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Circular Economy Practices among Industrial EMAS-Registered SMEs in Spain

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Abstract: The Eurobarometer report from December 2019 revealed that 80% of European Union (EU) citizens believe that industry is doing too little to protect the environment and that more work needs to be done to help companies transition to a more sustainable economic model. In recent years, the EU has made the Circular Economy (CE) a priority, and an environmental management system based on the EMAS Regulation can help companies achieve this goal by assisting them in analysing and measuring an efficient and sustainable use of resources. Thus, this study analyses EMAS companies' environmental statements in order to identify and quantify the CE practices they have implemented. Findings identify 23 circular practices and show that the majority of companies focus their efforts on reducing emissions by optimizing the materials cycle and improving internal production processes. Eco-design stands out as the main driver amongst the circular transformation practices. This study has also detected a lack of uniformity in the way companies quantify the various circular practices currently operating, or how they communicate this information. These results may be useful to companies, professionals and administrations responsible for promoting the CE, and it can also provide guidance on what information to include in future environmental statements.

Keywords: Circular Economy (CE); sustainability; circularity; implementation; Environmental Management System (EMS); Eco-Management and Audit Scheme (EMAS); Small and Medium Sized Enterprises (SMEs); industrial; Spain

1. Introduction

Neither the planet nor the economy can survive if it continues to follow the traditional economic model based on raw material extraction, manufacturing, use and disposal. Preserving valuable resources and fully exploiting their full economic value has become crucial [1]. The Circular Economy (CE) is rooted in the principles of reducing waste and protecting the environment as well as dramatically transforming the way the economy works. By rethinking the way in which we produce, work and buy products, new opportunities and occupations can be created [2,3]. The CE needs to be able to generate value which is less dependent on natural resources by taking a systemic and holistic approach and integrating the whole value chain. The concept of a CE requires, and accommodates to a greater or lesser extent, the participation of a wide spectrum of agents varying in size and nature such as public and private agents, consumers or research centres.

Aspiring to replace single-use products with ones that are circular by design and creating reverse logistic networks have become powerful stimuli for new ideas. Thus, everything related to circular supplies, resource recovery, product life extension, sharing platforms and products as a service represents a vibrant business terrain for entrepreneurs [4]. Businesses should reap the benefits of an economy that operates with higher rates of technological development, optimized and improved materials, energy efficiency and greater opportunities for productive and resource-efficient companies.

Hence, activities and actions aligned with the new CE paradigm in the business environment have become more and more frequent for all types of organisations and sectors, and increasingly, researchers are focusing their efforts on studying the key role played by businesses in developing the CE at company and organization level [5–8]. However, a more in-depth study of how businesses on the road to circularity integrate the principles of this new paradigm is needed [9,10].

Companies that have implemented an Environmental Management System (EMS) are considered to have greater environmental awareness and show a special sensitivity towards protecting the environment, as well as being one step ahead of the rest [11–13]. The Environmental Maturity Model (EMM), developed by Ormazábal et al. [14], which assesses the level of maturity of companies transitioning to a CE, ranging from the most reactive to the most proactive maturity stage, considers that companies implementing an EMS would be located at a medium stage of maturity in their progress towards circularity (Systematization) on a 6-stage scale. Traditionally, proactive EMS adoption and certification have been associated with large companies, usually endowed with more capital than small and medium-sized enterprises (SMEs), and which have a clear strategic vision and regard EMS implementation as a genuine commitment to competition [15]. However, this situation has been changing, and increasingly, SMEs are also reaping the benefits of implementing EMS in their organisations. Proof of this are the data available from the European Commission's EMAS Helpdesk register of 15 June 2020, which reveals that only 26% of EMAS-registered businesses are large companies [16]. Nevertheless, a company's green image and commitment to a paradigm shift towards the CE needs to be translated into action [17].

Research on CE adoption in companies at regional level is still limited [18], so the aim of this study is to help reduce this deficit. Therefore, this article aims to identify CE practices being reported by SMEs implementing EMS in their move towards a CE model. The following Research Questions (RQ) have been posed:

- RQ1: Do companies include the CE concept in their environmental statements?
- RQ2: What CE activities or practices do companies claim to have adopted? Are some activities more commonly adopted than others?
- RQ3: How are CE practices reported and quantified in environmental statements? How are these practices reported to stakeholders?
- RQ4: Does a relationship exist between circularity practices and economic performance?
- RQ5: What information should be included in environmental statements in the future to help evaluate the application of circularity practices in EMAS-registered companies?

The aim of this study is to answer these questions by analysing the environmental statements of EMAS-registered SMEs in Spain, currently the second country in the EU in number of companies with EMAS registration (1092 companies), behind Germany (1099 companies). Specifically, we have analysed companies from the industrial sector in Catalonia (northeast Spain), one of the most industrialized regions of Spain, with a business network mainly made up of SMEs.

This study is focused on companies in the industrial sector as the challenges of environmental pollution and worldwide scarcity of resources have meant that these companies must simultaneously cope with the pressure of environmental regulations, the challenges of resource price volatility and supply chain risks in a far more critical way [19]. At the same time, this sector has been included in the priority areas of activity on which the 2030 Spanish Strategy for the Circular Economy is focused.

The main novelty of this research is that it focuses on exploring the actions that industrial EMAS-registered SMEs have claimed to have taken in relation to adopting CE practices. These companies are supposedly located at a higher stage of circularity than the rest of industries that still have a very traditional, linear business model, as suggested by Marrucci et al. [12]. We believe this study can be useful for other companies operating in similar contexts, but which have not yet reached the mid-level maturity stage on the EMM scale developed by Ormazábal et al. [14]. Thus, this contribution aims to provide examples of practices implemented on the long road of transition towards the sustainable production and consumption model that the CE involves. Finally, this study also focuses on analysing the way in which companies quantify different circular variables, such as materials inflow and outflow, water and energy consumption, and how this information is communicated to different stakeholders.

At Spanish state level, studies analysing CE implementation have been conducted in the Basque Country and Navarra [20,21] and Aragon [22,23]. This study will help expand the geographical scope of the research by analysing the situation in Catalonia.

This article is organized into 5 sections. Section 2 reviews the literature on CE-related concepts in the field of SMEs and their relationship with EMS. Section 3 describes the methodology designed to respond to the research questions based on information in the environmental statements. The results are presented in Section 4. Finally, results analysis and the main conclusions and limitations of the study are contained in Section 5.

2. Overview of the Research Context

In 2015, the United Nations presented the 2030 Agenda for Sustainable Development, which established 17 Sustainable Development Goals (SDG) focusing on people, planet and prosperity. The CE is one of the central elements for achieving some of the goals, among which five are especially noteworthy:

- SDG 7: Ensure access to affordable, reliable, sustainable and modern energy.
- SDG 8: Promote inclusive and sustainable economic growth, employment and decent work for all.
- SDG 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation.
- SDG 12: Ensure sustainable consumption and production patterns.
- SDG 13: Take urgent action to combat climate change and its impacts.

Since then, the CE has been vigorously implemented in the EU Commission's economic policy with the aim of promoting the transition towards production and consumption systems based on the principles of circularity [24]. In a global context of strained, over-exploited resources, no one questions the importance of taking sustainability into account in business strategies, business models and product and service design [6,25,26]. It is the key to moving towards a more competitive, responsible and circular economy for progress and social wellbeing.

The definition of CE has been widely debated depending on the field of knowledge and the issues addressed [7,9,23,27–30], but consensus does exist that CE is an economic model oriented towards achieving more efficient and resilient production and consumption systems that preserve resources within a continuous cycle optimizing their value [31–33]. Thus, the numerous, different definitions of CE can be classified according to whether they focus on its objectives, activities or outcomes [34]. Some of these contributions are summarized briefly in Table 1.

Table 1. Contributions to the definition of Circular Economy.

	EC Definition	References
Objectives	Closed flow of materials/Economy integrated with resources, environmental factors and territoriality	References [33,35–38] Yuan et al., 2006; Ellen MacArthur Foundation, 2015; Li et al., 2010; Andersen, 2007; Kama, 2015
Activities	Production processes/Industrial symbiosis	References [9,28,29,39–41] Zhijun y Nailing, 2007; Ehrenfeld y Gertler, 1997; Jacobsen, 2006; Walls and Paquin, 2015; Zeng et al. 2017; Katz et al., 2019
Outcomes	Energy efficiency/Waste minimization/Environmental conservation	References [34,42–44] Liu et al. 2009; Morlet et al., 2016; Ghisellini et al., 2016; Haas et al., 2015

In short, the new economic paradigm involving the CE requires a change in both business and individual outlook, rethinking the ways in which we produce and consume. Some authors [30,45,46] have established varying levels of analysis in the implementation of CE principles:

- Macro: includes national and supranational levels where work is being done to promote a society oriented towards recycling and circularity implemented nationally and supranationally. Includes cities and states.
- Meso: contemplates CE implementation through eco-parks, local industrial symbiosis initiatives and through the management of waste and the inflow and outflow of resources and raw materials in a territory.
- Micro: refers to companies and organisations and consumers. CE objectives for this level are focused mainly on more environmentally sustainable production.
- Nano: at process or product level.

Thus, this new paradigm shift should take place under a multi-level approach [47]. It should also be implemented at all levels simultaneously and always within the framework of the Triple Bottom Line perspective [48], which intersects economic aspects with social and environmental ones [39].

2.1. Adopting the Circular Economy in SMEs

According to the results of a new Eurobarometer survey (December 2019), 94% of citizens from all EU Member States said that protecting the environment was important for them. Ninety-one percent stated that climate change was a serious problem in the EU, and 80% of respondents, reaching 90% in the case of Spain, felt that industry was not doing enough to protect the environment. The survey also revealed that citizens believed responsibility should be shared by large companies and industry, national governments and the EU, as well as by the citizens themselves. It was recognized that fundamental changes may be needed as well as greater investment in research and development, more information and education, stricter legislative control and the promotion of company participation in sustainable activities.

SMEs play a fundamental role in the transition to a CE both at global and European level and in Spain, where they represent 99.83% of all companies [49]. Thus, SMEs are essential drivers for the transition towards a CE. Identifying all the opportunities gained and progress made by these companies in different territories in this field and highlighting their importance is a necessary starting point to attract new initiatives to help shape an environment that fosters more CE business strategies.

Challenges and opportunities for companies in their transition towards a CE model have been identified in different studies [47,50–54]. On this basis, it must be taken into account that business incentives and motivation to move forward in this direction may differ greatly, both qualitatively and quantitatively, depending on the sector, the company and its location [55]. In some cases, the focus will be on transforming existing business activities, while in others, new business models will have to be introduced for which there may be no precedent. It is also important to keep in mind that, although circularity may exist across the entire value chain, it is possible that in the early stages of implementing the new circularity paradigm, all progress with positive impacts should be recognized and encouraged, even though only one part of the value chain is affected and only a part of the possible stakeholders have been integrated.

It is well known that SMEs have a daily work routine that is packed with obligations, and they are very focused on their business, but they should take a moment to reflect on what routes to take and the possible benefits that transitioning to the CE can bring them [52,56,57]. Aside from traditional ways of approaching business, many other ways exist and being more sustainable is not the only reason for making this transition, but also being more competitive, having a mid- to long-term plan, or being innovative, to name but a few.

Some public incentives can help promote the adoption of sustainable CE manufacturing practices among SMEs [58–66]. Promoting the introduction of broader circular principles related to the exchange of goods and services through polices supporting corporate social responsibility is also useful [67].

At a European level, there are the European Structural and Investment Funds, the SME Instrument, or Fast Track to Innovation [24]. In Spain, the 2030 Spanish Circular Economy Strategy was passed on 2 June 2020, in line with the objectives of the two European Commission Circular Economy Action Plans:

(1) Closing the loop: an EU action plan for the Circular Economy, and (2) A New Circular Economy Action Plan for a Cleaner and more Competitive Europe (2020) in addition to the European Green Deal and the 2030 Agenda for Sustainable Development. At the level of Catalonia, the Government of Catalonia Strategy for Promoting Green and Circular Economy in Catalonia and the Catalan Eco-design Strategy have been created to promote a CE based on eco-innovation. The PIMEC business organization has also approved its own strategy for promoting a green and CE.

However, apart from the support that SMEs can obtain through the state, regional governments or business associations, it is worth highlighting where business opportunities can be found, so SMEs can focus on increasing their income in this area. Lacy and Rutqvist [68] identified five circular business models (Circular Supplies, Resource Recovery, Product Life Extension, Sharing Platforms and Product as a Service), and the consulting firm Accenture [56] highlighted 10 technologies (in particular, digital technologies in the form of social networks, cloud computing, analytics and mobility), which are enabling levels of speed and flexibility not seen before. Thanks to these business models and technologies, companies can focus on circular advantage from the customer's point of view instead of on simply improving efficiency.

2.2. Environmental Management Systems and the Circular Economy

The Pact for a Circular Economy [24] was spearheaded by various government entities in order to define the process of transition towards a CE model. One of its actions is to develop guidelines to boost innovation and the overall efficiency of production processes by introducing measures such as EMS. Since the Pact was written, certifiable EMS have been adopted by a significant number of businesses and institutions [69–71], and a considerable number of studies have highlighted their strengths and weaknesses [72–79]. Other institutions and researchers have also highlighted the importance of adopting environmental management standards [80] and eco-labels [81,82] to foster CE within companies.

One of the standards underpinning the transition to CE is the Eco-Management and Audit Scheme (EMAS). EMAS was developed in 1993, a year before the first version of the international standard ISO 14001 was published, and a year after the 1992 Rio Summit. At the Rio Summit, a broad intergovernmental agreement on a global action plan to promote sustainable development, called Agenda 21, was approved and the United Nations Commission for Sustainable Development was created. After 27 years, the EMAS model continues to be a reference of excellence for environmental management systems. Throughout this time, the scheme has been evolving alongside organisations, adapting to their needs and expectations, and to changes in European policies and strategies. It has undergone up to four revisions, the last one in January 2019 [83].

The EMAS Regulation can help businesses on the path towards a CE as it evaluates the environmental impact of their activities, as well as encouraging improvements in their energy efficiency and developing systematized audits. It also monitors and guarantees the transparency of their processes [80]. In essence, EMAS contributes to circular development by analysing and measuring the efficient use of resources [12,83,84].

The benefits of a circular model can be reaped by taking both the context and stakeholders into account, identifying the environmental aspects and legal requirements, as well as any associated risks and opportunities; in other words, adopting a Lifecycle perspective and risk-based thinking. In addition, a circular model enables organisations to not only ensure legal compliance but also plan ahead for new environmental requirements to be approved, which in turn contribute to minimizing risks and identifying new business opportunities.

Approaching EC implies changing the business model and incorporating new management practices. To do so, involving employees is essential. This is a long-standing requirement in the EMAS and makes employees aware of the importance of participating in the system. It is particularly important for senior management to be involved as they bear the greatest responsibility for the company's environmental strategy and can therefore demonstrate their leadership.

EMAS requires that organisations demonstrate continuous improvement in their environmental performance on an ongoing basis. This encourages the organization to investigate the efficiency of resource consumption, changes in processes, the search for less contaminating materials and other actions that are a driving force for innovation. The annual publication of the environmental statement gives EMAS organisations a major opportunity for transparency. This additional initiative, compared to the ISO 14001 standard, for example, is recognized by all interested parties, including public administrations. This is what makes it a very powerful communication tool which highlights the actions taken to move towards circular models. It also serves as an example for other organisations to verify the advantages of adopting the principles that govern the CE.

Hence, this study aims to identify the CE practices currently reported by EMAS-registered industrial sector SMEs. The question that arises at this point is what adopting a CE model means for companies in this sector. The literature refers to sustainable manufacturing as a radical change within the context of closed-loop product systems. The concept of Resource Conservative Manufacturing, ResCoM, has been introduced as a new paradigm for sustainable manufacturing [85]. Since traditional business models, products and supply chains have been designed to operate in linear systems, they are unable to cope with the dynamics of closed-loop systems. Therefore, a novel approach is proposed in which the dynamic interaction between business models, product design, supply chains and customers is essential, and at the same time treated as an integral part of industrial firms [86]. The concept of ResCoM includes the concept of multiple product lifecycles and, together with energy conservation, material and added value with waste prevention and environmental protection are integrated components of the product design and development strategy [10]. A difficulty for many SMEs is the fact that these companies often work on a B2B basis and producers cannot control the final product. The majority lose their traceability, which means that they cannot take action in the reclaiming materials stage, and this limits their actions regarding clean production practices to within the company alone [13,47].

2.3. Models for Measuring Micro Level Circularity Actions

In order to measure the degree to which businesses adopt CE, several studies in the literature that propose definitions of micro-level circularity indicators were identified [87–92]. Their novelty, together with the very generic definition given to them, may explain the low degree of CE adopted by businesses [93–95]. Park and Kremer [96] warn that companies need to understand the usefulness, importance and potential benefits of environmental sustainability indicators in order to be able to use them in their operations management [97]. Another key issue is obtaining the considerable amount of data these indicators require. Much of the necessary data is difficult to gather and often has to be provided by various actors linked to the product lifecycle. This difficulty in obtaining data, both in terms of time and cost, is one of the main stumbling blocks for extending the use of indicators to a company or organization level, due to the lack of information exchange between companies and confidentiality issues [98,99]. Despite this, advances in digital technology should make it easier and faster to obtain data [27]. Standards publications such as the BS8001:2017-Framework for implementing CE principles in organisations [92] should also help guide organisations in implementing the standards.

Various models proposing to measure circularity activities or practices in companies have been identified in the literature: Garza-Reyes et al. [100] carried out a review of various models used to measure CE in SMEs and proposed a model that includes 36 practices grouped into 7 factors; Masi et al. [101] mention 25 CE practices; the European Environmental Agency (EEA) [3] proposes 16 actions grouped into 5 key characteristics; Mura et al. [52] identify 20 practices; Aranda-Uson et al. [18] propose 13 activities grouped into 4 levels; Fonseca et al. [13] propose 15 dimensions; Prieto-Sandoval et al. [20] define 11 elements as fields of action for CE; Janik and Zafraniek [84] establish 12 practices grouped in the 5 categories described as key elements by the EEA [3]; and Rizos et al. [51] mention 8 main processes.

Some of these proposals have been put into practice, and the models used to measure the degree to which CE has been adopted by businesses at both national and regional level are shown in Table 2.

Table 2. Studies on EC implementation in companies.

Reference	Country (Region)	Sample	Methods	Main Conclusions
Ormazábal et al., 2016 [21]	Spain (Basque Country)	17	Case study	80% try to reduce consumption raw materials 18% water treatment or recirculate by-products 41% recovery of used products 53% no environmental criteria for supplier selection
Fonseca et al., 2018 [13]	Portugal	99	Survey	The segregation and valuation of waste is a priority The collection of end-of-life products and cooperation with suppliers and customers are no very intense
Oncioiu et al., 2018 [102]	Romania	384	Survey	14% strengthening the guarantees offered to consumers who purchase goods online 13% use of renewable energy 13% designing smart and green products and using energy labelling 10% use of advanced manufacturing facilities to achieve clean production
Ormázabal et al., 2018 [47]	Spain (Navarra -Basque Country)	95	Survey	42% try to reduce consumption raw materials Low use of ecological/biodegradable materials 17% use environmental criteria for supplier selection Not yet prepared for circular business models
Janik and Szafraniec, 2019 [84]	Poland	66	EMAS Statement Review	50% try to minimize the waste production 47% try to minimize energy and water usage
				Only 3% work on keeping the value of products/components/materials in the economy
Aranda-Usón et al., 2020 [18]	Spain (Aragón)	52	Interviews	Most frequently implemented activities: 82% industrial waste recycling 75% energy efficiency 60% reduction of environmental impact
Kumar et al., 2020 [103]	UK (Midlands)	130	Case study Focus group Survey	CE fields of action (Take, Make, Distribute, Use and Recover) are correlated to economic performance, Only Make and Use are related to environmental and social performance.
Mura et al., 2020 [52]	Italy	254	Interviews Survey Focus group	84% apply separated waste collection 38% apply recovery/reuse of packaging 32% work on energy conservation Only 14% work on resource saving practices

In this study, the model proposed by Prieto-Sandoval et al. [20] was followed to analyse the CE practices reported in the environmental statements. The underlying concept of this model is that CE can be understood through 5 areas of action: Take, Make, Distribute, Use and Recover. Each of these areas is specified in a series of circular practices in line with the key characteristics proposed by the EEA [3], enabling comparisons with similar studies to be made (see Table 3). We found that only 3 fields of action (Take, Make and Recover) had key related characteristics.

Table 3. Circular practices following the model of fields of action.

Field of Action	Elements	EEA Key Characteristic
TAKE The way in which industries take energy and resources from the environment	Selection of biodegradable materials in different value chains	Non-renewable resources replaced with renewable ones within sustainable levels of supply
		Increased share of recyclable and recycled materials that can replace the use of virgin materials
	Selection of easy recirculated materials in different value chains	Minimised and optimised exploitation of raw materials, while delivering more value from fewer materials
		Closure of material loops
		Sustainably sourced raw materials
	Environmental efficiency of production processes to reduce resources use	Reduced import dependence on natural resources
		Efficient use of natural resources
		Minimised overall energy use
		Minimised overall water use
	Environmental efficiency of production processes to reduce emissions	Reduced emissions throughout the full material cycle through the use of less raw material and sustainable sourcing
		Less pollution through clean material cycles
	Sustainable energy sources for production	Energy replaced with renewable ones
MAKE Processes can be carried out in a sustainable way with eco-innovations and the best technological practices	Environmental innovation in the design of sustainable products and services, in order to extend their lifecycles and facilitate recovery in the future.	Extended product lifetime keeping the value of products in use
	The recovery of raw materials and resources in the internal process of the company	–
DISTRIBUTE The way in which a product or a process is delivered to the customer	The development of a sustainable logistics systems	–
USE Refers to reduce the environmental impact associated with the use of the product	The development of business models where the final consumer is not the owner of the goods	–
	The offer of services that extended the life of the products of services	–
	Design of products that work with sustainable energies	–
RECOVER In the CE, eco-innovation processes are boosted to recover the waste, materials and energy that remain in use products at the end of the lifecycle	Channels of communication with costumers to retrieve products that they no longer use or that they want to renew	–
	Recovery and industrial recirculation of materials that consumers do not use any more	Build-up of waste minimised
		Incineration and landfill limited to a minimum
		Dissipative losses of valuable resources minimised
		Reuse of components
		Value of materials preserved in the economy through high-quality recycling

3. Methodology

The research questions posed in the study are answered based on the theoretical framework described in the previous section, and an analysis of the environmental statements of EMAS-registered businesses in the industrial sector in Catalonia (northeast Spain). The study presents an exploratory analysis of public environmental statements, or those verified by accredited third parties. To achieve this, the research was carried out in several stages.

Firstly, access was gained to the European Commission's EU EMAS Helpdesk register, and in June 2019, a list of 845 EMAS-verified centres in Spain was obtained. Of these, 233 pertain to businesses in Catalonia and 59 to the industrial sector. Of these, 31 are SMEs, and make up the study population (see Table 4).

Table 4. Description of the study population.

Sector	Number EMAS Register
Industry and manufacturing	59
Services/Education/Health	27
Tourism	37
Retail/Logistics	16
Construction	16
Public administration	23
Waste management	38
Others	17
TOTAL Catalonia	233

The second step was to search for the statements directly on the company websites, or when they were not found directly, using the web search engine. In the search, the following criteria were taken into account: (1) most recent environmental statement and (2) Spanish and/or Catalan language and the key words: "Name of the company" + "EMAS statement/Environmental statement" and/or "EMAS verification number". A review process was then carried out to ensure that the documents met the above criteria and were accessible for Optical Character Recognition (OCR). In addition, in order to ensure the information was relevant, all documents were verified by an accredited verification body.

Thirdly, to determine what data should be collected from the statements and which ones would provide relevant information on circularity practices, the characteristics of the two models were used in way that was complementary: Fields of action and the EEA key characteristics (see Table 3). Based on the above, a list of 23 CE practices was obtained, grouped into 6 categories: Natural Resources (NR), Renewable Energy (RE), Raw Materials (RM), Reduce Emission (EM), Waste Management (WM) and Product Lifecycle (LC) and classified according to the fields of action proposed by Prieto-Sandoval et al. [20] (see Table 5).

Table 5. Elements of Fields of Action model and CE practices.

Field of Action	Elements	Code	CE Practices	Category
Take	Selection of biodegradable materials in different value chains	RM2	Replacement of materials with renewable ones	Raw Materials (RM)
		RM3	Selection of biodegradable materials	
	Selection of easy recirculated materials in different value chains	RM1	Improved raw materials use efficiency in production	
		RM4	Use of sustainable/renovable raw materials	
		RM5	Use of recycled/recirculated raw materials	
		RM6	Certification/evaluation of suppliers' environmental behavior	
	Environmental efficiency of production processes to reduce resources use	NR1	Improved water efficiency in production	Natural Resources (NR)
		NR2	Improved energy efficiency in production	
	Environmental efficiency of production processes to reduce emissions	EM1	Reduced emissions due to less extraction of raw material	Emissions (EM)
		EM2	Reduced emissions stemming from using clean energies	
		EM3	Reduced emissions by optimizing materials/machinery/processes	
	Sustainable energy sources for production	RE1	Use of renewable energy	Renewable Energy (RE)
Make	Environmental innovation in the design of sustainable products and services, in order to extend their lifecycles and facilitate recovery in the future.	LC1	Extended product lifetime	Product Lifecycle (LC)
		LC3	Eco-design	
		LC6	Product traceability	
	The recovery of raw materials and resources in the internal process of the company	WM1	Decreased no-hazardous waste generation concerning production	Waste Management (WM)
			Decreased hazardous waste generation concerning production	
		WM3	Waste recovery	
		WM4	By-products	
		WM5	Reintegrated waste into the internal production process	
Recover	Recovery and industrial recirculation of materials that consumers do not use any more	LC2	Reused/refurbished/remanufactured products	Product Lifecycle (LC)
		LC4	Easy components separation	
		LC5	Returning materials to the factory after use	

The data grid (Table S1) was designed, corroborated and validated by the researchers to establish whether the information was available in the statements. Both qualitative data on circularity practices mentioned (1) and no mentioned (0), and quantitative data (positive (1) or negative (0) performance variation) were gathered. Quantitative data compiled consumption of water, energy, raw materials and waste, which was related to both the production volume, as well as differences in comparison to the previous year (see Figure 1).

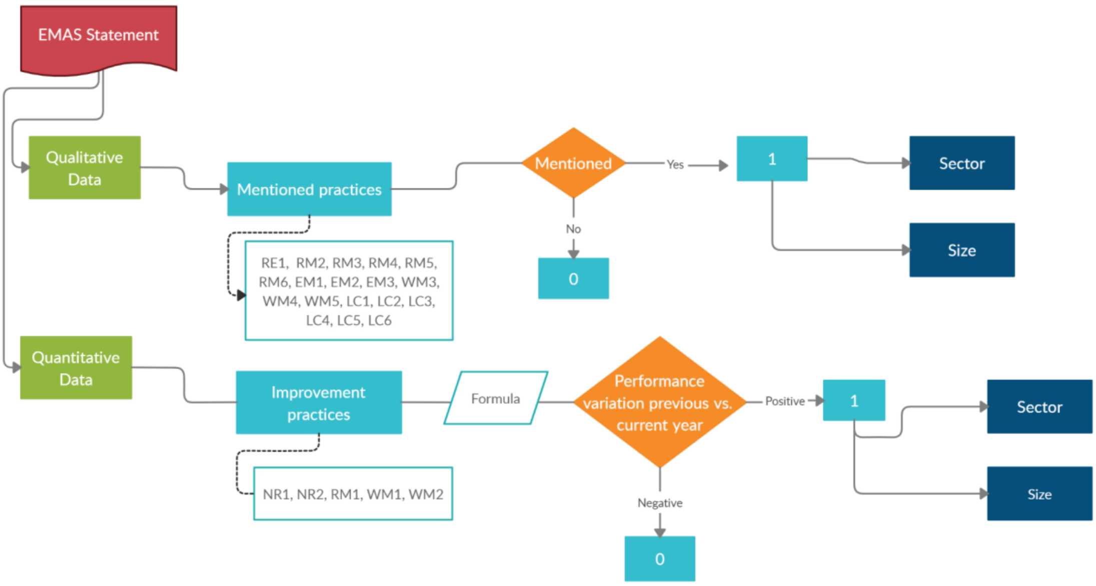

Figure 1. Data coding and classification process.

The fourth step involved searching for the data, then coding it using *Atlas.ti* software. All three researchers analysed and categorized all the information in the documents following the research model (see Table S1, Figures S1 and S2 in Supplementary Materials). The same protocol of action was followed and added the grid designed and agreed by all members of the group in order to ensure reliability and validity [104].

Finally, the data gathered independently was verified and discussed by the researchers in order to avoid errors before adding them to the grid with the final information chosen. The data was subsequently statistically processed using the SPSS v25 software.

4. Results

In accordance with the objectives of the study, the Research Questions are thus answered.

4.1. RQ1: Do Companies Include the CE Concept in Their Environmental Statements?

Of the 31 statements analysed, only 3 explicitly mentioned the term "Circular Economy". It should be noted that the time period of the statements studied is from 2016 to 2019, and the incursion of the term is relatively recent in the business world.

4.2. RQ2: What CE Activities or Practices do Companies Claim to Have Adopted? Are Some Activities More Commonly Adopted than Others?

Although the term is not explicitly mentioned in most of the statements, one of the aims of the study was to explore which circularity practices are mentioned in the environmental statements of EMAS-registered organisations in the industrial sector in Catalonia. A total of 23 practices were identified, which can be grouped into 6 categories (1) Natural Resources, (2) Renewable Energies, (3) Raw Materials, (4) Emissions, (5) Waste Management;, and (6) Product Lifecycle. Figure 2 shows the number of companies mentioning these practices in their environmental statements. We can conclude that the most commonly implemented practices belong to the fields of action Take and Make.

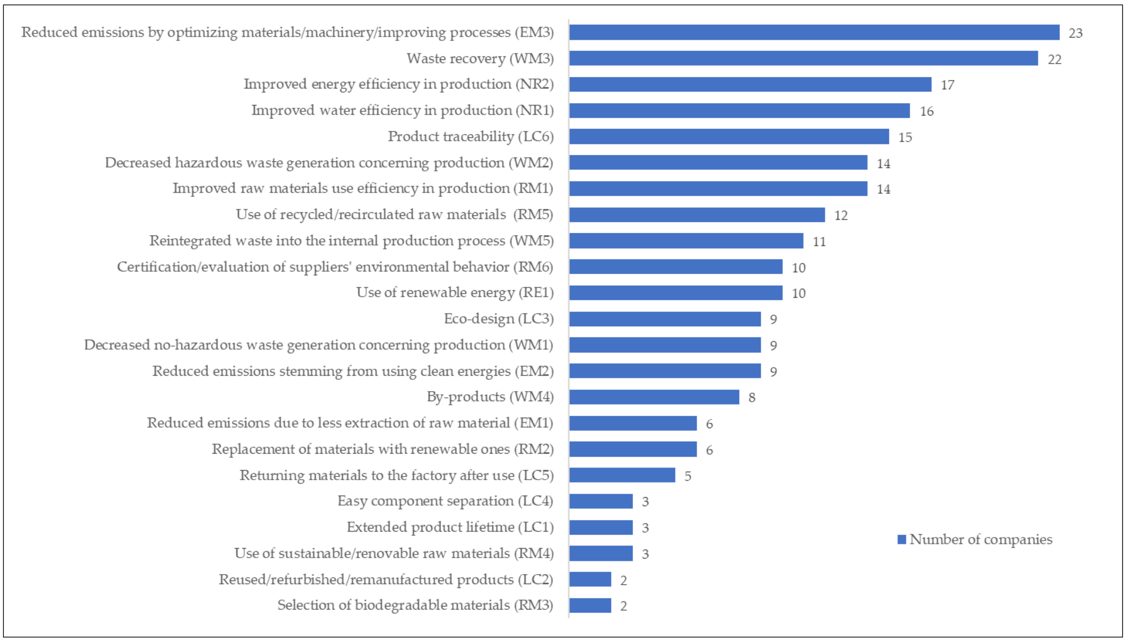

Figure 2. Circularity practices mentioned in the Eco-Management and Audit Scheme (EMAS) Environmental Statements.

To analyse the practices mentioned above, organisations were examined to see how they were distributed according to size and grouped by industrial sectors (Figure 3).

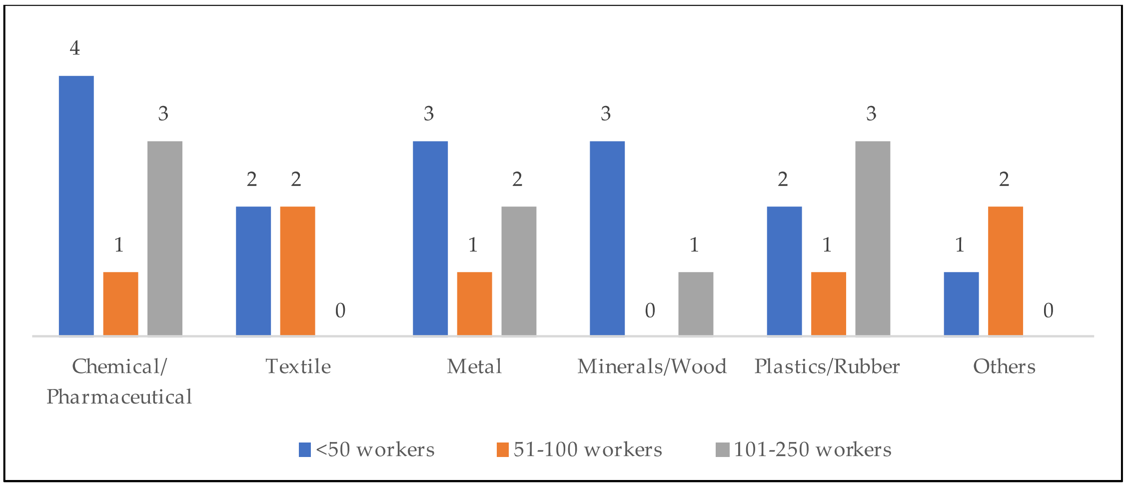

Figure 3. Population distribution by size and sector.

The practices were divided into two types: quantitative, which enabled the increase or decrease in yield to be calculated, and qualitative, which determined whether actions related to the practices were mentioned or not. For the quantitative practices, the following formula was used and adapted to either the consumption of natural resources or raw materials:

$$\textbf{Performance} = \frac{\frac{Water\ consumption\,\frac{m^3}{energy}(MWh)}{Annual\ production}\,\textbf{year} - \frac{Water\,\frac{consumption\left(m^3\right)}{energy(MWh)}}{Annual\ production}\,\textbf{previous year}}{\frac{Water\,\frac{consumption\left(m^3\right)}{energy(MWh)}}{Annual\ production}\,\textbf{previous year}}$$

and for waste reduction:

$$\textbf{Waste generated} = \frac{\frac{\underline{Hazardous\ and\ Non\ Hazardous\ waste}}{Annual\ production}\,\textbf{year} - \frac{\underline{Hazardous\ and\ Non\ Hazardous\ waste}}{Annual\ production}\,\textbf{previous year}}{\frac{\underline{Hazardous\ and\ Non\ Hazardous\ waste}}{Annual\ production}\,\textbf{previous year}}$$

Table 6 shows the practices organisations have implemented corresponding to the size or industry sector group. In the performance practices (Improved water efficiency in production, Improved energy efficiency in production, Improved raw materials use efficiency in production) those with increased performance were counted.

Table 6. Contingency table. Distribution of practices by company size and sector groupings.

			Size (No. Workers)			Sector							
CE Practice		**CE practices by category**	**<50**	**51 to 100**	**101 to 250**	**Chemical /Pharma**	**Textile**	**Metal**	**Minerals /Wood**	**Plastics /Rubber**	**Others**	**Total Per Practice**	**%**
#	Code	*General distribution of practices by groupings*	15	7	9	8	4	6	4	6	3	-	-
		Natural resources category (NR)											
1	NR1	Improved water efficiency in production	8	3	5	4	1	4	2	4	1	16	52%
2	NR2	Improved energy efficiency in production	9	6	2	3	3	3	1	5	2	17	55%
		Renewable energy category (RE)											
3	RE1	Use of renewable energy	5	0	5	3	0	2	4	0	1	10	32%
		Raw materials category (RM)											
4	RM1	Improved raw materials use efficiency in production	7	2	5	5	1	2	1	4	1	14	45%
5	RM2	Replacement of materials with renewable ones	3	1	2	3	0	0	1	1	1	6	19%
6	RM3	Selection of biodegradable materials	0	1	1	1	0	0	0	0	1	2	6%
7	RM4	Use of sustainable/renovable raw materials	1	1	1	1	0	0	1	0	1	3	10%
8	RM5	Use of recycled/recirculated raw materials	6	1	5	3	1	1	2	5	0	12	39%
9	RM6	Certification/evaluation of suppliers' environmental behavior	4	1	5	1	1	1	2	4	1	10	32%

Table 6. *Cont.*

			Size (No. Workers)			Sector							
CE Practice		CE practices by category	<50	51 to 100	101 to 250	Chemical /Pharma	Textile	Metal	Minerals /Wood	Plastics /Rubber	Others	Total Per Practice	%
		Reduced emissions category (EM)											
10	EM1	Reduced emissions due to less extraction of raw material	3	1	2	1	0	1	2	2	0	6	19%
11	EM2	Reduced emissions stemming from using clean energies	5	1	3	3	0	0	4	1	1	9	29%
12	EM3	Reduced emissions by optimizing materials/machinery /improving processes	10	5	8	5	2	5	4	5	2	23	74%
		Waste management category (WM)											
13	WM1	Decreased no-hazardous waste generation concerning production	3	4	2	2	1	1	1	3	1	9	29%
14	WM2	Decreased hazardous waste generation concerning production	7	3	4	2	1	2	4	4	1	14	45%
15	WM3	Waste recovery	11	4	7	4	3	4	3	5	3	22	71%
16	WM4	By-products	5	1	2	0	2	1	3	2	0	8	26%
17	WM5	Reintegrated waste into the internal production process	5	2	4	3	3	1	3	1	0	11	35%
		Product lifecycle category (LC)											
18	LC1	Extended product lifetime	2	0	1	0	1	1	1	0	0	3	10%
19	LC2	Reused/refurbished/remanufactured products	2	0	0	1	0	0	1	0	0	2	6%
20	LC3	Eco-design	4	0	5	1	1	1	1	4	1	9	29%
21	LC4	Easy components separation	1	0	2	0	0	0	1	2	0	3	10%
22	LC5	Returning materials to the factory after use	2	1	2	0	1	1	1	1	1	5	16%
23	LC6	Product traceability	8	3	4	2	1	2	4	4	2	15	48%

The aim of colouring the practices is for better understanding. Grouping by size coloured in yellow; Grouping by sector coloured in green.

It was noted that some practices were mentioned more frequently in the statements; for example, reducing emissions by optimizing materials, machinery or improving processes (74%). Within this practice, it is worth highlighting that the main practice mentioned by the majority of organisations was that renewing equipment or machinery enables them to reduce the consumption of natural resources and/or raw materials, which in turn reduces emissions. The second most frequently mentioned practice is waste recovery (72%), most of which was carried out through an authorized manager. No information was found in the statements on the behaviour of organisations in relation to limits of waste in landfill or incineration, and confusion was detected when using the terms recovery, waste treatment and by-products.

All the statements were checked for mention of practices employed to improve water and energy consumption performance, and calculations were made to determine differences in performance compared to the previous year. Of the 31 organisations analysed, findings showed that 52 per cent achieved improvements in water use performance and 55 per cent in energy use performance.

In the Product Lifecycle category, fewer CE-related actions were found, with the exception of product traceability (48%). Organisations generally mentioned that they take the product lifecycle into account, but there were no details available regarding how they could monitor or track products, parts or components once they had left their facilities or production plants.

The contingency table (see Table 6), in which binary data compare 3 or more independent groups, was carried out in order to check whether the participation of the analysed companies in CE practices according to their sector and size.

Significant associations between circularity practices in size grouping were observed in the following cases:

- Improved energy efficiency in production: while companies with 51–100 workers showed increased energy efficiency (6 out of 7), only 1 out of 4 of the companies with 101–250 workers showed a decrease.
- Renewable energy use: companies with <50 workers and those with 101–250 workers mention renewable energy (5 out of 15, and 5 out of 8, respectively). Companies with 51–100 workers do not report using renewable energy (0 out of 7).
- Eco-design: companies with <50 workers and those with 101–250 workers mention eco-design in their statements (4 out of 15, and 5 out of 8, respectively). Companies with 51–100 workers do not report any eco-design actions (0 out of 7).
- By sector, significant differences were found in the following cases:
- Renewable energy use: while the total of the companies in the Minerals/Wood group (4 out of 4) reported using renewable energies, the Textile and Other industries groups do not mention using renewable energies (0 out of 4 and 0 out of 6, respectively).
- Reduction in emissions stemming from using clean energies: The Minerals/Wood group mentions a reduced emissions from clean energy use (4 out of 4); the Textile and Metal groups do not mention any actions taken regarding clean energies (0 out of 4 and 0 out of 6).

Finally, in order to analyse the relationship between circularity practices, the Phi correlation coefficient test was carried out as these are nominal dichotomous variables [105]. The correlation matrix (see Table S2) indicates that practices are related, both within the same category (Raw Materials, Emission Reduction, Waste Management and Product Lifecycle) and between categories. The coloured cells are significant relationships.

Table 7 summarizes the practices most frequently related to CE and Table 8 shows the cases in which correlations were found between practices in various categories.

Table 7. Relationship between practices considered drivers of change towards a CE.

Relationship between Practices Considered Drivers	
LC3—Eco-design	EM3—Reduced emissions by optimizing materials/machinery/improving processes
	RM1—Improved raw materials use efficiency in production
	LC1—Extended product lifetime
	LC4—Easy components separation
	LC5—Returning materials to the factory after use
LC5—Returning materials to the factory after use	RM4—Use of sustainable/renewable raw materials
	RM5—Use of recycled and/or recirculated raw materials
	LC1—Extended product lifetime
	LC3—Eco-design
	LC4—Easy components separation
RM5—Use of recycled and/or recirculated raw materials	EM1—Reduced emissions due to less extraction of raw material
	WM5—Reintegrated waste into the internal production process
	LC1—Extended product lifetime
	LC5—Returning materials to the factory after use
LC1—Extended product lifetime	RM5—Use of recycled and/or recirculated raw materials
	WM5—Reintegrated waste into the internal production process
	LC3—Eco-design
	LC5—Returning materials to the factory after use

The aim of colouring the practices is for better understanding. Eco-design coloured in green (5 related practices), Material return coloured in blue (5 related practices), Use of recycled and/or recirculated raw materials coloured in yellow (4 related practices) and Product life cycle extension strategies coloured in grey (4 related practices).

Table 8. Relationship between CE practices with significant correlation ($p < 0.05$).

No.	Practice *a*	Practice *b*	Phi Coefficient	Correlation
1	RM3 - Selection of biodegradable materials	RM4 - Use of sustainable/renovable raw materials	0.802	high
2	LC1 - Extended product lifetime	LC5 - Returning materials to the factory after use	0.745	high
3	LC1 - Extended product lifetime	LC3 - Eco-design	0.509	moderate
4	LC3 - Eco-design	LC4 - Easy components separation	0.509	moderate
5	LC3 - Eco-design	LC5 - Returning materials to the factory after use	0.488	moderate
6	WM2 - Decreased hazardous waste generation concerning production	WM4 - By-products	0.484	moderate
7	WM4 - By-products	WM5 - Reintegrated waste into the internal production process	0.48	moderate
8	RE1 - Use of renewable energy	EM2 - Reduced emissions stemming from using clean energies	0.463	moderate
9	LC4 - Easy components separation	LC5 - Returning materials to the factory after use	0.447	moderate
10	RM4 - Use of sustainable/renovable raw materials	LC5 - Returning materials to the factory after use	0.447	moderate
11	RM5 - Use of recycled/recirculated raw materials	EM1 - Reduced emissions due to less extraction of raw material	0.442	moderate
12	WM5 - Reintegrated waste into the internal production process	LC1 - Extended product lifetime	0.438	moderate
13	RM5 - Use of recycled/recirculated raw materials	LC1 - Extended product lifetime	0.408	moderate
14	RM1 - Improved raw materials use efficiency in production	LC3 - Eco-design	0.408	moderate
15	EM2 - Reduced emissions stemming from using clean energies	LC2 - Reused/refurbished/ remanufactured products	0.408	moderate
16	WM1 - Decreased no-hazardous waste generation concerning production	WM2 - Decreased hazardous waste generation concerning production	0.408	moderate
17	RE1 - Use of renewable energy	EM3 - Reduced emissions by optimizing materials/machinery /improving processes	0.390	low

Table 8. *Cont.*

No.	Practice *a*	Practice *b*	Phi Coefficient	Correlation
18	RM2 - Replacement of materials with renewable ones	EM1 - Reduced emissions due to less extraction of raw material	0.375	low
19	RM5 - Use of recycled/recirculated raw materials	WM5 - Reintegrated waste into the internal production process	0.367	low
20	RM5 - Use of recycled/recirculated raw materials	LC5 - Returning materials to the factory after use	0.365	low
21	WM3 - Waste recovery	WM4 - By-products	0.364	low
22	EM2 - Reduced emissions stemming from using clean energies	EM3 - Reduced emissions by optimizing materials/machinery /improving processes	0.361	low
23	EM3 - Reduced emissions by optimizing materials/machinery /improving processes	LC3 - Eco-design	0.361	low
24	NR2 - Improved energy efficiency in production	RE1 - Use of renewable energy	-0.381	low (negative)

Correlations between practices of the same category coloured in yellow; Correlations between practices of different categories coloured in green.

Within the group of businesses analysed, 23 directly positive correlations were found: 2 high (with correlation strength between 1 and 0.7), 14 moderate (between 0.69 and 0.4), 7 low (between 0.39 and 0.10) and 1 low inverse correlation (<0) was also found. The practices showing the highest correlation were using biodegradable raw materials and raw materials of sustainable and/or biodegradable origin ($r\varphi = 0.802$), followed by extending product life cycle and returning materials to the factory after use ($r\varphi = 0.745$). In contrast, practices employed to improve energy efficiency and use renewable energies showed a low negative correlation ($r\varphi = -0381$).

4.3. RQ3: How Are CE Practices Reported and Quantified in Environmental Statements? How Are These Practices Reported to Stakeholders?

As mentioned above, previous studies on implementing circularity practices at micro level, especially in SMEs, were taken as a reference for this study. From there, the list of search criteria for CE practices within the statements was established (see Table S1). Although the majority of the statements are structured in accordance with the indications of the EMAS regulation, a wide disparity was found in the way the results were presented, especially with regard to the consumption of natural resources, raw materials, particularly the production indicator (m^3, tones, physical units or by number of workers) which indicate whether yields show an improvement or a decrease.

The statements also differed widely regarding the number of workers involved, the length of the documents and the way in which each organisation presents the information. Standardising the information required by EMAS could help stakeholders access the data in a clearer and simpler way, as well as enabling comparative studies between companies to be carried out.

4.4. RQ4: Does a Relationship Exist between Circularity Practices and Economic Performance?

To analyse the economic performance of the companies in the study, Turnover, Net Profit and Economic Profitability variables of the SABI database were examined (see Table S1). Finally, we chose to only focus our analysis on Turnover due to the differences in the types of organisations in both size and sector. No significant correlation was found which could determine a relationship between incorporating circularity practices and economic performance.

4.5. RQ5: What Information Should Be Included in Environmental Statements in the Future to Help Evaluate the Application of Circularity Practices in EMAS-Registered Companies?

With a view to strengthening the statements beyond being just a tool for providing information on the consumption of natural resources, raw materials and environmental behaviour in generating waste and emissions, it would also be useful to know if the organisation is registered with an industrial cluster of some kind in order to reuse by-products, or for companies to provide more precise information on changing to renewable energies and the percentage of use with respect to total consumption, and whether this is self-generated.

Of the six categories analysed (see Table 6), Product Life Cycle is the least covered or addressed, but it offers the most opportunities for entering into CE and close the cycle of processes and products.

5. Discussion and Conclusions

Based on the analytical framework and models proposed at the micro level, this study has identified 23 circularity practices that are currently being adopted by SME companies with EMAS regulation in the industrial sector in Catalonia. Based on the model proposed by Prieto-Sandoval et al. [20], we can conclude that of the 5 fields of action needed to make the transition to the CE model (Take, Make, Use, Distribution and Recover), the majority of the practices implemented only mainly refer to Take and to a lesser extent to Make and Recover. The results of our study are in line with those obtained in Spain by Ormazábal et al., 2016 [21] (Take and Recover); Ormázabal et al., 2018 [47] (Take), and Aranda-Usón et al., 2020 [18] (Take and Recover). At the European level, in Portugal, Fonseca et al., 2018 [13] highlight Take and Recover, as does Mura et al., 2020 [52] in Italy. Janik and Szafraniec, 2019 [84], describe practices associated with Take in Poland. Therefore, it can be concluded that most of the studies detected coincide in highlighting circular practices mainly in the fields of Take and Recover.

EMAS companies have made headway in measuring and quantifying consumption of natural resources and emissions and waste generated. However, it is clear that the EMAS model has not contributed to standardising how information is presented in statements nor to using general indicators to facilitate comparisons between companies. Several statements showed that companies report their environmental impacts without making reference to their annual production volumes. Results also showed that the units used to give the data differ from one company to another, making it very difficult to compare the progression of implementing circularity actions between companies, as pointed out by Janik and Szafraniek [84]. As mentioned by Aranda et al. [18], findings demonstrate that standardized metrics need to be implemented in order to measure the environmental impact of CE activities within companies.

To date, no consensus has been reached in the literature as to which indicators are the most suitable for measuring circularity and can be applied by SMEs. Therefore, the authors of this study propose taking the key characteristics of CE into consideration according to the fields of action. The implementation of a production model based on CE means much more than reducing waste through recycling. It also requires reducing the consumption of raw materials, designing environmentally friendly products that can be easily recovered and reused, lengthening product lifetimes through proper maintenance, using recyclable materials in products and taking actions to recover raw materials from waste streams [1].

In relation to groups by size and sector, the results show that organisations with <50 and 101–250 workers, and those in the Minerals/Wood sector are more concerned about practices related to using renewable energies and the reduction of emissions. These same groups of companies, by size, also correspond to those that reported practices aimed at product eco-design. Similarly, the correlation matrix clearly demonstrates that using renewable energies is linked to emission reduction practices. Future studies could analyse this in greater depth by looking at different years and standardizing production indicators for CE practices among companies.

Eco-design was one of the practices with the highest correlation and is associated with Returning materials to the factory after use, Extending product lifecycle, Reintegrating waste into the internal production process and Using recycled and recirculated raw materials (see Table 8). This analysis enables associations between practices to be detected; however, future research could investigate whether causality between CE practices exists and what factors motivate internalizing environmental discourse within companies [78].

Other practices such as using biodegradable raw materials are closely linked to raw materials of sustainable origin or from renewable sources. Reusing/reconditioning/remanufacturing products and parts is beginning to appear in statements, although in an incipient way and may require emphasising the areas of Distribute and Use to facilitate its implementation.

Although waste recovery occurs in 71% of the companies researched, it is only linked to by-products. This corroborates the study by Daddi et al. [106], which points out the importance of encouraging the development of eco-industrial parks and strengthening business associations, clusters, and all kinds of groups and networks in order to work at a meso level and move towards an economy based on collaborative networks. The fact that no practices have been detected in the areas of Distribute and Use indicates that CE practices need to be extended beyond the internal level in EMAS-registered companies in Catalonia's industrial sector. It is essential to understand that the CE model does not affect individual companies but rather refers to the interconnection of the business fabric as a whole [101,107], as well as the rest of stakeholders in order to successfully introduce the concept of CE on a large scale [10]. A key factor could be to facilitate communication between the various stakeholders (organisations, customers, users, administration). However, for this to occur, more efficient information and communication tools need to be developed whichthat will enable companies and organisations to continue improving the practices implemented, as well as making inroads into others that will enhance the circular model.

Finally, along the lines of Aranda-Usón et al. [18], this study has also failed to detect any significant correlation that could determine any relationship between the incorporating circularity practices and a company's economic performance.

This study is limited to analysing CE practices in industrial sector SMEs with EMAS in Catalonia. Several proposals are put forward for future research: (a) widen the study to include the trade and service sectors, (b) extend the study to companies with other types of EMS already in place such as ISO 14001, (c) replicate similar research in other regions or countries and (d) carry out studies based on developing surveys or questionnaires enabling an in-depth analysis of the extent to which these CE practices are adopted by businesses.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/21/9011/s1, Figure S1: Example Codification 1 with Atlas.ti. Source: screenshot of document encoding in Atlas.ti (Version 8.4.24.9), Figure S2: Example Codification 2 with Atlas.ti. Source: screenshot of document encoding in Atlas.ti (Version 8.4.24.9) Table S1: Data collection grid; Table S2: Phi coefficient correlation matrix of circularity practices.

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