ISSN No: - 2347-1735

Journal of Corporate Social Responsibility

Volume No. 13

Issue No. 2

May - August 2025

ENRICHED PUBLICATIONS PVT. LTD

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ISSN No: - 2347-1735

Journal of Corporate Social Responsibility

Aims and Scope

The journal aims to bring the quality research articles, research studies and real world case studies in the domain of Corporate Social Responsibility and Sustainability. The journal is aimed at bringing the best of the knowledge in niche domain of CSR. The journal would cover the various facets of CSR & Sustainability comprehensively. The research papers based on the primary data analysis as well as secondary data analysis would be published. The real world case studies implemented in the different parts of the world would also be included. The tested and verified models for implementation of the Social Responsible business practices may be considered after close review by the expert review board. All the contributions submitted to this journal shall go through a double blind peer review and plagiarism check.

ISSN No: - 2347-1735

Journal of Corporate Social Responsibility

(Volume No. 13, Issue No. 2, May - August 2025)

Contents

ISSN No: - 2347-1735

The overall sustainability index(OSI):Asuitable way to measure the sustainability of electrical industry in Italy

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A B S T R A C T

The objective of this research is to develop a comprehensive and effective quantita tive method to measure the overall sustainability performance of electric companies in Italy. Due to the vast diversity of the sustainability issues, many methods have been developed to measure the sustainability performance of companies, but with results that are, in our opinion, not fully satisfactory, either because they are difficult to apply or because they only cover some of the sustainability aspects. Inanattempt toovercome these shortcomings, we have applied amethodology tomeet the requirements of our research, on the basis of its high versatility (https://lab24.ilsole24ore.com/qualita-della-vita/). The analysis was carried out on the 12 largest Italian electricity companies, by calculating the over all sustainability index (OSI) for the years 2020 and 2021, taking intoaccount 56 different indicators, chosen from those made available by the Global Reporting Initiative (GRI) for corporate sustainability reporting. For a more comprehensive evaluation of the sustainability perfor manceof the electricity companies, elected sindicators were chosen from all the three pillars of sustainability (economic, environmental, social). The OSI results of this research have allowed to high light the critical points of the corporate reporting sys tems on sustainability providing valuable indications on the targets achie vedand achievable in view of the European Commission'sGreen Deal 2050.This workal so highlighted the strengths and weaknesses of the method.

KEYWORDS
electricity company, GRI,OSI, sustainability index, sustainability report

INTRODUCTION

The 2021‘Reporton the National Energy Situation’1prepared by the Italian Ministry of the Environment and Energy Security (MASE), shows how the country's energy sector reacted positively following the pandemic shock of 2020: primar yenergy demand was153,024 thousand tons of oil equivalent (ktep), an increase of 6.2%over the previous year.

How do these changes affect the levels of sustainability achieved by Italian electricity companies? Is there away to assess this sustainability concretely, starting from the datacontained in the corporate sustainability reports published annually by electricity companies? Are the data obtained comparable with those of the previous year ?All the sequestions form the basis of this work.

For several years now, energy production and distribution opera tors in Italy have been adopting an approach aimed at decarbonisation, decentralisation and digitisation of data, while implementing solutions to support cybersecurity and sustainability. This also responds to a necessity imposed by the European Community through directive (EU) 2022/2464 concerning corporate sustainability reporting, which requires companies, as identified on the basis of the same directive, operating in the EU, to have a sustainability statement (balance sheet) reporting on economic, environmental and social sustainability aspects, starting with an appropriate materiality assessment.

The Directive was implemented through Delegated Regulation (EU) 2023/2772, which provides for mandatory sustainability reporting from the financial year 2024. Gradually, this reporting obligation will be extended to a larger group of EU companies, as indicated in Directive 2022/2464, art. 5. The companies analysed in this work, however, have already been operating in this context for several years, starting with a serious materiality assessment. It is therefore necessary to identify the right method of analysis and return of the information shared by the companies themselves.

Fortunately, Italian electricity companies have a fairly standar dised method of reporting their sustainability performance, based on the use of the indicators made available by the GRI (Li et al., 2012; Singh et al., 2012), chosen by all the TBL pillars of sustainability (economic, environmental, social) (Singh et al., 2007). The indicators developed by the GRI are to be considered a guarantee/warranty in terms of choice. Thus, the fact that Italian electricity companies have chosen the GRI indicators for their sustainability reports has made it possible to consider those indicators as already standardised and ready to use for this study. Starting from the data provided in the 2021 and 2022 annual sustainability reports of the 12 largest energy producers in Italy (ENEL, Edison, Hera, A2A, AXPO, Eni, Green Network, E.ON., Iren, Acea, Duferco and Alperia) (ARERA, 2021), it was possible to calculate an overall sustainability index (OSI) of each company for the years 2020 and 2021. Each company has been assigned a progressive number, by which it will be identified from now on. The objective of this work is to describe the method and prove its effectiveness, rather than to go deep into the data, as accomplished in other publications (Carrabba & Padovani, 2022; Carrabba & Padovani, 2023).

2 | METHODS

Scientific literature proposes a number of sustainability performance measurement systems for different types of productive sectors, but a lot of difficulties are reported on various aspects (Cagno et al., 2019). For example, the need to address industrial sustainability taking into account the different pillars of the triple bottom line (TBL): environment, social, economic (Trianni et al., 2017; Wicaksono et al., 2020). The evaluation of sustainability performance requires the use of standardised indicators, adapted to the industrial sector chosen and organised into a performance measurement system (PMS) (Krajnc & Glaviˇc, 2003). Some difficulties are related also to the size of the industries that should be comparable to each other (Ferrari et al., 2019). Nonetheless, it is important to know the current status of sustainability measurement in today's industrial practices; hence, the development of a unique single index—easy to be understood by the end users (Soler & Soler, 2008)—to measure the environmental, economic, and social dimensions of sustainability (Li et al., 2012; Parris & Kates, 2003).

The first step of this study identifies a synthetic index capable of analysing the values coming from very different variables. In the analysis of sustainability, in fact, several elements should be taken into consideration, both in terms of objectives and values, such as emissions into the atmosphere, the percentage of women employed by the company and the economic value that has been generated and distributed. Many different indices and methods are used to evaluate sustainability in numerous areas (Cagno et al., 2019; Singh et al., 2012), but none seemed suitable to provide a synthetic index truly representative of the multifactorial reality of sustainability in the Italian electricity industries.

For the analysis of corporate sustainability reports, 56 indicators were used among those made available by the Global Reporting Initiative (GRI, 2020; Singh et al., 2012), chosen by all the three pillars of sustainability (economic, environmental, social) (Singh et al., 2007; Wicaksono et al., 2020). The choice of the Italian electricity companies to use already standardised GRI indicators for their sustainability reports, allowed to use them directly (or to adapt them) for the study carried out here, without further selections. The criteria of the indicators' selection include their relevance to the purpose of the analysis of sustainability and the wider availability during the years in the corporate sustainability reports (Li et al., 2012; Singh et al., 2007). The chosen indicators, specific for the electricity companies, covered all the TBL pillars and their intersection (Cagno et al., 2019; Singh et al., 2007): 31 are environmental, 6 are economic, 19 are social indicators, in a way to obtain as much as possible an overall perspective of the sustainability of industrial activities. The quantitative distribution of the indicators in the three pillars of sustainability is in line with the scale of importance of the indicators identified by Wicaksono and Sodri (2020). The system can be applied to companies with different size, due to the way in which indicators are utilised in the construction of the index.

In the end, the most suitable method was the one developed by Il Sole 24 ore2 in its annual ranking of the Quality of Life of Italian Provinces.3 The method analyzes heterogeneous dimensions through the use of an easy-to-apply synthetic index.

The 56 basic indicators are divided into thematic macro categories (governance; economic performance, energy, water and effluent, employment and so on), already established by GRI in the identification of its indicators.

The basic indicators undergo a prior transformation in order to be subsequently used to obtain the synthetic indices. The transformation is necessary because the starting data are represented by units of

measurement that are mostly not comparable with each other; they also have different directions (positive or negative) with respect to the phenomenon they quantify (Quality of Life in the case of Il Sole 24 Ore; Sustainability in the case of the present work).

In the case of positive indicators (defined as 'quality' or Q), that is, when a higher value of the indicator corresponds to a higher value of sustainability, the transformation is the ratio between the figure expressed by the individual company and the maximum value expressed by the indicator among all the companies analysed, according to the equation:

$$X_{(t)}iq = (xiq/\max xq) \times 1000.$$

In the case of negative indicators (defined as "distress" or D), that is for which it is the minimum value of the indicator that expresses high sustainability, the ratio is inverted. The value assumed by the equation will then be given by the ratio of the minimum value expressed by the indicator xid among all the analysed companies to the figure expressed by the individual company, according to the equation:

$$X_{(t)}id = (\min xd/xid) \times 1000,$$

where iq stands for quality indicator; id stands for discomfort indicator.

According to each indicator, 1000 points are awarded to the company with the best value and zero points to the one with the worst value. The scores of the other companies are distributed according to their distance from the extremes (between 1000 and 0).

Subsequently, to each electric company is assigned a score for each of the thematic macro-categories, determined by the score assumed by the company indicators in comparison with the other companies, each weighted equally to the other (simple arithmetic mean). Finally, for each company, the final ranking is constructed based on the simple arithmetic mean of the 18 sector rankings (Singh et al., 2007).

Table 1 shows the indicators chosen for the calculation of the OSI.

The index described so far, applied with this paper to the area of sustainability, has been defined as the OSI.

Some indicators, whose values are difficult to be assessed in a quantitative manner, have been classified in a qualitative way, giving them a different weight from the GRI value. To be precise, for some indicators, it was chosen to attribute the value 'YES' if the hypothesis turned out to be true; the value 'NO' if the hypothesis turned out to be false.

For example, in the case of indicator 55 (Activities with significant potential and actual negative impacts on local communities), the value "YES" was assigned if the company, during the reporting period, reported company activities with possible negative impacts on local communities; the value "NO" if the company excluded that its activities had possible negative impacts on local communities.

In assigning a quantitative score to uniquely qualitative indicators, in order to be able to start comparing data, indicators with a "YES/ NO"value were given the following value:

(i) indicator type Q: (yes = 1000; no = 0).

(ii) indicator type D: (yes = 0; no = 1000).

Some GRI indicators in absolute values (e.g. total fuel consump tion within the organisation from non-renewable energy sources, in joules or multiples) have been transformed into percentage data (total fuel consumption within the organisation from non-renewable energy sources, as a percentage of total energy consumed) to allow for easier comparison between companies that are also very different in size.

On the other hand, in the case of indicators referring to defined parameters, where different units of measurement were used in the reporting of individual companies, the data were all standardised to one and the same unit of measurement (e.g. TJ in the case of energy; Mm3inthe case of water withdrawal, and so on).

The comparison between companies was made on a fixed time basis, that is, referring to the reporting year 2020 and the reporting year 2021, which is available for all companies considered.

At the time of writing, the data reported by the companies, refer ring to the 2 years under consideration, are now consolidated. However, it should be borne in mind that in sustainability reports, the data referring to a given year are to be considered provisional until the publication of the following year's sustainability report. Indeed, at the time of publication of the sustainability report, the data referring to some variables of the current year may not yet be final, and are only consolidated with the following sustainability report.

The OSI results in a definite magnitude and direction, so the index can be uniquely interpreted (Singh et al., 2007).

3 | RESULTS

The overall data obtained with the described methodology, relative to each of the 56 indicators considered, are presented in the original work published by ENEA in 2023 (Carrabba & Padovani, 2022; Carrabba & Padovani, 2023). By way of example only, in order to provide a better description of the method, the summary sheet of the scores obtained by the electricity companies in the analysis of the values indicated in the Sustainability Reports for SCOPE 1, SCOPE 2 and SCOPE 3emissions is shown here (Table 2).
For the complete tables, please consult the published work in full. Table 2 shows:

1. The progressive number assigned to the Company.
2. The number of the GRI indicator considered.
3. The value taken for the figure (X(t)iq/X(t)id), as reported in the Sustainability Report of the individual company in 2020 and 2021.
4. The value actually considered for the indicator in 2020 and 2021. This field was necessary because for calculation purposes, values of X less than 1 were transformed by multiplying them by appropriate multiples of 10.

TABLE1 Indicators chosen for analysis.

N	GRI Number/ESRS	Indicators	Quality/ discomfort indicator	Value or unit of measurement considered
Governance (GRI 102)				
1	102–20/ESRS 2	Executive-level responsibility for economic, environmental, and social topics	Q	Y/N
2	102–21/ESRS 2	Consulting stakeholders on economic, environmental, and social topics	Q	Y/N
3	102–26/ESRS 2	Role of highest governance body in setting purpose, values, and strategy	Q	Y/N
4	102–42/ESRS 2-S3-S4	Identifying and selecting stakeholders	Q	Y/N
Economic performance (GRI 201)				
5	201–1/ESRS 2	Direct economic value generated and distributed	Q	%
6	204–1/ESRS 2	Proportion of spending on local suppliers	Q	%
Materials (GRI 301)				
7	301–1/ESRS E5	Materials used by weight or volume (i) non-renewable materials used	D	%
8	301–1/ESRS E5	Materials used by weight or volume (ii) renewable materials used	Q	%
9	301–2/ESRS E5	Recycled input materials used (a) percentage of recycled input materials used to manufacture the organisation's primary products and services	Q	%
Energy (GRI 302)				
10	302–1/ESRS E1-5	Energy consumption within the organisation (a) total fuel consumption within the organisation from non-renewable sources	D	%
11	302–1/ESRS E1-5	Energy consumption within the organisation (b) total fuel consumption within the organisation from renewable sources	Q	%
12	302–1/ESRS E1-5	Energy consumption within the organisation (d) total energy consumption within the organisation, in joules or multiples	D	TJ
13	302–3/ESRS E1-5	Energy intensity	D	MJ/kWh
Water and Effluents 2018 (GRI 303)				
14	303–3/ESRS E3-1	Water withdrawal (a) total water withdrawal from all areas in megaliters, and a breakdown of this total by the following sources, if applicable: (i) Surface water; (ii) groundwater; (iii) seawater; (iv) produced water; (v) third-party water	D	Mm^3
15	303–3/ESRS E3-1	Water withdrawal (b) total water withdrawal from all areas with water stress	D	Mm^3
16	303–3/ESRS E3-1	Water withdrawal (c) total water withdrawal: (i) freshwater	D	Mm^3
17	303–4/ESRS E3-4	Water discharge a. Total water discharge to all areas in megaliters	D	Mm^3
18	303–4/ESRS E3-4	Water discharge (b) a breakdown of total water discharge to all areas in megaliters by the following categories: (i) Freshwater (≤1000 mg/L Total Dissolved Solids); (ii) Other water (>1000 mg/L total dissolved solids)	D	Mm^3
19	303–4/ESRS E3-4	Water discharge (c) total water discharge to all areas with water stress in megaliters, and a breakdown of this total by the following categories: (i) freshwater (≤1000 mg/L total dissolved Solids); (ii) other water (>1000 mg/L total dissolved solids)	D	Mm^3
20	303–5/ESRS E3-4	Water consumption (a) total water consumption from all areas in megaliters	D	Mm^3

(Continues)

TABLE1 (Continued)

N	GRI Number/ESRS	Indicators	Quality/ discomfort indicator	Value or unit of measurement considered
43	403–9/ESRS S2	Work-related injuries (b) for all workers who are not employees but whose work and/or workplace is controlled by the organisation: (iii) the number and rate of recordable work-related injuries	D	Number of fatalities as a result of work-related injury * Number of hours worked /1,000,000
Training and education 2016 (GRI 404)				
44	404–1/ESRS S1	Average hours of training per year per employee	Q	n
45	404–1/ESRS S1	Employees who have had access to training processes	Q	%
Diversity and Equal Opportunity 2016 (GRI 405)				
46	405–1/ESRS S1	Diversity of governance bodies and employees (a) percentage of individuals within the organisation's governance bodies in each of the following diversity categories: i. Gender (CPO)	Q	%
47	405–1/ESRS S1	Diversity of governance bodies and employees (a) percentage of individuals within the organisation's governance bodies in each of the following diversity categories: (i) gender (manager + middle manager)	Q	%
48	405–1/ESRS S1	Diversity of governance bodies and employees (b) percentage of employees per employee category in each of the following diversity categories: (i) gender	Q	%
49	405–2/ESRS S1-16	Ratio of basic salary and remuneration of women to men (a) ratio of the basic salary and remuneration of women to men for each employee category, by significant locations of operation.	Q	%
Non-discrimination 2016 (GRI 406)				
50	406–1/ESRS S1-17	Incidents of discrimination and corrective actions taken (a) total number of incidents of discrimination during the reporting period.	D	Y/N
Rights of Indigenous People 2016 (GRI 411)				
51	411–1/ESRS S1-17	Incidents of violations involving rights of indigenous peoples (a) total number of identified incidents of violations involving the rights of indigenous peoples during the reporting period	D	Y/N
Human rights assessment 2016 (GRI 412)				
52	412–1/ESRS S1-17	Operations that have been subject to human rights reviews or impact assessments (a) total number and percentage of operations that have been subject to human rights reviews or human rights impact assessments, by country	D	Y/N
53	412–2/ESRS E1	Employee training on human rights policies or procedures	Q	Y/N
Local communities 2016 (GRI 413)				
54	413–1/ESRS S3	Operations with local community engagement, impact assessments, and development programs	Q	Y/N
55	413–2/ESRS S3	Operations with significant actual and potential negative impacts on local communities	D	Y/N
Supplier social assessment 2016 (GRI 414)				
56	414–1/ESRS S2-1	New suppliers that were screened using social criteria	Q	Y/N

Note: Modified from: GRI, 2020. Consolidated Compendium of GRI Sustainability Reporting Standards (Consolidated Standards) 2019. Column (1) progressive number attributed to the indicator in this paper; column (2) reference GRI number/ESRS; column (3) indicator declaration; column (4) quality or distress indicator (Q/D); column (5) value or unit of measure with which the indicator is expressed in this paper.

Abbreviations: ESRS, European Sustainability Reporting Standards; GHG, greenhouse gas emission; GRI, global reporting initiative; mln, million; Tj, terajoule.

TABLE2 IndicatorsrelatedtoSCOPEemissions.

Electricity companies	N° indicator and GRI	$X_{(t)}iq/X_{(t)}id$ 2020	X transformed 2020	Indicator value 2020	$X_{(t)}iq/X_{(t)}id$ 2021	X transformed 2021	Indicator value 2021
Emissions (GRI 305)							
1	26	45,73	45,730	0,01	51,57	515,700,00	0,008
2	26	6282	6282	0,05	5855	58,550,00	0,068
3	26	0,986	986	0,30	0,9818	9818,00	0,407
4	26	5,85	5850	0,05	7127	71,270,00	0,056
5	26	1,82	1820	0,16	0,000694	6,94	576,369
6	26	37,76	37,760	0,01	40,08	400,800,00	0,010
7	26	N.A.	0	0,00	N.A.	0	0,000
8	26	0,0003	0,3	1000,00	0,0004	4,00	1000,000
9	26	4069	4069	0,07	3978	39,780,00	0,101
10	26	0,0454	45,4	6,61	0,0508	508,00	7874
11	26	0,592	592	0,51	0,50	5000,00	0,800
12	26	0,42	42	7,14	0,4	4000,00	1000
1	27	4,06	40,600	0,02	4,31	431,000	0,009
2	27	0,07	700	1,43	0,065	6500	0,615
3	27	0,0001	1	1000,00	0,154	15,400	0,260
4	27	0,107	1070	0,93	0,108	10,800	0,370
5	27	0,47	4700	0,21	0,000108	10,8	370,370
6	27	0,73	7300	0,14	0,81	81,000	0,049
7	27	N.A.	0	0,00	N.A.	0	0,000
8	27	4,82	48,200	0,02	0,00004	4	1000,000
9	27	0,099	990	1,01	0,111	11,100	0,360
10	27	0,0348	348	2,87	0,0254	2540	1575
11	27	0,136	1360	0,74	0,162	16,200	0,247
12	27	0,38	3800	0,26	0,35	35,000	0,114
1	28	6,9	690	0,87	7,11	71,100	0,024
2	28	0,11	11	54,55	0,105	1050	1657
3	28	0,044	4,4	136,36	0,0466	466	3734
4	28	0,006	0,6	1000,00	0,0016	16	108,750
5	28	N.A.	0	0,00	0,000174	1,74	1000,000
6	28	N.A.	0	0,00	N.A.	0	0,000
7	28	N.A.	0	0,00	N.A.	0	0,000
8	28	6,06	606	0,99	N.A.	0	0,000
9	28	0,154	15,4	38,96	0,031	310	5613
10	28	0,0255	2,55	235,29	0,0218	218	7982
11	28	0,188	18,8	31,91	0,22	2200	0,791
12	28	0,27	27	22,22	0,26	2600	0,669
1	29	64,9	6490	0,35	69,15	6915	27,129
2	29	0,0228	2,28	1000,00	21,617	2161,7	86,784
3	29	11,613	1161,3	1,96	11,7235	1172,35	160,020
4	29	1464	146,4	15,57	1876	187,6	1000,000
5	29	0,76	76	30,00	N.A.	0	0,000
6	29	205,8	20,580	0,11	176	17,600	10,659
7	29	N.A.	0	0,00	N.A.	0	0,000
8	29	108,21	10,821	0,21	N.A.	0	0,000

TABLE2 (Continued)

Electricity companies	N° indicator and GRI	$X_{(t)}iq$/ $X_{(t)}id$ 2020	X transformed 2020	Indicator value 2020	$X_{(t)}iq$/ $X_{(t)}id$ 2021	X transformed 2021	Indicator value 2021
9	29	4087	408,7	5,58	4538	453,8	413,398
10	29	2833	283,3	8,05	2871	287,1	653,431
11	29	N.A.	0	0,00	N.A.	0	0,000
12	29	4,87	487	4,68	5,33	533	351,970

Note: column 1: progressive number of the company; column 2: number of the GRI indicator considered (26: SCOPE 1; 27: SCOPE 2 L.b.; 28: SCOPE 2 m. b.; 29: SCOPE 3); columns 3 and 6: value assumed by the figure (X(t)iq/X(t)id), as reported in the individual company's Sustainability Reports in 2020 and 2021; columns 4 and 7: value actually considered for the indicator in 2020 and 2021; columns 5 and 8: final value assumed by the indicator in 2020 and 2021.

Abbreviation: GRI, global reporting initiative.

5. The final value assumed by the indicator in 2020 and 2021, apply ing the formulas given in the Section 2.

In yellow are indicated the zero values attributed to the data not available (N.A. = not available), not to be confused with the zero values corresponding to the zero data reported by the individual company. It may indeed be the case that a company declares a zero value referring to a certain indicator. In this case that indicator (highlighted in orange) will be given a score of X(t)iq equal to 1000; a value of X(t) id equal to 0.

After the construction of the overall tables, the value of the corporate OSI was extrapolated for each company from the analytical scores achieved for each indicator per year.

As an example, Table 3 shows the calculation of the OSI value for the company n1.

The table summarising the values of the electricity company n° 1 by the indicator (Table 3) shows how the company expresses the best in organisational and formal aspects. Governance and economic performance have very high ratings. Highest values are also obtained in the ethical aspects relating to indigenous peoples and human rights. Social aspects relating to relations with personnel achieve mediumhigh values, with a peak of excellence related to training. The more production-related aspects, on the other hand, receive medium-low ratings in the indicators relating to energy used, use of water resources, and impacts on biodiversity. Particularly low values were obtained for indicators relating to waste and, especially, indicators relating to emissions. Company n°1 does not report on the materials used.

The value of OSI obtained by Company n°1 in the years 2020 and 2021 is almost identical, although it shows an increase in the Index of about 26 points. The difference found, however, is not statistically significant ($p \leq 0.05$).

Table 4 shows the values of the OSI calculated for each company for the 2 years under consideration.

The data, ordered in descending order according to the year 2021, range from a OSI value of 589 achieved by Company n°4to 47 by Company n 7. We recall here that, due to the way the index is constructed, the OSI does not represent an absolute value, but rather a relative one, based on the comparison of the performance achieved by each company compared with the performance of the others. Taking into account that the maximum attainable value is 1000, we see how even the best performing companies from a sustainability point of view only slightly exceed the average value. Company n4 itself, which in 2020 reaches an OSI value exceeding 600, in 2021 shows a drop of no less than 33 points. More or less marked declines are also seen for Companies n 3, 9, 12, 10 and 5. On the other hand, Companies n2, 1, 11 and 6 show an index improvement of varying degrees. The change in the index for Company n8 from 119 to 337 is essentially due to the shift from a qualitative to a quantitative sustainability report. Company n7, on the other hand, remained on a qualitative sustainability report, which does not allow the sustainability performance achieved to be assessed appropriately with this methodology. In order to statistically assess the change in the OSI values of individual companies over the years, we applied a t-test for paired data to the values, where H0: x2020 = x2021. The tests performed allow us to state that the companies analysed show no significant differences between the data of 2020 and 2021 except in the case of Company n8. The differences recorded between the years must therefore be considered as a trend only.

Figure 1 describes graphically what is shown in Table 4. The graphical representation allows even better appreciation of the comparison of the index performance per company per year. Note how all companies, except Companies n8, 5 and 7, reach values above 300 in 2021. While the marked improvement in performance of Companies n2 and 8 is clearly noticeable, the deterioration recorded by Company n5is also noticeable.

4 | DISCUSSION

The first interesting aspect of using the OSI is that of the possibility of comparing data from different reporting years, in this case 2020 and 2021, provided that the indicators analysed are the same for each year. This made it possible, on the one hand, to verify the replicability of the method over time, and on the other hand, to check its sensitivity in photographing changes, even small ones, due both to variations

TABLE3 Companyn1:summarytableofvaluesexpressedperindicatorandcalculatedvalueofOSI.

Company n°1		2020		2021	
Macro-categories	Indicator	Score	Partial	Score	Partial
Governance	1	1000		1000	
	2	1000		1000	
	3	1000		1000	
	4	1000	1000	1000	1000
Economic performances	5	915,8742		941,4457	
	6	877,551	896,7126	795,9184	868,682
Materials	7	0		0	
	8	0		0	
	9	0	0	0	0
Energy	10	338,6243		368,305	
	11	80,29,412		76,308	
	12	0,005267		0,003	
	13	1000	354,7309	1000	361,1538
Water	14	33,74,757		23,995	
	15	25,08207		24,839	
	16	37,29,614		31,604	
	17	26,89,934		0,001	
	18	1000		0,001	
	19	1000		1000	
	21	1000	400,7948	1000	260,077
Biodiversity	22	0		0	
	23	0		0	
	24	1000		1000	
	25	0	250	0	250
Emissions	26	0,00656		0,008	
	27	0,024631		0,009	
	28	0,869,565		0,024	
	29	0,35,131		27,129	
	30	1000		55,556	
	31	0,553,661		0,597	
	32	0,043802		0,102	
	33	0,483,092	125,2916	0,673	10,512
Waste	34	90,67,797		96,66,667	
	35	456,4706	273,5743	168,1356	132,4011
Compliance	36	0	0	0	0
New suppliers	37	1000	1000	1000	1000
Employment	38	1000		1000	
	39	1000		1000	

	40	1000		1000	
	41	1000		1000	
	42	230,0319		253,165	
	43	575,1438	800,8626	90,883	724,008
Training	44	1000		1000	
	45	935	967,5	957	978,5

TABLE3 (Continued)

Company n°1 Macro-categories	Indicator	2020		2021	
		Score	Partial	Score	Partial
Diversity	46	1000		990,991	
	47	983,2776		999,673	
	48	671,875		408,126	
	49	850	876,2881	791,220	797,503
Anti-discrimination	50	0	0	0	0
Indigenous people	51	1000	1000	1000	1000
Human rights	52	0		1000	
	23	0	0	1000	1000
Local communities	54	1000		1000	
	55	0	500	0	500
Supplier social assessment	56	1000	1000	1000	1000
OSI 2020/2021			524,7642		549,046

Abbreviation: OSI, overall sustainability index.

TABLE4 OSI values per company, per year.

Company number	2020	2021
4	622,6497	659,332
3	584,6152	581,688
2	443,7367	578,924
1	524,7642	549,046
9	535,4231	505,812
12	519,9225	489,506
6	474,1091	483,662
11	454,4454	480,805
10	434,3626	412,162
5	406,502	352,686
8	119,6891	338,889
7	47,55,787	47,4631

Abbreviation: OSI, overall sustainability index.

in the conduct of corporate affairs and policies and to social, political and economic changes in society in general.

After a period of recession characterised by a contraction in the use of energy sources and expressed at the level of electricity companies with emissions never as low as in 2020, there is a partial reversal of the trend in 2021. Electricity companies have, in general, produced more energy to meet the increased energy demand from both industrial and civil users, resulting in a partial increase in emissions.

Ageneral worsening trend in sustainability performance (although not supported by statistical evidence ($p \leq 0.05$)) led to a lower OSI value in 2021 than in 2020 for 5 out of 12 companies (Companies n 4, 3, 9, 12 and, 10). Another 4 companies (Companies n 2, 1, 11 and 6) instead showed a slightly higher OSI value, and thus sustainability performance, in 2021 compared with 2020, although, even in this case, the figure was not statistically significant.

Company n8 shows a doubled OSI value in 2021 compared with 2020. This clear improvement, which is statistically significant ($p \leq 0.05$), is due to a different sustainability performance reporting policy, which in 2020 was of a qualitative type and in 2021 became of a more quantitative type, responding better to the requirements of the method used here. In 2021, Company n8 therefore fits, on merit, into the group of companies for which the analysis was successful.

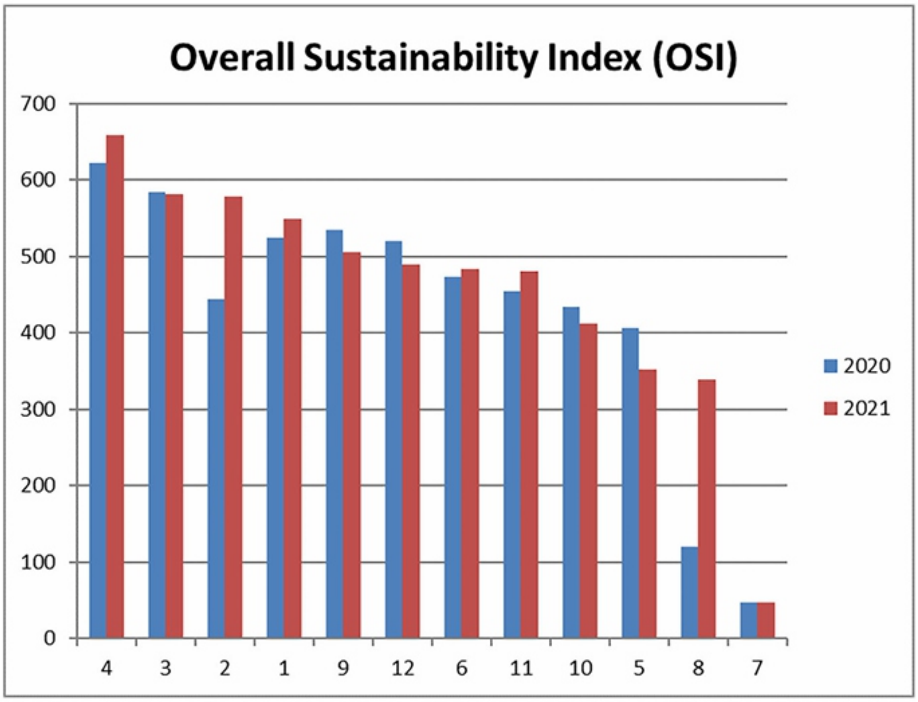
Company n7 has not changed its way of reporting sustainability, and its OSI remains the lowest of the twelve. In both years, the company opted for a type of reporting that follows qualitative rather than quantitative logics, effectively preventing access to the data required for the methodology used in this work. The company therefore remains, essentially, outside the group of companies for which the analysis was successful.

Company n 5 showed a clear decrease in the OSI between 2020 and 2021. The index is, in fact, almost halved, although the figure is not statistically significant ($p \leq 0.05$). Over the past year, the company has evidently changed its policies concerning the drafting of the Sustainability Report.

It is interesting to consider the aspect of the percentage of data present per group of indicators in the Sustainability Reports in the two different years considered (Figure 2).

In general, all companies received very high values in reporting on governance and economic performance, which meet modern corporate policy criteria. The percentages of presence of governance data reach more than 80%. This information is very easy to find and to report on, and is also generally present in traditional company financial statements, especially with regard to economic performance aspects. Much scarcer is the information on more purely environmental issues, information that has become important precisely in connection with the drafting of sustainability reports.

FIGURE1 Annual development of the overall sustainability index per company per year.



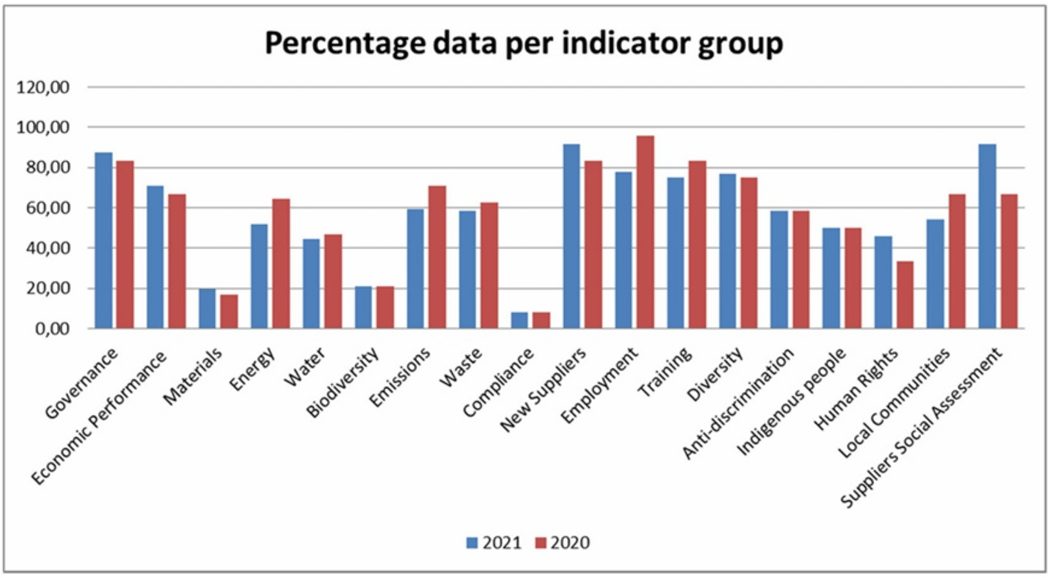


FIGURE2 Percentage of datain sustainability reports per indicator group for the years 2020–2021.

On the materials used and their type, only a few companies respond, with very low values, apart from Company n11, which reports satisfactorily. The percentage of data presence is less than 20%(Figure 2).

Even on energy, an indicator that is well represented in all Sustainability Reports, the companies reach very low values, with the exception of Company n10. In fact, the companies all declare quite high levels of fuel consumption from non-renewable energy sources. Only Company n10 declares a use of fuel from renewable sources above 65%, the rest of the companies below 20%. The figure, which was above 60% in 2020, stands at 52% in 2021 (Figure 2).

Another sore point is the reporting of water use, from with drawals to discharges. Many companies do not report (the figure is around 45% (Figure 2)), or report only partially, reaching generally very low to low values. Only Company n12 reports satisfactorily on this group of indicators, partly because water is fully part of its corporate commitment; however, it too reaches a fairly low value. The group of indicators on biodiversity is scarcely taken into account (percentage of presence of the figure at 20% (Figure 2)). Companies generally either ignore this aspect or consider it as a sideline topic in relation to their sustainability objectives. The exception is Company n11, which achieves a fairly high score in this group of indicators, indicating a sensitivity to the topic that goes beyond mere production interests. On emissions, almost all companies respond for at least one of the 2 years considered, as this is the group of indicators centred on the focus of company activities. The percentage of data presence (Figure 2), reaches 70% in 2020, while it drops to just under 60% in 2021. The values achieved by the indicators are, however, quite low to very low. This is undoubtedly the thorniest issue in relation to sustainability performance, depending to a large extent on the technological and innovation choices made by companies, but also on the company's volume of operations. Only Company n10 in 2021 achieves a fairly high score. The data will have to be reconfirmed by the Sustainability Report for 2022.

With regard to waste, some companies do not consider the figure at all, as if this issue were completely outside the scope of sustainability reporting, while others report only partially. Company n4 in 2021 scores well in relation to waste management, as it declares a very high level of recycling. The same for Company n9 in 2020 and for Company n11 in both years. The figure is around 60% in both years (Figure 2). It must be said that this indicator can be a problem, as multifunctional companies such as Company n12 also deal with waste collection and recycling. They therefore have to manage such quantities of waste that it is difficult to achieve very high levels of recycling. Following the evolution of these indicators over time will make it possible to monitor the company's performance in this respect.

On the compliance indicator, that is, the awarding of fines for non-compliance with environmental laws or regulations, all companies receive the lowest mark (zero), either because they state that they have received fines, or because they do not report the figure. The presence of the figure is very low, with a percentage of less than 10% (Figure 2). Only Company n8 receives the highest score in both years, as it states that it has not received penalties on aspects of noncompliance with environmental regulations. On this aspect, therefore, there is much to be done.

On the other hand, the aspect of new suppliers assessed for compliance with environmental and social issues is very much felt by the companies, which always report the figure for at least one of the 2 years under consideration (the percentage of presence of the figure in 2021 exceeds 90% (Figure 2)). The exception is Company n 7, which does not mention the issue. This aspect, which is one of the socio-environmental aspects of sustainability, is very good news, as it is an important lever for influencing the sustainability of the electricity market. The issue of employment is very strongly felt and highly represented among the data provided by companies, both in its social and equality aspects and in respect for rights and combating discrimination. Scores are generally between medium-high and very high, with peaks of excellence. The exception is Company n8, which does not include these topics except marginally in its Sustainability Reports. It must be said, however, that it is precisely thanks to the presence of these issues, which come from a long history of bargaining also with the trade unions, that a fairly high OSI score was achieved for most companies. Note the decrease in the presence of the figure between 2020 and 2021, where the percentage drops from 95 to 77%, an indication, perhaps, of some rethinking in the structure of sustainability budgets. Yet the social aspects of work are fundamental in defining the sustainability of a company.

Finally, the issues of respect for indigenous peoples and human rights are quite strongly felt, although not all companies report on the latter. The indicator on indigenous peoples was included last year in consideration of the fact that larger companies, such as Company n1, also operate internationally in areas where the presence of indigenous peoples is an important reality to take into account when describing the levels of sustainability achieved. In view of the fact, however, that some of the companies operate only domestically and that this, therefore, may disadvantage them in the calculation of the OSI, its use in any future work should be evaluated.

Finally, as far as the indicators reporting on relations with local communities are concerned, since electricity companies experience the local area as a privileged partner, they generally score very high, although the figure varies between 66% in 2020 and 54% in 2021 (Figure 2—Percentage of data in Sustainability Reports per indicator group for the years 2020–2021).

5 | CONCLUSIONS

The possibility of relying on a standardised method to analyse the data declared by companies in their sustainability reports, gives the possibility of following the trend of changes over time due to new company policies or even to changes in the social, political, economic horizon of society. Indeed, there is no doubt that energy demand (and thus the production/emission levels of electricity companies) can change profoundly as national conditions change. Proof of this was the COVID-19 pandemic crisis, which profoundly affected industrial and social energy consumption profiles. The OSI is therefore a useful tool for companies interested in assessing their own performance and more easily identifying areas that still need to be investigated or implemented from scratch in order to improve their reporting. Well-done reporting can in fact, also have a positive impact on company policies, indicating areas in which to invest to improve productivity and sustainability.

This contribution can also be a useful tool for all those companies that do not yet have a sustainability report but are now obliged to produce one, on the basis of Directive (EU) 2022/2464, an obligation that came into force for reports from the financial year 2024 onwards, or for those companies that already have a sustainability report, but would like to arrive at a more concise and quantitative rendering of their company data. The methodology adopted in this paper is in fact not only a tool for verifying sustainability reporting, but also for verifying the policies undertaken by the company as the boundary conditions change, again in the light of the European sustainability goals. The data reported in this paper were provided by companies up to 2022 and are broadly comparable with the European Sustainability Reporting Standards4 (ESRS-Delegated Regulation (EU) 2023/27725), expressly required by the Directive (EU) 2022/2464, given that the development of the ESRS was largely based on the GRI standards. On these premises, in view of the next sustainability reports, both the GRI indicators and the corresponding ESRS indicators have been reported in Table 1. With the aim of facilitating the transition from one reporting system to another and/or compare them. It is important to underline that GRI and EFRAG collaborate from the early stages by defining the ESRS to ensure the best possible interoperability between the two standards. Therefore, the OSI method, described in this work, can be also usefully utilised in the future using ESRS.

Going back to the GRI data used in this work, companies reported quite unevenly.

The results showed the need for the companies object of this study to work more concretely on the reporting of aspects such as materials, impact on biodiversity, water resource management, and waste. A further step should be taken on the emission factor, working more determinedly on the acquisition of more innovative technologies on both the production/optimisation and emission reduction sides. Starting in 2024, when Delegated Regulation (EU) 2023/2772 becomes fully applicable, it will be possible to consider which changes to make to the OSI calculation. Indeed, the method allows to change both the number of companies and the type of indicators considered, without compromising the results obtained. Of course, the comparability of the data presupposes that the indicators and the companies taken into account are the same from year to year. With regard to the evaluation of the proposed method, it is useful to remember that the OSI is a relative and not an absolute index, therefore it is based on the comparison of balance sheets of different companies. The method cannot, therefore, be applied to assess the level of sustainability achieved objectively by an individual company. The possibility of transforming some of the indicators from absolute to percentage values makes it possible to usefully compare even companies of significantly different sizes.

For example, directly generated and distributed economic value, calculated in percentage terms on the amount of economic value generated, rather than absolute value, creates no difficulty in comparing companies operating at a multinational level with others operating at a purely national/local level. Being a multi-factor synthetic index, the OSI undoubtedly rewards companies that report more comprehensively. Thus, companies that report even low values of an indicator achieve a higher value than those that omit the data. Nonetheless, the method allows to compare companies that have different Industrial Sustainability Performance Measurement Systems (Full, Intermediate or Core ISPMS; Cagno et al., 2019). Again, data on environmental performance, which is generally quite low, is compensated for by the higher values of data on social aspects such as employment, training, local communities.

A limitation (or a virtue) of the method is that sustainability reports, in order to be used for the construction of the OSI, must be quantitative and not qualitative. On the other hand, a qualitative balance sheet hardly allows a useful comparison even between data from the same company but referring to different years. Furthermore, since the data analysed come from the sustainability reports made available by the electricity companies themselves, the availability of indicators of the three pillars of sustainability is not always balanced as it would be desirable, in order to allow a more scientifically correct analysis (Singh et al., 2007).

A strength of the method proposed here is that there is no limit to the number of indicators and the number of companies that can be compared. The slowest step in the method is the analysis of sustainability reports, which often differs in the structure and type of indicators described. Often, there is also a difference in the unit of measurement used to describe a given parameter, which is why it is necessary to standardise the data before proceeding to the calculation of the OSI.

From what has been said so far, it emerges that there is still a long way to go towards truly comprehensive sustainability reporting, capable of representing a useful tool for companies and for the country. However, the data reported here may represent a good starting point for reflection and improvement, not only for performance reporting and the identification of corporate trends, but also for the identification of the most appropriate policies to be implemented from the corporate point of view (Trianni et al., 2017) in order to assess the effects of the adoption (Arena & Azzone, 2012; Asiaei et al., 2021) and make a real progress on the road to sustainability (Koufteros et al., 2014).

ACKNOWLEDGMENT

Open access publishing facilitated by ENE A Agenzia Nazionale per Le Nuove Tecnologie l'Energia e lo Sviluppo Economico Sostenibile, as part of the Wiley- CRUI-CARE agreement.

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ISSN No: - 2347-1735

Design and evaluation of a blockchain-based system for increasing customer engagement in circular economy

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A B S T R A C T

The purpose of this study is to design, develop and evaluate a block chain platform in the field of circular economy (CE).To achieve this aim, the research demonstrates the feasibility of designing a decentralised architecture and prototyping a distributed system to increase customer engagement in the transition to ward CE. Building on previous research and leveraging on the design science research approach, the paper identifies the technical and managerial issues that must be addressed to adopt blockchain as an enabling technology in the CE domain. More in details, starting with the identification of circular sharing economy (CSE) processes, a conceptual frameworkwas designed to evaluate how block chain implementation has the potential to enhance the role of customers involved in CSE processes. As for the practical implications, the suggested conceptual framework reduces the knowledge gap between blockchain developers and corporate social responsibility specialists. To bridge the gap, it identifies future directions and practical guidelines for designing and implementing blockchain to support the digital and sustainable innovation of more circular firms and supply chains.

KEYWORDS
blockchain, circular economy (CE), circular sharing economy (CSE), circular supply chain, corporate social responsibility (CSR), customer engagement, design science research (DSR), digital sustainable innovation, environmental management, sustainability

INTRODUCTION

Blockchain research is critical across all business school are as, as this technology is projected to disrupt business processes (Tan et al., 2021), operations(Filimonau & Naumova,2020) and marketing processes (Kumar, 2018), resulting in disrupting innovation in how firms and customers operate (Tapscott & Tapscott, 2017).Notably, blockchain technology(BT) enablesa new type of economic coordination and governance (Asif et al., 2022; Guoet al., 2024;Massaro et al., 2020; Puschmann & Khmarskyi, 2024; Sansone et al., 2023; Schmidt et al., 2024).

Although prior research examined blockchain applications in terms of their benefits/values, challenges, and potential (Hughes et al., 2019), the majority of scholars examine blockchain' s relationship to finance (Ali et al.,2020), supply chain (Hew et al.,2020;Tsolakis et al.,2021)and human resource domains (Christ & Helliar,2021).A slight emphasis has been placed on demonstrating how marketing research should be conducted systematically and theoretically, highlighting the three critical foundations of marketing, that is, institutions, processes and value creation (Tan & Salo,2021). Indeed, multiple notable scholars have identified blockchain as a key component affecting corporate social responsibility (CSR) and circular economy (CE) domains (Cui et al., 2020; de Villiers et al., 2021; Eckhardt et al., 2019; Gligor et al., 2021; Kumar, 2018). Local and global government, as well as customer pressures and awareness to achieve sustainability objectives motivate researchers to examine how new technologies might assist organisations in implementing environmental strategies and achieving sustainability objectives (Ali et al., 2024; Broccardo & Mauro, 2024; Campos-García et al., 2024; Cerquetti et al., 2024; Friske et al., 2024; In et al., 2024; Roche & Baumgartner, 2024; Shashi et al., 2018). In this context, BT has the potential to increase trust, traceability and transparency of circular sharing economy (CSE) processes (Centobelli et al., 2016; Swan, 2015; Zhu, Shah, & Sarkis, 2018; Zhu, Song, et al., 2018).

One of the most significant aspects of blockchain application is monitoring social and environmental factors to prevent and control social sustainability issues (Adams et al., 2018). Adopting BT allows individual firms and supply chains to ensure human rights and fair labour standards. For instance, a visible product history record guarantees customers that the products they are purchasing are sourced and realised sustainably. Smart contracts may be particularly adapted to respect the standards governing the monitoring and verification of sustainable regulatory terms and policies (Fahimnia et al., 2015; Iansiti & Lakhani, 2017; Selmi et al., 2018).

BT has the potential to disintermediate the network where it works, as fewer levels result in cheaper transaction costs and faster processing times, hence eliminating company waste (Chang, Chen, & Lu, 2019; Chang, Iakovou, & Shi, 2019; Pereira et al., 2019; Ward, 2017). To begin, BT can assist ensure security and authenticity by reducing resource use. For instance, traditional energy systems are managed centrally, with high-pressure drops in extremely long networks. On the contrary, a peer-to-peer network based on BT may decrease network amplitude, significantly reducing energy lost over long distances and requiring fewer storage facilities (Hou et al., 2020). As a result, various solutions based on BT exist with the potential to minimise supply chain waste (e.g., Echchain, ElectricChain, Suncontract). Furthermore, blockchain can certify that products labelled as environmentally friendly are indeed ecologically beneficial. One example is the acceptance of a forest certification scheme that uses BT to trace the origins of over 740 million acres of certified forests worldwide (Rosencrance, 2017). In the context of CE, the blockchain can provide an increase in recycling performance. For example, in Northern Europe, people are rewarded for recycling with cryptographic tokens. In this direction, the blockchain-based initiative social plastic has proven how plastic waste can be reduced by monetizing it (Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

With these premises in mind, trust, traceability and transparency become essential considerations when designing blockchain platforms for CSR and CE processes. In this context, it emerges a research gap in evaluating the importance of bridging customer engagement with the main CE processes (i.e., recycle, redistribute, remanufacture, refurbish) and the three primary factors affecting the implementation of blockchain technologies (i.e., trust, traceability, transparency). In fact, despite the growing attention of the scientific community and the increasing number of recent theoretical debate on the subject, this study aims to cover the research gap by designing, developing, and evaluating a blockchain platform. More in details, this article aims to examine the evolution of trust, traceability and transparency in CSE processes before to and after the adoption of BT. The specific research objectives are the following: (1) defining a blockchain-based CSE framework; (2) developing proof-of-concept (PoC) of the blockchain platform; (3) assessing the potential value added in a CSE network; and (4) providing research and managerial guidelines for adopting blockchain platforms to support the transition toward CSE.

The blockchain platform was designed and tested in a CSE net work involving a manufacturer, a selection centre (SC), a recycling centre (RC), a landfill and a network of customers responsible for CSE issues. The remainder of this paper is organised in the following manner. Section 2 discusses the theoretical background of BT in green marketing, CE and CSE domains. Section 3 introduces a conceptual framework of the blockchain-based system for CE, while Section 4 presents the design science research methodology (DSRM). Section 5 explains the design of the blockchain-based CSE system. Section 6 presents the findings related to the implementation in a testing network. Finally, Section 7 summarises the conclusions and implications.

2 | THEORETICALBACKGROUND

2. 1 | Blockchain and green marketing

Transparency of information on BT can support in green marketing processes and activities. Customers are more inclined to purchase environmentally friendly products if they are confident that the same product is truly green (Groening et al., 2018; Peattie, 2001). This confidence grows as a result of BT visible, verifiable and immutable data. In general, BT has significant environmental implications for customers. Two examples of these blockchain-based activities are customer token incentive systems for purchasing environmentally friendly products and product tracing for customers returning end of-life products. Substantial green customer theories, ranging from social confirmation to perceived behavioural control, can be used to explain the benefits of BT for green customer behaviour and action (Groening et al., 2018). With regard to blockchain in marketing context, past research indicates that several of the false concepts associated with BT—such as disintermediation, data accountability and traceability—have been exaggerated by the media, given that BT is a distributed database architecture. The reasons given are that BT cannot replace all marketing functions required for disintermediation, it has inherent limitations when it comes to ensuring the reliability of information, and it cannot conduct a recall of an unsafe product, particularly when customer pay in cash, resulting in the loss of traceability. According to Laczniak and Murphy, marketing ethics is the systematic examination of how marketing decisions, behaviours and institutions are integrated with moral standards. There are two distinct approaches to marketing ethics: 'positive ethics' refers to the evolution of marketing-related moral standards based on empirical data, whereas 'normative ethics' provides justifications and reasons for practising and expressing a particular moral standard. Surprisingly, several of BT's basic characteristics (e.g., transparency, trustworthiness and data integrity) are strongly associated with normative marketing ethics. Dierksmeier and Seele conducted an ethical examination of the implications of blockchain ethics using a variety of normative frameworks, including utilitarianism, contractarianism, deontology and virtue ethics. Normative marketing ethics are critical because they endow ethical marketing activities with rules for decision-makers to make more socially responsible choices.

Notably, while a blockchain ecosystem is multistakeholder, no study has used a stakeholder theory framework to launch blockchain ethics research. As a result of these considerations, this study will focus on stakeholder thinking in ethical marketing concerning blockchain research, rather than adding to the body of knowledge on blockchain applications and the ethics domain. BT can imply economically motivated access and can act as a platform for involvement, particularly in supply chain management (Bai & Sarkis, 2020). Additionally, it expands the customer's position to that of a prosumer—for example, in the energy sector—in which resources are accessible and verified by a diverse set of stakeholders (i.e., crowdsourcing). As BT is a distributed ledger system, it enables peer-to-peer trading (Avital et al., 2015). Thus, BT should be nested within a sharing platform and play a decentralised role in the sharing economy, as demonstrated in the tourism industry, logistics industry, the financial industry and auditing industry. In fact, regardless from the money transaction that is not required in a sharing economy system, the BT can certify the transaction (Eckhardt et al., 2019).

Due to the fact that the blockchain-based sharing economy is a new phenomenon with implications for sustainability and ethical issues (Saberi, Kouhizadeh, & Sarkis, 2019; Saberi, Kouhizadeh, Sarkis, & Shen, 2019), empirically rigorous work and theory-driven research on BT are required to gain a better understanding of how individual, group and organisational behaviour vary in the context of an openly available sharing economy. For instance, argued that BT is a governance mechanism because it enables cooperation (e.g., establishing a credible reputation system) and coordination (e.g., enabling transparency) between diverse actors in the sharing economy, which is based on implicit rather than explicit transactions. However, this research does not mention the blockchain-based economy's ethical or stakeholder notions.

2.2 | Blockchain and CE

In the CE field, blockchain and smart contracts can be a viable solution for addressing counterfeiting, data security and privacy, operational costs and bureaucratic barriers (Christidis & Devetsikiotis, 2016; Saberi, Kouhizadeh, & Sarkis, 2019). To begin, the CE is a mature domain, with the majority of dynamics substantially standardised and a diverse set of legitimate key performance metrics to draw upon for smart contract code (de Villiers et al., 2021; Dehghani et al., 2022; Tsolakis et al., 2021). Second, the CE ecosystem is a multi-layered collection of material streams generated by suppliers, manufacturers, logistics service providers, distributors and retailers, all of which generate a significant amount of data (di Francesco Maesa & Mori, 2020; Saberi, Kouhizadeh, & Sarkis, 2019; Saberi, Kouhizadeh, Sarkis, & Shen, 2019). Smart contracts can process enormous amounts of data in a matter of seconds, bypassing intermediaries and lowering transaction costs (Christidis & Devetsikiotis, 2016). Third, a massive amount of information and data is exchanged between participants as a result of the CE network's regular exchanges and cooperation (Kouhizadeh et al., 2019; Wang et al., 2019). Fourth, the distributor–consumer relationship is evolving. A novel dynamic distributor-to-consumer (D2C) process demonstrates the importance of defining the function of a smart contract-based model capable of enhancing the efficacy of D2C transactions and preventing counterfeiting (Wang et al., 2019).

Additionally, BT can enable new decentralised systems and applications in the CE area to improve data management, sharing, transparency and control level costs. For instance, various authorities can reap the benefits while maintaining control over the expenditures associated with blockchain applications (Casino et al., 2019; Kouhizadeh et al., 2019; Saberi, Kouhizadeh, & Sarkis, 2019; Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

This aspect enables environmental regulators to exert control over all prospective assets (di Francesco Maesa et al., 2017; Kouhizadeh et al., 2019; Wang et al., 2019), and smart contracts represent an appealing and more efficient alternative to a centralised CE asset monitoring system (Shermin, 2017; Wang et al., 2019). Smart contracts are used in conjunction with BT to expedite and improve the efficiency of transactions between multiple users (Casado-Vara et al., 2018). Smart contracts are executed automatically and independently on each network node based on the transaction data (Kouhizadeh et al., 2019). To achieve sustainable development, it was necessary to strike a balance between social, economic and environmental concerns (Krajnakova et al., 2019). Implementing BT systems will streamline energy supply procedures, reduce request volatility and enable real-time production of the market's required quantity (Krajnakova et al., 2019). This would allow for optimising and conserving natural resources (Sánchez & Cardona, 2008).

2.3 | Blockchain and CSE

The applications of BT in CSE network are still being defined and developed. Although many blockchain applications use public privacy systems, CSE networks may necessitate a private and permissioned blockchain with multiple and limited actors (Steiner & Baker, 2015). The administrators determine which data should be shown and added based on each CSE participant's function. The fundamental configuration of the blockchain handles transaction nodes and defines their roles in accessing and changing the blockchain, as well as the identity of each CSE participant in the blockchain network (Yusuf & Surjandari, 2020). Thus, authorities are essential to identify the function of each CSE player, even if consensus methods are used to ensure that no one feels disadvantaged (Gupta, 2018; Surjandari et al., 2021).

Four primary entities play critical roles in a blockchain-based environment: certificate authorities (who provide unique identities to network actors), network administrators (who define network standards schemes, such as blockchain policies and technological requirements), membership service providers (who provide certifications to network actors for participation) and other additional actors (Saberi, Kouhizadeh, Sarkis, & Shen, 2019; Steiner & Baker, 2015). These players ensure that the blockchain network's nodes and processes are totally trustworthy. When a new actor is introduced to the network, the certificate authority establishes a temporary account with limited capabilities after verifying the new users' eligibility for the duties for which they have been added to the network (Surjandari et al., 2021).

Once this new user is added, user inclusion is published on the network via a smart contract, and the certifiers conclusively validate the new user based on a historical analysis of business behaviour conducted by the membership service provider. If the new actor proves to be a trustworthy actor, the certificate authority will definitively unlock all permissions provided during the initial phase (Surjandari et al., 2021). Similarly, network administrators are responsible for developing new processes and rules.

Indeed, with BT's assistance, all key parties have direct access to product information. With restricted access, it is possible to provide a certain amount of security by using a unique digital key to the compo nents involved (Chen et al., 2021). Each phase allows collecting all pertinent product information (Tian, 2017). A product-specific information tag connects actual objects to their blockchain-based virtual identities (Abeyratne & Monfared, 2016). The many actors will play a vital role, acquiring authorization to modify the product's profile or initiate an exchange with another party, which may involve smart contracts and consensus. Before transferring or selling a product to another actor, both parties can sign a digital contract to authenticate the transaction. Subsequently, the transaction's details are updated on the blockchain ledger (Abeyratne & Monfared, 2016). Numerous blockchain applications may be discovered in the CSE paradigm, with most of them in the waste sector. For instance, Swachhcoin (Swachhcoin Foundation, 2018) is a blockchain-based platform that enables the micromanagement of home and industrial waste and the effective and ecologically friendly conversion of garbage into valuable products. A diverse spectrum of high-value raw materials is derived from processed garbage. Swachhcoin is a decentralised autonomous organisation that is self-governing via specified instructions in the form of smart contracts. Swachhcoin implements an iterative process cycle through various innovative technologies, which renders the system entirely autonomous, efficient and productive. This iterative process cycle focuses on the data transferred between ecosystem participants, analyses it and makes real-time recommendations based on predictive algorithms.

Anetwork built on BT offers a new circular business model. While linear supply networks are predominately built on the takemake-dispose paradigm, blockchain-based supply chains enable the implementation of a make-use-recycle model. The blockchain enables the tracking of all products along their supply chain, from origin to sale and eventual recycling. The benefit of this model is that all products are monitored using BT, allowing for the provision of substantial services to ultimate final customers, such as ensuring the products' provenance (Casado-Vara et al., 2018).

3 | CONCEPTUAL FRAMEWORK OF A BLOCKCHAIN - BASED SYSTEM FOR CSE

A blockchain ecosystem is often comprised of multi-stakeholder collaborations that enhance the efficiency and transparency of asset transfers. Apart from enhancing business efficiency and competitiveness, the majority of blockchain solutions are positioned or communicated to advance common goals related to stakeholder well-being in the sharing economy, and have been evaluated from the perspective of stakeholder engagement. For instance, Maersk's TradeLens has been evaluated for corporate citizenship, IBM's TrustChain for final customer well-being, Dubai Blockchain Platform for environmental sustainability, and Walmart's Food Trust for food transparency. Regrettably, due to the reliance on economic benefits and datasharing governance, the abovementioned cases face difficulties in enlisting more stakeholders. One significant reason is the absence of a concept of stakeholder capitalism—only a few parties benefit from long-term value creation, while the majority of stakeholders are constrained by BT adoption barriers, which include inter-organisational, intra-organisational, system-related, and external barriers (Saberi, Kouhizadeh, & Sarkis, 2019; Saberi, Kouhizadeh, Sarkis, & Shen, 2019). Thus, in the CSE blockchain-based environment, it is critical to evaluate whether BT abides by the principles of stakeholder capitalism proposed by, including the principles of stakeholder cooperation, stakeholder engagement, stakeholder responsibility, complexity, continuous creation and emergent competition.

Moving away from the previous literature, Figure 1 shows the CSE testing network highlighting the flow of material and information before and after BT implementation. The main actors are represented by manufacturer, SC, RC, landfill and final customers; two distinct material flows can be identified in the network: a linear flow and a reverse flow. While the first is a flow of the direct material stream, the second refers to reverse material processes (Kshetri, 2018). There are several possibilities for materials to circulate in the loop: remanufactured or refurbished from the original manufacturers, redistributed by SCs, or recycled by RCs. Everything is no more reprocessable than goes to the landfill after reuse activities aimed to reduce wastes. However, the information flow has different directions depending on the adoption of BT. Following the adoption of the blockchain, every actor can communicate with every partner in the network independently from the others. Every transaction is carried out by means of a smart contract and recorded in a block. Each link in the network is

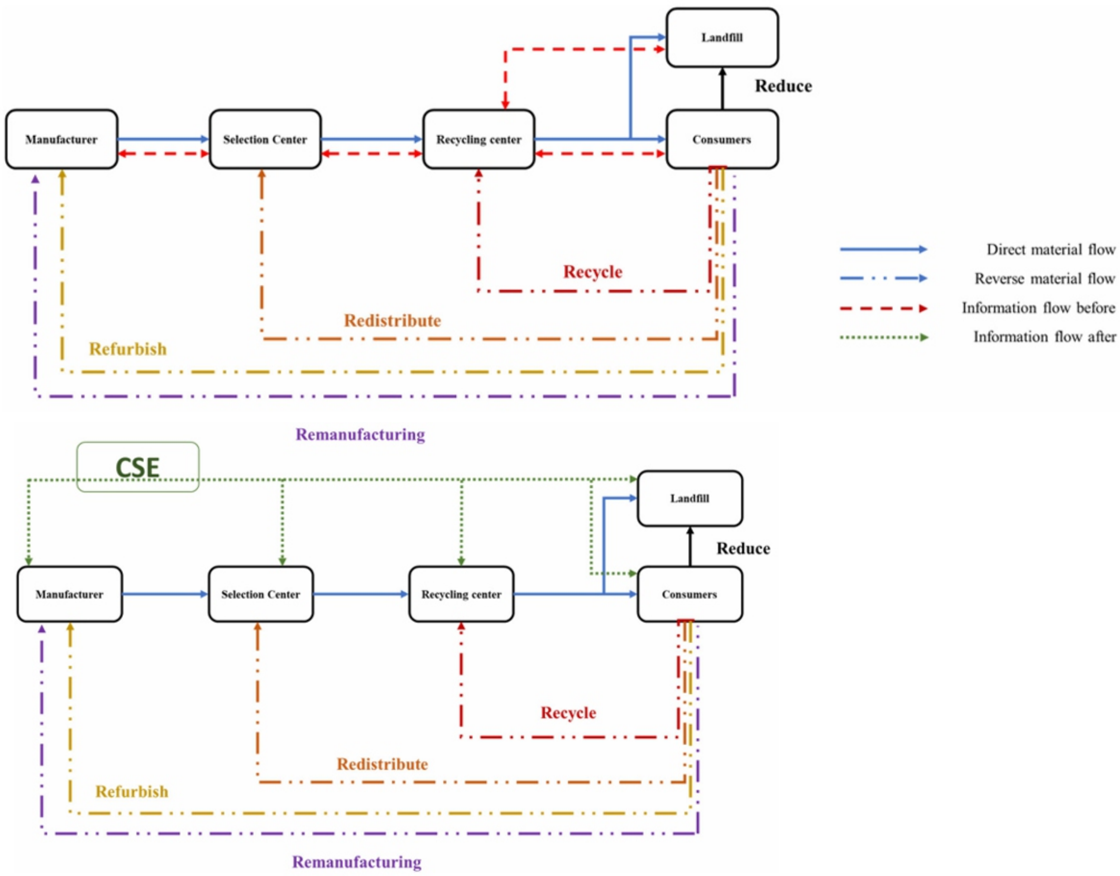


FIGURE1 Representati on of typical circular sharing economy (CSE) reverse processes.

able to query the system in this manner to learn more about materials and procedures.

The role of BT for bridging trust, traceability and transparency to CSE network processes represented in Figure 1 is analysed in the following sections.

3.1 | Trust

Trust indicates an exchange of actor expectations that the other party can rely on, behave as expected and act reasonably (Mayer et al., 1995). Trust is one of the main features of BT (Notheisen et al., 2017). The main characteristic of BT protocols is to provide an immutable recording of transactions by combining a distributed database whose transaction blocks are connected historically and cryptographically through decentralised consensus processes (Nofer et al., 2017). This structure avoids spreading false/fraudulent information and self-regulates agents' behaviour without central authorities' intermediation (Douceur, 2002). The technology has allowed through smart contracts to surpass the level of cryptocurrencies and finds use in various commercial and industrial sectors (Kiayias et al., 2017; Nakamoto, 2008).

Blocks must be verified with a lot of energy and time in a public, permissionless blockchain; Sybil attacks are less likely to occur in private networks (O'Dwyer & Malone, 2014). In practice, the Proof of Work (PoW), Proof of Stake (PoS) and Byzantine Fault Tolerance mechanisms artificially create costs for the addition of new blocks and, therefore, discourage potentially harmful nodes from interference (Bellare et al., 2009; Li et al., 2015). On the other hand, the energy, time and scalability costs increase, and consequently, the efficiency of the system is affected (Kochovski et al., 2019). The expenses associated with security concerns drop if the participants in the private network are known, as there is no fear of attacks. Therefore, identity-based authentication (such as hash-based users) provides more effective substitutes that permit various levels of privacy (Meng et al., 2018; She et al., 2019). The data structure mainly consists of two parts: the first is represented by the block header, which includes the previous block hash, where the hash value is used to connect the previous block and meets the requirements for blockchain integrity; the second part, regrettably, contains the primary information of the block and associated transactions (e.g., position, ID, status). Solutions are required to maintain the nodes' dependability without necessitating high energy and time expenditures because cyberattacks are becoming more frequent and sophisticated (Abeyratne & Monfared, 2016).

3.2 | Traceability

The capacity to track products and provide details (such as originality, constituents and locations) during manufacture and distribution is known as traceability (Sodhi & Tang, 2018). Researchers are paying more attention to CSE visibility and traceability (Agnoli et al., 2016). Final customers demand improved product traceability and origin information from manufacturers and merchants in response to these issues (Awaysheh & Klassen, 2010). Therefore, the real economic and social challenge is to bridge the gap in the traceability of the CSE related to control, even though the production is ethical, respectful for sanctions, or safe (Galvez et al., 2018; Tapscott & Tapscott, 2017). Defining the origin is often difficult due to the complexity of the CSE and product flows over extended networks. This complexity requires that products be followed throughout the entire life cycle, from procuring raw materials to production, distribution and consumption (Lu & Xu, 2017; Xu et al., 2019). An example of traceability architecture is represented the OriginChain (Xu et al., 2019). OriginChain currently uses several private blockchains distributed geographically to the traceability service provider. The aim is to establish a reliable traceability platform involving other organisations, including government-certified laboratories, large suppliers and retailers with a strong relationship with the company. This platform has better performance and lower costs than a public blockchain. OriginChain stores two types of data on the chain as variables of smart contracts to be preserved: the hash of traceability certificates and the necessary traceability information required by the regulation (Bai & Sarkis, 2020; Mannet al., 2018).

3.3 | Transparency

The degree to which information is readily available to all counterparties in an exchange and outside observers is referred to as transparency (Bai & Sarkis, 2020). Transparency is, therefore, a fundamental parameter in assessing the performance of the CSE, given the emerging secure environment associated with the blockchain. Even before reaching the final customers, products travel through a vast network in which different actors are present (e.g., extractors, producers, retailers, distributors, conveyors and storage facilities) (Perboli et al., 2018; Roeck et al., 2020). In this way, managing clear and precise information for each stage while ensuring compliance, safety and accuracy while focusing on sustainable and social responsibility needs (Kashmanian, 2017; Zhu, Shah, & Sarkis, 2018; Zhu, Song, et al., 2018). Markets operate most efficiently under various conditions; among these, all stakeholders' access to complete and accurate information is critical. First, one of the primary issues it is witnessing is a lack of transparency: closing the knowledge gap between network stakeholders is critical. Besides, the secondary market for reused materials' operation is contingent upon linking buyers and sellers; however, there are gaps in buyer comprehension of the types of materials available, their sources and the terms of the sale. In this way, locating suitable destinations for separated recycled materials may be difficult. Secondary resource markets may not appear to be as fluid and transparent as markets for newly created parts and other virgin inputs. Sometimes, the information and market dynamics are unknown because no systematic analysis exists. Information would assist producers in determining the market potential for their own waste products and in identifying prospects for waste purchase loop-cycles.

Current markets require transparency of CSE information and sustainable economic dynamics for both the environment and society (Abeyratne & Monfared, 2016; Mann et al., 2018; Zhu, Shah, & Sarkis, 2018; Zhu, Song, et al., 2018). For this reason, many companies are adopting these practices in conjunction with emerging technologies to improve transparency, especially where markets are very competitive, scattered and complex.

Blockchain has the potential to promote system transparency, resulting in reduced failures (Zelbst et al., 2020). No great hardware investments are required to upgrade the blockchain, but changes in the current system are necessary to improve network speed and processing times (Acharyulu, 2007; Zhu, Song, et al., 2018). Greater transparency enhances the ability to increase productivity, provide customers with better service, reduce expenses and improve performance (Zelbst et al., 2020).

4 | DESIGN SCIENCE RESEARCH METHODOLOGY

The DSRM aims to reduce the gap between theory and practice, design and develop artefacts that can solve various problems, thus highly relevant for the practical field. This methodology makes the research operational because it aims to design or create an artefact. The DSRMwas used to carry out the stages of this research. Notably, the DSRM was selected for its capacity to investigate the relationship between research and professional practice by developing, implementing and assessing objects that respond to a specific need. In this way, the main feature of this methodology is that it is oriented toward problem-solving. Indeed, DSRM carefully examines human-made artificial occurrences to propose artefacts as solutions, evaluate how they work or have been designed, and communicate the results obtained. The goal of Hevner was to comprehend and explain the DSRM. They asserted that it is crucial to push information system specialist to accept research and establish credibility among the most extensive array of design science investigators in the different fields of engineering, architecture, and other design-oriented communities. DSRM research involves a rigorous process of designing an innovative

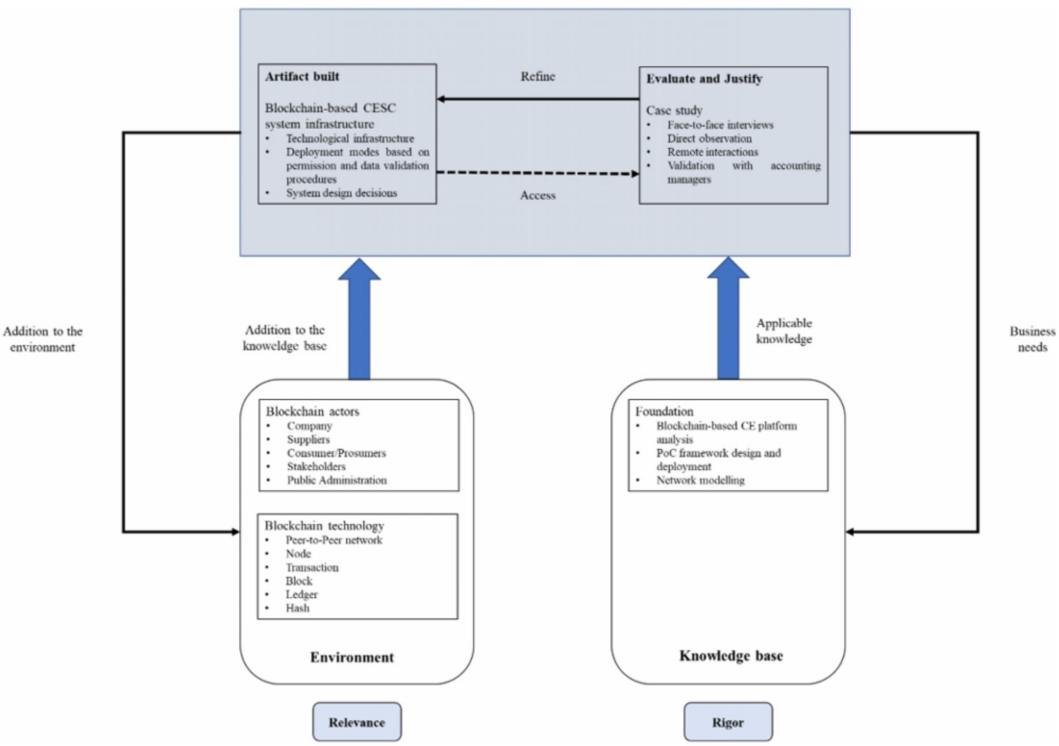


FIGURE2 Blockchain-based artefact. CE, circular economy; CESC, circular economy supply chain; PoC, proof-of-concept.

artefact to address and solve a practical problem, contribute research, evaluate designs and report results. The output of this methodology can be classified as constructs, models, methods and instantiations. This paper aims to produce a model based on BT. Inherently, design science is a process of solving problems. The fundamental principle of DSRM was derived from seven guidelines for this study. (1) Design as an artefact: it is necessary the description of application and implementation of it in a relevant domain; (2) problem relevance: it is essential the creation of an innovative, purposeful artefact for a given problem area; (3) design evaluation: it is therefore essential a thorough assessment of the object to give the specified problem a tool; (4) research contributions: the artefact has to be innovative and more efficient to resolve a previously unsolved problem or resolve a known problem; (5) research rigour: the design research has to rely on strict methods in the construction and assessment of the design artefact; (6) design as a search process: the problem often simplifies by representing a subset of the corresponding means, purposes and laws or by transforming a problem into a simple sub-problem; (7) communication of research: the results of design-science research must be effectively communicated to a technical audience (researchers who are going to extend them, practising them) and to a management audience (researchers who will study them in context and practitioners who will decide if they should be implemented within their organisations). DSRMis particularly good for developing a CSE architecture based on blockchain, ensuring transactions and activities between actors in the same network in a secure, verifiable and permanent way.

Moving from the above framework in Figure 2, the research aims to evaluate the CSE management processes and identify the technical and functional specifications that the technical architecture of the blockchain must possess to favour the development and consolidation of the relationships between the various actors of the network. Specifically, the characteristics of the reference sector, the socioeconomic and technological context and the companies' innovation, technological and productive processes will be considered.

The environment describes the problem space in which the phenomena of interest exist. It includes blockchain actors, and their existing and future technologies (Silver et al. 1995). Taking a CSE perspective, it contains the priorities, obligations, problems and opportunities that define business needs. The higher will be the environment description precision, the higher will be the relevance of the design of the artefact.

The knowledge base serves as the input for analysis and comprises the foundations and methodologies.

Past research and findings from related disciplines include the foundational theories, structures,tools, constructs, models, processes and instantiations used throughout the research study's establishing and creating processes. To achieve rigour, established foundations and methodologies are used. In DSRM, computational and mathematical approaches are usually used to evaluate the quality and efficacy of artefacts; however, analytical techniques can also be used. Contributions are analysed as they are used for a business requirement in a suitable setting and contribute to the knowledge body for future research and practice.

DSRM allows to create and evaluate an artefact, in this case, a blockchain-based system infrastructure that is developed to fit the market's requirements. Truth and utility are inseparably linked. Design is influenced by reality, while theory is influenced by utility. Because of some yet unknown reality, an artefact can be useful. Before a theory's reality can be implemented into design, it may need further development. In both cases, research evaluation via the justify/evaluate activities will reveal flaws in the theory or artefact, as well as the need to refine and reassess.

In order to design a PoC for the blockchain based system, a case study approach was used for primary data collection, made directly in participants of the testing network: interviews, mapping of the CSE processes, operations, skills and times and validation workshops. Secondary data were also collected, such as order reports, order modification reports and databases from the past 10 months, activity descriptions, product requirements and monthly/quarterly reports. Secondary data were used to integrate and triangulate sources with primary data. Triangulation of data was necessary to strengthen the validity and reliability of this research. The first data collection consisted of over 50 h of direct contact:

1. Face-to-face interviews with individual customers and company managers operating in the marketing, operations management and IT management departments.
2. Direct observation of CSE processes, mapping the activities and timing them.

The other data collection method that was used over 10 months of the study included:

1. Active remote dyadic (back-and-forth) interactions. For example, multiple questions and clarifications over the phone, e-mail and Skype.
2. Avalidation workshop with customers and company managers.

The implementation in the CSE sector of a blockchain-based platform, particularly for marketing purposes, is highly favoured (Behl et al., 2022; Chaudhuri et al., 2022). The network analysed in this study is located in the South of Italy. It is currently based and has its facilities in a relevant network for recovery of waste from electrical and electronic equipment (WEEE) at the regional and national level. This investigation background seems suitable because CSE management represents a critical factor in promoting reuse, recycling and other forms of recovery, and rethinking waste management processes from a large range of devices such as computers, fridges and mobile phones at the end of their life also plays a crucial role. To collect data following the seven phases typically used in DSRM, behind semi-structured interviews, document analysis and active participation in meetings. Data were collected and analysed in iterative–incremental cycles as part of an in-depth qualitative field research.

To describe the environment, a review of relevant documents concerning CSE activities was conducted to understand better the entire data collection process associated with the annual creation of this inventory. CSE processes were studied involving customers to reuse, remanufacture/refurbish, redistribute, recycle products and reduce wastes. To propose the artefact, it takes the shape of a level 1 architecture diagram. This diagram contains notations for capturing system descriptions in preparation for future development. This artefact was given during the third meeting and following that, there was a final discussion about the implications for the future directions. Further semi-structured interviews were conducted analysing the suggested design's potentials and constraints and implementation challenges, providing insight into the artefact's implementation. At this point the artefact was implemented and a new round of interviews were done after a few times.

5 | DESIGN OF THE BLOCKCHAIN-BASED CSESYSTEM

This section discusses the process of design of the blockchain platform and represents the empirical contribution of this research. The design process of a CSE blockchain-based platform is organised into two main phases:

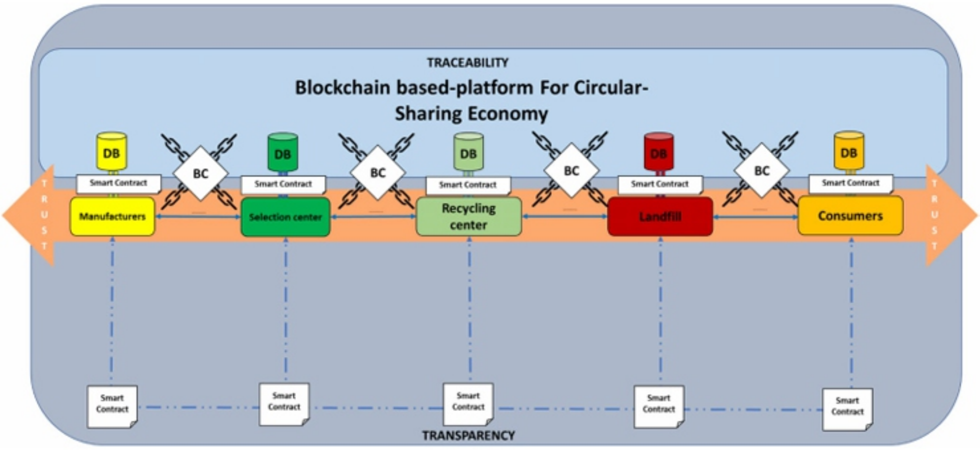
1. PoC framework design and deployment.
2. Network modelling.

Adetailed description of each phase is provided in the paragraphs that follow.

5.1 | PoC framework design and deployment

In computer science, a PoC is an empirical demonstration of a software application in its basic operations or in entire system, integrating it into an already existing environment. The PoC development is used to demonstrate a vulnerability in a software or in a computer system, the exploitation of which may allow unauthorised access to the data contained in the system or compromise its functionality. For the realisation of this structure, the research team involved in this project decided to use Hyperledger, an open-source project founded by Linux Foundation in 2015, created to enable the construction of blockchain permissioned. Compared with alternative private

FIGURE3 Proof-of-concept framework and circular sharing economy network deployment. BC, blockchain; DB, database.



and permissioned solutions, Hyperledger was selected for its stability, flexibility and conformity to the specific functional requirements (e.g., absolute control of access, transactions and information between the various players in the network). The feature that distinguishes Hyperledger is represented by modularity that allows defining consensus mechanism and membership management (Cachin, 2016). It also offers the possibility of creating private channels, allowing a group of participants to create a ledger where transactions are recorded completely privately, which can only be viewed by the nodes that participated in it, namely a fundamental prerequisite for the creation of a supply blockchain. Furthermore, Hyperledger features a modular design that is fully configurable and capable of meeting a number of requirements related to data confidentiality and cloud configuration. Cloud configuration was necessary to implement the blockchain at the network level. The leading cloud service providers (e.g., IBM Bluemix, Microsoft Azure, Google Cloud Platform, AWS Amazon Web Services) are all compatible with Hyperledger. Therefore, it was selected as the best platform to support the functional requirements identified.

5.2 | Network modelling

The network modelled in Figure 3 was used to identify the main actors to be involved as nodes of the blockchain platform to be developed.

The specific network included:

1. Manufacturer (M): This node represents the company that manufactures, remanufactures and refurbishes products.
2. SC: This node represents the company that selects the products received for distribution or redistribution.
3. RC: This node represents the company that recycles the products received.
4. Landfill (L): This node disposes of non-reusable wastes.
5. Customers ©: These nodes use products and at the end of their life collect and transfer them to M, SC, RC or L.

Afundamental aspect of the CSE blockchain platform is the possibility to create private channels to carry out operations with each of the actors participating in the network to allow the individual participants to maintain privacy on their information, further strengthening their position in the network. On the other hand, the CSE blockchain platform allows displaying any movement of products and documents that occur between the various nodes in the network, although it does not participate directly in operations. In addition to greater transparency in the origin and reliability of the CSE service provided, this would also simplify the control carried out on possible returns of goods.

An asset is identified by any property owned by a network member that can be monetised. Tracking network assets is a fundamental process and an investment for a network that wants to save money and time and have sustainable behaviour: developing and implementing asset traceability reduces administration costs and streamlines the business, improving the quality of customer service and pushing to the scalability of business optimise the marketing and purchasing actions. Besides, the possibility for customers to verify that their CSE behaviours is continued also by manufacturers, SCs, RCs and landfill can increase their willing to have more sustainable behaviours.

In the testing case designed, the Service and Material classes represent the assets of network transactions.

The Service class is identified by ID Protocol and Type:

1. ID Protocol.

a. ID: ID is a code that uniquely identifies an information.

b. Protocol Type (PT): PT represents the type of information to be transmitted within the CSE network.

c. Notes.

2. Type.

a. Request for Circular Service (RfCS): RfCS is a request in which the manufacturer asks customers to submit a quote on the possibility of providing certain CSE services. In addition to the price, RfCSs usually also include details of payment such as terms and deadlines.

b. Circular Service Quotation (CSQ): CSQ represents the list of services that the customer is willing to provide according to the established conditions.

c. Statement of Work (SoW): SoW is a document to define the specific activities, tasks, results and deadlines expected. This document also includes requirements and detailed prices with annexed terms, regulatory and governance conditions.

d. Circular Service Order (CSO): CSO is a commercial document and represents the first official offer issued by the manufacturer to a customer, which indicates the types, tasks and prices agreed for circular services. The issue of a CSO does not constitute a final contract but can serve as a legally binding document when accepted by the two parties.

e. Circular Delivery Plan (CDP): If at the time of finalising a contract, the details of the time delivery are already known, a CDP is used. A CDP is not a real program, but a program solution for the generation of CSO promptly.

f. Circular Service Notification (CSN): CSN is a document describing the conformity of service with respect to a quality requirement and contains a request to take appropriate actions within it.

g. Circular Service Waiver (CSW): CSW is an agreement or additional clause attached to a policy that excludes a specific type of loss, limits the amount of the claim to a specified amount and finally extends the coverage to include items not included in a standard policy.

The Material class is identified by Material ID and Material category:

1. Material ID:

a. ID: ID is represented by a part number or serial number.

b. Notes.

2. Material category:

a. Solid (S): Category of solid material.

b. Liquid (L): Category of liquid material.

c. Gaseous (ME): Category of gaseous material.

The move product and send document classes describe the operations that will be executed in the CSE blockchain. These operations will be recorded on the distributed platform. In this way, all the waste movements that will be made in the network and the related documentation will be traced uniquely and irrevocably. The various nodes will thus have a platform that can overcome the problems related to the integration of information from different information systems, which often have a significant impact on management costs.

6 | DISCUSSION OF RESULTS

This section analyses the characteristics of the implementation of BT and the relative improvement carried by the blockchain adoption.Eliminating centralised authorities increases transparency, which has an effect on how partners cooperate. Additionally, increased transparency is obtained as a result of the inherent tamper-resistant mechanism that distinguishes BT.

Storing distributed records on a blockchain platform increases transparency in the flow of process status information, hence increasing the operational efficiency of individual actors and the network in terms of time efficiency and system automation (Fahimnia et al., 2015; Selmi et al., 2018).

Additionally, by storing data on the blockchain platform, there is no need for a hybrid of on-chain and off-chain systems. By requiring access control to authorised data, a private and permissioned blockchain increases transparency and makes information access more effective and safer. Finally, the distributed ledger's immutability ensures long-term transparency via inviolable and node-verified methods, disintermediation and automated processes, convenience and streamlined data extraction and comprehension (Leng et al., 2019; Swan, 2015; Zhu, Shah, & Sarkis, 2018; Zhu, Song, et al., 2018).

Compared with other technologies such as distributed databases, the added value of blockchain comes from the synergy of all its components, which include immutability, consensus, decentralisation and encryption. Operational efficiency has as a consequence the possibility by each actor in the network that is authorised to verify information about goods and processes that they receive. This direct effect on the end of the direct flow has the side effect to promote in the final customer the awareness to have sustainable behaviour. In fact, customers are conscious that they can return used goods to give them a a second chance to be used, and track how that happens. In this way customers are no more passive member where everything ends, but they can be the beginning of a new process: for instance, consumers are now prosumers and the CE model, including the pivotal role of customers, become also a sharing model. But the role of the consumers–prosumers is not limited in return used goods, but also in monitoring that the process continues to be circular and participate in the design of the goods to make easier its reverse phase. This process is also favoured by the shift in trust, that is no more connected with people but to the technology. Besides traceability and transparency, trust is the other pillar of the BT adoption in the CSE environment (Hughes et al., 2019; Tan & Salo, 2021).

The use of BT reduces the number of intermediary nodes necessary in the process. Since the BT transaction mechanisms are trusted and transparent, and the information available in real-time, the accounting blockchain-based process does not require a middle-node. Data registered in the blockchain are immutable, and this allows reaching a system where each member of the network can negotiate and share goods directly with other members. The direct negotiation has additional benefits on efficiency, service cost reduction and fraud detection (Palfreyman, 2016; Tapscott & Tapscott, 2017). This is a key characteristic since it allows automatic contract execution and payment, bypassing intermediaries, most notably lawyers (in the case of smart contracts), banks (in the case of cryptocurrencies), green auditors (in the case of green patents) and governments might find themselves out of business because of the strong privacy possible for both contract terms and payments (Bonsón & Bednárová, 2019).

The study proposed a conceptual framework supporting the establishment of a blockchain-based CSE network with the goal of contributing to the growth of knowledge in this subject by highlighting the implications of blockchain in the creation of a CSE environment. The framework is organised in three scalable layers. At the first level, it presents a technological infrastructure based on a distributed database, with peer-to-peer storage based on interconnection and following system consensus. Permissions and validation ensure increasing levels of control at the intermediate level. The system also integrates business and security applications at a higher level.The implementation of a structured blockchain-based ecosystem is contingent upon the establishment of a private network of nodes capable of validating transactions. However, blockchain disrupts the way activities are carried out and the environment functions. Individual actors are no longer required to maintain control over data or supervise the actions of other actors. They can simply trust technology, since block chain contributes to the development of a verifiable and transparent real-time transaction system.

Adoption of BT for CSE purposes necessitates a more comprehensive and specialised culture among stakeholders, including internal and external players, to enable adequate rule and procedure updates and monitoring. Additionally, BT can aid in the development of a functioning CSE network, by removing the need for intermediaries and regulatory platforms for value exchange transactions, reducing manual registration and verification and enabling the automation of numerous processes and activities with resulting efficiency gains (Chang, Chen, & Lu, 2019; Chang, Iakovou, & Shi, 2019; Pereira et al., 2019). By overcoming the limitations highlighted in the literature, this study can contribute to the debate on blockchain's transformation of CSE network by analysing the ecosystem's dynamics and comprehending the meaning of issues such as truth, trust and transparency in social interactions conducted within the community of actors populating the system. From an environment perspective, the adoption of a blockchain CSE system is expected to optimise the management of the network's complexity by increasing trust, transparency and realtime availability for the entire stakeholders' community, as well as revealing new scenarios of digital transformation. Through the use of smart contracts, individual actors can monitor a state change triggered by an automatic event mechanism (Swan, 2015; Zhu, Shah, & Sarkis, 2018; Zhu, Song, et al., 2018). Because smart contracts can automatically activate information push methods, partners who are registered on specific contracts can monitor the updated process status in real time.

The suggested blockchain network can maximises operational efficiency by notifying users of information updates in real time using push mechanisms. As a result, ecosystem partners can significantly minimise the expenses associated with standard monitoring methods for information synchronisation (Xu et al., 2019). In summary, the use of a blockchain platform can enables the synchronisation of monitoring data and the reduction of resources necessary to verify process status. This in turn accelerates the automation of processes and the disintermediation of services through the use of smart contracts (Pereira et al., 2019). Besides, the transparency and trust of the system, can aid to generate the awareness around the CSE and enforcing the recycling loop instead of cycles going to the landfill.

The suggested artefact is novel in that it aggregates knowledge from green and sustainable program personnel, companies reporting inventories, certificate issuers and blockchain experts who contributed to the proposed solution. Nonetheless, there remain impediments to widespread adoption of such an artefact. Wang et al. (2019) note that not all participants desire more supply chain trans parency. For instance, dominating market firms may be fearful about losing revenue streams. Additionally, Wang et al. (2019) claim that the blockchain may eliminate existing intermediaries in the network while creating new ones. As a result, traditional certificate issuers may resist, while a new generation of blockchain-based certificates poses a threat to their more established rivals. As Hoek suggests, new blockchain applications in networks should begin with a small number of interested stakeholders. For mindful implementations to be successful, applications must answer challenges from the businesses perspective, making the collaboration between technology and sustainability professionals critical. Not unexpectedly, some interviewees expressed concern that BT may be a solution looking for a problem. Nonetheless, the proposed artefact may support in the continued development of critical competences within both businesses and circular and sharing processes by removing obstacles and promoting indirect learning to other players throughout the value chain. As a result, this study has the potential to benefit the whole network of firms and customers involved in waste management and distribution by assisting in the spread of a blockchain culture inside this sector with a global enhancing of the market performances bot for firms and for customers. Another component of this study's case is the DSRM, which has been used in a number of other technological marketing studies. Additionally, the economic gains associated with blockchain implementation may undercut the existing trade-off between cost and long-term success in CSE management and more in general of sustainable supply chain management (Saberi, Kouhizadeh, & Sarkis, 2019; Saberi, Kouhizadeh, Sarkis, & Shen, 2019). Thus, actor organisation and resistance may be as critical as cost in the implementation of new technology in more circular supply chains.

7 | CONCLUSIONS AND IMPLICATIONS

While there is ample research on the usage and deployment of technologies to improve circular and sharing economy networks, there is growing interest in blockchain as a core technology due to its disruptive potential and ability to transform the communication between CSR actors. BT is one of the most promising and powerful technology in the digitalization process of CSR. Despite widespread interest in the literature, a complete understanding of the scenarios for implementing BT in CSE remains still fragmented and limited to technical difficulties. The digital transformation appears to be accelerating, with the formation of new consortiums to expedite the formulation of extended industrial standards and stimulate collaboration (Kokina et al., 2017). Additionally, novel approaches to security and privacy controls are gaining traction. The desire for openness across CSE operations can prompt the decision to create and install a blockchain network.

In this context, to combine the main actors in circular sharing processes (i.e., manufactures, RCs, SCs, landfills, final costumers) and the factors that influence blockchain technologies (i.e., trust, traceability, transparency), this contribution proposed an integrated framework to design CSE blockchain model and implement blockchain platforms. This provides the blockchain's implementation framework and PoC in a circular sharing environment and demonstrates the main effects on trust, traceability and transparency of the CSE network's processes and transactions (Carter & Koh, 2018; Palfreyman, 2016). This study contributes to the CSE literature, demonstrating how blockchain-based CSE models can be designed and how CSE blockchain platforms can be implemented from technology and information systems.

Thus, this study makes three significant contributions. To begin, it introduces the debate about blockchain adoption in the CSE network from a marketing perspective by suggesting how this technology can improve the engagement in market operations. Second, it employs DSRMtoexpress a solution centred on an artefact where its potential contribution is also intelligible to actors unfamiliar with blockchain technologies. Thirdly, it highlights the main features necessary for identifying the main functional requirements for the development of a blockchain platform in CSE, establishing the permissions to visualise and/or approve transactions, identifying and tracking the assets of network operations that are executed. These operations are recorded on the distributed platform. In this way, all the waste movements or material reuse made in the network and the related documentation are traced uniquely and irrevocably. Therefore, the various network actors involved can have at their disposal a platform that is able to overcome the problems related to the integration of information from different information systems, which often have a significant impact on management costs.

From a methodological point of view, the key goal of design science research is to develop a model that provides feedback and a deeper understanding of the problem in order to boost the design process. The aim is to generate a framework, the proposed artefact in this case, that can be used for defining, justifying and predicting: the principal purpose of DSRM is to create and apply in a specific environment a planned artefact that is able to increase knowledge and appreciation of the problem field. In a DSRM approach, before the implementation, there is a computational simulation used to evaluate the quality and effectiveness of the artefact; however, empirical techniques may also be employed. The research approach is thus extremely problem-driven and artefact-orientated and is justified on three levels: first, the management of a complex product poses a range of design and management issues; second, the effective execution of the blockchain process needs that all parties involved build and share purposeful technological and contextual knowledge; and third, an increase of the process performances. The research phases in this study included problem identification, objectives, artefact creation, presentation of solution, artefact evaluation and dissemination of findings in conjunction with the design science approach.

7.1 | Implications

As for the theoretical implications, this research contributes to the theory by providing theoretical and practical implications according to circular and sharing economy (Saberi, Kouhizadeh, & Sarkis, 2019). By building a theoretical model that applies the principles of BT to a network, it has been possible to understand how it is possible to combine the characteristics of these principles in a CE domain and how this synergy can have positive implications for the conception and execution of its transition toward a sharing economy configuration (Böckel et al., 2021; Farooque et al., 2019). In particular, it has emphasised how to connect the blockchain concepts of trust, traceability and transparency to the network management of circular and sharing processes (Saberi, Kouhizadeh, & Sarkis, 2019; Steiner & Baker, 2015). As for the managerial implications, this research highlighted the blockchain implementation path for a circular-sharing economy network, as shown by the blockchain design and implementation analysis. This provides clear guidelines for management regarding the implementation of the blockchain within CE networks. The fact that the system has been developed independently and without third parties support and relatively low use of physical and monetary resources shows that the implementation of blockchain solutions in their processes can take place in a reasonably economical way. The established framework allows managers to identify the critical factors to achieve a successful blockchain implementation. The case considered in this work concerns a specific circular-sharing economy network process, but it is possible to extend the theoretical model to other network processes (e.g., order fulfilment, delivery).

7.2 | Limitations

This research is based on an in-depth case of a single network that aims to be tested in different contexts in the future. However, it can be argued that the results are generalisable, and it is possible to apply them to other processes in the circular-sharing network since many of the activities will be standard among the processes (collection, modification and order processing). Future research must confirm this by studying the impact of blockchain on different processes and actors in the network, including customer-supplier dyadic relationships and supply networks.

7.3 | Future directions

In the next future, the BT will be fully implemented in order to test on the field how the theoretical results are aligned with the empirical ones. Network service blockchain applications will be interested in a great transformation. In this context, a pivotal role concerns the time-limited privacy in blockchain and transactional privacy, enabling applications where people's privacy is managed and guaranteed by regulations. In the public field, electronic voting and digital health records are two of the main applications discussed, and they have the potential to impact environmental, financial and social sustainability issues. New security and privacy protocols must be developed for new distributed databases where regulations guarantee data privacy and security. With regard to the supply chain domain, it is necessary to design new business models involving all the supply network partners in order to achieve the greatest performance both in circular and sharing economy indicators. Finally, an additional research direction concerns the necessity to conduct future research on the role of BT in managing trust, traceability and transparency of CSE processes in developing countries to underline the research advancements and highlight similarities and differences with developed countries.

ACKNOWLEDGMENT

Open access publishing facilitated by Universita degli Studi di Napoli Parthenope, as part of the Wiley- CRUI-CARE agreement.

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ISSN No: - 2347-1735

Disclosure and transparency of sustainability information in Spanish social enterprises: Anempirical study of audited special employment centers

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A B S T R A C T

The research analyzes how certain factors such as activity sector, size, and economic-financial performance can influence the level of disclosure and transparency of sustainability information in special employment centers. This publication is based on an empirical study applying a quantitative methodology in194 social economy enterprises with data from 2020.The results confirm that companies that disclose sustainability information do so based on GRI standards and in all areas of sustainability. Belonging to certain activity sectors and size influence the disclosure of sustainability information.Also, theresults show that assets, operating income, liquidity and economic profitability have an influence. This research contributes to improving the disclosure and transparency of sustainability information in socialeconomy enterprises and provides indicators onmanagement in sustainability aspects, useful for the analysis of subsidy management.

KEYWORDS
ESG, financial in formation, GRI standards, non-financial information, social enterprises, special employment centers, sustainability report

INTRODUCTION

Society demands information on the behavior of its organizations in the social, economic and environmental framework, which goes beyond the analysis of the income statement. Since the end of the 1990s, there has been a phenomen on of diversification of business information that has caused companies toprovide information to more users and make an effort to produce and disseminate financial information on their activity and, in addition to sustainability, that is, on environmental, social, and corporate governance (ESG) aspects. In this sense, sustainability disclosure has been gaining importance incorporate reporting and, to gether with financial information, has proven to be very useful for stakeholders (Hernández -Salido et al.,2018;Ortíz & Didy chuk, 2021).

Special employment centers (SECs) have among the irobjectives to participate in market operations, in order to ensure gainful employment for persons with disabilities and to be a means of inclusion in ordinary employment. In addition, they enjoy economic benefits from the subsidies they receive from public administration saimed at creating and maintaining employment. SECs can be created by public administrations or by natural or legal persons, they must be registered in the Register of Centers of the

State Public Employment Service and their management is subject to the same rules that affect companies (Ministry of Labour and Social Economy, 2023). Therefore, these organizations have a mercantile form and must provide reliable, transparent, and quality financial information in accordance with the rules governing accounting information and Law 22/2015 on Auditing of Accounts. There are numerous studies on SECs that use economic indicators to analyze their financial statements (Gelashvili, 2015; Gelashvili et al., 2016, 2020, 2022; Gómez-González & CanoMontero, 2021; Gómez-González et al., 2022, 2023; López-Penabad et al., 2019; Manzano-Martín et al., 2016; Morales-Calvo et al., 2017; Redondo-Martín, 2013; Segovia-Vargas et al., 2021), profitability is considered as a measure of economic sustainability (Gelashvili et al., 2016, 2020; Gómez-González & Cano-Montero, 2021; GómezGonzález et al., 2022, 2023; López-Penabad et al., 2019; MoralesCalvo et al., 2017).

Due to the condition of these companies, they must respond to sustainability commitments. Law 11/2018, derived from the transposition into Spain of Directive 2014/95/EU of the European Parliament and of the Council on non-financial disclosure, obliges companies that meet a series of requirements to submit the sustainability report. However, sometimes these reports are not fully comparable, and some reports are dominated by narratives rather than numbers, so that non-financial information requires an appropriate balance between descriptive and quantified information (Czaja-Cieszyńska, 2020). Regarding the homogenization and comparability of the information contained in sustainability reports, Cerioni et al. (2021) indicate that there are differences in the rules adopted, but not in the way they are applied.

In this context, different indicators and indices have been developed, including the Global Reporting Initiative (GRI) Standards. GRIs aim to create a common language for organizations and allow stakeholders to make decisions regarding the economic, environmental, and social impacts of organizations (Global Reporting Initiative, 2016a, 2016b, 2020, 2022). Therefore, the main objective of this article is to analyze the disclosure and transparency of sustainability information in audited SECs, considering factors that may influence the sector, size, and economic-financial performance of the organization.The specific objectives of the research are: (i) to identify audited SECs that publish sustainability reports based on GRI standards and (ii) to analyze the relationship between the level of disclosure of sustainability information and the factors activity sector, size and economic financial performance. To this end, 194 SECs audited in 2020 are identified and sustainability reports are studied to examine the relationship between disclosure indicators and transparency of sustainability information in accordance with GRI standards and factors. This article is structured in this introduction, followed by the theoretical framework, theoretical analysis, and research questions, definition of the variables and model and, finally, results and conclusions.

2 | THEORETICALANALYSISAND RESEARCH QUESTION

Along these lines, one of the most commonly used tools by companies to communicate the actions they carry out in terms of CSR is the sustainability report. The publication of non-financial information is associated with the term "triple bottom line" which refers to the integration of information on economic, social, and environmental aspects (Iturrioz-Campo et al., 2019) from Carroll's pyramid (1991). Stakeholder demand has helped raise awareness of sustainability reporting, which is why companies around the world have opted for sustainability reporting (Ikpor et al., 2022). The GRI standards address all dimensions of sustainability and are in line with the Sustainable Development Goals (SDGs), promoting sustainability, accountability, and transparency.

The importance, evolution and growth of SECs in society have been highlighted on numerous occasions (Aguilar-Conde & YustaSainz, 2017; Calderón & Calderón, 2012; Camacho-Miñano & PérezEstébanez, 2012; Cueto, 2007; Jordán de Urríes & Verdugo, 2010; Laloma-García, 2007; Redondo-Martín, 2013; Romeo & YepesBaldó, 2019). As well as they have been analyzed through economicfinancial analysis by several authors (Gelashvili, 2015; Gelashvili et al., 2019; Gelashvili et al., 2022; Gelashvili et al., 2016, 2020; GómezGonzález & Cano-Montero, 2021; Gómez-González et al., 2022, 2023; López-Penabad et al., 2019; Manzano-Martín et al., 2016; Morales-Calvo et al., 2017; Redondo-Martín, 2013; Segovia-Vargas et al., 2021). There are studies that contemplate the influence of the sector (Bain, 1959) and the size of the organization (Grant, 1991) in profitability (Acedo-Ramírez & Rodríguez-Osés, 2004; Ayala & Navarrete, 2004; Claver-Cortés et al., 2002; González, 2000; Iglesias-Antelo et al., 2007; Ramón-Dangla & Bañón-Calatrava, 2022; Sánchez-Ballesta & García-Pérez De Lema, 2003). However, the disclosure and transparency of non-financial or sustainability information based on GRI standards have not been studied in this type of company.

The SECs are social economy companies that play a decisive role in the group of people with disabilities and are a clear example of how social progress is compatible with business efficiency. These companies must address profitability and sustainability in all areas of sustainable development, taking into account different factors that can influence them, such as economic and financial indicators (Alshehhi et al., 2018; Arimany-Serrat et al., 2016; Garg, 2015; Gelashvili et al., 2022; Hou et al., 2016; Kiessling et al., 2016; Luptak et al., 2016; Pié et al., 2019; Wang et al., 2017; Wiengarten et al., 2017; Zhu et al., 2014; Zorn et al., 2018), the sector of activity and the size of the company (Acedo-Ramírez & Rodríguez-Osés, 2004; Ayala & Navarrete, 2004; Claver-Cortés et al., 2002; González, 2000; Iglesias-Antelo et al., 2007; Ramón-Dangla & Bañón-Calatrava, 2022; Sánchez-Ballesta & García-Pérez De Lema, 2003). In recent years, there has been a transformation of the business information provided by organizations that has led to the need and obligation to disclose sustainability information on ESG matters based on Corporate Social Responsibility (CSR) theories such as stakeholder theory (Clarkson, 1995; Fernández-Fernández & Bajo-San Juan, 2012; Freeman, 1984, 2004; Freeman et al., 2010, 2020; Gray et al., 1997) or the theory of legitimacy (Chen & Roberts, 2010; Goldsmith & Pereira, 2014; Islam, 2017; Santana, 2012; Suchman, 1995; Weidner et al., 2019; Zyznarska-Dworczak, 2018).

Along these lines, one of the most used tools by companies to communicate the actions they carry out in terms of CSR is the sustainability report. The publication of sustainability information is associated with the term "triple bottom line" which refers to the integration of information on economic, social, and environmental aspects (Iturrioz-Campo et al., 2019) from Carroll's pyramid (1991). Stakeholder demand has helped raise awareness of sustainability reporting, which is why companies around the world have opted for sustainability reporting (Ikpor et al., 2022). The GRI standards address all dimensions of sustainability and are in line with the SDGs, promoting sustainability, accountability, and transparency.

There are numerous authors who investigate the level of disclosure of sustainability information based on the GRI standards and ESG aspects by companies (Abate et al., 2021; Bien-Feng et al., 2024; Clementino & Perkins, 2021; Cordazzo et al., 2020; Nicolo & Andrades-Peña, 2024; Zhang et al., 2023). Some establish a positive correlation between the level of non-financial disclosure and corporate performance (Wu & Yuan, 2020), others reveal a positive correlation between the non-financial disclosure index and the publication of the non-financial report (Belenes¸i et al., 2021), others indicate that the disclosure of information among stakeholders benefits in a lower opacity of information (Romito & Vurro, 2021) and others show that companies with higher environmental performance reflected in their reports receive better credit ratings (Yoo, 2021). However, some authors impulse companies to improve non-financial disclosure (Gutiérrez-Ponce, Arimany-Serrat, & Chamizo-González, 2022) and others indicate that the levels of non-financial reporting are satisfactory in environmental matters but need to improve in social and governance matters (Vlaˇsic & Poldrugovac, 2022). Other authors analyze the relationship between the level of disclosure of sustainability information based on the GRI standards with factors such as the sector of activity and the size of the organization and with the economic-financial results (Gutiérrez-Ponce, Chamizo-González, & Arimany-Serrat, 2022; Hategan et al., 2021; Iturrioz-Campo et al., 2019; Sierra-Garcia et al., 2018). Along these lines, some researchers show the association of the level of disclosure of nonfinancial information with the sector (Herrador-Alcaide & HernándezSolís, 2019; Sierra-Garcia et al., 2018; Tarquinio et al., 2018), others show that size is a significant variable (Iturrioz-Campo et al., 2019) and others state that larger, more profitable companies belonging to specific sectors have a greater commitment to non-financial disclosure (García-Benau et al., 2022). In addition, several authors study the association of the level of disclosure with economic-financial indicators and indicate a positive correlation with financial results (Gutiérrez-Ponce et al., 2022b; Hategan et al., 2021), others that liquidity is an inversely significant variable (Iturrioz-Campo et al., 2019), others that economic profitability and good levels of indebtedness influence the disclosure of sustainability information (Tarquinio et al., 2018; Gutiérrez-Ponce, Arimany-Serrat, & Chamizo-González, 2022).

The disclosure of sustainability information based on the GRI aims to improve sustainability and increase stakeholder confidence and contributes to measuring, monitoring, and managing the performance of companies and their impact on society. In addition, the sustainability report has a positive impact on the sustainability disclosure index (Belenes¸i et al., 2021). The information included in the sustainability report is verified by an independent professional to demonstrate the relevance, quality, and reliability of the information provided (García-Sánchez, Amor-Esteban, & Galindo-´ Alvarez, 2020; García-Sánchez, Martín-Zamora, & Rodríguez-Ariza, 2020). Companies are more likely to report on sustainability-related performance when their reporting is verified (Sierra-García et al., 2022) and highlights the importance of the quality of sustainability information reporting in order to achieve more comparable, relevant and reliable information, incorporating the creation of value for stakeholders into accounting (Fiandrino & Tonelli, 2021).

The level of disclosure of sustainability information is often related to different factors (García-Benau et al., 2022; GutiérrezPonce, Arimany-Serrat, & Chamizo-González, 2022; Gutiérrez-Ponce, Chamizo-González, & Arimany-Serrat, 2022; Hategan et al., 2021; Herrador-Alcaide & Hernández-Solís, 2019; Iturrioz-Campo et al., 2019; León-Silva et al., 2022; Sierra-Garcia et al., 2018; Tarquinio et al., 2018). There is a significant influence between the disclosure and transparency of non-financial information and financial results (Gutiérrez-Ponce, Chamizo-González, & Arimany-Serrat, 2022;

Hategan et al., 2021). Also, the size of the company is a determining variable of disclosure and transparency of sustainability information, along with liquidity (Iturrioz-Campo et al., 2019). Thus, larger and more profitable companies that belong to specific sectors and have a commitment to sustainability are more likely to disclose this information in the sustainability report (García-Benau et al., 2022), as well as good levels of indebtedness influence a higher level of sustainability reporting (Gutiérrez-Ponce, Arimany-Serrat, & ChamizoGonzález, 2022). Table 1 compiles the previous literature cited where sustainability information is analyzed. Consequently, and under the premise that the sector, size and certain economic-financial aspects can influence the disclosure and transparency of non-financial information based on the GRI standards, and alongside the established objectives the following research questions (RQ) are elaborated:

RQ1. Do audited SECs disclose sustainability informa tion? Those who disclose sustainability information do so based on GRI standards?

RQ2. Do the activity sector, the size of the organization and/or the economic and financial results influence the level of disclosure and transparency of ESG information?

RQ2a. Does the sector influence the level of disclosure and transparency of ESG information?

RQ2b. Does the size of the organization influence the level of disclosure and transparency of ESG information?

RQ2c. Do economic and financial results influence the level of disclosure and transparency of ESG information?

Author	Countries	Sample	Variables	Methodology	Research Objectives
Abate, Basile, and Ferrari (2021)	Europe	634 investment funds	High ESG funds and low ESG funds.	Data envelopment analysis (DEA)	Check whether investment funds with a high ESG rating perform better than funds with a low ESG rating taking into account the risks.
Beleneşi et al. (2021)	Rumania	60 empresas cotizadas	Disclosure ESG index, environmental, social, economic, governance, industries.	Categorical principal component analysis (CATPCA)	Slight increase in the non-financial disclosure index and revealed differences in the average non-financial disclosure ratio and the disclosure ratio of ESG indicators.
Bien-Feng, Mirza, Ahsan, and Qureshi (2024)	China	3.045 empresas	Dependent variable: ESG performance. Independent variables: environmental uncertainty, financing constraints, industry competition, size, operating cash flow, leverage, corporate growth, ROA board size, board independence, duality, shareholding ratio of the largest share.	Econometric model regression	Examine how environmental uncertainty affects ESG performance.
Clementino and Perkins (2021)	Italy	57 companies	ESG ratings based on quality, level, and performance. Two dimensions: meeting the criteria and interactions and commitment.	Interviews with scores on a Likert scale between −3 and 3 based on four dimensions	Examine how companies react to ESG ratings and the factors that influence their response.
Cordazzo et al. (2020)	Italy	231 listed companies	Dependent variables: non-financial disclosure index. Independent variables: if firms prepare a sustainability report, book value of equity per share, earnings from continuing operations per share.	Econometric model regression	They investigate whether the transition to the EU Non-Financial Reporting Directive influences the value of non-financial reporting in relation to ESG aspects.
Fiandrino and Tonelli (2021)	Worldwide	101 articles	Non-financial information	Bibliometric analysis	Examine the quality of non-financial reporting reports, standardization, materiality, and assurance and suggest ways to improve management policies to achieve more comparable, relevant, and reliable information, incorporating value creation for stakeholders into accounting.
García-Benau et al. (2022)	Spain	249 listed companies	Dependent variable: Non-Financial Information. Independent variables: sector, size, assets, current ratio, indebtedness and ROA.	Logistic regression	To analyze the non-financial information disclosed by Spanish listed companies.
García-Sánchez, Amor-Esteban, and Galindo-Álvarez (2020); García-Sánchez, Martín-Zamora, and Rodríguez-Ariza (2020)	Spain	35 listed companies (Ibex-35)	Non-financial information disclosure	Analysis of legislation	Analysis of the NFIS regulation and see if the obligation to disclose entails a commitment to CSR.
Gutiérrez-Ponce, Arimany-Serrat, and Chamizo-González (2022)	Spain	35 companies (IBEX-35)	Dependent variable: ESG Information. Independent variable: ROA, ROE, liquidity and indebtedness	Econometric model regression	Assess companies' willingness to report ESG through their communication channels and web transparency.
Gutiérrez-Ponce et al. (2022)	Germany and Spain	65 companies (IBEX-35 and DAX30)	Dependent variable: ESG information. Independent variables: ROA, ROE, indebtedness and liquidity.	Econometric model regression	Evaluate web disclosure of non-financial information through a compliance analysis.
Hategan et al. (2021)	Rumania	542 companies (non-financial sector)	Dependent Variable: non- financial information score. Independent variables: ROA, ROE, Employees, website, foreign or private property, publicly traded company.	Hypothesis Testing and Feasible Generalized Least Squares Regression Model	Assess mandatory non-financial reporting operating in the non-financial sector.
Herrador-Alcaide and Hernández-Solís (2019)	Spain	50 companies (electronic credit market)	GRI (social, employees, human rights and anti-corruption) according to sector and size.	Descriptive Analysis, test Kruskal–Wallis, test Mann–Whitney, ANOVA.	Study the range of compliance with European rules on the disclosure of non-financial information.

TABLE1 Previous research on the analysis of sustainability information.

TABLE1 (Continued)

Author	Countries	Sample	Variables	Methodology	Research Objectives
Iturrioz et al. (2019)	Spain	102 companies (listed, unlisted and with CSR indices)	ESG disclosure score, ROA, ROE, liquidity, solvency, indebtedness, and size.	Correlations	Analyze the relationship between the publication of CSR-related data and economic and financial indicators.
León-Silva et al. (2022)	Pacific Alliance (Latin America)	99 local governments	Dependent variable: Sustainability disclosure (GRI). Independent variables: number of inhabitants (size), internet access, budgetary capacity and economic level.	Econometric model regression	It analyses the socioeconomic factors that influence the disclosure of information on sustainability on websites associated with the internal and external demands that public entities have to be accountable in social and environmental matters.
Nicolo and Andrades-Peña (2024)	Worldwide	253 state-owned enterprises	Dependent variables: ESG general disclosure, environmental disclosure (ED), social disclosure (SD), corporate governance disclosure (GD). Independent variable by board of directors and governing council: size, independence, gender diversity, number of meetings, presence of CSR committee.	Fixed and random effects panel regression model	Discusses new perspectives on the impact of corporate governance mechanisms on ESG disclosure practices.
Romito and Vurro (2021)	USA	187 companies (S&P500 index)	Dependent variable: Information asymmetry. Independent variables: non-financial disclosure depth, breadth, concentration, idiosyncratic risk, solvency, firm performance, age, ownership type.	Econometric model regression	To check whether the structure of non-financial disclosure, defined as the dissemination of financial, social and environmental information, reduces the symmetry of the information.
Sierra-Garcia, Garcia-Benau, and Bollas-Araya (2018)	Spain	34 companies (IBEX-35)	Dependent variable: non-financial information index. Independent variables: sector, size, sustainability committee, sustainability report.	Econometric model regression	Analyze the publication of non-financial information considering whether companies are merely complying with regulations or voluntarily providing additional information.
Sierra-García et al. (2022)	Spain	105 listed companies	Dependent variables: SDGs. Independent variables: ESG score, type of assusor, quality index report, sustainability committee, size, ROA, leverage, sector, year.	Logit regression	Investigate the relationship between corporate reporting on SDG-related issues and the quality of non-financial reporting.
Tarquinio et al. (2018)	Italy, Spain, and Greece.	134 companies	Dependent Variable: GRI indicators. Independent Variables: assurance, country, sector, size, ROA, ROE.	Multivariate analysis with regression trees	Explore the performance indicators disclosed in the sustainability reports based on the GRI and see how business variables can explain the disclosure of the GRI indicators.
Vlašić and Poldrugovac (2022)	Croatia	104 hotel companies	Non-financial information based on GRIs: general information, emissions and pollution, sustainability, other information, directive requirements.	Descriptive analysis	Investigar el contenido de la información no financiera divulgada por las empresas hoteleras desde que es obligatorio su cotización en el mercado.
Wu and Yuan (2020)	China	326 reports from listed companies	Dependent variables: ESG disclosure (corporate performance TOBINQ). Independent variable: corporate risk, agency cost (sales divided by assets), non-financial information disclosure, equity concentration, financial leverage, ROA, size ability to grow (growth rate of net profit).	Econometric model regression	Study the relationship between business performance, agency cost, and ESG disclosures.
Yoo (2021)	South Korea	1085 companies (capital markets)	ESG information according GRI. Dependent variables: credit rating of bonds. Independent variable: environmental strategy, organization and management; Communication with stakeholders, majority share ownership, foreign investor ownership, interest coverage ratio, fund value, leverage, Quality of Benefits, ROE, size.	Econometric model regression	Analyze which dimensions of non-financial information on environmental liability are most reflected in credit ratings.
Zhang et al. (2023)	China	8145 comments	ESG score, liquidity, director ratio, ROA, cash flow, company size, turnover.	Regression model using the difference-in-difference (DID)	Empirically analyzes the impact of carbon emissions trading policy on ESG performance and its channeling mechanism.

Abbreviations: ESG, environmental, social, and corporate governance; GRI, Global Reporting Initiative; ROA, return on assets; ROE, return on equity; SDG, Sustainable Development Goal.

3 | METHODOLOGY

3.1 | Sample and sources of information

The research is based on an empirical study with a quantitative methodology with information and data from social economy companies declared SECs by the end of 2020. Information on the characteristics of the companies has been found on the websites of the Autonomous Communities (regional governments), the Observatory on Disability and the Labour Market and the State Public Employment Service. The economic and financial information is obtained from the SABI (Sistema de Análisis de Balances Ibérico) through the financial statements. The research is completed with information on the sector of activity according to the National Classification of Economic Activities (CNAE 2009), the size according to Regulation (EU) 651/2014 of the European Commission (Regulation EU 651/2014/EC) and the legal form. With regard to the collection of non-financial information, nonfinancial information statements or sustainability reports published by companies on their official websites were used.

A standardized list of 2033 SECs was obtained, among which 668 were companies under mercantile legal forms and presented complete information. The sample was filtered to exclude companies with no audit report of their financial statements, therefore, the final sample was made up of 194 companies. In short, 194 companies are investigated within 6 sectors of activity, classified into 4 sizes and the number of employees, 2 variables related to the balance sheet and the profit and loss account, 4 economic-financial ratios and 4 variables related to the disclosure of non-financial information are added. Thus, 20 variables and 3880 observations were analyzed.

3.2 | Description of variables and statistical methods

3.2.1 | Dependent variables

In the preparation of the dependent variables, the sustainability reports are examined, compiling all the information related to ESG aspects based on the GRI standards. Therefore, four GRI-ESG indices are prepared and determined in accordance with GRI standards, in accordance with the GRI 300 on environmental issues, the GRI 400 on social issues and the GRI 101, 102 and 103 on corporate governance aspects. The dependent variables, therefore, are the GRI-ESG Index that encompasses all ESG aspects, the GRI-E Index that deals with environmental information, the GRI-S Index that deals with social information and the GRI-G Index that deals with governance information, determined based on the count of the GRI standards. The content of Law 11/2018 is more specific with respect to non-financial key performance indicators, establishing that with the objective of facilitating the comparison of information, both over time and between entities, especially non-financial key indicator standards that can be generally applied and that comply with the European Commission's guidelines will be used. The standard encourages companies to use Global Reporting Initiative (GRI) indicator standards. These

TABLE2 Dependent variables.

Approach	Code	Indicators
Environmental approach	GRI-E Index (GRI 300)	8 GRI standard
Social approach	GRI-S Index (GRI 400)	19 GRI standard
Governance approach	GRI-G Index (GRI 101, 102 y 103)	3 GRI standard
GRI ESG approach	GRI-ESG Index (global)	30 GRI standard

Abbreviations: ESG, environmental, social, and corporate governance; GRI, Global Reporting Initiative.

indexes have been prepared based on other classifications made by different authors (Czaja-Cieszyńska, 2020; García-Sánchez, AmorEsteban, & Galindo-´ Alvarez, 2020; García-Sánchez, Martín-Zamora, & Rodríguez-Ariza, 2020; Krawczyk, 2021; Perello-Marin et al., 2022). These indexes were configured as shown in Table 2.

3.2.2 | Independent variables

As for the independent variables, six sectors of activity are included, encompassing administrative activities (sector_1), trade and distribution (sector_2), industry (sector_3), comprehensive services (sector_4), the social and health sector (sector_5) and other sectors (sector_6) in which several sectors are included (arts and printing, agriculture, catering, other professional activities, transport and telecommunications). In addition, four sizes are included: microenterprise (size_1), small (size_2), medium (size_3) and big (size_4). The sector and the size are treated as dummy variables that serve to identify categories, that is, they take the value of zero and one depending on whether or not they belong to the indicated category. In terms of numerical variables are, the volume of operating income and the volume of total assets, as relevant variables in the profit and loss account and the balance sheet, in addition to the number of employees. Also, economic and financial indicators are taken into account as relevant aspects of the company's performance. The indicators included are economic profitability (return on assets [ROA]), defined as earnings before interest and taxes divided by total assets; Financial profitability (return on equity [ROE]), defined as earnings after interest and tax divided by equity; liquidity, defined as current assets minus inventories divided by current liabilities; and indebtedness, defined as total liabilities divided by total assets. The definition and detailed description of the variables is shown in the Table 3.

3.2.3 | Research design

To explore the level of disclosure and transparency of sustainability information based on the GRI standards in SECs, first, a univariate analysis is carried out using frequencies and descriptives to estimate measures of central tendency, position and dispersion and to

TABLE3 Independent variables.

Indicator	Code	Description
Administrative activities	Sector_1	1-Yes; 0-No
Trade and distribution	Sector_2	1-Yes; 0-No
Industry	Sector_3	1-Yes; 0-No
Integral services	Sector_4	1-Yes; 0-No
Health	Sector_5	1-Yes; 0-No
Other sectors	Sector_6	1-Yes; 0-No
Microenterprise	Size_1	1-Yes; 0-No
Small	Size_2	1-Yes; 0-No
Medium	Size_3	1-Yes; 0-No
Big	Size_4	1-Yes; 0-No

Total assets	Assets	Volume of assets
Employees	Employees	Number of employees
Operating income	Income	Volume of operating income
Return on assets	ROA	Earnings before interest and taxes / total assets
Return on equity	ROE	Earnings after interest and taxes / equity
Liquidity	Liquidity	Current assets—inventories / current liabilities
Indebtedness	Debt	Total liabilities / total assets

Abbreviations: ROA, return on assets; ROE, return on equity.

characterize the variables under study (García-Benau et al., 2022; Gelashvili et al., 2022). Next, a bivariate analysis is carried out through correlations and econometric models using multiple linear regressions by ordinary least squares (OLS) with heteroscedasticity correction to establish the predictive models (Sierra-Garcia et al., 2018; Hategan et al., 2021; García-Sánchez et al., 2021; Gutiérrez-Ponce, ArimanySerrat, & Chamizo-González, 2022; Gutiérrez-Ponce, Chamizo-González, & Arimany-Serrat, 2022).

Correlations analysis makes it possible to determine the intensity and direction of the relationship between two variables. In this case, it is verified that the variables are continuous and normal and, therefore, Pearson's correlation coefficient is used. Multiple linear regression analysis is a model that explains the relationship between variables in which a dependent or endogenous variable is assumed and different independent or exogenous variables. In this case, the expression of the models is presented in the following equation:

$$\begin{aligned}\text{Model 1: GRI} - \text{ESG Index} = {} & \beta_0 + \beta_1\,\text{sector\_1} + \beta_2\,\text{sector\_2} \\ & + \beta_3\,\text{sector\_3} + \beta_4\,\text{sector\_4} \\ & + \beta_5\,\text{sector\_5} + \beta_6\,\text{sector\_6} + \beta_7\,\text{size\_1} \\ & + \beta_8\,\text{size\_2} + \beta_9\,\text{size\_3} + \beta_{10}\,\text{size\_4} \\ & + \beta_{11}\,\text{assets} + \beta_{12}\,\text{employees} \\ & + \beta_{13}\,\text{income} + \beta_{14}\,\text{ROA} + \beta_{15}\,\text{ROE} \\ & + \beta_{16}\,\text{liquidity} + \beta_{17}\,\text{indebtedness} + \mu_i\end{aligned}$$

$$\begin{aligned}\text{Model 1a : GRI} - \text{E Index} = {} & \beta_0 + \beta_1\,\text{sector\_1} + \beta_2\,\text{sector\_2} \\ & + \beta_3\,\text{sector\_3} + \beta_4\,\text{sector\_4} \\ & + \beta_5\,\text{sector\_5} + \beta_6\,\text{sector\_6} + \beta_7\,\text{size\_1} \\ & + \beta_8\,\text{size\_2} + \beta_9\,\text{size\_3} + \beta_{10}\,\text{size\_4} \\ & + \beta_{11}\,\text{assets} + \beta_{12}\,\text{employees} \\ & + \beta_{13}\,\text{income} + \beta_{14}\,\text{ROA} + \beta_{15}\,\text{ROE} \\ & + \beta_{16}\,\text{liquidity} + \beta_{17}\,\text{indebtedness} + \mu_i\end{aligned}$$

$$\begin{aligned}\text{Model 1b : GRI} - \text{S Index} = {} & \beta_0 + \beta_1\,\text{sector\_1} + \beta_2\,\text{sector\_2} \\ & + \beta_3\,\text{sector\_3} + \beta_4\,\text{sector\_4} \\ & + \beta_5\,\text{sector\_5} + \beta_6\,\text{sector\_6} + \beta_7\,\text{size\_1} \\ & + \beta_8\,\text{size\_2} + \beta_9\,\text{size\_3} + \beta_{10}\,\text{size\_4} \\ & + \beta_{11}\,\text{assets} + \beta_{12}\,\text{employees} \\ & + \beta_{13}\,\text{income} + \beta_{14}\,\text{ROA} + \beta_{15}\,\text{ROE} \\ & + \beta_{16}\,\text{liquidity} + \beta_{17}\,\text{indebtedness} + \mu_i\end{aligned}$$

$$\begin{aligned}\text{Model 1c : GRI} - \text{G Index} = {} & \beta_0 + \beta_1\,\text{sector\_1} + \beta_2\,\text{sector\_2} \\ & + \beta_3\,\text{sector\_3} + \beta_4\,\text{sector\_4} \\ & + \beta_5\,\text{sector\_5} + \beta_6\,\text{sector\_6} + \beta_7\,\text{size\_1} \\ & + \beta_8\,\text{size\_2} + \beta_9\,\text{size\_3} + \beta_{10}\,\text{size\_4} \\ & + \beta_{11}\,\text{assets} + \beta_{12}\,\text{employees} \\ & + \beta_{13}\,\text{income} + \beta_{14}\,\text{ROA} + \beta_{15}\,\text{ROE} \\ & + \beta_{16}\,\text{liquidity} + \beta_{17}\,\text{indebtedness} + \mu_i\end{aligned}$$

To determine the adequacy of the model, the usual assumptions of independence, homoscedasticity, normality, and non-collinearity were tested. Independence or randomness is checked by the streak test or Durbin-Watson statistic, concluding that the observations are independent. On the other hand, the homogeneity of the variances was tested using the Levene statistic and it was concluded that not in all cases the variables were homogeneous, so it was decided to perform multiple linear regression by OLS with heteroscedasticity correction. For the normality test, the Kolmogorov–Smirnov test was performed with Lilliefors significance correction and a normal distribution of the data is assumed. For collinearity, the variance inflation factor (VIF) was used and multicollinearity was not detected, so, no variable had a VIF > 10.

Also, to consider the adjustment of the multiple linear regression mode, the F-tests and R2 are considered. The F-test explores whether the independent variables significantly explain the dependent variable with a p-value <0.05. On the other hand, the coefficient of determination R2 determines the percentage of variance explained by the independent variables. The significance of the independent variables is analyzed using the t-statistic, to contrast whether the β parameter associated with each of these variables is non-zero. In the case of the t-statistic, different levels of significance are taken, p < 0.10, p < 0.05 and p <0.01, the smaller the p-value, the greater the association between the variables. In addition, the Akaike criterion (AIC) is used to compare the models. AIC is a measure of the quality of the econometric model and serves as a means of selection, so the best model will be the one with the lowest AIC.

4 | RESULTS AND DISCUSSION

4.1 | Disclosure of sustainability information based on GRIstandards

IntheTable4it is foundthat34%(66)of companies disclose ESG information based on the GRI standards in their sustainability reports and66%(128) do not publish sustainability information. Regarding environmental issues or GRI-E, it is observed that 33.5%(65) of companies publish ESG information in accordance with the GRI and 66.5% (129) do not. In social matters or GRI-S,33.5%(65)of the SEC sdisclose this type of information and 66.5%(129)do not. If we look at the information on corporate governance or GRI-G, it can be seen that information based on the fundamentals of the company (GRI101) is disclosed by 20.1% (39) of companies and 79.9% (155) do not. Regarding the information they disclose related to general information of the organization (GRI102),only34%(66)of the companies studied disclose this information and 66%(128)do not. Like wise, the information related to management approach (GRI103) is published by 33.5% (65)of the companies and 66.5%(129)do not.

To detail the indicators covered by the companies studied, the following is presented inTable 5the number of companies disclosing the total GRI indicators for each ESG category. 8 GRI-E indicators were identified, and it was found that 56 companies (28.9%) disclosed 100%of the environmental aspects. In addition, it is found that 38 (19.6%) companies publish information on social aspects. On the other hand, in terms of corporate governance, it can be seen that

TABLE4 Number of special employment centers disclosing sustainability information based on the GRI standards.

N° SECs/%	Yes	No
GRI-G (GRI 102)	66 (34.0%)	128 (66.0%)
GRI-E (GRI 300)	65 (33.5%)	129 (66.5%)
GRI-S (GRI 400)	65 (33.5%)	129 (66.5%)
GRI-G (GRI 103)	65 (33.5%)	129 (66.5%)
GRI-G (GRI 101)	39 (20.1%)	155 (79.9%)
GRI-ESG	66 (34.0%)	128 (66.0%)

Abbreviations:ESG,environmental,social,andcorporategovernance;GRI, Global Reporting Initiative.

TABLE5 Number of SECs disclosing the total GRI indicators for each ESG category aspects.

Category		N° SECs / %		GRI: N° indicators / %	
Environmental	GRI-E	56	28.9	8	100
Social	GRI-S	38	19.6	19	100
Corporate governance	GRI-G (fundamentals)	39	20.1	1	100
	GRI-G (general)	66	34.0	1	100
	GRI-G (management)	65	33.5	1	100

Abbreviations:ESG,environmental,social,andcorporategovernance;GRI,GlobalReportingInitiative; SEC, special employment centers.

39SECs(20.1%)publish100%oftheinformationrelatedtothefundamentalsoftheorganization,66(34%)publish100%oftheindicator referring to general information about the company and 65(33.5%) disclose the indicator related to the management of the organization.

4.2 | Descriptive analysis

IntheTable6andTable7, the results of descriptive statistics are disclosed to know the values of the measures of position, central tendency, and dispersion for the economic-financial variables considered and for the continuous variables that make up the sustainability information indices. If we look at the median value as a measure of central tendency in the Table 6, it is found that the value of assets amounts to 4267.8euros, the number of employees is 120.5, the operating

TABLE6 Descriptive statistic for economic and financial variables.

	Min	Max	Median	SD
Assets (€)	48,600	892,198.3	4267.8	82,981.7
Income (€)	81,700	958,616.0	4659.7	88,759.2
Employees (N°)	2	45,236	120.5	3316.0
ROA (%)	−118.9	49.7	4.4	18.6
ROE (%)	−427.9	859.3	10.9	86.6
Liquidity (%)	0.1	54.8	2.0	5.2
Indebtedness (%)	1.6	627.7	43.7	49.4

Abbreviations: ROA, return on assets; ROE, return on equity.

TABLE7 Descriptive statistic for non-financial disclosure variables.

	Min	Max	Mean	SD
GRI-E index (%)	0.0	100.0	29.9	45.5
GRI-S index (%)	0.0	100.0	30.4	45.5
GRI-G index (%)	0.0	100.0	31.1	44.6
GRI-ESG index (%)	0.0	100.0	31.4	45.5

Note: N=194.

Abbreviations:ESG,environmental,social,andcorporategovernance;GRI, Global Reporting Initiative.

TABLE8 Dummy variable frequencies.

	Frequency	%	N
Sector			
Services	47	24.2	194
Administrative	37	19.1	
Industry	33	17.0	
Other sectors	31	16.0	
Health and social care	29	14.9	
Commerce	17	8.8	

Size			
Medium	95	49.0	194
Big	57	29.4	
Small	32	16.5	
Micro	11	5.2	

income amounts to 4659.7 euros, the ROA is 4.4%, the ROE is 10.9%, liquidity is 2% and indebtedness is 43.7%. Regarding the descriptive analysis of the dependent variables (see Table 7), the GRI-ESG Index reaches an average value of 31.4%. On the other hand, the GRI-E Index has an average value of 29.9%. The GRI-S Index takes an average value of 30.4%. Regarding the GRI-G Index, it has an average value of 31.1%.

In the Table 8 The frequency of the dummy, sector and size variables is disclosed to identify which sector and size are most prevalent. If we look at the sector variable, we can see that 24.2% (47) of the SECs operate in the comprehensive services sector. In the industry sector, 17% (33) of the companies studied are present, 19.1% (37) are present in the administrative activities sector and 16% (31) in the other sectors. In last place is the social and health sector with 14.9% (29) and the trade sector with 8.8% (17) of the companies analyzed. Regarding the size variable, 49% (95) are medium-sized companies, 29.4% (57) are large, 16.5% (32) are small, and 5.7% (11) are microenterprises.

4.3 | Relationship between sustainability indicators and factors

In the Table 9, The results of the statistical associations of the study are presented through parametric correlations between the dependent variables that measure the sustainability reporting and the independent variables in order to verify if there is, a priori, a statistical relationship between them. The results of the Table 9 confirm a direct association between large companies, total assets, and operating income with levels of sustainability information disclosure based on GRI standards. This direct relationship confirms that the larger the size of the company and the higher the operating income and assets, the higher the levels of sustainability information disclosure across the board. Also, it is found that there is a direct correlation between the number of employees and the GRI-S Index variable, that is, the

greater the number of employees, the greater the disclosure of information on social issues. On the other hand, it is confirmed that ROE and liquidity are inversely related to sustainability information disclosure rates, that is, the lower the levels of ROE and liquidity, the higher the levels of sustainability information disclosures. In the light of Table 9 results, several econometric models were proposed with combinations of the variables being tested. Finally, four linear regressions by OLS are proposed to explain the variables representing the level of disclosure of sustainability information based on the GRI standards globally (GRI-ESG Index) and specific to each of the areas (GRI-E Index, GRI-S Index and GRI-G Index). Through the estimated models, the aim is to predict the dependent variables indicated from the explanatory or independent variables. It should be taken into account that, for all models, the system omits the variables presenting collinearity issues, hence with correlation between these explanatory variables.

The Model 1 (see Table 10), reveals that the level of sustainability information globally, the GRI-ESG Index, is explained in 84.4% (R2 = 0.844) by the independent variables. The most explanatory of the model with a direct association are total assets (β = 0.000; p =0.000) and operating income (β = 0.000; p = 0.000) and with an inverse relationship liquidity (β = 1.218; p = 0.008) with a p-value of less than 1% (p<0.01). The variables industrial sector (sector_3) (β = 19.037; p=0.021) and microenterprise size (size_1) (β = 23.939; p = 0.026) explain the model to some extent with a pvalue of less than 5% (p < 0.05) and an inverse association in both cases. The variables administrative activities sector (sector_1) (β = 16.939; p=0.064), integral services sector (sector_4) (β = 15.445; p=0.093) and small company size (size_2) (β = 20.094; p = 0.051) explain the model at a significance level of less than 10% (p < 0.10) with an inverse association.

The Model 1a (see Table 10), shows that 87.4% of the environ mental disclosure index, the GRI-E Index, (R2 = 0.874) is explained by the independent variables. The variables that best explain the model with an inverse association are the administrative activities sector (sector_1) (β = 27.151; p = 0.003), the trade sector (sector_2) (β = 31.490; p=0.007), the industrial sector (sector_3) (β = 28.500; p =0.000) and with a direct association total assets (β = 0.000; p = 0.000) and operating income (β = 0.000; p = 0.000) with a p-value of less than 1% (p < 0.01). The variables integral services sector (sector_4) (β = 22.393; p = 0.0157) and liquidity (β = 1.029; p = 0.023) explain the model at a level of significance of less than 5% (p < 0.05) with an inverse relationship. The variables microenterprise size (size_1) with an inverse association (β = 21.125; p=0.051) and ROA with a direct association (β = 0.344; p = 0.09) explain the model at a significance level of less than 10% (p < 0.10).

The Model 1b (see Table 10) shows that 83.4% of the index of dissemination of information on social matters, the GRI-S Index, is explained by the independent variables (R2 = 0.834). The variables that best explain this model are total assets (β = 0.000; p = 0.000) and operating income (β = 0.000; p = 0.000) with a p-value of less than 1% ($p < 0.01$) and a direct relationship. As for the variables

TABLE9 Parametric correlations.

		GRI-E index	GRI-S index	GRI-G index	GRI-ESG index
Sector_1	Pearson	0.106	0.102	0.098	0.098
	Sig.	0.142	0.156	0.173	0.173
Sector_2	Pearson	0.037	0.033	0.007	0.026
	Sig.	0.607	0.644	0.924	0.715
Sector_3	Pearson	0.007	0.002	−0.017	−0.009
	Sig.	0.918	0.983	0.814	0.899
Sector_4	Pearson	−0.068	−0.072	−0.072	−0.054
	Sig.	0.344	0.319	0.316	0.457
Sector_5	Pearson	−0.011	−0.013	0.000	−0.015
	Sig.	0.883	0.861	0.997	0.838
Sector_6	Pearson	−0.057	−0.039	−0.007	−0.037
	Sig.	0.428	0.591	0.922	0.610
Size_1	Pearson	−0.112	−0.115	−0.122	−0.121
	Sig.	0.119	0.110	0.091	0.094
Size_2	Pearson	−0.116	−0.118	−0.110	−0.122
	Sig.	0.109	0.101	0.127	0.091
Size_3	Pearson	−0.028	−0.023	−0.020	−0.009
	Sig.	0.695	0.751	0.781	0.902
Size_4	Pearson	0.186**	0.184*	0.177*	0.174*
	Sig.	0.009	0.010	0.013	0.015
Assets	Pearson	0.165*	0.165*	0.159*	0.159*
	Sig.	0.022	0.022	0.027	0.026
Employees	Pearson	0.140	0.143*	0.139	0.138
	Sig.	0.051	0.047	0.053	0.055
Income	Pearson	0.208**	0.211**	0.204**	0.204**
	Sig.	0.004	0.003	0.004	0.004
ROA	Pearson	−0.011	−0.015	−0.033	−0.012
	Sig.	0.880	0.835	0.647	0.872
ROE	Pearson	−0.153*	−0.163*	−0.179*	−0.162*
	Sig.	0.033	0.023	0.013	0.024
Liquidity	Pearson	−0.150*	−0.154*	−0.165*	−0.161*
	Sig.	0.037	0.032	0.022	0.025
Indebtedness	Pearson	−0.045	−0.043	−0.045	−0.045
	Sig.	0.531	0.553	0.534	0.530

Note: N=194.

Abbreviations:ESG,environmental,social,andcorporategovernance;GRI,GlobalReportingInitiative;

ROA, return on assets; ROE, return on equity.

*p<0.05.**p<0.01.

administrative activities sector (sector_1) (β= 21.679; p=0.025), industrial sector (sector_3) (β= 22.109; p=0.010), servicesector (sector_4) (β= 19.809; p=0.04), microenterprise size (size_1) (β= 26.233;p=0.012)andliquidity(β= 1.031;p=0.014), they explain the model a ta levelofsignificancelowerthan5%(p<0.05) with an inverse association. The variables trade sector (sector_2) (β= 23.346; p=0.058) and small firm size (size_2) (β= 19.184; p=0.054) explain the model at a level of significance of less than 10%(p<0.10)withaninverserelationship.

The Model 1c (seeTable10)states that the index of disclosure of information on corporate governance, the GRI-GIndex, is explained in 79.2%(R2=0.792)by the explanatory variables. It is confirmed that the variables that best explain the model are microenterprise size (size_1) (β= 30.070; p=0.002) and liquidity (β= 1.127; p=0.007)with an inverse association and total assets (β=0.000; p=0.000), operating income (β=0.000; p=0.000) with a direct relationship at a significance level of less than 1 %(p<0.01).The variables industrial sector (sector_3) (β= 20.353; p=0.022), integral

TABLE10 Econometric OLS regression models with heteroscedasticity correction.

Model 1c (DV: GRI-G index)		
β	*t*-test	*p*-value
57.169	5.327	0.000***
−18.218	−1.851	0.065*
−20.605	−1.814	0.071*
−20.353	−2.306	0.022**
−20.698	−2.159	0.032**
−13.137	−1.167	0.245
−30.070	−3.119	0.002***
−21.191	−2.271	0.024**
−13.768	−1.556	0.122
0.000	4.568	0.000***
−0.001	−0.415	0.678
0.000	4.771	0.000***
0.104	0.554	0.581
−0.039	−1.108	0.269
−1.127	−2.728	0.007***
−0.018	−0.328	0.743
0.792		
42.153 (0.000)		
695.339		

ISSN No: - 2347-1735

Model 1 (DV: GRI-ESG index)			Model 1a (DV: GRI-E index)			Model 1b (DV: GRI-S index)		
β	t-test	p-value	β	t-test	p-value	β	t-test	p-value
53.252	4.966	0.000***	55.212	4.789	0.000***	54.802	4.943	0.000***
−16.939	−1.864	0.064*	−27.151	−3.029	0.003***	−21.679	−2.266	0.025**
−19.412	−1.572	0.118	−31.490	−2.734	0.007***	−23.346	−1.905	0.058*
−19.037	−2.332	0.021**	−28.500	−3.806	0.000***	−22.109	−2.604	0.010**
−15.445	−1.687	0.093*	−22.393	−2.440	0.016**	−19.809	−2.121	0.035**
−11.715	−1.120	0.264	−17,212	−1.551	0.123	−14.442	−1.339	0.182
−23.939	−2.244	0.026**	−21.125	−1.960	0.052*	−26.233	−2.546	0.012**
−20.094	−1.964	0.051*	−16.739	−1.549	0.123	−19.184	−1.941	0.054*
−11.654	−1.173	0.242	−13.974	−1.334	0.184	−14.552	−1.512	0.132
0.000	7.451	0.000***	0.000	6.473	0.000***	0.000	7.491	0.000***
−0.001	−0.416	0.678	−0.001	−0.505	0.614	−0.001	−0.588	0.557
0.000	5.11	0.000***	0.000	5.358	0.000***	0.000	5.084	0.000***
0.147	0.904	0.367	0.344	1.662	0.098*	0.213	1.115	0.266
−0.034	−0.878	0.381	−0.011	−0.285	0.776	−0.024	−0.625	0.533
−1.218	−2.686	0.008***	−1.029	−2.297	0.023**	−1.031	−2.476	0.014**
−0.023	−0.392	0.695	−0.002	−0.036	0.971	−0.006	−0.105	0.916
0.844			0.874			0.834		
59.967 (0.000)			76.525 (0.000)			55.383 (0.000)		
738.13			770.724			730.345		

	const	Sector_1	Sector_2	Sector_3	Sector_4	Sector_5	Size_1	Size_2	Size_3	Assets	Employees	Income	ROA	ROE	Liquidity	Indebtedness	R^2	F (*p*-value)	Akaike

Abbreviations:Const,constant;DV,dependentvariable;GRI,GlobalReportingInitiative;OLS,ordinaryleastsquares;ROA,returnonassets;ROE,returnonequity. *p<0.10;**p<0.05;***p<0.01.

services sector (sector_4) (β = 20.698; p = 0.032) and small firm size (size_2) (β = 21.191; p = 0.024) explain the model with a p-value of less than 5% ($p < 0.05$) and an inverse association. The variables administrative activities sector (sector_1) (β = 18.218; p = 0.066) and trade sector (sector_2) (β = 20.605; p = 0.071) explain the model at a significance level of less than 10% ($p < 0.10$) with an inverse association.

As a result of the above (Table 10), it can be observed that, for the dependent variable GRI-ESG Index, certain sectors influence the disclosure of sustainability information. It is observed that belonging to the administrative activities and services sector influences the disclosure of sustainability information with a $p < 0.10$, as well as belonging to the industry sector with a $p < 0.05$. Regarding the dependent variable GRI-E Index, it is stated that belonging to the administrative activities, commerce and industry sector influences the disclosure of information on the environment with $p < 0.01$, as well as belonging to the services sector influences with a $p < 0.05$. With regard to the dependent variable GRI-S Index, it is found that belonging to the administrative, industry and socio-sanitary activities sector influences the dissemination of information on social matters with a $p < 0.05$, as well as belonging to the commerce sector influences with a $p < 0.10$. In relation to the dependent variable GRI-G Index, it is stated that belonging to the industry and services sector influences the disclosure of information on corporate governance with a $p < 0.05$, as well as belonging to the administrative activities and commerce sector influences with a $p < 0.10$.

If the size variable is taken into account, for the variables GRI ESG Index and GRI-S Index, it is stated that being a micro and small company influences the disclosure of sustainability information in the three areas and in social matters, with a $p < 0.05$ and $p < 0.10$, respectively. For the GRI-E Index, it is found that being a microenterprise influences the disclosure of environmental information with $p < 0.10$. Regarding the influence of size for the GRI-G Index variable, it is evident that being a microenterprise influences the disclosure of information on corporate governance with a $p < 0.01$, as well as being a small company influences with a $p < 0.05$.

Regarding the variables total assets and operating income, it is stated that they influence the disclosure of sustainability information in all areas with a $p < 0.01$. ROA influences environmental disclosure with a $p < 0.10$. It is also confirmed that liquidity influences with a $p < 0.01$ the disclosure of information in the three areas (GRI-ESG Index) and the disclosure of information on corporate governance

TABLE11 R2,Akaikecriterion and p-value of the F-test of econometric models.

Model	R^2	Akaike	*p*-value (F)
Model 1 (DV: GRI-ESG Index)	0.844	738.130	0.000
Model 1a (DV: GRI-E Index)	0.874	770.724	0.000
Model 1b (DV: GRI-S Index)	0.834	730.345	0.000
Model 1c (DV: GRI-G Index)	0.792	695.339	0.000

Abbreviations: DV, dependent variable; ESG, environmental, social, and corporate governance; GRI, Global Reporting Initiative.

(GRI-G Index) with a $p < 0.01$, as well as influences the disclosure of information on environmental and social matters with a $p < 0.05$. Finally, in Table 11 it is verified that based on R2 the best model is Model 1a (R2 = 0.874) and based on Akaike's criterion the best model is Model 1c (Akaike = 695.339). In addition, it is found that the p-value ($p = 0.000$) for the F-test in all models is significant, therefore, the independent variables significantly explain the dependent variables.

5 | CONCLUSIONS

In recent years, the disclosure and transparency of sustainability information has acquired an important role for government institutions, governments, and society in general to try to solve the problems arising from economic development and globalization, as well as improve the quality of life of society and ecosystems. The culture of sustainable development has led companies to adopt economic, social, environmental, and governance measures in order to achieve sustainable development in all areas.

Along these lines, SECs as socially responsible companies that integrate people with disabilities into the labour market, are no strangers to this circumstance. These companies perform a great importance in society and have been studied by different authors (Redondo-Martín, 2013; Gelashvili, 2015; Gelashvili et al., 2016, 2020; Gelashvili et al., 2022; Manzano-Martín et al., 2016; MoralesCalvo et al., 2017; López-Penabad et al., 2019; Segovia-Vargas et al., 2021), but none of them have analyzed sustainability disclosure. This research provides a perspective on sustainable development by taking into account the environmental, social and corporate governance aspects of this type of company, following the line of several authors studying the release of this type of information (Abate et al., 2021; Belenes¸i et al., 2021; Bien-Feng et al., 2024; Clementino & Perkins, 2021; Cordazzo et al., 2020; García-Benau et al., 2022; Gutiérrez-Ponce, Chamizo-González, & ArimanySerrat, 2022; Hategan et al., 2021; Nicolo & Andrades-Peña, 2024; Sierra-Garcia et al., 2018; Wu & Yuan, 2020; Zhang et al., 2023).

This study highlights the importance of providing transparent and reliable non-financial information. In addition, it emphasizes the need to keep stakeholders well informed in order to make the best deci sions and shows how these organizations contribute to achieving sustainable development. Thus, the main objective of this research was to analyze the level of disclosure and transparency of the sustainability information published by this type of companies that are included in the framework of the social economic sector, taking into account different factors that may influence the levels of disclosure of sustainability information, such as sector, size, and economic-financial results.

First of all, according to the results obtained, it can be concluded that 34% of the companies analyzed disclose information based on the GRI standards in 2020. It is evident that all SECs that disclose sustainability information do so in accordance with GRI standards. In addition, it is confirmed that most of the companies that disclose information of this type do so in all three ESG areas. It can also be concluded that 29% of the companies disclose 100% of environmental indicators and 19.6% disclose all social indicators. With regard to the publication of governance indicators, 20% publish the total number of indicators related to the company's fundamentals, 34% publish the total number of indicators related to general aspects of the company and 33.5% disclose the total number of indicators related to the company's management. Along these lines, the findings show that, despite the fact that they are social economy companies, they do not treat social GRI in all cases, so greater efforts should be made to require this type of company to provide information on their social actions. The results of this study enabled to respond to Rq1.

Second, the results confirm that total assets, operating income, financial profitability, liquidity and being a large company influence the disclosure and transparency of sustainability information in all aspects analyzed, thus responding to RQ2. In addition, the results show in response to RQ2a that being a company belonging to the administrative activities sector, the industrial sector and the service sector contributes to less sustainability information disclosure in all areas. Also, being a company in the commercial sector contributes to communicating less information on social and governance issues. Regarding the influence of the size of the organization and in response to RQ2b, it is concluded that being a micro and small company influences a lower disclosure of ESG information, specifically in social and governance aspects. On the other hand, the size of microenterprises influences a lower level of disclosure of environmental information.

Regarding the study of the relationship between economic and financial results and the level of disclosure and transparency of sustainability information, in response to RQ2c, the results show that the volume of assets and operating income influence a higher level of disclosure and transparency of sustainability information in all areas. Liquidity influences a lower level of disclosure and transparency of ESG information. In the same way, the economic profitability of these companies contributes to the disclosure of more sustainability information on environmental matters. However, it cannot be confirmed that the social and health sector, being a medium-sized company, the number of employees, the sales figure, the financial profitability and the indebtedness, contribute to the disclosure and transparency of ESG information. In summary, the conclusions obtained based on the research questions and the proposed objectives (Table 12). This research provides a response to the different stakeholder groups interested in the disclosure and transparency of sustainability information. The study makes an exhaustive analysis of the

TABLE12 Questions and conclusions.

Request question	Aims	Conclusion
RQ1: Do the audited SECs disclose sustainability information? Do those who disclose sustainability information do so based on the GRI standards?	Identify audited SCEs that publish sustainability reports based on GRI standards.	34% of the companies analyzed disclose information based on GRI standards in 2020. It is evident that all SECs that disclose non-financial information do so in accordance with the GRI standards and in all three aspects of non-financial information.
RQ2: Do the activity sector, the size of the organization and/or the economic and financial results influence the level of disclosure and transparency of ESG information?	To analyze the relationship between the level of disclosure of sustainability information and the factors sector, size and economic-financial results.	Total assets, operating income, financial profitability, liquidity, and being a large company all influence the disclosure and transparency of non-financial information in all aspects analyzed.

RQ2a: Does the sector influence the level of disclosure and transparency of ESG information?	Companies belonging to the administrative sector, the industrial sector and the service sector contribute to the disclosure of less non-financial information in all areas. Also, being a company in the commercial sector contributes to communicating less information on social and governance issues.
RQ2b: Does the size of the organization influence the level of disclosure and transparency of ESG information?	Micro and small companies influence lower ESG disclosures, specifically in social and governance aspects. On the other hand, the size of micro-enterprises influences a lower level of disclosure of environmental information.
RQ2c: Do economic and financial results influence the level of disclosure and transparency of ESG information?	Assets and operating income influence reporting a higher level of disclosure and transparency of non-financial information across the board. Liquidity influences a lower level of disclosure and transparency of ESG information. The ROA contributes to the disclosure of more non-financial environmental information.

Abbreviations: ESG, environmental, social, and corporate governance; GRI, Global Reporting Initiative; ROA, return on assets; SEC, special employment centers.

contributions in the field of sustainability reporting and how these companies report this information. It provides a novel approach by bringing SECs closer to sustainability from their different perspectives. In addition, it shows how the hiring of disabled people does not undermine the profitability of companies and contributes to sustainability. This research provides indicators on the management of these companies in economic and social aspects, useful for relating it to the analysis of the management of subsidies. It also concludes that companies should be provided with effective and useful tools and establish policies that allow them to advance in the achievement of sustainable development. Research such as this can be an important reference to provide insight and contribute to improving integrated reporting. In future lines of research, it is intended to broaden the sample under study and the variables used. It is also intended to be applied to non-profit SECs. In the same way, this research could be applied to other types of companies that are not SECs or to other sectors, and even to social enterprises or charities in other European countries or outside Europe.

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