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Using Financial and Sustainability Ratios to Map Sectors. An Approach With Compositional Data

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ABSTRACT

The article aims to visualize in a single graph Spanish fish and meat processing companies with respect to solvency, energy, waste and water intensity and gender employment gap. These financial, environmental, and social indicators are ratios, which require specific statistical analysis methods. We use the compositional data methodology and the principal-component analysis biplot. Fish-processing companies have more homogeneous financial, environmental, and social performance. Firms with higher solvency tend to be less efficient in energy use. Firms can be visually ordered along all indicators simultaneously and thus can visually see their areas of improvement in financial, environmental, and social performance compared to their competitors. This is the first time in which visualization tools have combined financial, environmental, and social indicators. The main limitation is the small sample size. As of now, few Spanish firms publish reports according to the EU Corporate Sustainability Reporting Directive.

JEL Classification: C38, C49, L66, M14, M41, M49

MSC Classification: 62H25, 62P05, 91B76

1 | Introduction

The European Sustainability Reporting Standards (ESRS) of the Commission Delegated Regulation 2023/2772, aligned with the EU's Corporate Sustainability Reporting Directive (CSRD) 2022/2464 and the Global Reporting Initiative (GRI), are designed to improve the transparency and consistency of companies' sustainability reporting compared to the previous Non-Financial Reporting Directive (NFRD) 2014/95. The new CSRD supports the creation of integrated reports in accordance with the ESRS and requires studies to evaluate the compliance of companies with these guidelines.

Similarly, the integration of accounting information and Environmental, Social and Governance (ESG) metrics has advanced with the establishment of the International Sustainability Standards Board (ISSB) under the International Financial Reporting Standards (IFRS) Foundation. The ISSB has released the IFRS S1 (general sustainability disclosures) and S2 (climate disclosures) standards. These aim to unify and make sustainability disclosures comparable to traditional financial reporting (IFRS Foundation 2025a, 2025b).

While strict environmental rules in Europe create immediate cost challenges for industries, they also encourage sustainable practices and offer long-term benefits. This transition is vital for green economic growth and environmental sustainability, while ensuring that markets remain competitive (Duran and Saqib 2024; Mohammed et al. 2024).

Since July 2025, over 30 jurisdictions have incorporated these standards into their regulatory frameworks (KPMG 2025), ensuring the reliability of ESG information in accounting processes and strategic decision-making (Zhou et al. 2025).

Additionally, many companies are already preparing mandatory or voluntary sustainability reports (Anguiano-Santos and Rodríguez-Entrena 2024; Villacampa-Porta et al. 2025), although Anguiano-Santos and Rodríguez-Entrena suggest that ESG disclosure is limited in accordance with the NFRD regulations.

The global agrifood sector plays a crucial role in shaping both economic and social structures around the world. However, it also has a significant environmental impact, which manifests itself in various areas, such as water pollution, Greenhouse Gas (GHG) emissions, deforestation and the generation of solid waste. It has also been linked to the discharge of toxic substances into aquatic ecosystems, biodiversity loss due to intensive production practices and the excessive use of natural resources. Furthermore, the production of food that is ultimately not consumed represents a significant energy and water waste (IRTA—Institut de Recerca i Tecnologia Agroalimentàries 2024).

These dynamics, alongside the evolving regulatory landscape, highlight the urgent requirement for the food sector to implement stricter environmental policies and encourage more sustainable production and consumption practices (Forética 2025; Villacampa-Porta et al. 2025).

Companies in this sector are undergoing significant financial and sustainability-related transformations. The financial transformation of the agrifood sector is becoming increasingly linked to technological advances under Industry 4.0 and other digital innovations (Dadi et al. 2021; Sahoo et al. 2021), with financial and sustainability information being integrated (Anguiano-Santos and Rodríguez-Entrena 2024; Cricelli et al. 2024). In this context, companies with robust digital capabilities, effective financial management, and a strong commitment to ESG criteria achieve superior overall results through the implementation of integrated reporting (Marczewska et al. 2025).

Several studies have shown that food processing companies are adopting comprehensive strategies to reduce their environmental impact. On the one hand, this involves the use of technological innovations. These include using recyclable materials, biodegradable packaging, lightweight designs, and renewable resources (Abatan et al. 2024). It also involves the efficient management of resources. The sector is therefore showing a trend towards more sustainable production models, with environmental actions focused on the efficient management of water, energy, and waste (Cantino et al. 2017; Esposito De Falco et al. 2021; Lindkvist and Saric 2020; Yilmaz 2022) as well as social action in this regard (Siew 2023).

In addition, we should consider the circular economy and digitalization. These companies' traditional business models are shifting towards a circular model that follows ESG criteria to reduce their carbon footprint, GHG emissions, water consumption and waste (FAO 2019; Gustavsson et al. 2011). Similarly, strategies for circularity and digitalization demonstrate how traceability and waste management can be incorporated into the value chain (Geissdoerfer et al. 2017). Currently, ecodesign and the quantification of environmental footprints are promoted to improve process efficiency (Alvarez et al. 2014). However, the sector faces challenges including potential greenwashing, underscoring the importance of independent assessments (Delmas and Burbano 2011).

The objective of this research is to graphically visualize the relationship between the long-term solvency ratio and sustainability performance (Cantino et al. 2017; Gómez-González et al. 2025; Lindkvist and Saric 2020; Yilmaz 2022), as measured with some ratios defined according to Directive 2022/2464 (CSRD) and the 12 ESRS: *energy intensity* (total energy consumption per net revenue, megawatt-hours per million euros); *water intensity* (total water consumption in cubic meters per million euros); *waste intensity* (company waste generation in tons per million euros); and *gender employment gap* (proportion of male and female workers). Specifically, the ESG indicators considered in this study include relevant examples from the ESRS regulation focused on key environmental and social aspects, such as energy and water resources management, the circular economy, and transparency in the proportion between men and women in the value chain.

This article is also a methodological illustration of how to relate financial and ESG indicators. Ratios, be they financial or sustainability related, are subject to serious problems of asymmetry and outliers in statistical analysis (Frecka and Hopwood 1983; Iotti, Ferri, et al. 2024; Iotti, Manghi, and Bonazzi 2024; Isles 2020; Linares-Mustarós et al. 2018, 2022). The Compositional Data (CoDa) methodology (Aitchison 1982, 1986; Pawlowsky-Glahn et al. 2015) effectively solves these problems. As of now, few firms publish complete and comparable ESG reports, so that samples are small and not representative, lending themselves more to graphical and descriptive statistical tools than modeling and inference. As a joint graphical visualization tool for the financial and ESG ratios, we use the CoDa biplot, which up to now has been only done for financial (Carreras-Simó and Coenders 2020; Saus-Sala et al. 2021, 2023) and ESG ratios (Todorov and Simonacci 2020) separately. This is also the first time in which visualization tools have combined financial, environmental and social indicators, with any methodology.

After this introduction, the methodological section will discuss the challenges related to ratios, the CoDa approach, and particularly the biplots, which make it possible to represent all companies along any ratio between any two financial or ESG figures. The results section shows how to interpret the results and draw conclusions visually, providing both recommendations for single companies based on integrated information and establishing relationships among indicators. The discussion opens new avenues for research when the obligation to submit sustainability reports will be more extensive and the information and the indicators required in these reports (ESG ratios) will be understandable and standardized. Only then will the analysis of sustainability reports become more general, verifiable and comparable.

2 | Methodology

2.1 | Use and Limitations of Financial Ratios in Business Analysis

Since the late 1800s, business analysis has employed ratios (Horrigan 1968), a practice with both supporters and critics. The idea that a simple division provides valuable information for analysis or prediction (Barnes 1987) has led to their use for many purposes.

In general, financial analysis using ratios can be divided into two main groups of studies: those that assess the economic and financial situation of a company and prediction models. In the assessment domain, ratios are used as a tool for decision making. Examples can be found in the analysis of liquidity (Herrera Freire et al. 2017), analysis of corporate profitability (Qin et al. 2022; Trejo-Pech et al. 2023), debt capital (Iotti, Manghi, and Bonazzi 2024), equity valuation (Nissim and Penman 2001) or a combination of all of them (Piotroski 2000). Examples of prediction models include those dealing with bankruptcy or failure (Altman 1968; Beaver 1966; Dimitras et al. 1999; Hillegeist et al. 2004; Soukal et al. 2024; Staňková and Hampel 2023; Veganzones and Severin 2021; Wilson and Sharda 1994), sometimes combined with credit risk (do Prado et al. 2016). They are also used to predict fraud (Amat Salas 2020) or stock market returns (Dimitras et al. 1999).

Ratios have been used to analyze one or more companies, or to directly examine a sector, sub-sector or companies in a particular geographical location. Examples include studies of small firms (Tascón et al. 2018), dotcom companies (Ravisankar et al. 2010), Belgian manufacturing industries (Buijink and Jegers 1986) or the biogas sector (Iotti, Manghi, and Bonazzi 2024).

In the current business environment, financial ratios alone are insufficient for a comprehensive company analysis. It is also necessary to consider other key performance indicators, including efficiency, sustainability, impact, engagement, and innovation (Siew 2023). These new indicators, which are also ratios, allow the degree of compliance to be monitored and comparisons to be made between companies. Ratios are sufficiently objective to satisfy all interest groups (Denčić-Mihajlov and Zeranski 2017).

Ratios are a proven tool for the analysis of one company, or for the comparisons between very few companies. When applied to a statistical analysis of a data set, the use of ratios has a few limitations.

- It is difficult to achieve symmetry with the raw values of financial ratios. Statistically, asymmetry leads to invalid inferences about the population being studied because many statistical methods require normal distributions to produce valid results (Faello 2015; Frecka and Hopwood 1983; Iotti, Manghi, and Bonazzi 2024; Linares-Mustarós et al. 2018; Oktaviano et al. 2024; Trejo-Pech et al. 2023).
- Outliers are inconsistent observations that have a large effect on the statistical results. The reason for this can not only be that the data comes from an atypical company, but also that the ratio denominator is close to zero, resulting in an unreasonably high ratio (Faello 2015; Frecka and Hopwood 1983; Linares-Mustarós et al. 2018).
- Non-linearity of the relationships distorts the correlations and covariances on which statistical models and principal component analysis are based (Carreras-Simó and Coenders 2021; Cowen and Hoffer 1982).
- Finally, results are inconsistent when permuting the denominator and the numerator of the ratio, for instance when considering assets over liabilities—solvency—instead of liabilities over assets—indebtedness (Coenders, Sgorla, et al. 2023; Frecka and Hopwood 1983; Linares-Mustarós et al. 2022)

2.2 | Overcoming Limitations and the Application of Compositional Data

The prevailing approach to the ratio problems is to identify solutions for each individual case. For outliers, the challenge lies in both their detection (Frecka and Hopwood 1983; Sullivan et al. 2021) and treatment. Simple methods that have been commonly used include their elimination or winsorizing (Deshpande 2023; Lev and Sunder 1979). More robust methods such as Mahalanobis distances (Sullivan et al. 2021) have also been employed.

In terms of techniques to achieve symmetry and linearity, there are several options to consider. These include data transformation techniques, such as square or cubic roots (Deakin 1976; Martikainen et al. 1995), Box-Cox transformations (Watson 1990), and rank transformations (Kane et al. 1998), among others.

A variety of methodologies have been employed in the treatment of violations of normality. These include non-parametric methods (Iotti, Ferri, et al. 2024; Iotti, Manghi, and Bonazzi 2024) and robust standard errors (López-Gutiérrez et al. 2015).

Despite the existence of partial solutions to the ratio issues, it was of significant interest to researchers and professionals to identify a technique that could resolve all the issues simultaneously. This objective was achieved through the implementation of a well-developed toolbox known as Compositional Data (CoDa) Analysis (Aitchison 1982; Coenders, Egozcue, et al. 2023; Pawlowsky-Glahn et al. 2015), which originated in the STEM scientific fields but has since been applied to numerous other areas, including financial analysis (Arimany Serrat et al. 2022; Coenders, Sgorla, et al. 2023; Fry 2011; Magrini 2025).

The employment of the CoDa methodology has been demonstrated to facilitate the elimination of asymmetry, non-linearity and outliers and to enable the permutation of the numerator and denominator of the ratios (Carreras-Simó and Coenders 2020). Furthermore, the methodology is applicable to different statistical methods, parametric and non-parametric, with and without robust standard errors, and with a full non-trimmed sample, which represents a significant advantage.

The starting point of the CoDa methodology is the composition, defined as an array of D strictly positive numbers called parts, for which ratios between them are considered to be relevant by the researcher (Egozcue and Pawlowsky-Glahn 2019).

$$\mathbf{x} = (x_1, x_2, \ldots, x_D) \text{ with } x_j > 0, j = 1, 2, \ldots, D \tag{1}$$

Even if the CoDa methodology was first developed to analyze the parts of a whole with a fixed sum in chemical, biological and geological analyses (Aitchison 1982, 1986; Barceló-Vidal and Martín-Fernández 2016), this is by no means a requirement. An early application of the CoDa methodology to analyze ratios among parts that neither constitute a whole nor have a fixed sum is in Azevedo Rodrigues et al. (2011). The objective of the CoDa methodology, broadly understood as a focus on ratios among the parts, is thus the same as in financial ratio analysis. This means that positive accounting figures can be treated as compositional parts if researchers are interested in their relative structure, enabling a better analysis of their ratios with the CoDa methodology. See Egozcue and Pawlowsky-Glahn (2019), and Barceló-Vidal and Martín-Fernández (2016) for the mathematical foundations, and Linares-Mustarós et al. (2018) for the applicability to management ratios.

2.3 | Selection of Variables

The first step is to select the parts to be analyzed and adapt them to the CoDa methodology. The idea of our study is in line with the idea of Triple Bottom Line (TBL) reporting (Elkington 1998; Nogueira et al. 2023; Zaharia and Zaharia 2021), which recognizes that to achieve corporate sustainability we need to link the economic, social and environmental roles of the company. The selection of indicators for each company will therefore be a mixture of financial and sustainability indicators. There are many potential such indicators and what follows is only a simple example aimed at the illustration of the proposed methodology, subject to the limited data availability as explained below.

In the example which follows and in terms of financial indicators, net revenue, total assets, and total liabilities have been selected, while the rest are indicators that allow us to examine sustainability issues. In terms of sustainability, some indicators have been selected related to energy, water resources, circular economy, and employee gender distribution.

All indicators are represented by the x_j parts in the composition, which are the $D=8$ positive financial and sustainability figures. The parts that need to be selected are just those needed to compute the financial and ESG ratios of interest. In this illustrative example they are:

- x_1: net revenue,
- x_2: total assets,
- x_3: total liabilities,
- x_4: energy consumption,
- x_5: water consumption,
- x_6: waste generation,
- x_7: male employees,
- x_8: female employees.

The financial ratio we will use is the solvency ratio because it is related to capital structure and is critical in its relationship to sustainability performance and can be affected by the investments needed to improve said performance (Cantino et al. 2017; Lindkvist and Saric 2020; Yilmaz 2022).

- The solvency ratio measures the extent of a company's leverage:

$$\text{Solvency ratio} = \text{total assets} / \text{total liabilities} = x_2 / x_3 \tag{2}$$

Sustainability has been measured in a variety of ways, including semi-structured interviews (Khan and Quaddus 2015), the use of a balanced scorecard (Vu et al. 2017), an integrated model (Castro and Chousa 2006), or a questionnaire survey (Andersson et al. 2022). In this article, we have chosen to analyze sustainability using ratios as key performance indicators (Siew 2023).

Following the implementation of the CSRD and the ESRS, companies will transition to reporting sustainable indicators in a unified manner. The ESRS represent a practical implementation tool, organized in 12 standards. Each standard includes information on governance, strategy, impact, risk, and opportunity management across the value chain, as well as metrics and guidance on disclosure targets for each topic. In addition, there is a section on calculation guidelines, which contains ratios.

- Energy intensity: Included in the ESRS under the climate change theme and the energy sub-theme, it assesses the efficiency of energy use. It is measured as total energy consumption per net revenue, and the units are megawatt hours per million EUR.

$$\text{Energy intensity} = \text{energy consumption} / \text{net revenue} = x_4 / x_1 \tag{3}$$

- Water intensity: Classified in the ESRS under the theme of water and marine resources and the sub-theme of water use, it measures efficiency in the use of clean water and sanitation. This key performance indicator is measured as total water consumption in cubic meters per million EUR in net revenue.

$$\text{Water intensity} = \text{water consumption} / \text{net revenue} = x_5 / x_1 \tag{4}$$

- Waste intensity: Classified in the ESRS under the circular economy theme and the waste sub-theme, it is a measurement of the company's waste generation. The unit of measurement is tons per million EUR.

$$\text{Waste intensity} = \text{waste generation} / \text{net revenue} = x_6 / x_1 \tag{5}$$

- Gender employment gap: Classified in the ESRS under the theme of workers in the value chain and the sub-theme of equal treatment and opportunities for all, it measures the ratio of male and female employees.

$$\text{Gender employement gap} = \text{male employees} / \text{female employees} = x_7 / x_8 \tag{6}$$

2.4 | Log-Ratio Transformations

The use of CoDa does not remove the need for interpretation and visualization, as would be the case with any other statistical data. However, it does mean that the input data must be prepared according to the CoDa methodology for visualization purposes (Saus-Sala et al. 2023; Todorov and Simonacci 2020). Computing logarithms of the ratios (log-ratios) is the necessary transformation of the input data (Pawlowsky-Glahn et al. 2015). The simplest form of log-ratios is the so-called pairwise log-ratios (PLR), computed between only two parts, as in Equations (2–6), just adding the log (Aitchison 1983):

$$\log\left(\frac{x_i}{x_j}\right) \tag{7}$$

After log-ratio transformation, ratios have fewer outliers and lower asymmetry, are closer to a normal distribution and have close to linear relationships (Aitchison 1986; Carreras-Simó and Coenders 2021; Linares-Mustarós et al. 2018, 2022; Pawlowsky-Glahn et al. 2015). Besides, log-ratios are invariant to numerator and denominator permutation, which affects only their sign:

$$\log\left(\frac{x_i}{x_j}\right) = \log(x_i) - \log(x_j) = -\left(\log(x_i) - \log(x_j)\right) = -\log\left(\frac{x_j}{x_i}\right) \tag{8}$$

Such permutations are common in practice. As an alternative to the solvency ratio in Equation (2), the permuted ratio (*total liabilities*)/(*total assets*)$=x_3/x_2$ is also commonly used, measuring indebtedness as opposed to solvency.

Furthermore, a change of units of measurement results in just adding a constant to the log-ratios, without affecting their variances and covariances. There is thus no problem in using log ratios when different parts have different units of measurement, as in our example (million EUR, megawatt hours, tons, cubic meters, and employees).

$$\log\left(\frac{kx_i}{x_j}\right) = \log(k) + \log\left(\frac{x_i}{x_j}\right) \tag{9}$$

Another useful type of log-ratio employed in CoDa is the centered log-ratio or CLR (Aitchison 1983). Although the CLR transformation has no direct interpretation, it is highly useful in multivariate analysis and can be used as raw data for the visualization tools such as the biplot, which will be discussed in more detail later. The process involves obtaining a centered log-ratio for each part, which in our case will be eight. For each of these, the CLR will relate the part to the geometric mean of the total set.

$$\begin{aligned} \mathrm{CLR}_1 &= \log\left(\frac{x_1}{\sqrt[8]{x_1 x_2 \dots x_8}}\right) \\ \mathrm{CLR}_2 &= \log\left(\frac{x_2}{\sqrt[8]{x_1 x_2 \dots x_8}}\right) \\ &\dots \\ \mathrm{CLR}_8 &= \log\left(\frac{x_8}{\sqrt[8]{x_1 x_2 \dots x_8}}\right) \end{aligned} \tag{10}$$

The fact that the CLR are not interpretable constitutes no drawback. In following subsections we will show that the results are interpreted on the PLR.

2.5 | Data Collection

The data refers to 2023 and was obtained using three tools: the Sabi INFORMA (Iberian Balance sheet Analysis System, accessible at https://sabi.bvdinfo.com) database, the companies' websites, and the annual financial statements and management reports. The financial indicators required (x_1: net revenue, x_2: total assets, and x_3: total liabilities) can be obtained from the financial statements that companies are obliged to file annually with the Commercial Registry, which are public.

The remaining parts (x_4: energy consumption; x_5: water consumption; x_6: waste generation; x_7: male employees; x_8: female employees) are non-financial variables that can be obtained from companies' ESG reports. However, as of now, the format, detail, and depth of data vary significantly between companies. This situation will be resolved once Directive 2022/2464 is transposed and companies submit a sustainability report in accordance with the ESRS.

Until 2017, Spanish companies had the option of disclosing their non-financial data. However, following the transposition of Directive 2014/95 in 2018, all companies preparing consolidated accounts must include a non-financial information statement in the consolidated management report if they meet the following criteria:

a. The average number of employees is more than 500.
b. They are public interest entities, or that for two consecutive financial years they meet at least two of the following circumstances:
    1. The total assets of the company exceed EUR 20 MM.
    2. The net revenue exceeds EUR 40 MM.
    3. The average number of employees exceeds 250.

In the case of companies that form part of a corporate group, the requirements are based on the same criteria referring to the employees of the group and to the total consolidated assets and net revenue. Individual companies have the option of either including a statement of non-financial information in the management report or producing a separate report. Groups, on the other hand, are required to provide a consolidated annual report that includes both financial and non-financial information. For our reporting needs, the consolidated annual report filed with the Commercial Register was the most appropriate document, as it has the advantage that many groups present all information we need, financial and non-financial. The disadvantage is that we must manually extract the relevant information.

2.5.1 | Sabi INFORMA

The Sabi INFORMA tool is a software solution that facilitates the analysis of financial data from Spanish and Portuguese companies.

TABLE 1 | Descriptive statistics for the $n = 17$ company groups in the sample.

	Mean	SD	Minimum	Q1	Median	Q3	Maximum
Net revenue (MM EUR)	974	1035	54	211	713	1040	4148
Total assets (MM EUR)	635	660	44	123	376	992	2622
Total liabilities (MM EUR)	378	380	23	80	255	603	1424
Energy consumption (megawatt hours)	195,489	238,643	6269	42,281	111,003	212,310	878,780
Water consumption (m^3)	1,421,715	1,432,267	35,730	323,252	944,041	1,548,640	4,448,501
Waste generation (metric tons)	45,369	104,225	329	3441	13,166	27,783	453,002
Male employees	1371	1278	82	408	608	1949	4964
Female employees	830	597	117	236	763	1118	2017

Its advanced search system, complete with filters, allows users to specify the necessary restrictions to obtain data tailored to their study's requirements. It also allows users to consult the financial statements filed by companies in the Commercial Registry.

The following restrictions were applied:

- The companies were active,
- operated within the sectors classified according to the NACE codes 101X (Processing and preserving of meat and production of meat products) and 102X (Processing and preserving of fish, crustaceans, and molluscs),
- submitted consolidated financial statements,
- and fulfilled the requirements for submitting the consolidated management report.

Following a thorough evaluation of the established requirements set out in Spanish Law 11/2018 for the 2023 financial year, 20 company groups belonging to the meat production sector and 8 to the fish and seafood sector were identified. Once the resulting list of companies has been obtained, it is possible to define a report with the necessary variables. However, in our case, due to the requirement for non-financial data, an individual data search was necessary.

2.5.2 | Financial Statements and Management Reports Filed With the Commercial Registry

Non-financial information is subject to the same regime of formulation, approval and publication in the Commercial Registry as the financial statements. For this reason, we were able to consult the deposited consolidated management reports of the above company groups to obtain the eight financial and non-financial indicators we needed. The parent company is obliged to prepare the consolidated non-financial information statement, including all its subsidiaries and for all the countries in which it operates.

After deleting companies with incomplete data for key variables, the final sample comprised 17 company groups, representing 60% of the total. These company groups are also representative of their respective sectors: 11 groups are from the meat sector (accounting for 44.8% of the sector's total net revenue), and six are from the fish sector (accounting for 59.5% of the sector's total net revenue). There was also a need for harmonization of the data, as some companies had different measurement units for the same part (e.g., kilowatt vs. megawatt or thousand vs. million EUR).

We also conducted a thorough review of the websites of all relevant company groups but were unable to identify any additional data beyond what was previously outlined. The descriptive statistics are in Table 1.

In conclusion, we find the information provided to be relevant. While it is not feasible to infer structural aspects at this stage, we are dedicated to presenting descriptive results and new methodological approaches that will lay the groundwork for a later analytical framework. This framework can be applied once more ESG data from companies complying with the ESRS become available.

2.6 | Compositional Biplot

To visualize and interpret the financial and sustainability PLR, a CoDa biplot was drawn. A CoDa biplot is based on a principal component analysis of the covariance matrix of the CLR (Aitchison 1983; Aitchison and Greenacre 2002; Greenacre et al. 2022).

Principal component analysis is a multivariate descriptive or exploratory statistical method that has been widely applied in the analysis of financial statements (Carreras-Simó and Coenders 2020; Coenders 2025; Coenders and Arimany-Serrat 2025; Saus-Sala et al. 2021, 2023). The biplot's key strength is its ability to simultaneously visualize all companies in the sectors of study and all their possible PLR. In this article we apply it for the first time to financial and sustainability data, thus broadening the spectrum of analysis and applicability of the tool. The biplot is generated using CaDaPack2.03.06, which is available free of charge at https://ima.udg.edu/codapack/.

The horizontal and the vertical axis of the CoDa biplot are the first two principal components, but they are not needed for

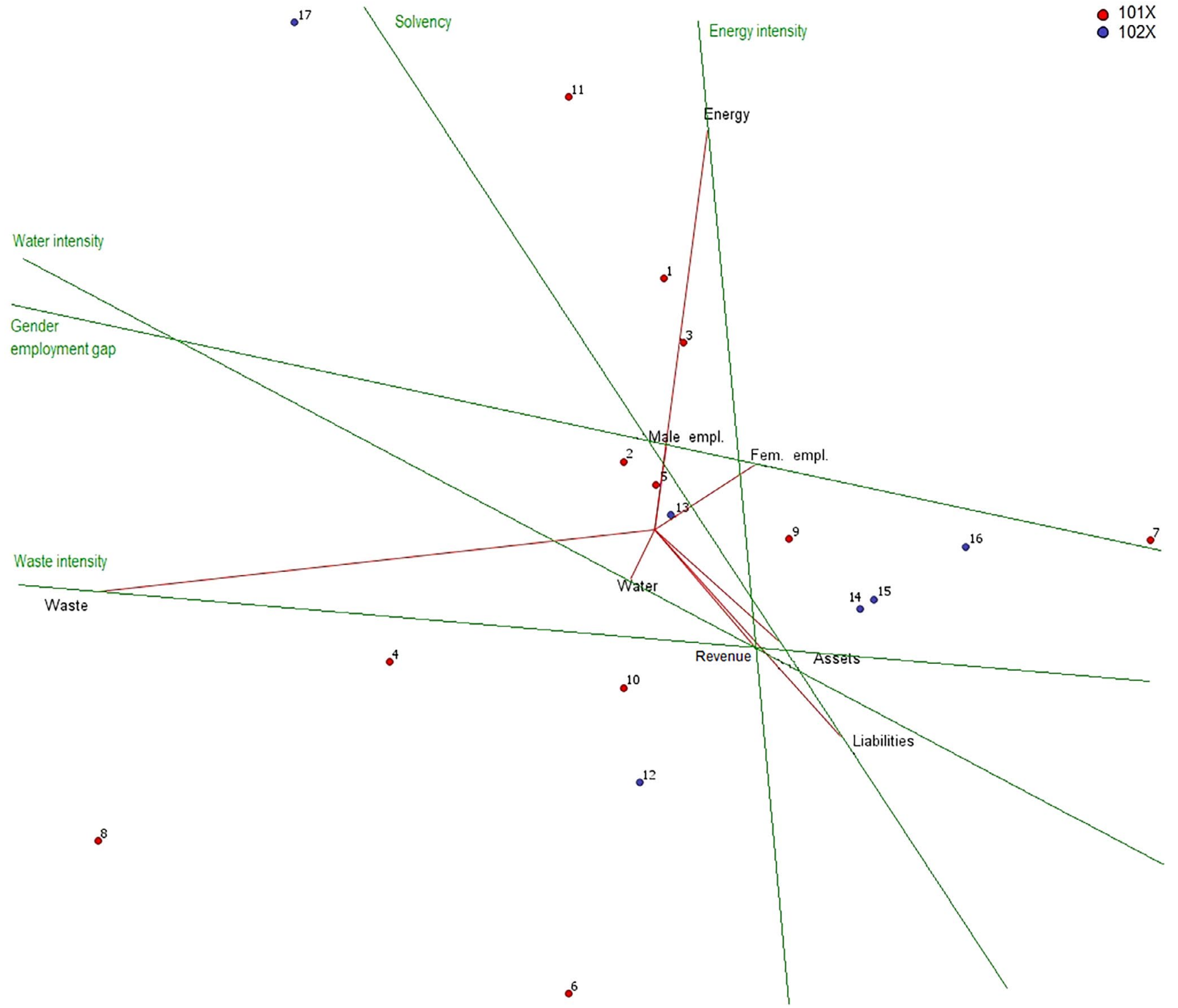

FIGURE 1 | CoDa biplot of the financial and ERSR ratios on our example.

interpretation and are not drawn. The company groups under study are represented by a point. The CLR corresponding to the eight parts in Equation (10) are plotted using rays emanating from the origin of coordinates. The extreme end of these rays contains the relative importance of the part in the numerator of the CLR. The origin of coordinates itself represents the sample average. A company close to the origin would have an average behavior in all parts.

Since CLR are not directly interpretable in financial or sustainability terms, the key interpretational tool in the biplot is that it allows lines to be drawn between two extremes of the rays between any two parts in order to obtain the PLR between them. These additional lines, called links, make it possible to rank all the company groups according to any particular ratio like those in Equations (2–6). To do this, the companies are projected orthogonally (i.e., at 90° to the link) onto the line. Once projected onto the corresponding ratio, they are sorted according to their proximity to the numerator or denominator of the ratio displayed.

The angles between the links can be interpreted as correlations between PLR. Two links that are close to being parallel and run in the same direction have a strong positive correlation. Two links that are close to being parallel and run in the opposite direction have a strong negative correlation. Two links that are close to being orthogonal have a weak correlation. It must be taken into account that only links with no parts in common have an interpretable correlation. When the two PLR are computed from common parts, correlations are unavoidably spurious (Pearson 1897).

3 | Results

The CoDa biplot in Figure 1 is the main result of the study. The visualization of the company groups has been set so that companies in the meat production sector (NACE 101X) are colored red, while those in the fish sector (NACE 102X) are colored blue.

An initial analysis of the distribution of the colored points is warranted. This analysis reveals that the blue-colored company groups exhibit higher levels of concentration, while the red-colored company groups demonstrate greater dispersion, indicating a lower degree of similarity between them.

By joining the extreme of the assets CLR ray with that of the liabilities CLR ray, we obtain the link representing the log of the solvency ratio (assets/liabilities) in Equation (2), represented as a green line. The company groups are then orthogonally projected on this line. In this way, it is interpreted that those companies whose projection is closer to the asset side have a significantly high solvency ratio. Conversely, those closer to the liability side have a high indebtedness. Distance to the link does not matter. Company groups 11 and 17 stand out for the highest solvency and company group 6 for the lowest.

By joining the extreme of the energy and revenue rays we obtain the link representing the log of the energy intensity ratio (energy/revenue) in Equation (3). The company groups projecting closer to the energy extreme have a significantly high energy intensity ratio, and those closer to the revenue ray have a lower energy intensity ratio. Company groups 11 and 17 stand out for the highest energy intensities and company group 6 for the lowest.

The link between the extremes of the water and revenue rays in Equation (4) yields the water intensity ratio (water consumption/revenue). The company groups projecting closer to the water extreme exhibit a higher water intensity ratio, whilst those approaching the revenue ray demonstrate a lower water intensity ratio. It is notable that companies in groups 17, 8, and 11 display the highest levels of water intensity, while those in groups 7 and 16 exhibit the lowest.

The link between the extremes of the waste and revenue rays represents the waste intensity ratio (waste/revenue) in Equation (5). The company groups that are closer to the waste extreme have a significantly high waste intensity ratio, while those that are closer to the revenue ray have a lower waste intensity ratio. Company groups 8, 17, and 4 are distinguished by the highest levels of waste intensity, while groups 16 and 7 are notable for their comparatively low levels of waste intensity.

The gender employment gap (male employees/female employees) in Equation (6) is represented by the link between the extremes of the male and female employee rays. The company groups with a greater propensity to have more male employees have a much more pronounced gender gap. Conversely, the company groups that are closer to the female extreme have a smaller gender gap, characterized by a higher proportion of female employees relative to male employees. It is noteworthy that company groups 17, 8, and 4 have the most pronounced gender gaps, while company groups 7 and 16 have the least pronounced gaps.

Company groups 2, 5, and 13 are very close to the origin of the rays, which indicates that they have financial and ESG performance close to the sample average.

If we look at the near parallel links relating financial and sustainability indicators, companies with greater long-term solvency present a higher energy intensity. The correlation can be interpreted because the two links have no part in common (energy vs. revenue and assets vs. liabilities). The actual correlation is 0.28. As an example of a non-interpretable correlation, waste and water intensity are also close to being parallel, but their correlation (0.35) is largely due to they having a common denominator and is not interpretable.

4 | Conclusions and Discussion

This research visualizes energy, water and waste efficiency as a strategic need for the competitiveness and sustainability of the meat and fisheries sector, due to its resource intensity and ecological impact. Specifically, in terms of energy, the adoption of efficient refrigeration technologies, heat recovery and the integration of renewable energies reduce emissions and costs (Schröter 2025). In terms of water, the implementation of recirculation systems and the reuse of wastewater with appropriate technologies help reduce the water footprint, especially in sectors such as meat, which is responsible for 75% of the water loss associated with food waste (Skawińska and Zalewski 2022). Regarding the fish sector, there are studies that show an increase in the water footprint per ton produced (Pahlow et al. 2015), with the need to optimize refrigeration and washing systems. Regarding waste management, the valorization of by-products and the reduction of plastic packaging help to achieve circular economy models (Singh et al. 2022).

It is also relevant to consider the gender perspective in the meat and fish sectors to improve sustainability, productivity and innovation, as gender equality is directly linked to more inclusive, resilient and competitive societies on a global scale.

Once the results of the study have been presented and according to the analysis developed in the meat sector (in red) and the fish sector (in blue), considering the long-term solvency ratio (which measures a company's capacity to meet its long-term financial obligations); energy, water and waste intensity; and the gender employment gap, using a CoDa biplot, the study shows that fish companies present higher levels of concentration, while meat companies show greater dispersion. This situation indicates a lower degree of similarity between these companies, despite belonging to the agri-food sector.

On the other hand, the study concludes that companies with greater long-term solvency exhibit lower energy efficiency. It is possible to link solvency with energy efficiency, although this relationship may depend on more than one economic and management mechanism. Firstly, investments in energy efficiency technologies require significant resources, which can be financed through debt, potentially reducing future solvency. This situation hinders progress toward the challenges of the 2030 Agenda and can even generate greenwashing risks. Subsidies such as Next Generation EU can mitigate this negative relationship. In other words, the inverse relationship between long-term solvency and energy efficiency is conditioned by the necessary financial flexibility required for environmental innovation, which is difficult to achieve depending on adaptive capacities and institutional structures. Companies with financial adaptability show a greater propensity for environmental innovation if they have adaptive capacities and favorable institutional structures (Wang et al. 2025).

Second, low solvency limits the future capacity to finance the investments needed to improve energy efficiency. Potentially, companies with greater solvency can aspire to have better environmental management systems, audits, ESG metrics, and certifications to continuously improve their environmental performance. Greater solvency could also improve environmental governance capabilities and facilitate energy efficiency. This second mechanism would result in a positive relationship between solvency and energy efficiency, but our results show a predominantly negative relationship in the sample of Spanish meat and fish processing companies that publish comprehensive ESG reports. It is worth noting that studies suggest that sustainability practices are not necessarily limited to financially sound and solvent companies (Čater et al. 2023). Furthermore, although solvent companies have resources to invest in environmental management, there are cases such as ExxonMobil, Shell, JBS, or Volkswagen that show that financially strong companies can maintain poor environmental practices or resort to greenwashing, which demonstrates that solvency does not necessarily imply environmental effectiveness (García 2024; Siano et al. 2017).

The strength of the CoDa biplot lies in its ability to interpret the position of single company groups, which can result in tailored management recommendations. Specifically, company groups 11 and 17, meat and canned fish respectively, stand out for their high solvency and high energy and water intensities, in contrast to meat company group 6. It should be noted that company group 17 has ISO 14001 and ISO 45001 certifications and has received subsidies to improve energy efficiency with co-financing from the European Regional Development Fund (ERDF). Specifically, it received a subsidy co-financed by the European Agricultural Fund for Rural Development. In addition, company group 17 has a high intensity in waste and a high gender gap. In spite of their certifications and subsidies, these two companies stand out for their need to continue improving their environmental efficiency. As for company group 6, which has a low solvency, it has implemented renewable energy and thermal recovery systems, has the best energy intensity, and needs more actions only with respect to waste intensity and the gender gap, whose investments should be financed by shareholders' equity in order to improve solvency.

Regarding water consumption intensity, meat company group 8 also presents high levels of consumption, unlike company groups 7 and 16, meat and fish respectively, which have lower levels. Regarding waste intensity, company groups 4, 8, and 17 are distinguished by high values, compared to company groups 7 and 16, which are lower. It is noteworthy that company groups 4, 8, and 17 present pronounced gender gaps, while company groups 7 and 16 do not present so much inequality. It is noteworthy that meat company group 8, despite having high water consumption, high waste generation, and a high gender gap, has a commitment to sustainability and has installed self-consumption solar panels in all its production centers, generating more than 15 GWh per year and significantly reducing CO_2 emissions. At the same time, it has implemented measures to improve the efficiency of water use and has incorporated circular economy practices into its processes. It also promotes gender equality and regional development through a foundation, which supports vulnerable groups.

Meat company group 7 applies measures to optimize energy and water consumption in its production processes, as well as protocols for waste management, and promotes gender equality initiatives. In Figure 1, water and waste intensity is low, as is the gender gap.

Therefore, the companies in the sample analyzed that strongly deviate from the average are mostly meat company groups (6, 7, 8, 11) and one canned fish company group (17). The study shows that Spanish food processing companies have different strategies in terms of sustainability. Specifically, company group 6 is committed to renewable energy and thermal recovery, as well as efficient water and waste management with a circular economy model recognized with external certifications. Fish company group 17 integrates sustainability into its logistics and production, with special emphasis on reducing its carbon footprint through rail transport and plans more gender equality policies. Company group 8 has promoted an ambitious solar self-consumption plan and has incorporated measures for water efficiency and circularity, while strengthening its social responsibility through its foundation. Finally, company group 7 communicates good practices in the meat sector, optimizing resources, waste management and initiatives for labor equality. The study highlights the high solvency of meat company group 11 and fish processing company group 17, unlike meat company group 6, which has low solvency.

The study also identifies company groups 2, 5, and 13, which are the closest to the sample average in terms of solvency, energy intensity, water intensity, waste intensity, and gender gap. All three company groups have the operational capacity to finance the necessary environmental transitions. Regarding sustainability performance, company group 13 (canned fish) has more than 95% of waste destined for recycling and/or recovery. Company group 5 (meat) has a plan that sets measurable objectives (−10% water and emission reductions) and communicates progress regarding their own renewable energy and the reduction of GHG emissions from 2020. Finally, meat company group 2 communicates photovoltaic investments and decarbonization. Regarding long-term solvency, all three have the operational capacity to finance environmental transitions.

Methodologically, this article presents the first joint visualization of ESG and financial indicators. Since ESG indicators are also ratios (Todorov and Simonacci 2020) the same CoDa biplot used for financial ratios (Carreras-Simó and Coenders 2020; Saus-Sala et al. 2021, 2023) can accommodate both. In just two dimensions company or company groups can be ordered according to the ratio between any two magnitudes, be they financial or ESG.

The research has limitations. The first two, small sample and single-year data are dictated by the slow and progressive adoption of the ESRS in the sustainability reports in Spain. The third is the few financial and ESG indicators included in this first example, a consequence of the ambiguity in the old regulations governing the information and indicators included in the non-financial reports. While its value as an illustration of the methodology is not diminished, its value as an exhaustive and representative picture of the population of companies is. This greatly limits the generalizability of the results and may lead to patterns driven by individual firms rather than structural trends. Precisely, the CoDa biplot is specialized at representing just this, the individual firms. The need to extend this type of study as soon as more firms publish more comprehensive reports is obvious. To this end, future lines of study will focus on sectors of activity that start to have larger samples with complete ESG information, data from more than 1 year, and more indicators which will be standardized and comparable between firms, such as short-term solvency in terms of cash flow, profitability, GHG emissions, percentage of employees with disabilities, gender pay gap, and board's gender diversity, to assess this integrated information that is crucial for making business decisions.

The biplot is by nature a descriptive and exploratory statistical tool. Statistical modeling and inference using other tools within the CoDa methodology will also be possible as soon as larger samples which are representative of the selected sectors become available, as it is already being done for studies of financial indicators only, for which large samples are always available (Carreras-Simó and Coenders 2021). In the case of biplots, large samples can be a mixed blessing, as many points can make the biplot difficult to read. In this case, only selected companies may be displayed even if all contribute to the CLR covariances leading to the biplot (Carreras-Simó and Coenders 2020). Alternatively, a cluster analysis can be carried out before the biplot representations, in which only cluster centers would then be shown.

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Data Availability Statement

The curated anonymized data file is available from the corresponding author upon reasonable request.

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