Circular economy in the agri-food sector: Insights into Portuguese companies' practices.

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Abstract

Relevant cultural and financial factors hamper circularity in Portuguese agri-food sector companies. To capture so, an empirical analysis of circular practices in agri-food companies was carried out. Being the agri-food sector central to the Portuguese economy and the numerous circular economy initiatives in the Country, the study aims to comprehend how circularity is achieved from an environmental, social, and financial perspective in Portuguese companies of the sector. Therefore, a survey of a selected sample of companies identified 9 examples of organisations involved in circularity to interview.

Results evidence: (i) strong cultural and financial barriers in implementation and evaluation; (ii) generation of social value through community-centred initiatives and collaborations with local companies; (iii) urgency to valorise and communicate financial impact to conquer new funding opportunities.

The analysis contributed with new knowledge on the social value-creating capacity of circularity and the impact on companies' financial performance in the agri-food sector, providing interesting future insights into academia and policymaking.

Keywords: Circular Economy; Agri-food sector; Circularity assessment; Interviews; Financial performance; Social value creation.

Introduction

The agri-food sector (AFS) is traditionally linked to the linear 'take-make-dispose' paradigm, the sustainability of which is now debated [1]. The Food and Agriculture Organization (FAO) estimated that today one-third of food produced worldwide is lost or wasted through the supply chains, while 795 million people face hunger [2]. This will worsen by the expected population increase in 2050 which will additionally increase the food burdens [3]. In this context, the circular economy (CE) is emerging as a sustainable paradigm contributing to the ecological transition by generating economic advantages, reducing environmental degradation, and promoting the well-being of the present and future society [4]. There are several definitions of CE, in scientific literature well know is the one provided by Kircherr et al., [5], who defined CE as an "economic system that replaces the

‘end-of-life reducing, alternatively reusing, recycling 'end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes” ([5], page 229).

Thus, including productive strategies based on CE can support agri-food systems in maintaining productivity while improving their environmental sustainability, as suggested by Castillo-Diaz et al., [6]. In addition, as highlighted by Scandurra et al., [7] circularity appears already embedded in the agri-food dynamics. The prevalence of conventional circular practices suggested the maturity of the sector in implementing CE. CE is strategically valued in AFS because it reduces environmental impacts, promotes community health and employment, and reduces companies' operating costs [8]. However, there are few company-level empirical studies in the field, which makes it difficult to understand why companies still struggle to translate circularity principles into business strategies [9]. Therefore, further empirical studies are needed to explore the implementation and characterisation of CE in the sector. Hence, this study investigates the benefits and issues faced by companies implementing CE in AFS, examining the environmental, social and financial aspects of adopting CE through an empirical analysis, in a southern European country. Europe has been ahead in terms of CE implementation in the industrial sectors with several regulations as drivers, such as the Green Deal [10]. In this context, Portugal is a valuable case study to explore CE dynamics and empirical evidence. Indeed, in this sense, the AFS is a pillar of the Portuguese economy. Food production is one of the main engines of its manufacturing industry, characterizing 14.5% of total sales in 2016 [11]. Moreover, it is one of the largest employers in the country, with approximately 294,000 people and 135,000 companies [12]. In the last years, Portugal has promoted different CE-oriented initiatives in the agri-food context. Examples are the Alentejo Circular project [13] to foster circular practices in pork, wine, and olive production, representing the excellence of the Alentejo region, or the “REiNOVA Si” project [14], a cross-border collaboration between Portugal and Spain to map circular best practices for the AFS in SMEs. For these reasons, Portugal has been chosen as the country location of the proposed empirical analysis. Thus, this study aims to obtain an improved understanding of how Portuguese companies of the AFS consider CE within their activities. For this purpose, the authors conducted nine semi-structured interviews engaged in CE, previously specifically selected through a survey administered to a convenient sample of Portuguese AFS companies.

Previous research explored several features of CE in AFS (Hamam et al. [15]; Abbate et al. [4]; Zhang et al. [16]). However, companies still face several challenges to CE adoption in the sector [9]. Among them is the lack of shared assessment systems for measuring CE [17]. This makes it difficult for companies to evaluate the impact of circularity on their performances and consequently to further include circularity in their business strategy [18]. Moreover, circularity is still associated with the environmental scope [7], while limited attention has been posed of the social and financial value it generates in the AFS.

The remainder of the present article includes the theoretical overview, underlining the research gaps and questions (Section 2); the methodologies employed (Section 3); the survey interviews outcomes (Section 4); the critical analysis of the results (Section 5) and finally, the concluding remarks with possible future research suggestions (Section 6).

Theoretical overview

CE IN AFS

The aim of this section is to provide the reader an overview of how CE is addressed in the AFS context, given the interest that the topic has received since the introduction of the CE action plan [19]. Despite CE is not explicitly mentioned, it may contribute to achieving several Sustainable Development Goals (SDGs) included in the United Nations's agenda for 2030. For example, Belmonte-Urena et al., [20], pointed out the relevant contribution to SDG12 (Responsible Consumption and Production), especially in terms of waste reduction strategies (Target 12.5). While Schroeder et al. [21] evidenced CE direct and indirect contribution to several SDGs, such as SDG 12 and SDG2 (Zero hunger). Examples of the latter are the use of human waste for larvae cultivation and then as animal feed, indirectly contributing to agricultural productivity and sustainable food production systems (Targets 2.4 and 2.5) [21]. In this context, Cecchin et al. [22] evidenced the support of Industrial Symbiosis (IS), as a better-defined CE sub-field, to several SDGs, especially SDG 12 and 9 (Industry, innovation and infrastructure), e.g., by promoting inclusive and sustainable industrialization (Target 9.2). Moreover, social and organizational context matters for CE; thus, it may contribute to the social side of sustainability, for instance through SDG 3 (Good health and well-being) by reducing waste production (Target 3.9) [23].

For further insights, please refer to other review works (Esposito et al. [24]; Scandurra et al., [7]. Among the most relevant contributions, Barros et al. [25], mapped CE agricultural practices for energy production. The analysis pointed out that the AFS has been closing the loop for materials and waste for a long time, thus evidencing how circularity is not new in the sector. Esposito et al. [24] collected examples of circular practices and assessment tools along the agri-food chain, emphasising the lack of shared assessment methodologies to compare circular practices among different supply chains. More recently, Silvestri et al., [3] explored inter- and intra-organizational practices of CE in the agri-food context, evidencing the limited consideration of the social perspective. On the contrary, Poponi et al., [26] analysing CE's impact on value optimization in the food supply chain, highlighted the social value generation of CE e.g., by promoting good practices for sustainability along the supply chain and the surrounding community. Moreover, recent European policy interventions included circularity in their scope. Namely, the EU Taxonomy Regulation [27], which aims to support environmentally sustainable investments, and the Corporate Sustainability Reporting Directive (CSRD) [28], which aims to move Europe towards a carbon-neutral economy by 2050. Specifically, the European Sustainability Reporting Standards (ESRS), which set the sustainability information in compliance with the CSRD new directive, directly include disclosure requirements regarding “Resource Use and Circular Economy” (ESRS 5) [29]. In addition, the new CSRD involves more types of companies, e.g., listed Small and Medium Enterprises- SMEs [28]. Finally, the just released ISO 59020 provides a framework able to support organizations of different size and type in measuring and assessing the circularity of their strategies by calculating mandatory and optional indicators [30].

Despite the increasing necessity for companies to link circularity to financial outcomes, there is a lack of studies that explore how CE implementation impacts the financial performance at the company level, especially in the AFS, which already indicated financial resources as a key driver and barrier [31, 32]. Companies will apply the

new rules in 2024's financial year [28]; this makes it urgent to consider new methodologies for measuring and reporting the financial impacts of the CE.

Despite CE implementation in the AFS being widespread in the literature, there are still relevant gaps which limit the adoption of circularity, especially in SMEs. Given the identified lack of literature on CE assessment, CE social value creation and financial impact, these topics will be further explored in the following sections.

Barriers and benefits to CE assessment

The CE assessment is a crucial driver since it allows tracking and quantifying progress towards circularity [33]. Several assessment approaches are available in the [34, 35], but their application is still limited in the private sector [36]. Only a few studies explore empirically the benefits and barriers of circularity assessment. Roos Lindgreen et al., [9], who investigated the assessment practices of CE frontrunner companies in the private sector in Italy and Holland, highlighted that many of the perceived internal barriers are in common with the measurement of sustainability. These include the presence of methodological issues, as the lack of assessment standards, often translated into a lack of interest or awareness for the assessment by clients. Among the key benefits, the improvement of transparency stands out, which increases collaborative opportunities for companies. Droege et al., [37], analysing the public sector, identified relevant cultural and structural challenges for CE assessment. The first regards the lack of awareness of the necessity to measure CE, while the latter considers the absence of obligation for the assessment, which leads to a lack of clarity of targets and goals. Although there are already studies that have synthesised and analysed the evaluation tools available for AFS [38, 39, 17, 40], the assessment of circularity is still limited [41]. One possible explanation is the high number of circularity indicators evidenced for the AFS [42], which may generate confusion among practitioners on which to choose and what boundaries to give to their assessment practice. However, the reasons for this reduced measurement of circularity are scarcely investigated in this sector. Thus, understanding companies' perspectives is essential to examine the adoption of such tools and to identify the main obstacles and benefits encountered. The lack of empirical evidence on CE assessment in the AFS and the benefits and barriers faced led to the following research sub-questions (RSQs):

RSQ1A: How do Portuguese companies of the AFS assess CE?

RSQ1B: What are the main barriers perceived for assessing/not assessing circularity in the sector?

RSQ1C: What are the benefits perceived in assessing circularity in the sector?

Social performance

CE adopts the triple bottom-line vision of sustainability, which includes the environmental, social, and economic perspectives [43]. It proposes to enhance the well-being of the present and future generations, but it addresses the social aspect only implicitly [44]. In literature, Kirchherr et al., [45] mentioned CE's capacity to increase employment and foster participative democratic decisions. Such importance is confirmed by the inclusion of the SDGs, which include the social dimension in the CE agenda [46]. Nevertheless, there is no consensus on how CE can enhance social value [43]. One relevant issue regards the lack of a clear definition of what is meant by social value for companies since it includes several stakeholders and is context-related [47]. Padilla-Rivera et

al., [46], in their systematic review, identified “employment” as the most relevant feature regarding social value in the company setting, followed by “health and safety”, and “democratic participation”. Job creation is the most common social metric in literature. Nevertheless, it is not the only social category affected by CE practices [48]. Social value can be understood as a value-added service or an outcome of CE implementation, where the latter received limited attention in the literature. For this reason, Atanasovska et al., [49] conducted a review exploring the social value derived from CE practices in agri-food eco-industrial parks; the analysis showed that social value, understood as the achievement of social equity from industrial operations, is generally understudied and often limited to tackling food security and resilience. Addressing this gap, this study aims to broaden the discourse on the social value generated from circular practices through the empirical analysis of what happens in the sample of CE-experienced companies analysed. This has generated the following RQs:

RSQ2A: How does CE generate social value in the AFS?

RSQ2B: How do companies of the AFS include social value in their circular strategies?

Financial performance

Growing environmental, economic, and social issues have led international organizations and country systems to devise strategies for sustainable development; among them relevant is the Environmental, Social and Governance (ESG) framework [50]. The European Banking Authority (EBA) defines ESG principles as “environmental, social or governance matters that may have a positive or negative impact on the financial performance or solvency of an entity, sovereign or individual” [51, p. 31]. Financial regulation actions like the European "Action Plan: Financing Sustainable Growth" already defined a roadmap for the financial system to approach sustainable investments. This flow encouraged the identification and quantification of ESG risks through different standards and taxonomies, like the EU taxonomy [51]. In this sense, the EU taxonomy proposed a classification system for low-carbon and resource-efficient economic activities and recognizes CE transition as one of its environmental objectives [51]. Indeed, ESG assessment allows companies to discover areas of improvement and potentially identify the best strategies to start their journey into circularity [52]. The "Taxonomy Regulation" [27], and the Corporate Sustainability Reporting Directive (CSRD) [28] have pushed financial institutions to introduce CE terminology [53].

Moreover, previous studies evidenced a positive relationship between ESG adoption and companies' financial performance (FP) [54]. Specifically, FP is a meta-construct that measures the profitability of business strategies in terms of effectiveness and efficiency, which is a relevant factor for companies’ transition to CE [55, 56]. However, the lack of guidelines and empirical studies makes it difficult for companies to capture and communicate the effects of circularity on their FP [55]. Today, the FP of circular companies is mainly measured through short-sight accounting- indicators, which do not capture circular timelines [55]. Indeed, compared to linear ones, CE investments show longer timelines and involve multiple life cycles [55]. Indeed, positive cashflows are not generated at the beginning of the product’s life [57], and this increases the uncertainty for future cashflows [58].

Some studies, in mapping circularity, ingenerated the AFS, identify economic indicators that can quantify production costs and the economic value generated, however, they are not strictly financial indicators [3, 17].

Moreover, as in the measurement of circularity in general, there is no information on their effectiveness in measuring circular performance. Overall, CE financial assessment should involve the identification and re-evaluation of relevant costs and revenues connected to company processes, capturing the characteristics appointed by circularity [59]. However, the heterogeneous risk profile that characterizes companies involved in circularity makes it difficult to define a standardized financial instrument to measure and monitor financial performance [58]. As a result, the following RSQs are proposed:

RSQ3A: How does CE impact the FP of companies of the AFS?

Methods

The present study adopts a mixed research approach based on a survey and following interviews. Using a mixed method allows us to better tailor the research method to the aim of the analysis and the characteristics of the sample. Conducting interviews after a survey allows to dive deeper into a topic, e.g., asking for clarifications in case of unclear survey responses [60]. The approach is articulated into a three-step methodology represented in Fig. 1.

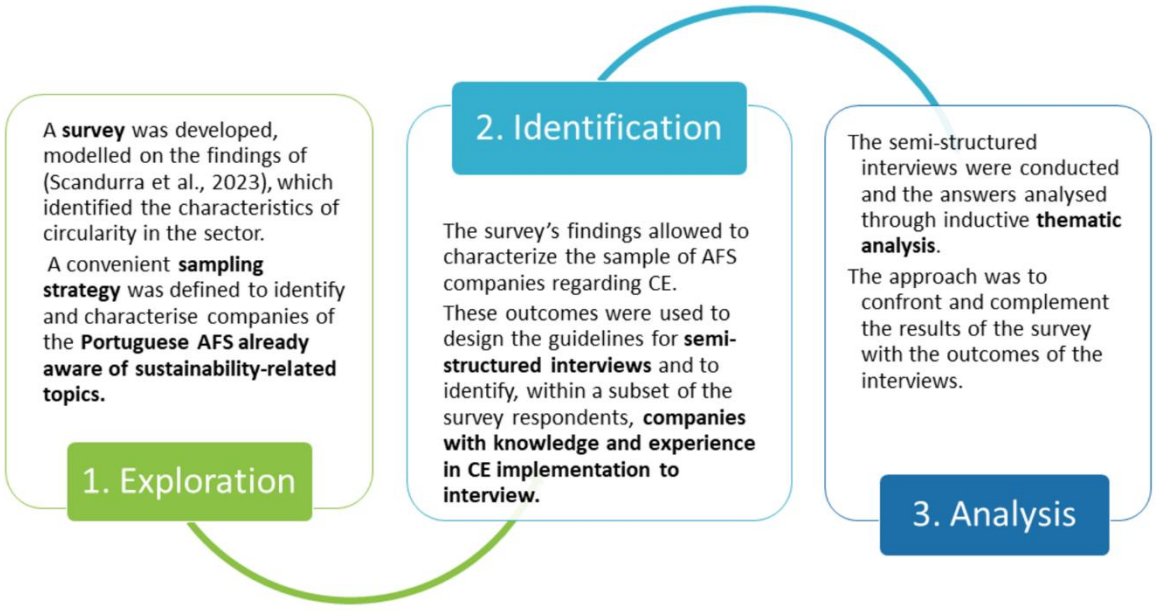

Fig. 1 Overview of the three methodological steps of the study.

Step 1-Exploration

To achieve the goal of interviewing companies with experience in the field of CE, agri-food networks that represent companies that are in touch with circularity and sustainability issues were first identified; thus, a purposive sampling method was adopted. Purposive sampling is a non-probability technique that allows the selection of respondents that address the study aim and, by doing so, increases the depth of the analysis [61].

The sample includes only companies whose attributes meet the research goal of the study [62]. In this case, the authors included only private companies directly operating in the AFS: i) companies' members of the non-profit association "PortugalFoods" [63], which brings together food industry companies and entities from the Portuguese scientific ecosystem; the Portugal Foods innovation office identified them as having differentiated innovation and sustainability actions in the food sector; ii) companies' part of the project "Alentejo Circular" project [13], developed by the Instituto Soldatura e Qualidade (ISQ) and the University of Évora, to mobilize economic actors towards circularity in the olive oil, wine, and pig farming in the Alentejo region (Portugal). To evaluate the implementation of circularity within the sample, a survey was developed. The survey was articulated into three sections as presented in Fig. 2.

Section 1

General information about the company and the respondent-This preliminary section allows to classify companies per region, size, supply chain type and stage, but also to evaluate some basic characteristics of the respondent.

Section 2

Analysis of company's awareness of CE and SD- This section allows to test the respondent's level of awareness regarding both SD and CE, it enables to deep dive into the topic thanks to a combined approach given by closed multiple questions and ranking questions, adopting the Likert scale technique.

Section 3

Agri-food companies - The present section of the survey was oriented to identify and analyze the circular practices implemented by the sector's companies.

Classifying practices according to e.g., the 4 Rs framework; Per level of innovativeness: conventional (established in the literature), incrementally innovative (based on existing knowledge) or radically innovative (based on new, disruptive knowledge)-Scandurra et al., 2023.

Fig. 2 Overview of the survey structure

More detail on the survey structure is provided in Table 1 of Supplementary Materials. The survey enables the authors to collect information regarding companies' backgrounds, which later helps the interviewers to drive their questions to the core subject [64]. The survey was initially written in English and subsequently translated into Portuguese. The researchers tested it in both languages. The survey was designed through Microsoft Forms. It was delivered with email invitations on 26 January 2023 and was open until 13 March 2023. The average compilation time was 28 minutes. In between, not-responding participants were solicited by phone calls. The last question of the survey asked about respondents' interest in continuing the research by having follow-up interviews with the researchers.

Step 2-Identification

At the end of the survey, the authors translated the responses into English and exported them to Microsoft Excel. Information was analysed through an exploratory and descriptive approach based on respondents' knowledge and application of CE. For this, descriptive statistics were applied to characterize the companies and their reported CE practices. These findings allowed to the identification of CE attributes in the sector and were used to get insights to design a semi-structured interview guide of open-ended questions with the following dimensions: i) the CE drivers and barriers, ii) the CE assessment, iii) the CE capacity to generate social value, and iv) the impact of CE on companies' FP. In the survey, 28 companies claimed to include initial or consolidated stage-circularity principles in their activities; however, only 16 companies described practices that

231 can be classified as circular. Among the 16 implementing companies, nine with CE experience coherent with the
232 RSQs were available for the following research step. Thus, the final interview sample consisted of nine
233 companies.

234 ## Step 3- Analysis

235 After the survey, nine semi-structured interviews were conducted to understand in detail how the companies of
236 the sector implement and monitor circularity. The interviews were conducted in English either via video call
237 (n=8) or in written form (n=1), depending on the interviewers' preference, and at the time of their choice,
238 between March and June 2023. Moreover, all the interviews were conducted in the presence of a native
239 Portuguese speaker to facilitate the interviewee and reduce possible bias due to language.

240 The call interviews lasting, on average 60±34.5 min, were video recorded for accuracy of transcription and
241 analysis, following participants' permission, and the recordings were anonymously transcribed verbatim.

242 Subsequently, the nine interviews were analysed through an inductive thematic analysis [65]. The choice of
243 inductive coding, namely identifying themes from the data itself, is due to the exploratory nature of the present
244 analysis since inductive coding has proved to be useful in exploring novel research areas [66]. The analysis was
245 performed on a qualitative data analysis software, QSR NVivo 1.4 [67]. During the process of coding and
246 identification of themes, inconsistencies and discrepancies were monitored to ensure a deep understanding of the
247 text. To illustrate the analysis, consumer direct quotes were transcribed, serving as a description of the theme
248 explored. Note that the same extract may be assigned to more than one theme.

249 # Results

250 ## Survey Sample characterization.

251 The survey was administered to 148 companies and completed by 31 (response rate: ≈ 21%), in line with other
252 studies adopting surveys such as Roos Lindgreen et al., [9], which reported a response rate of 19%. Table 1
253 summarizes the main characteristics of the survey sample.

254 **Table 1 Descriptive overview of the survey sample. Note that the percentages of**
255 **responses may be higher than 100% since respondents could choose more than**
256 **one option.**

Main characteristics	Survey respondents (n=31)
Company size	
Micro companies (0-10 employees)	10%
SME (0-250 employees)	61%
Large companies (>250 employees)	29%
Company location	
North	32%
Centre	19%
Metropolitan Area of Lisbon	23%
Alentejo	26%

Supply chain stages	
Processing and packaging	77%
Primary production	29%
Food distribution	26%
Handling and storage	29%
Retail	14%
Hotels and restaurants	3%
Respondent's department	
Sustainability-related	23%
Production	13%
Management	23%
Marketing and Sales	19%
Research and Development	6%

Survey responses.

In answering about their vision of CE, 42% of respondents depicted it as a societal paradigm which aims at producing and consuming economical goods and services respecting the environment, embracing a systemic vision of it, or 29% as a paradigm focused on a regenerative use of resources, closing energy and material cycles, fostering an environmental one. Lastly, present but limited are the economic and social conceptions of the term. Respondents largely consider CE to be one of the tools for achieving SDGs, but it is not the only one available. Moreover, they tend to focus on the environmental benefits connected to CE. The social dimension appears to be a questionable and unclear factor since most of the respondents are not able to agree or disagree with CE's capacity to increase this kind of value in companies.

Regarding CE implementation, respondents indicated the practices adopted in an open-ended question; 28 circular practices were identified out of the 31 companies. Note that the number of practices does not match the number of companies in the sample since respondents could describe more than one practice. As shown in Fig. 3, most of the 31 respondents identified incrementally innovative practices implemented (e.g., fixation of nitrogen by rhizobia leguminous plants). Conventional practices (e.g., use of organic waste to produce compost) characterize a limited fraction of the sample. None of the respondents claimed to have implemented radically innovative circular practices.

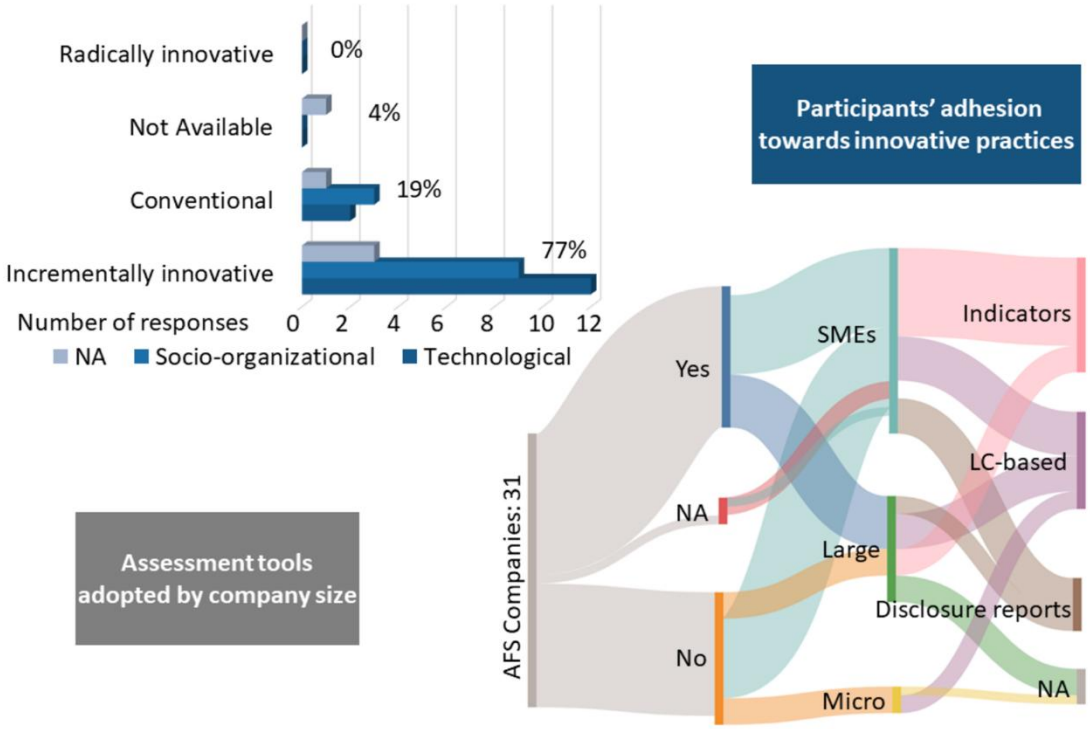

Fig. 3 Overview of the principal survey findings

In implementing CE, respondents claim more than one R strategy, as a large portion adopts all the 4 Rs (23% of the sample, 4 from large companies and 3 from SMEs). Whereas only SMEs focused on single Rs, reuse and recycle strategies are the most adopted and reduced ones the least considered. Concerning the practices identified, the 28 respondents that indicated a specific goal, represented in Fig. 4, were mainly directed to the recycling or reusing materials (4 large and 4 SMEs). This could be explained by the fact that 77% of the sample belongs to the "processing and packaging" supply chain stage. Another relevant portion (3 large and 4 SMEs) was directed to the production of food and feed or to the production of soil nutrients (4 large and 4 SMEs). Some practices (3 large) are directed to sensibilization on sustainability-related topics. The production of energy is limited in the sample (2 large and 1 SME). Finally, some companies put regenerative farming techniques in connection to CE (1 large and 1 SME).

Fig. 4 Overview of the 28 circular practices described in the survey

Concerning the measurement of circularity, approximately 60% of the companies that are assessing CE are SMEs, and the other 40% are large companies. Of the 15 assessing companies, around 64% of the assessing companies did not explain the type of indicators used, the remaining ones adopted lifecycle-based tools and disclosure or communicative reports, some in line with Global Reporting Initiatives (GRI) standards, others not specifying the internal or external nature of such communications. Even though a significant part of the sample states does not measure circularity, many companies use some of the proposed monitoring tools. In detail, 10 of the 15 non-assessing companies adopt lifecycle-based tools (50%), specific indicators (40%), or disclosure reports (10%).

The interviews

The analysis of the nine interview responses provided an in-depth understanding of how circularity is implemented and monitored in a convenient sample of Portuguese agri-food companies (Fig. 5). Three broad levels of analysis were identified, which combined many themes, cutting across the different topics of discussion. The sample is diversified in terms of size, especially considering the percentage of large and SME realities. Most of the companies are involved in processing and packaging supply chain stages, whether the retail stage has limited impact. In terms of supply chain types, the drinks and beverage segment is the most common, while livestock and the various categories (namely, one retail company) are the least represented.

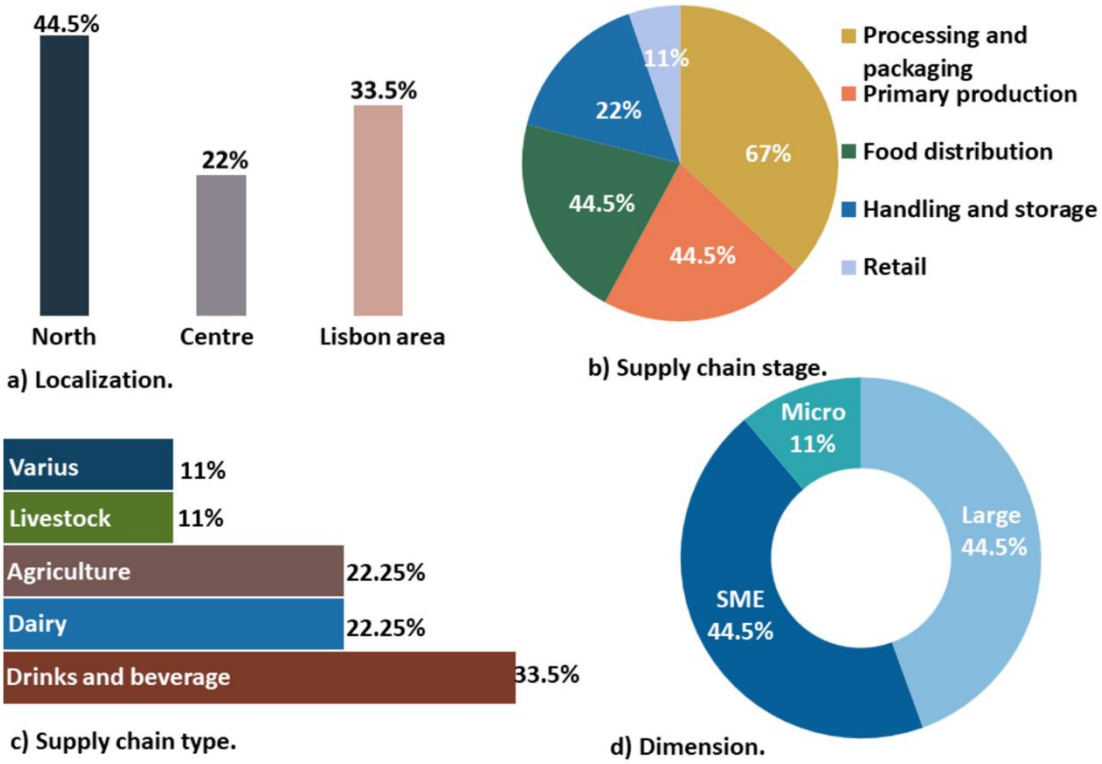

Fig. 5 Descriptive overview of the interview sample. Note that the percentages of responses may be higher than 100% since respondents could choose more than one option

Drivers and conceptualization

Several factors determine the adoption of CE. Regarding the environmental implications of CE, participants emphasize the importance of a clear strategy for the environment, for the company's long-term viability. The environmental considerations are often coupled with the economic ones. As observed, adopting environmentally friendly practices saves resources that would otherwise be needed to offset the impacts of polluting practices. In detail, the economic implications are largely related to cost reductions due to processes and material efficiency. Overlooked are the social implications of circularity, namely, engaging the surrounding community, e.g., through job opportunities or donations, but also as a potential guide for people's choices, exploiting the scope of the company's activity. The generation of brand value is furthermore reported by the interviewees in the sense that CE improves brands, making sustainability and circularity distinctive traits of a company's products and allowing their recognition on the market.

Besides the drivers, companies mentioned company culture, which meant the willingness of the company's management to embrace CE. Circularity requires a strong commitment. In small companies, this is even more important. CE investments are perceived as something not related to the companies' core business that requires sacrifices for the company.

Interestingly, CE is not perceived as a new concept but a renewed one. Some of the participants interviewed consider it as part of conventional agri-food practices, even if companies use a different name for it. So, the

sector does not need to be reshaped to circularity (Interviewee #8, Large). One tangible example is the reuse of whey. As pointed out by one small but old business interviewed, whey used to be poured into the rivers or the soil, but during the 1940s, some companies started to reuse it as animal feed. Over the years, companies kept adding value to the whey, e.g., today, it is sold to obtain protein extracts for food, feed, or cosmetic products.

In the interviews, participants also reported different barriers that they faced when implementing CE, which can be categorised into financial, cultural, and legislative. Implementing CE requires considerable investments and additional costs. That is, the additional cost of recycled materials is not shared along the supply chain, so food companies can feel squished in their chain, as one company (SME) mentioned. The cultural barriers concern internal and external factors. The first regards companies' scepticism around CE-related investments, while the latter concerns retailers' and consumer's lack of interest or awareness. For the interviewees, consumers are perceived as reluctant to change their mindset, given the importance of convenience in their lives (Interviewee #6, Large). Finally, legislative issues relate to the uncertainty of upcoming regulations which may impose new measures on companies, as evidenced by the large companies interviewed.

CE assessment: benefits and barriers

The five participants who stated not conducting any form of CE assessment in their corresponding companies, one large, one micro, and three SMEs discussed the reasons for their choice and the barriers perceived. The root cause seems cultural since CE assessment is not perceived as a priority. Consequently, companies state of not aware of the methodologies available for CE measurement. Only one large company is approaching the assessment, focusing on the circularity of packaging.

Different barriers and benefits of CE assessment were debated by our interviewees (Table 2). Based on the literature, four barriers emerged. The *Company's capacity* seems influenced by the small size of companies, which implies a limited budget and operational team. The S*tructural issues* evidence the non-compulsory nature of the CE assessment, which makes companies not interested. The *Technical challenges* stress the complexity and slowness of the assessment process. The *Lack of external demand* highlights the difficulty of involving stakeholders in the assessment. However, demand for assessment by actors like consumers would push companies to start assessing, as declared by one SME. The not-measuring companies claim they will give it more attention shortly due to external pushes from the supply chain and legislation.

In contrast, the four participants, who were part of the companies, three large and one SME, started assessing CE and discussed the perceived benefits obtained. Answers were grouped into i) I*nternal insights*, which deal with internal improvements margins, and ii) E*xternal communication* benefits, which allow companies to improve their reputation (e.g., by offering consumers quality products with low environmental impacts), but also to engage both consumers and employees. Finally, one large company mentioned the need to anticipate the legislation and be ready for the future, so introducing CE measurement tools now will put the company on the right path for the future.

Moreover, these companies mentioned the importance of benchmarks to compare with other companies, generating a virtuous development path. For small-size companies, having benchmarks with larger companies is

essential, they are on average more likely to try out different paths as they have more resources at their disposal compared to SMEs (Interview #9, Small).

Table 2 CE assessment: Benefits and Barriers

Barriers	Description	Reference
a) Company's capacity	Lack of a company structure able to support the assessment and control of CE.	Roos Lindgreen et al., [9]; Droege et al., [37].
b) Structural issues	Skepticism towards measuring being perceived as non-rewarding, and the lack of legislative obligation for CE assessment.	
c) Technical challenges	Perceived complexity in the assessing process. CE because the process is considered long and complex.	
d) Lack of external demand	Supply chain partners lack interest.	
Benefits	**Description**	**Reference**
i) Internal insights	Process efficiency, impact reduction and decision-making support.	Roos Lindgreen et al., [9]
ii) External communication	Improve the company's reputation. Sensibilize consumers and employees to the importance of impact reduction.	

The tools mentioned by the interviewees are reported in Fig. 6. Some benefits and challenges were evidenced in using such tools, e.g., GRI reporting standards require an external audit. Still, they will prepare the company for the future, given the increasing attention to sustainability reporting (Large). LCA, which identifies and quantifies all the resources consumed and the emissions on the environment related to goods or services [68], allows to valorise the improvements made by the company but is not suitable for comparison with competitors, and its high technicality makes it difficult to communicate its results to other departments (Large). Whereas concerning tailor-made indicators, one company (SME) indicated using a platform for regenerative agriculture where companies from different sectors share the indicators adopted as a guide to start the assessment journey.

Eventually, participants were asked about first the relationship between CE and sustainability and then, only the assessing companies, about the possibility of using the same monitoring tools for sustainability and CE. Most of the interviewees consider CE as part of sustainability. One company (Large) argued a different scale of intervention between the two concepts: CE is focused on the business perspective, including some stakeholders, while sustainability also looks at the overall supply chain. Another considerable portion considers the concepts as interconnected, without clarifying their specific features. Only one company (SME) warned by adopting the two concepts interchangeably, mentioning potential rebound effects. Concerning the assessment, most of the companies adopting CE tools agree on using the same tools for both, while a marginal portion feels they do not have enough information to answer.

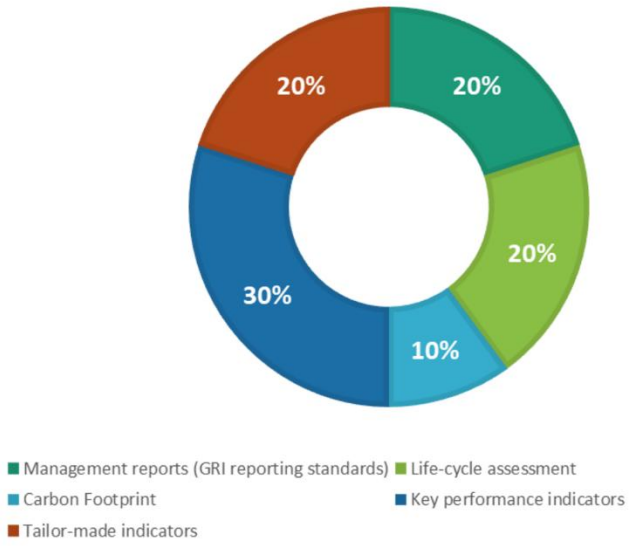

Fig. 6 CE Assessment tools adopted

Social value

Our participants referred to the social impact of CE at two levels: i) possible social impacts, and ii) effective social impacts. The first considers the potential capacity of CE to generate social value; the sample generally agrees upon this statement. Going into detail, respondents mentioned the generation of social inclusion, cohesion, commitment, and employment. As participants outline, CE improves process efficiency and generates new business opportunities, leading to additional revenues and potentially more employment. Some participants mention CE's capacity to introduce sustainability into the individual mindset, enhancing responsible consumption. Finally, social cohesion (people in a neighbourhood or region feeling more strongly connected) and inclusion (connecting employees with a distance to the labour market, more diversity) are limitedly mentioned in the sample.

The second is inspired by the framework of Labuschagne et al. [69] (shown in Fig. 7). a) Employees are focused on ensuring employment conditions, as well as involving employees in decision-making processes. b) Local community is oriented to creating assets and infrastructures for the community, but also on the effect of CE on social relationships Interviewees evidenced the importance of opening to neighbours' companies to develop collaborations able to develop a shared upgraded solution for CE, supporting the community. c) Stakeholders' participation focused on companies influencing supply chain partners, namely distributors and suppliers by establishing strict provision requirements, or being influenced by retailers and consumers. However, within stakeholders' participation, the role of consumers is ambivalent. Some companies consider consumers interested in the sustainability of their choices, although not always willing to accept the price differential for product quality, but the majority, perceive them as unresponsive and resistant to changing their purchasing habits (Interviewee #6, Large). According to the interviewees, companies perceived academia and other companies as valuable partners. Circularity encourages companies to be receptive to surrounding businesses, even if they are

still in start-up form. Then, d) Policy, meant as policy impacts are limited in the sample and expressed by pushes for policy changes and connected to large companies.

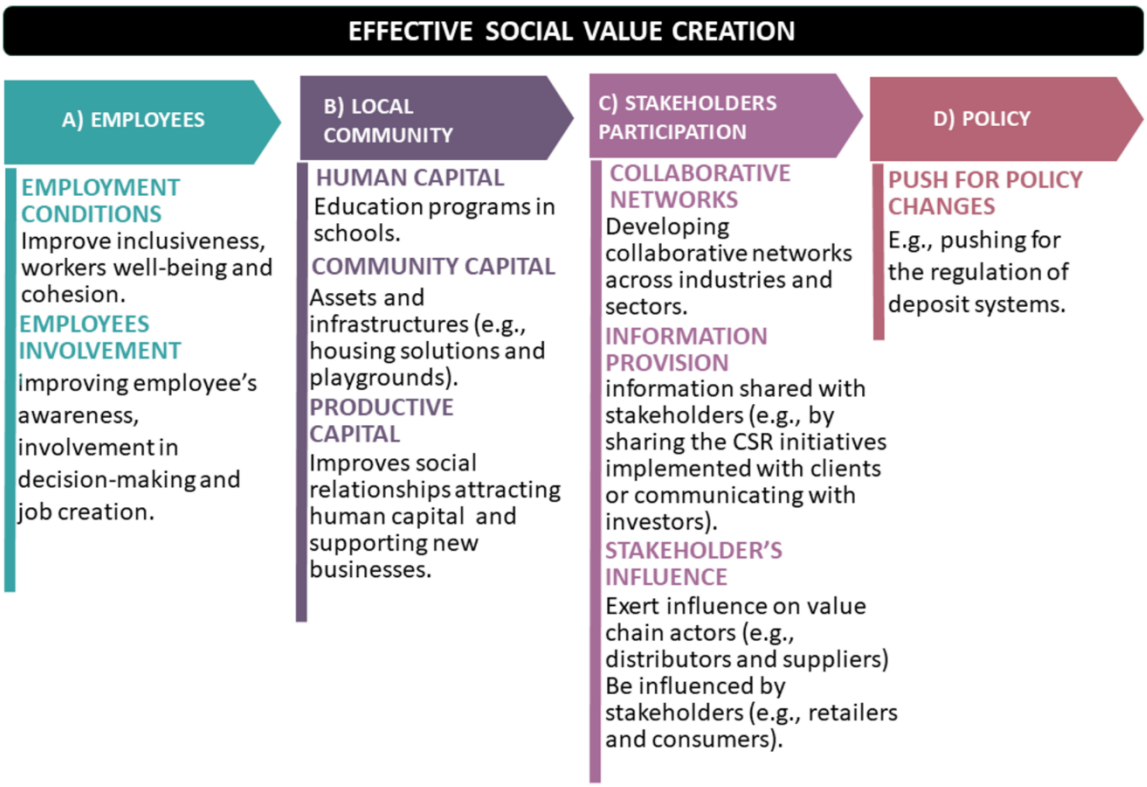

Fig. 7 Effective social value creation scheme. Adapted from Labuschagne et al. (2005)

Financial Performance

All the participants interviewed agree that CE has a clear impact on their FP. Due to increased efficiency in inputs and resources, cost reduction is the main benefit associated with CE. Some companies stressed the relationship between the circular practices implemented and positive FP. Specifically, linear practices generate costs for external input purchase but also costs to restore the ecosystem equilibrium. CE also allows entering new markets and reaching more consumers and a positive brand image. CE-related investments offer valuable payoffs, especially related to product quality, and are communicated through marketing initiatives. However, according to our interviewees, they need time to be profitable and involve additional costs that are difficult to forecast.

The analysis identified using ordinary monitoring tools (e.g., ROI, ROA, payback periods) to measure the FP of circular-related investments. One company, however, is working on a framework to value products by combining financial and sustainability criteria. Such a tool will allow us to overcome the dichotomy between costs and revenues to include key sustainability areas. As reported by one interviewee (Interviewee #8, Large), the brand manager was solely focused on the financial performance, but now is starting to familiarize with sustainability and to combine the two perspectives.

Exploring the FP issues to CE (evidenced in Fig. 8), the most relevant is the time constraint. Market's logic pushes companies to focus on short-term financial horizons. The same can be concluded for SMEs, which deal with limited structures and sometimes managers do not have the time to broaden their business perspective since they are too focused on putting out daily fires (Interviewee #5, SME). The Portuguese SMEs of the AFS are additionally challenged in accessing credit, being already overexposed to the banking and financial systems (Interview#5, SME), as evidenced during the interviews. Finally, an increased uncertainty for CE-related investments has been detected, since circularity is an old approach presented as new.

Overall, participants stress the cultural scope of CE. There are various financial indicators, some of which may give negative results in a single year, and this is why they must be assessed from a broader perspective, always considering the overall profitability of the company (Interviewee #2, Large). This is even more important for SMEs, where having a clear picture from the beginning is crucial to balance the investments required and to do so a company leader with such vision is needed (Interviewee #9, SME).

Fig. 8 Main barriers (Time and Uncertainties) perceived in financial assessment of CE strategic visions (investments and proposals for improvement)

Discussion section

The survey findings highlighted CE as one of the tools to address several SDG goals. Indeed, the AFS can contribute to SDG12, reducing food loss and waste, to SDG2, eliminating hunger through sustainable agriculture. Nowadays, CE is increasingly considered from a systemic perspective, although the environmental dimension is still strong. The ability of CE to generate social benefits remains the most controversial. Inquiring

about the drivers of CE, the interviewees identified environmental protection and financial gains as the main reasons for adoption. The first focused on reducing the environmental impact and ensuring the company long-term viability. The second is the generation of profit margins and cost savings. This confirms that environmental and economic drivers are prominent in the sector [31]. Undervalued is still the social driver of CE, as evidenced in the literature, e.g., by Murray et al., [70] and Geissdoerfer et al. [44]. Inquiring about barriers, the most impactful are the lack of financial resources and the company's culture. CE is undoubtedly costly for companies; it entails relevant costs for upfront investments [71, 32]. Moreover, the AFS deals with additional risk due to the seasonality and perishability of food products, exposing companies to price risk [31]. The lack of strong commitment and an unfavourable organizational culture proved to hamper the development of the dynamic capabilities necessary to implement CE [32]. The lack of CE consumer awareness [72], the lack of support from supply chain actors, and policy uncertainty are other hampering factors. Especially, consumers are perceived as reluctant to change. Indeed, according to Kirchherr et al., [45], the lack of consumer interest and awareness contributes to slowing down the transition towards a CE.

Regarding the maturity of the sector, results are ambivalent. One-third of the companies interviewed consider CE embodied in traditional agri-food practices since CE principles can be retraced to the roots of the agri-food system. CE has gained momentum as a new and disruptive approach, but it is an old one. In the past, the optimization and valorisation of waste and resources was a need, more than a choice for companies. Indeed, the same companies connect CE to efficiency drivers. Companies are even unaware of following CE principles. On the contrary, survey respondents largely defined the CE practices implemented as incrementally innovative; in contrast with scientific literature, where the large presence of conventional practices suggested the maturity of the sector [7]. However, some practices claimed to be innovative are established in the scientific literature, suggesting different perceptions among practitioners and academia. The survey was used to identify companies implementing circularity, since many of the practices mentioned in the survey lack an explicit link to CE (e.g., the use of solar panels). In this sense, most of the respondents who reported mismatched practices are not operating in sustainability-related departments: this may suggest a lack of internal communication within the company division, evidencing the overall necessity to raise awareness on CE in the AFS. Rotolo et al., [73], already pointed out the need to invest in education programs at different levels to strengthen the communication of CE in agriculture.

Concerning the assessment, the interview and survey sample present some differences in size of the assessing companies; in the survey, most of the assessing companies are SMEs, while within the interviews, they are large companies. However, when asked about the type of assessment, assessing SMEs are vague on the type of indicators included. Interestingly, some of the non-assessing companies claimed to adopt the measurement tools proposed; this suggests that the use of such tools is not for CE, and companies may not be aware they can use them for CE. Further investigation led to identify the benefits and barriers of CE assessment. Within the interview sample, four companies conduct forms of CE assessment, while the remaining five do not. First, size matters in CE assessment; only one SME claims to assess circularity, while the non-assessing companies are all SMEs, except for one large company, which is now approaching assessment. Second, companies do not assess because it is not a priority, but it will be soon due to external pressure. The same substantial lack of awareness was registered in the Portuguese public sector and considered the main cause for the lack of assessment by

Droege et al., [37]. In general, large companies perceive CE assessment and adoption as a necessity, also due to upcoming regulation, while the SMEs and the micro company as something voluntary and linked to their environmental vocation.

Among the barriers, companies claim the lack of proper structures, meant as resources and human capital to monitor CE, and structural, e.g., due to the voluntary nature of assessment [37]. Others are related to external factors like the lack of demand from supply chain partners or clients [74]. Nevertheless, as confirmed in the sample, a push from the consumer would be relevant for CE assessment. Concerning assessing companies, the benefits identified are focused on efficiency due to resource optimization. Secondly, assessment supports decision-making, allowing companies to focus on efficient CE strategies and communicating this information to improve brand reputation. One critical point for large and SMEs is the lack of benchmarks for CE assessment. This severely limits the possibility of contextualizing the assessment outcomes [9]. The new ISO 59020 [30] focused on assessing CE performance is designed to support companies in measuring CE, nevertheless it is not sector-specific [30]. Strictly related is the issue of communicability, which emerged by the tool analysis; CE requires technical tools (e.g., life cycle based), which outcomes are difficult to convey both among stakeholders and company's departments. Focusing on the size, the only assessing SME employed tailor-made indicators adapted from an online platform where other companies shared their experience. SMEs are generally forced to make careful choices due to fewer resources, but following the example of other companies allows them to understand how and where to focus their efforts.

Concerning the link between sustainability and CE assessment, both survey and interviewed companies consider CE part of sustainability, recognizing though wider scale of sustainability, which involves the whole supply chain. However, only one interviewed considered that circularity does not always imply improved sustainability due to possible rebound effects, namely the reduced environmental gain at one stage may more than offset the increased emissions at another stage [75]. Overall, the assessing companies agreed on the possibility of using the same tools for both. Such findings suggest confusion over the boundaries of the two concepts, as already assessed in the literature by Roos Lindgreen et al., [9].The little interest found on CE assessment suggest that more empirical studies; aimed at increasing the sector's awareness of the potential benefits of measurement and, at the same time, at identifying standardised and sharable forms of measurement based on companies' reality that allow the sector to implement and monitor CE effectively.

From a social point of view, CE pushes companies to move from a firm-centric vision to an ecosystem one, fostering close collaboration with multiple stakeholders. Such vision supports start-ups and corporations venturing into circular business models, where economic value includes social and environmental ones [76]. Most of the initiatives reported by the sample are directed to external actors, namely the local community, and companies' stakeholders. Although the employment potential role is significant in CE, the initiatives implemented are rarely translated into the creation of new jobs, in contrast with the literature [48, 77]. Companies tend to focus solely on the positive impacts of their social initiatives, emphasizing win-win situations but underestimating the possible tensions e.g., due to conflicting stakeholders' interests. As pointed out by Quintelier et al., [43], the relationships between resource circularity and social value can have negative repercussions but companies often ignore such aspects. For this reason, it is urgent to deeply analyse the social

aspect and understand how the CE can overcome these repercussions. The boundaries of the social construct are still blurred, and this may hamper companies' adoption of social CE practices clarity [46]. Interesting is the position of consumers, as they are considered relevant actors in the transition to CE but are often perceived as resistant to change [45]. In this sense, involving consumers would be relevant to promote customer loyalty and raise awareness on CE-related topics [77]. At the same time, CE has an undoubted financial impact on companies. Relevant financial gains are linked to improved efficiency. The cost is relevant, but the positive trade-off is also considerable and often embedded in marketing strategies that increase brand value. However, CE cost is the biggest financial barrier in the sample. Moreover, the size of the company affects the viability of CE. SMEs, which largely represent the Portuguese AFS [8], have more costs due to limited scale gains [56]. The assessment follows ordinary financial tools, a tendency already observed [55]. One exception is the sustainability dashboard created to drive companies' investments towards the three pillars of sustainability. Their example evidenced considerable issues regarding the company's internal communication. Employees in the financial sector often struggle to include circular logic in financial planning and measurement due to poor communication between departments. This generates an information gap which fuels the cultural issue. Despite market and liquidity reasons pushing companies to consider the short-term horizon, it is crucial to combine short- and long-term perspectives. Circularity involves a longer period, thus only a long-term perspective can fairly represent related financial benefits [55]. The uncertainty found during the interviews should be interpreted critically. Linear investments also entail market and environmental risks, while CE provides a considerable competitive advantage in the long term [56]. Again, the point is cultural: companies want to keep what they are already doing or want to invest in something different that will probably have a lower return in the short term but with long-term potential. Companies need a strategic approach to CE, the financial variable must be embedded and interpreted within a broader business plan that has a clear medium- and long-term objectives. A partial or incorrect financial evaluation does not allow companies to communicate the value of their activities, limiting the quantity and quality of financial resources they could obtain from investors or the banking system. Policy interventions are hardly mentioned in the sample, although they are crucial drivers of financial incentives. In Europe, there are already various forms of supply and demand-side incentives (e.g., in terms of taxation and subsidies) for circular eco-innovation to support companies, especially SMEs, in the transition to CE [78].

Overall, the need to measure and communicate the financial impact of CE [55, 56], has become more and more urgent with the introduction of measures such as the 'Taxonomy Regulation' in Europe [27], and the Corporate Sustainability Reporting Directive (CSRD) [28]. Such interventions force companies to start preparing to meet the upcoming requirements. Such preparation will be challenging, especially for SMEs, given their limited reporting experience [79]. Within this context, the new ISO 59020 series will facilitate the sustainability and traceability of economic activities [30], potentially guiding organizations interested in the performance of companies adopting the requirements, like financial institutions and governments.

The AFS plays a crucial role in the global and Portuguese economy. The demand for sustainable investments in the sector is increasing; this may contribute to establishing more sustainable practices in the long run [79].

Studies on identifying company needs and capabilities towards CE are encouraged in the sector to gain more knowledge on the topic and support the design of assessment approaches that address business reality, namely in other EU countries, to study cross-cultural differences. Moreover, standards like the UNI/TS 11820 [80] and the recently released ISO 59020 [30] identified a set of CE indicators to assess circularity, though not sector-specific, which applicability to the AFS should be explored in future studies. Further studies on the impact of CE on companies' FP are recommended, especially for defining monitoring tools adequate to communicate CE potential. More attention is needed on social value creation and FP and how it can be integrated into CE and its conceptualization. At the same time, the analysis provides relevant insights for policymakers since navigating through circular models is challenging in complex contexts such as AFS. Thus, given the consistent need for financial resources to implement CE in the sector, policymakers can entail the drivers and barriers evidenced from the study to design supporting mechanisms (such as subsidised investments) for companies investing in CE calibrated to AFS companies' needs.

Conclusions

The present article, based on nine interviews conducted on a selected sample of Portuguese companies of the AFS adopting circularity principles and identified through a previous survey, offers an overview of the status of CE in a European AFS context. Portugal was selected thanks to the relevance of the AFS, as well as the numerous initiatives to promote CE in the Country. Empirical evidence was collected through an explorative survey and subsequent semi-systematic interviews with companies already adopting CE practices in their activities. Thus, the purpose of the analysis was not to gather a statistically relevant sample of companies, but to thoroughly evaluate companies that have experience in the CE.

CE is increasingly perceived as a holistic approach, and largely retrace the circular practices implemented to incremental innovation, being limitedly aware of the boundaries between innovative and conventional measures. Circularity assessment is limited; however, several companies already adopt assessment tools which potentially address circularity, revealing a low level of interest or awareness in the assessment. The companies interviewed engage CE to limit environmental damage but also to generate revenues, however cultural and financial factors hamper its uptake in the sector. Measurement is limited in the sample and often perceived as a secondary objective, although it is fundamental to ensure effective implementation of CE. CE generates social value through employment and commitment to the community. This is translated mainly into services for the community, attention to the employee’s well-being, and the development of collaborative networks. Finally, Financial performance is a barrier but also a potential driver for CE implementation. Companies’ capacity to valorise circular-related investments and to communicate their financial value increases their financing options, making CE part of the company's resilience strategy. Overall, company size affects the capacity to implement and measure circularity. Nevertheless, companies implementing CE could receive more financial support if their circular performance is measured according to a recognized set of technical screening criteria, such as the ones indicated by EU taxonomy.

The analysis provides interesting policy and operational implications, increasing awareness towards implementing and assessing CE for practitioners while providing information to policymakers to design efficient supportive initiatives to foster CE in the food system. Some limits arise such as focusing on a single Country,

which means results should be generalised carefully. However, Portuguese AFS centrality and the interest shown in CE in the sector make it a valuable case study for the aim of the analysis. Moreover, the limited number of responses is possibly due to the research strategy adopted, which deliberately restricted the interviews to companies with declared experience in CE practices. Regarding the research method, interviews were conducted in English, which might have generated some translation issues, which have been limited by the presence of a Portuguese native speaker during the interviews.

Given the limited assessment of CE, future studies could develop a framework for CE assessment and reporting in line with all the sustainability pillars for companies of the AFS. LCA and circularity indicators are the most common in the sample for CE assessment thus, a framework adopting both might optimize what companies are already doing to direct them towards circularity. This would support practitioners in CE adoption, avoid greenwashing, and guide policymakers in supporting transitioning companies.

Although exploratory and based on a reduced sample of companies, the study provides interesting insights on how CE can generate social value in the AFS and contribute to understanding the relationship between circularity and companies´ FP. Promoting sustainable production and consumption in the sector will have a cascading effect on society, and CE is a valuable tool for pursuing this path.

Acknowledgement

Part of this project had the support of FCT, Portugal through the strategic projects UID/AMB/04085/2019 awarded to CENSE. The authors want to acknowledge and thank all the survey and interview respondents who participated in this research for their time and valuable contributions. An additional thank to Portugal Foods for their support in recruiting the participants. Author A.P. Moura acknowledges financial support from the national funds from the FCT—Foundation for Science and Technology through programmes UIDB/05748/2020 (https://doi.org/10.54499/UIDB/05748/2020) and UIDP/05748/2020 (https://doi.org/10.54499/UIDP/05748/2020), supporting GreenUPorto.

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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