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EMAS environmental statements as a measuring tool in the transition of industry towards a circular economy

Alexandra Barón Dorado *, Gerusa Giménez Leal, Rodolfo de Castro Vila

Departament of Business Administration, Management and Product Design, University of Girona, Carrer de Maria Aurèlia Capmany I Farnés, 61, 17003, Girona, Spain

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A B S T R A C T

One of the European Commission's main objectives within its Green Deal strategy is to encourage organisations to adopt a circular economy (CE). Although the Eco-Management and Audit Scheme (EMAS) regulation is highlighted as a tool to help firms evaluate, report and improve their advances in this direction, no studies have been found that empirically validate the usefulness of EMAS as a circularity measuring tool. To address this gap, this paper analyses the information reported in the EMAS statements and determines whether it really is useful to be able to measure the level of adoption of the circular model in companies. Content analysis and statistical methods (Kendall rank correlation coefficient and Pearson's Chi-Square Test) are employed to provide empirical evidence from 122 companies. Results show that the information reported in the statements analysed is neither extensive enough nor provided as scalable and comparable quantitative data to be able to consider EMAS as a valid tool to measure and report the progress of companies in the transition towards a more circular model. Outcomes of the study have useful implications for policy makers and companies. Recommendations to regulators centre on establishing specific circular key performance indicators within the EMAS regulation, which would help companies transition towards a CE. Recommendations to managers include using EMAS reporting in a more comprehensive and indicator-focused way, which could help them visualise their current situation more clearly and be able to compare themselves to others more effectively, thus moving towards circularity in a more targeted way.

1. Introduction

At the end of 2019, the European Commission (EC) published the European Green Deal, a strategy that aims to reduce emissions by 55% by 2030 and achieve climate neutrality by 2050 (European Commission, 2019a). In recent years, the call for a more sustainable and circular economic model has grown, and the increasing support from businesses and governments shows that it is more important than ever (Blériot, 2020). However, despite this growing interest, the global economy is currently only 8.6% circular, compared to 9.1% two years ago (Circle Economy, 2021). This negative evolution in the global circularity gap is explained by three related latent aspects: high extraction rates, continuous stockpiling and low levels of end-of-use processing and recycling.

The linear economy, understood as the traditional linear production and consumption system, and all that it entails is still deeply rooted in today's society. However, despite the slow progress towards a more circular model, positive bottom-up actions are making headway worldwide. Entrepreneurs and companies see adopting the CE model as an opportunity to increase their profit margins through resource and energy efficiency (Mazzi et al., 2016a). They believe that eco-innovation can help them create new consumer-driven markets by demanding more sustainable, environmentally friendly products (European Environment Agency, 2020). Thus, both urgency and opportunity have encouraged an increasing number of countries and national governments to begin to shape their strategies to support investment in sustainable, targeted CE agendas.

Authorities can also strengthen the demand for more sustainable goods and services through green public procurement, thus stimulating eco-innovation (European Commission, 2019b). Corporate Social Responsibility (CSR) involves taking responsibility for one's impact on society and also advocates compliance with environmental product requirements (European Commission, 2018a). The UN Global Compact, an initiative that calls on companies to actively address environmental risks and opportunities, has a strong foothold in Europe, where it has the highest total number of participants compared to other regions (United Nations Global Compact, 2018). Representatives of business and

* Corresponding author. Carrer de Maria Aurèlia Capmany i Farnés, 61, 17003, Girona, Spain.
E-mail addresses: alexandra.baron@udg.edu (A. Barón Dorado), gerusa.gimenez@udg.edu (G. Giménez Leal), rudi.castro@udg.edu (R. de Castro Vila).

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industry are also key stakeholders in the multi-stakeholder platform on the Sustainable Development Goals (SDG). This is led by the EC, the Circular Economy Stakeholder Platform and the Bioeconomy Stakeholder Panel (European Commission and The European Economic and Social Committee, 2019).

One of the debate points in the transition to a CE focuses on evaluating progress towards the model (Mayer et al., 2019) and the role of various transition enablers. Environmental performance reporting and the way in which CE should be communicated remains in need of further clarity and research. The discussion of these topics is limited within both the academic literature and the reporting approaches related to sustainability and environmental performance themselves (e.g. Global reporting initiative (GRI), British Standards Institute (BSI), Carbon Disclosure Project (CDP), World Economy Forum (WEF), Underwriters Laboratories Standards (UL) and EMAS) (Opferkuch et al., 2021). Analysing the level to which companies adopt CE principles requires comprehensive and reliable information and reporting on progress towards the circular model. The company's environmental impact is key to the satisfaction of all stakeholders. Literature has been found focusing on the development of environmental reports from different perspectives. Some studies analyse this information based on the content of their environmental accounting reports (Lehman, 2017; Liu et al., 2018; Mata et al., 2018; Russell et al., 2017). Others analyse it from the point of view of legislative compliance (Mazzi et al., 2020). Studies have also been found that analyse reports from a circular perspective, although they do not use the same analysis indicators (Ghisellini et al., 2018; Scarpellini et al., 2020; Wang et al., 2014). One study also highlights the paucity of data provided to assess and compare performance in relation to CE adoption (Dagiliene et al., 2020).

At European level, the EC supports several approaches by helping companies willing to adopt CE principles in their production processes and gradually integrate the environmental dimension into their business models. An example is the EU EMAS, an Environmental Management System (EMS) that European companies and other organisations can use to assess, report and improve their environmental performance. Environmental statements, required by the EMAS, are a reliable information source as they are approved by an external environmental verifier, and annually updated reports are ratified in well-established accreditation bodies. The EC emphasises that EMAS organisations "must assess all their environmental impacts and report on six core indicators: energy efficiency, material efficiency, water, waste, biodiversity and emissions. Because they have to be publicly reported, these Key Performance Indicators (KPIs) allow for comparison of the environmental performance of various organisations and enable public authorities to assess the progress towards a CE" (European Commission, 2017). However, although companies with EMSs such as EMAS show a higher level of awareness and sensitivity to environmental protection, and are therefore one step ahead of companies with no such scheme in place (Barón Dorado et al., 2022; Fonseca et al., 2018; Marrucci et al., 2019), there has been no evaluation of whether the available indicators are really capable of assessing progress towards the CE model.

The aim of this study is to evaluate environmental statements published by manufacturing EMAS companies and to analyse if they provide relevant information on the companies' circular practices to be considered as measurement tools for the transition towards a CE. Thus, this article contributes to the existing literature by analysing if the EMAS can be considered as a measuring tool in industry's transition towards a circular economy by a) analysing the CE practices reported by industrial firms; b) analysing differences between companies in adopting these practices; and c) analysing the KPIs of circularity revealed in the statements.

The article is structured in 6 sections. Section 2 provides a literature review of concepts linked to the relationship between CE and environmental performance reporting. Section 3 describes the methodology used to answer the research questions by using information from the environmental statements. Section 4 outlines the results. Section 5 covers the discussion, and section 6 draws the main conclusions and outlines the limitations of the study.

2. Literature review

2.1. CE practices

Although research on CE has increased in recent years, attempts to find consensus on its concept, definition and related activities are still ongoing. Practice theory describes practice as the relationship between human action and its interaction with the system (Ortner, 2006). A review of the literature on CE practices at organizational level reveals different approaches by sector, applicability or degree of implementation (Acerbi and Taisch, 2020; Govindan and Hasanagic, 2018). Although previous studies often report on objectives or intentions, they seldom investigate actual actions or performance indicators. (Hopwood et al., 2005; Stewart and Niero, 2018). Furthermore, the main focus of research on the CE practices implemented in environmental reporting differs from report to report. Some of them are centred on resource efficiency, increased productivity and making use of environmental information (D'Amato et al., 2017). Other reports spotlight areas of management accounting such as material flow, life cycle assessment, or cost-benefit analysis (Dagiliene et al., 2020; Iacovidou et al., 2017). Last, some reports are associated with reusing and recycling (Stewart and Niero, 2018).

Exploring CE practices from a frame of reference delimited within the principles and concept of CE is useful. One of the reference frameworks for studying CE is classifying 10 R'imperatives or loop strategies to establish the scope of the model (Reike et al., 2018). By looking at CE practices in the various approaches to sustainability reporting that include standards, models or frameworks as tools (Opferkuch et al., 2021), different practices studied within the corporate performance and sustainability reports can be distinguished. Furthermore, the European Environment Agency et al. (2016) offers a list of characteristics and actions that companies can consider for the transition of the model, which would enable framing practices in relation to the R'imperatives. From this perspective, the following research question emerges:

RQ1. Do companies mention circularity practices in their statements?

Several studies have addressed the topic of barriers and drivers for a CE regardless of company size (Holzer et al., 2021). They recognise considerable barriers related to high investment costs for sustainable innovations (D'Amato et al., 2020) and difficulties in obtaining financial support (Garcés-Ayerbe et al., 2019). Researchers frequently mention technical factors as another main barrier (e.g., de Jesus and Mendonça, 2018; Govindan and Hasanagic, 2018). Large enterprises (LE), which are assumed to be well endowed with the capital and human resources to achieve goals, are leading this transition (de las Casas, 2021). One of the keys to achieving progress in CE is to establish concrete and measurable objectives, and it is LE that should promote them so that sustainable initiatives around the world continue to grow and achieve greater scope. Although LE are reported to have a greater environmental impact, and are often early adopters of new reporting practices, they are also more likely to have more environmental impact (Dagiliene et al., 2020). Only large companies have previously been studied under this approach (Dagiliene et al., 2020), but it is pertinent to observe what is happening with small and medium sized enterprises (SME), which in several countries represent a large percentage of the economy.

The neo-institutional theory is taken as a theoretical framework, according to which organisations are subject to mechanisms of knowledge, dissemination and/or pressure regarding what is happening in the environment (Demirel et al., 2018), leading to processes of isomorphism between them (Martínez-Ferrero and García-Sánchez, 2017; Milne and Patten, 2002). The concept of organisational isomorphism refers to the similarity of homogenisation that can occur between different organisations (in structure, operational processes and/or behaviours). Analytically, three types of isomorphism are identified (DiMaggio and Powell, 1983), although in practice they may coexist: 1) coercive isomorphism, related to political, legislative or regulatory influences, which does not necessarily mean that pressure is exerted by force; 2) normative or cultural isomorphism, related to people's academic training and experience, which standardises their way of acting in organisations so that they come to behave in a similar way; and 3) mimetic isomorphism, in which uncertainty due to the environment or the success of other organisations, generates imitation as a mechanism to help companies make decisions and take actions under conditions of uncertainty (Daddi et al., 2016).

This research analyses mimetic isomorphism and seeks possible differences between the adoption and communication of CE practices between SME and LE, and any possible mimetic influence that the latter exert. A sub-objective linked to RQ1 is therefore proposed:

RQ1_1. Do the CE practices reported differ according to company size?

2.2. Environmental reporting through EMS

An EMS is defined as "a set of interrelated elements used to establish policies and objectives, and to achieve those objectives" (International Organization for Standardization, 2015). The two most widely known EMS are ISO14001 and EU EMAS. ISO14001 has been in operation since 1996 and is a private international standard developed by ISO, while the EMAS regulation was first published in 1993 and developed by the EC.

Different authors have analysed the importance of EMS in improving environmental performance, finding divided opinions. Some have found significant improvements (Clarkson et al., 2008; Giménez et al., 2003; Herbohn et al., 2014), while others indicate that improvements are difficult to quantify as a result of the relatively high degree of emphasis placed on qualitative information (Siew, 2015); because of the interpretation and implementation of these requirements in the scope of the internal dynamics of each organization can widely differ among companies (Testa et al., 2014); or as a consequence of the lack of rigorous auditing and control systems for certifications to protect and reinforce the efforts organisations make in environmental matters (Lannelongue and González-Benito, 2012). Other authors point that the statements need to be reviewed over time (Iraldo et al., 2009; Mazzi et al., 2016b; Rennings et al., 2006). Other studies also indicate that firms' motivations for incorporating an EMS may differ both by firm type and by the cultural and regulatory environment (Heras-Saizarbitoria et al., 2015; Lam et al., 2011), the latter being crucial in the need to engage firms in environmental actions. In countries with stricter regulatory laws, companies tend to adapt less EMS, or at least maintain an internal self-regulatory system, but not necessarily certify it because the marginal legitimacy benefits of certification may be quite low (Glachant et al., 2002; Prakash and Potoski, 2014; Wätzold et al., 2001). In contrast, some companies with more lax regulations might opt more to implement these systems as a way to legitimise their actions.

With the aim of deepening the content of environmental reports of an EMS, this research focuses on EMAS and not on ISO14001 for several reasons:

- EMAS depends on a public body, unlike the private ISO 14001 standard (Testa et al., 2014), which allows us a glimpse of whether public environmental policies are being reflected at the operational level, and whether EU strategies are beginning to appear in the environmental communication discourse of European companies under its coercive influence.
- EMAS imposes stringent requisites, but the rewards of voluntary participation include improved environmental performance, enhanced credibility, better compliance with legislation and increased competitiveness, and also develop a basis from which to face future economic and ecological challenges (Álvarez-García et al., 2018; Álvarez-García and del RíoRama, 2016).
- Although both EMS require environmental performance reporting, the EMAS regulation sets stricter requirements on external reporting, requiring the updating of "environmental statements" on an annual basis and their availability to different stakeholders. Additionally, it is requested that the reported data must be validated by an external verifier (European Commission, 2018b). This feature not only provides some transparency and legitimacy by openly communicating performance on significant environmental aspects (Demirel et al., 2018; Mazzi et al., 2016a), but it also allows researchers to have truthful information for their review.
- In addition to presenting indicators at the operational level on environmental accounting, environmental performance reports also allow information at the strategic level to be observed (Guenther et al., 2016) for environmental policy, improvement targets, record of achievements and other relevant information on the EMS. The fact that environmental management processes of EMAS-registered organisations are systemized puts them in a privileged position regarding circular transition, while having to report on their continuous improvement through environmental statements makes this document a potential environmental reporting tool.

2.3. CE and environmental reporting

Various organisations, institutions and academics began to consider alternatives that could move the industry from a linear model based on "take-make-use-recover" to a more adaptive model that considers the disposal of finite, non-renewable resources, waste tracking and emissions generated in the manufacturing process. The Ellen MacArthur Foundation (2015), for example, defines CE as a restorative model that seeks to maintain the value of products and components within the economy for as long as possible, thereby reducing over-extraction of raw materials and making use of secondary materials already within the system or which end up as waste in landfills or incineration. The number of publications addressing CE from different aspects is growing rapidly, but there are still few that address it from environmental accounting (Liu et al., 2018) and environmental performance reporting (Sassanelli et al., 2019).

In recent years, some initiatives for measuring circularity at the micro-level have emerged with different systems and types of KPIs: MFA Indicator for the mining industry (Lèbre et al., 2017); CE Assessment Index System for phosphorus chemical companies (PCFs) (Liang et al., 2018); Circularity Assessment Model for the financial sector (Giacomelli et al., 2018); and other proposals for circularity indicator systems developed by independent organisations such as the Circulytics tool of the Ellen McArthur Foundation (Ellen MacArthur Foundation, 2020) and the WBCSD Circularity Transition Indicators with KPMG (WBCSD, 2021). However, very few studies have analysed the applicability of these systems and types of indicators, or the possibility of incorporating a circular indicator into the environmental reports currently used by companies (Barón et al., 2020; Dagiliene et al., 2020; Scarpellini et al., 2020).

As Arthur Lyon-Dahl (2012) points out, indicators are only as good as the data that support them, and in this regard, the verified environmental performance information from EMAS environmental statements could be very useful to implement some measurement indicator in the transition towards circularity, which is why it is relevant to analyse what kind of information within the reports can be useful when adopting the model (Mazzi et al., 2012). Considering the nature of environmental performance reports which, in addition to "measurable results of an organisation's environmental management (Mäkelä, 2017), communicate quantitative and qualitative information on environmental impacts and consequences of relevant environmental activities that support decision making" (Latan et al., 2018; Schaltegger et al., 2017), the following research question is put forward:

RQ2. In environmental statements, are there KPIs on circularity practice that enable EMAS to be considered a measurement tool?

3. Material and methods

3.1. Data sample

The sample selection in this research focuses on Spanish industrial companies, mainly because the study is funded by the Spanish government (Efficiency, Innovation, Competitiveness and Sustainable Business Performance research project), but also because Spain is among the countries with the highest number of EMAS-registered companies in the EU. First, access was gained to the EC's EU EMAS Helpdesk register and, in June 2019, a list of 845 EMAS-verified sites in Spain was obtained, taking the environmental statements of the production sites as a unit of analysis. Furthermore, to analyse companies that have a greater environmental impact and cover a larger number of indicators within the environmental statements, as mentioned above, 166 sites classified in Industry and Manufacturing according to NACE codes 10 to 32 were selected. This selection also considered the size of the company in line with the number of workers (OECD, 2005).

A representative sample was taken for the data analysis, establishing a confidence level of 0.95 and a margin of error of 0.05 (Suchmacher and Geller, 2012), which determined a sample size of 122 production centres throughout Spain. Of these centres, the sample was distributed according to the NACE classification by industrial sector and by company size: 57.4% SME and 42.6% LE (see Table 1). The five main regions of Spain where the centres in the sample were found were also observed: Catalonia represents 29.5%, Galicia 14.8%, Madrid 12.3%, Euskadi 11.5% and Andalucía 9.8%.

Once the sample was defined, the environmental statements were searched for directly on the companies' websites. Where this was not successful, the web search engine was used with the following criteria: most recent environmental statements, and the keywords "company name" + "EMAS Statements/Environmental Statements" and/or "EMAS verification number" in Spanish and/or Catalan.

Of the environmental statements, only those from the year 2016 onwards were chosen, considering that the CE action plan for the European Union was published in 2015 (European Commission, 2015), coinciding with the increase in scientific publications related to the CE (Korhonen et al., 2018). Of the total sample of 122 sites, the environmental statements of 119 were found, with only 3 of not available and therefore treated as "missing".

Table 1
Sample distribution.

Industrial Sector	Size		Total	%
	SME	LE		
Chemical/pharmaceutical industry	10	12	22	18%
Textile industry	6	1	7	6%
Graphic industry	7	2	9	7%
Food and beverage manufacturing	9	10	19	16%
Metallurgical industry	4	3	7	6%
Electrical and electronic equipment manufacturing	2	5	7	6%
Manufacture of machinery and equipment, except electronics	2	3	5	4%
Non-metallic mineral products industry (glass/ceramics)	6	5	11	9%
Paper industry	4	6	10	8%
Other extractive industries	3	0	3	2%
Manufacture of fabricated metal products, except machinery	6	0	6	5%
Car manufacturing	3	4	7	6%
Wood industry	1	0	1	1%
Rubber and plastic products industry	7	1	8	7%
Total	**70**	**52**	**122**	**100%**

3.2. Content analysis

Starting from the theoretical basis on the different loops of the CE (Reike et al., 2018) and the key characteristics of it (European Environment Agency et al., 2016), a list of CE practices applicable to different types of industrial enterprises was drawn up. After a preliminary review of the practices with respect to statements, the authors created a search grid to store both qualitative and quantitative information on each of the practices. To this effect, which CE practices were most frequently mentioned in the statements were classified and selected, until those that were the most relevant for the study were defined. Other data were also recorded, such as in which statements the term 'circular economy' appeared, and the size of the companies measured by the number of employees.

An Optical Character Recognition (OCR) of the statements was performed in the review process to ensure that the documents met the selection criteria. This also facilitated the search for words and concepts. All documents were checked to ensure that they were verified by an accredited verification body and that the information was relevant, then the content analysis was used to analyse the information contained in the environmental statements. Content analysis is a research technique used to make replicable and valid inferences by interpreting and coding textual material (Krippendorff, 2004), wherein qualitative data can be converted into quantitative data by systematically evaluating texts. This methodology is valuable as it enables researchers to retrieve and examine the nuances of organisational behaviours, stakeholder perceptions and social trends. It is also an important bridge between purely quantitative and purely qualitative research methods.

EMAS statements report information through qualitative statements and quantitative facts, followed by graphs and figures (European Parliament and the Council of the European Union, 2009). Thus, in this study, all information included in the documents was analysed and categorised, both at the level of declarative texts and at the level of reported quantitative data. For the declarative texts, the research team created a search grid to ensure adequate reliability and validity for the analysis (Schreier, 2012). The CE practices coding classification mentioned in the previous section was used to draw up the grid.

With reference to the quantitative data, the environmental indicators were identified from the numerical or graphic information in the companies' statements, tables, graphs and the body of the text. The CE practices sought in the documents were mostly analysed as dichotomous qualitative variables (yes/no) and as ordinal variables with respect to the number of CE practices that are reported. All the information was coded using Atlas.ti software, which was verified and discussed by the researchers to avoid errors before completing the grid with the final information.

Based on the literature review and the fact that there is still no consensus or general framework on CE practices adapted to the micro-level, and less so for the industrial sector, a mixed list of different circularity practices (European Environment Agency, 2020; Prieto-Sandoval et al., 2018) was reviewed and collated with regard to the structure of the EMAS environmental statements. Practices that are approached from the perspective of efficient resource management (e.g., efficient use of natural resources, reduction in the use of raw materials, reduction of emissions and minimisation of waste generation) were not included in the list. This is because, following the continuous improvement cycle of EMS and its primary focus on efficient management of processes and materials, these practices can be considered more of an outcome of the CE than an enabling practice. This resulted in 17 CE practices, which were divided into four groups: Materials, Energy, Waste Management and Life Cycle. In the coding, the practices that were found to be qualitative were identified with the word "text", and those with quantitative values (quantities, percentages, indices) with the word "KPI". Thus, each group contained the following variables:

- **Materials:** (M1text) Materials replaced with renewable ones; (M2text) Selection of biodegradable materials; (M3text) Use of sustainable/renewable raw materials; (M4text) Use of recycled/recirculated materials; (M5KPI) Quantification of the use of sustainable materials).
- **Energy:** (E1text) Use of renewable energies; (E2KPI) Quantification of the use of renewable energy.
- **Waste Management:** (WM1text) Waste recovery, (WM2text) By-products, (WM3text) Reintegrated waste into the internal production process.
- **Life cycle:** (LC1text) Extended product lifetime, (LC2text) Reused/refurbished/remanufactured products, (LC3text) Eco-design, (LC4text) Easy separation of components, (LC5text) Returning materials to the factory after use; and (LC6text) Product traceability.

Table 2 shows the classification of practices according to the type of information reported (Quantitative/Qualitative) and their relationship with the R-Imperatives.

3.3. Statistical analysis

The statistical analysis was carried out in three steps. First, a descriptive analysis was performed to identify the type of information used and the CE practices most reported in the environmental statements (Qualitative/Quantitative). Second, a correlation analysis was carried out to explore the relationship between the companies that mentioned the term 'Circular Economy' in their environmental statements and those that reported a higher number of CE practices, as well as the type of information used. Kendall's Tau-b coefficient was used for this, as the variables were both ordinal and categorical (Landis and Koch, 1977). This enabled the concordant and discordant ranges between factors to be determined. In practices where significant differences were found, the degree of association of proportions was observed by taking the standardised residuals to determine which groups showed a positive or negative association. In addition, the percentage contribution for each case was calculated. Last, a cross-tabulation and Pearson's Chi-Square Homogeneity test were used to compare CE practices between firm-size groups and KPIs reported in the environmental statements. The statistical treatment of the data was performed using the SPSS v25 programme.

Table 2
CE Practices detected.

Theoretical framework	Code	CE practices	Type of information reported	
10 R[a]			Qualitative	Quantitative
R0/R7	M1text	Materials replaced with renewables ones	X	
R0/R7	M2text	Selection of biodegradable materials	X	
R1/R7	M3text	Use of sustainable/renewable raw materials	X	
R7	M4text	Use of recycled/recirculated raw materials	X	
R1/R7	M5KPI	Quantification of the use of sustainable raw material		X
R8	E1text	Use of renewable energy	X	
R8	E2KPI	Quantification of the use of renewable energy		X
R7	WM1text	Waste recovery	X	
R6/R7	WM2text	By-products	X	
R7	WM3text	Reintegrated waste into the internal production process	X	
R8	WM4KPI	Quantification of waste recovery/re-integrated		X
R1/R6	LC1text	Extended product lifetime	X	
R3/R4/R5	LC2text	Reused/refurbished/remanufactured products	X	
R0/R6/R4	LC3text	Eco-design	X	
R1/R5	LC4text	Easy separation of components	X	
R8	LC5text	Returning materials to the factory after use	X	
R0/R6	LC6text	Product traceability	X	

[a] Producer oriented classification based on Reike et al. (2018): R0-Refuse; R1-Reduce; R2-Reuse; R3-Repair; R4-Refurbish; R5-Remanufacture; R6-Repurpose; R7-Recycle materials; R8-Recover energy; R9-Remine

4. Results

Based on the theoretical framework and following the established methodology, 17 CE practices reported by companies were identified using content analysis. In 334 cases, qualitative information was found in the statements analysed (79.33%), while quantitative information was found in only 87 cases (20.67%). The CE practices most reported were WM1text-Waste recovery (63.90%), M4text-Use of recycled/recirculated raw materials (41%), WM4KPI-Quantification of waste recovery/re-integrated (39.3%) and E1text-Use of renewable energy (38.5%). The least mentioned practices were M2text-Selection of biodegradable materials, LC1text-Extended product lifetime, LC2text-reused/refurbished/remanufactured products and LC4text-Easy Components separation, each representing 2.5% (see Fig. 1).

The possible relationship between companies mentioning the term 'Circular Economy' in their environmental statements and those reporting a higher number of CE practices was also explored. The statistical analysis for ordinal qualitative variables yielded a correlation value of 0.362 Kendall's Tau-b coefficient, with a significance of 0.000. Therefore, given that this figure was lower than the p-value of 0.05, there was a correlation between a higher number of reported CE practices and the mention of "circular economy" in the environmental statements.

Differences in reported CE practices according to the company size were analysed by applying Pearson's Chi-square statistical analysis to determine homogeneity between the groups. To this effect, a value of 13.354 was obtained with a significance of 0.1 (p-value of 0.05). This shows there were no significant differences in the two groups, but implementation of some practices was detected as being significantly different between them. Subsequently, a review was carried out to determine for which practices there was a stronger association between groups. The results showed that the reporting circularity practices had similar behaviour in 11 of the 17 CE practices for the two groups analysed (LE and SME), but the behaviours were not homogeneous in 6 of the 17 CE practices. The results obtained can be seen in Table 3. Additionally, the standardised residuals indicated a positive association in the LE group in 5 of the 6 cases, and only in the practice (L6text) was the association positive for SME companies.

Regarding the quantitative CE practices reported by company size, it was observed that only 1 of the 3 quantitative practices (WM4KPI, p-value 0.038) had different behaviour in relation to company size. The number of LE that reports this practice adoption is higher than the number of SME. Last, by obtaining a value of 0.274 with a significance of 0.002 by Kendall's Tau-b coefficient test (less than the p-value of 0.05), there was a correlation between the number of quantitative CE practices reported and the mention of "circular economy" within the statements.

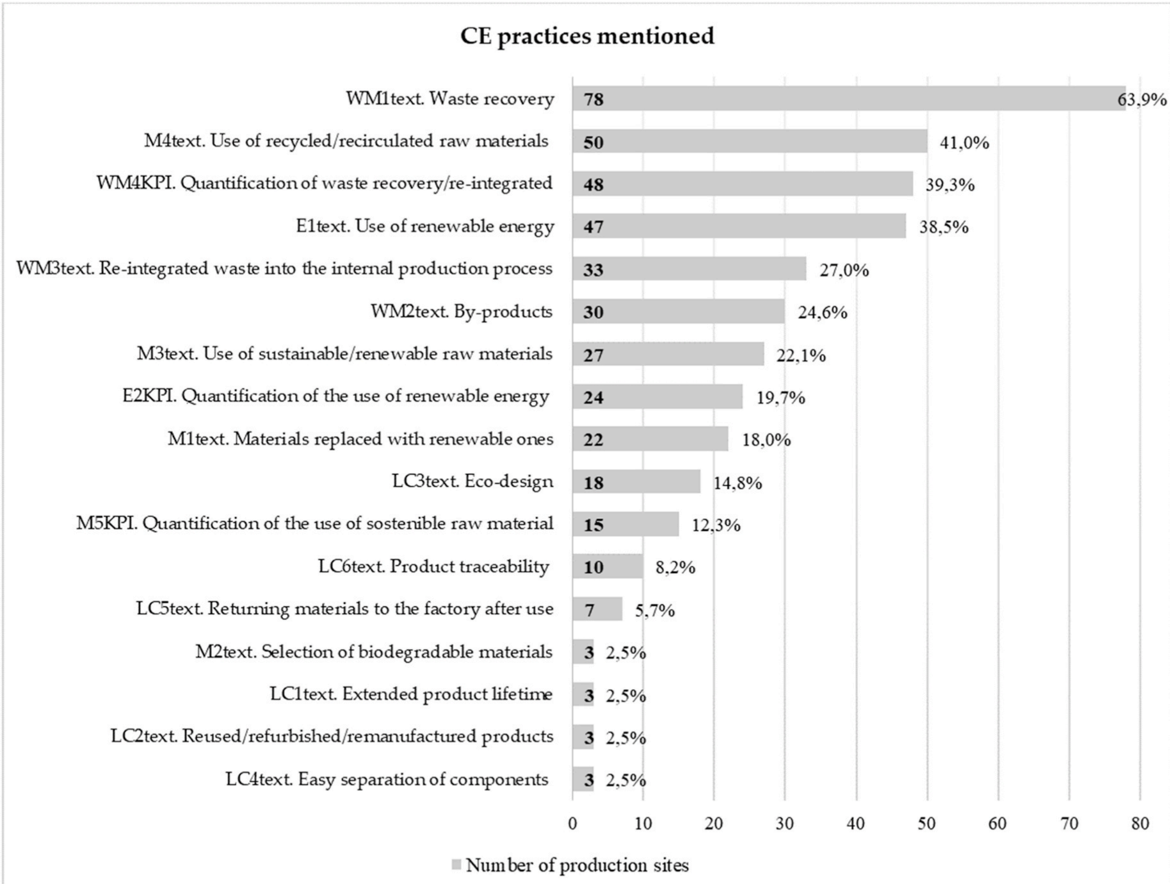

Fig. 1. Frequency and percentage of CE practices.

Table 3
CE Practices with significant differences according to size.

CE Practices	Chi-Square	Sig.	Association
E1*text.* Use of renewable energy	12.797	0.000	LE +
WM1*text.* Waste recovery	5.293	0.021	LE +
WM3*text.* Waste reintegrated into the internal production process	12.546	0.000	LE +
WM4*KPI.* Quantification of waste recovery/re-integrated	4.312	0.038	LE +
LC3*text.* Eco-design	4.548	0.033	LE +
LC6 *text.* Product traceability	8.317	0.004	SME +

5. Discussion

According to Korhonen et al. (2018), many recently published works have focused on more advanced stages of the adoption of the circularity model, but very few studies focus on the paradigm introduction. In fact, he also insists on the importance of using more qualitative research methodologies to address the first stages and the incorporation of practices from the new model. This paper analysed the information provided by the companies in the sample under these considerations.

Regarding RQ1, in the qualitative analysis of the EMAS statements, it was observed that the CE practices most mentioned by the companies were those related to Waste recovery, Use of recycled or recirculated raw materials, and the Use of renewable energy. Other practices that were crucial in the circular model, such as Reused/refurbished/remanufactured products and Extended product lifetime, were hardly mentioned, in line with the findings of Acerbi et al. (2021). In relation to differences in reported CE practices according to company size, for RQ1_1 no significant difference between the number of CE practices implemented in firms between LE and SME groups was found. This means that although it can be assumed that LE may have more resources and tools to initiate the transition to circularity, SME may have an advantage in terms of the ability to react and adapt certain practices. Of the 17 practices identified in this study, the Chi-square statistical test concluded that in only 6 of them was adoption behaviour significantly different between LE and SME. In 5 of them, LE are the main adopters of these practices, and only in the case of product traceability are SME the main adopters. This behaviour could be because SME can maintain a longer contact with their final customers, which allows the producer-manufacturer to follow up until the end of the product's life.

Regarding RQ2, and in line with the findings of Dagiliene et al. (2020), the study shows that the information reported by EMAS companies in their statements is not extensive enough, nor is it based on scalable and comparable quantitative data. Specifically, the study analysed whether there was any quantification of the information expressed in percentages or units. In this context, only three quantified practices were found (Quantification of sustainable raw material $M5_{KPI}$, Quantification of use of renewable energy $E2_{KPI}$ and Quantification of waste recovery/re-integrated $WM4_{KPI}$), corresponding to 20.6% of the total number of practices observed. This indicates the limited or inconsistent CE reporting by companies in the EMAS statements and the impossibility of considering this European regulation as a tool for measuring circularity at this time.

Last, the information collected from the environmental statements not only allowed us to know the level of familiarity of industrial enterprises with the term 'circular economy', but it also revealed that the its introduction is still at a very early stage. Of the observed sample, 18.8% of the companies mentioned the term in their statements, compared to

78.6% who did not. We have found out companies that mention the term 'circular economy' coincide with those that adopt a greater number of CE practices. This could indicate that a greater dissemination of the circularity model in companies could speed up the transition towards the new paradigm, and that greater knowledge of the CE model mainly among the company's workers could act as an accelerating normative force in the incorporation of a greater number of practices and intensity of their adoption.

Limitations of the study are, first, that only companies in the industrial and manufacturing sector were considered. Second, the range of years analysed (2016–2019) should perhaps be extended as many of the policies focused on promoting circularity among companies were implemented from 2015 onwards. Nevertheless, in 2017 the EC had already stated that the EMAS Statements should contain 6 core indicators valid for assessing circularity at the micro-level (European Commission, 2017). Third, the keywords selected in the content analysis could limit the data, in that while a company may not necessarily report CE practices in its environmental statement, this does not mean that it is not carrying out actions in this direction.

6. Conclusions

The study carried out contributes to the theoretical landscape as it is the first study that empirically analyses the content of the environmental statements of EMAS companies with the aim of studying whether the information reported can be useful as a tool to measure the circularity of a company.

The paper concludes that the information reported by EMAS companies in their environmental statements is not extensive enough nor is it based on scalable and comparable quantitative data to be able to consider this regulation as a tool to help firms evaluate, report, and improve their advances in the transition towards a circular economy. EMAS could be a great ally in the new challenge of moving towards circularity, but before proposing to companies that they adopt complex systems of circularity KPIs, efforts should be made to expand the use of indicators for implementing circularity practices. Environmental statements according to EMAS would solve some of the drawbacks mentioned by Testa et al. (2014), such as data reliability and data availability. However, the authors believe that the results of this study show that harmonisation and comparability of data remains a challenge. Therefore, it is important to introduce specific modular and scalable circular KPIs into the EMAS regulation, starting from simple measurements and taking advantage of the current state of performance measurements. Having a system for measuring circularity at micro-level, in addition to helping each company implement objectives and improve actions, would provide meso and macro-level actors with useful information for decision-making, designing action plans and drawing up political agendas in accordance with the objectives proposed in the Circular Plan 2030 (European Commission, 2019a; Ministerio de Economía Industria y Competitivi and dad, 2018; Clarkson et al., 2008). Further efforts are needed to move the CE model from a theoretical and conceptual level to a practical level.

Recommendations to regulators centre on boosting their coercive leverage to encourage companies to use standardising indicator statements. This would improve their measurement mechanisms, which in turn would help companies transition towards a CE. Results show that the companies most informed on CE mention a higher number of practices, and also include quantitative data in their environmental statements. This fact potentially facilitates the adoption of CE indicators. Regarding institutional theory, based on the coercive influence of an EMS regulated by the EC and reflected in corporate environmental reports, the need to promote communication of the CE, both internally and externally, is highlighted, as well as the lack of precise measurement and evaluation requirements for circularity practices.

Moving from simply mentioning circularity objectives within environmental reports to actually measuring them is crucial, and using indicators make it easier to ascertain progress, both in terms of number of actions and the rate at which they are being adopted. Recommendations to managers focus on using and reporting EMAS reporting in a more comprehensive and indicator-focused way to visualise their current situation more clearly, and to compare themselves with others more efficiently, thus moving towards circularity in a more targeted way.

Valuable conclusions can be drawn from this research; however, its generalisability is limited. A future line of research would be to replicate the study in different geographic regions, which would provide valuable insights, as well as serve validation purposes. The cost/benefit assessment of CE requires a long-term perspective, so this research could be extended by carrying out a longitudinal study.

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CRediT authorship contribution statement

Alexandra Barón Dorado: Methodology, Formal analysis, Conceptualization, Data curation, Investigation, Software, Writing - original draft, Writing - review & editing. **Gerusa Giménez Leal:** Methodology, Formal analysis, Conceptualization, Supervision, Visualization, Writing - review & editing. **Rodolfo de Castro Vila:** Methodology, Formal analysis, Conceptualization, Data curation, Software, Supervision, Validation, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data are available on EMAS Website

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