Sector

1/Initiative: When and how was your enterprise created? Was it a public or private initiative? What was the main goal of the project? Was a beneficial environmental impact from the beginning on part of your project?

2/Olive growing aspects: Could you describe the olive plantation and olive growing aspects? What varieties of olive are grown? (How are they adapted to the territory?) What kind of irrigation is used for the olives? How is the pruning of the olives done? (How many of the branches are discarded via pruning?) What kind of fertilizers do you use? How do you fight the olive fly and other pathogens? How is the harvesting done? How many olives do you harvest per hectare? How is the transportation done from the field to the mill?

3/Olive oil production: How much olive oil from 1 ton of olives? How much time between harvest and processing? What kind of technology do you use for oil extraction? (Which mill?) What type of storage and what kind of packaging do you have for the oil?

4/Wastewater and olive cake: How much olive cake from 1 ton of olives in the mill? How much wastewater from 1 ton of olives processed in the mill? What is done with the wastewater? What is done with olive cake? What is done with olive kernels?

5/Value proposition: What are your main products and services offered? What benefits and value are you providing for your customers and consumers beyond your product? Is beneficial environmental impact part of the value of your products?

5.1/Value proposition—olive oil: What are your main products and services offered regarding olive oil? What kind of certification do you have? What benefits and value are you providing for your customers and consumers beyond olive oil?

5.2/Value proposition—olive soap: What benefits and value are you providing for your customers and consumers beyond your product? Which type of resource (liquid/solid waste, by-products) do you use as entrants for olive soap?

5.3/Value proposition—biomass: What are your main products and services offered regarding biomass? What benefits and value are you providing for your customers and consumers beyond your product? Which type of liquid/solid waste (co-products) do you use as entrants?

6/Customers: Who are your customers? Private/Public? How do you find new customers? Who is buying the olive oil, the olive soap, and who is buying biomass? How do you communicate your value to the customers?

7/Customers relationship: Do you have long-term contracts/relationships with your customers/consumers? How do you sensitize them for the beneficial environmental impact? Would it be difficult for your customers to change the supplier? (for each of the product sectors) How are the consumers implied in the innovation/production/marketing process of your enterprise?

8/Channels: How do you recover olive oil and liquid/solid waste? Is it only from your own production sites? Do you collect oil and olive cake from other producers in the area? How is the (reverse) logistic chain/the waste collection organized? Who is paying for logistic costs? What are your distribution channels for each group of products? What are your marketing-communication and labeling strategies (individual-collective)?

9/Key partners: Do you have any mutualized equipment/technologies with partners? Do you have public, private partners? If you are collecting olive oil/olive cake from other producers, then why do they choose for your company to process/market their olive oil and utilize their waste?

10/Key activities: What are your key activities? Do you internalize the logistics, pre-treatments, post-treatments, waste storage? Do you externalize some activities? How do you manage the waste variability? How do you optimize the procedure?

11/Key resources: Does the company have to own the land for olive plantations? What are your technological/machinery resources and processing equipment? Do you have any patents or other intellectual rights? How many people are employed at your enterprise, permanently and seasonally? How do you adapt your resources to the product seasonality?

12/Costs: What is the production cost (for 1 ton of olive oil/for soap/biomass)? Does the size of your equipment allow you to achieve economies of scale? Do you have the possibility of sharing the equipment? Does the technology investment represent a major cost for you? How long is the time of ROI?

13/Revenue streams: How are the product prices determined? What is your pricing strategy? Do you receive a public subsidy? (If it is not confidential: approximate % of income.)

14/Stakeholders: Who are your stakeholders? How do you take into account their expectations? Are you involved in any cluster or business network?

15/Circularity impacts: Do you analyze your environmental impact and how (and why do you do it)? Which method or indicator do you use (tons of waste, carbon footprint, life cycle assessment, . . .) and why? How many tons of solid/liquid waste do you valorize? What are your final waste streams? Are there some usage conflicts about the waste that you valorize? How could you improve your environmental impact?

16/Trends and drivers: What is the policy about waste and by-product treatment in your country? How do the green energy prices evolve? How do you see the trends in the international market?

17/Critical success/risk factors: Are there some political, economic, social, technological, ecological, or legislative aspects (national or international) that have a positive/negative impact on your activity?

18/Lessons learned: What have you learned from the past and what is your vision for the future (any specific opportunities or threats)? Do you have future development projects? Are there any innovations (technological, organizational . . .) needed in your opinion?

19/Lessons learned/COVID crisis impact: What was the impact of the COVID crisis on your activity? What have you learned from the COVID crisis? How does it impact your relationship with key partners/key activities/key resources/your future development projects?

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