Business Strategy and the Environment

WILEY | Business Strategy and the Environment

RESEARCH ARTICLE OPEN ACCESS

The Sustainability Blind Spot in Manufacturing SMEs: A Contingency Perspective on Performance Measurement

Alessandra Neri[1] | Enrico Cagno[1] | Sandra Naomi Morioka[2] | Ivan Bolis[2]

[1]Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Milan, Italy | [2]Department of Production Engineering, Federal University of Paraíba, João Pessoa, Paraíba, Brazil

Correspondence: Alessandra Neri (alessandra.neri@polimi.it)

Received: 12 June 2025 | **Revised:** 5 June 2026 | **Accepted:** 8 July 2026

Keywords: indicators | manufacturing | performance | SMEs | sustainability

ABSTRACT

Measuring sustainability performance is crucial for small and medium-sized manufacturing enterprises and sustainability indicators must be incorporated into decision-making. However, companies tend to measure only the aspects that interest them, disregarding those considered less strategic or relevant. There is still no consensus on how to integrate sustainability indicators across different manufacturing contexts and the current literature lacks empirical research on their adoption. This study collected empirical data from 150 Italian small and medium-sized manufacturing enterprises to examine how they measure their sustainability performance. Furthermore, drawing on contingency theory, the study explores the influence of selected contextual factors (sector, size, understanding of sustainability and certifications held) on the measurement of sustainability performance and the relationships among these factors. The sampled companies primarily focus on sustainability aspects related to production or mandated by legislation. The most frequently covered aspects concern costs, income, waste, materials and occupational health and safety. Broader sustainability aspects involving customers, suppliers and the community are largely overlooked. Results show that the industrial sector significantly influences sustainability performance measurement systems, whereas size primarily affects the number of indicators measured. The sector also interplays with the certifications held and the understanding of sustainability, revealing an interesting interplay among different contextual factors. Lastly, the study suggests avenues for further research to enhance the understanding of sustainability performance measurement in small and medium-sized manufacturing enterprises. Practical implications indicate the need for sector-specific and size-specific solutions to support sustainability performance measurement, while promoting further certifications and improving understanding of the sustainability concept among practitioners.

1 | Introduction

There is urgency to measure sustainability performance in manufacturing companies. Companies receive pressure from stakeholders to improve their sustainability performance (Henao and Sarache 2022). As what is not measured cannot be improved (Neri 2021), measuring sustainability performance is a fundamental step. Even though studies investigating the integration of sustainability aspects into companies' performance measurement are not a recent debate (Morioka and de Carvalho 2016; Searcy 2016) and measuring sustainability performance is a strategic tool with a significant impact on decision-making (Osório De Andrade Guerra et al. 2023), there is still limited empirical evidence on which indicators companies actually adopt in practice and how these indicators reflect the real sustainability priorities perceived by companies.

The concept of sustainability can be described using the triple bottom line (TBL) model proposed by Elkington (1997), which comprises three pillars: economic, environmental and social.

An appropriate measure of sustainability performance should thus be derived from evaluating the three pillars (Nordheim and Barrasso 2007) and their intersections (Cagno et al. 2019).

Performance measurement is a relevant part of the decision-making process in companies (Osório De Andrade Guerra et al. 2023). It helps reveal strategic priorities and identify actionable areas for improvement while also addressing trade-offs (Pazienza et al. 2026). Performance indicators can reflect a company's interests, as companies select and prioritise them accordingly. Often, companies measure only what internal stakeholders are interested in (Henao and Sarache 2022), possibly complementing it with requirements from external stakeholders. Therefore, a deeper understanding of sustainability measurement in manufacturing companies can shed light on their real sustainability interests.

The prioritisation of sustainability performance indicators can be particularly critical for small and medium enterprises (SMEs). However, measuring sustainability performance is fundamental for SMEs to thrive over time and consistently contribute to improving industrial sustainability supply chains and networks (D. Adams et al. 2021; Carlsson and Nevzorova 2025). As for Europe, SMEs constitute more than 99% of companies (Eurostat 2022) and have consistent environmental and social impacts (Madrid-Guijarro and Duréndez 2024; Rojas-Lema et al. 2021). Although SMEs are pivotal to sustainability goals in the manufacturing sector, they are often unaware of their impact (Setyaningsih et al. 2024); SMEs usually lack the resources or competencies to measure sustainability performance effectively (Cristofaro et al. 2024).

Despite recent studies propose tools to support sustainability performance measurement (Cantele et al. 2024; Carlsson and Nevzorova 2025), they do not provide a picture of the indicators adopted by companies in practice (Gennitsaris and Sofianopoulou 2026). In other words, few studies have empirically investigated how manufacturing SMEs measure their sustainability performance. Studies are also scarce on which aspects of SMEs' activities or contextual factors influence the measurement (Salvador et al. 2023). Specifically, few broad empirical studies are available and they tend to analyse the SME sector as a possible factor influencing the performance measurement. However, while the sector is undoubtedly a relevant contextual factor (Hemdi et al. 2013), other factors may affect the measurement of sustainability performance. For instance, certifications have been shown to have a controversial impact on performance, indicating the need for further studies (Govindan et al. 2013). Besides, the wide range of meanings of sustainability (Joung et al. 2013) can also lead to diverse implications for SMEs' decisions. These factors have been repeatedly highlighted in prior research as potential determinants of managerial systems, yet their combined influence on sustainability measurement in SMEs remains unexplored. Leveraging contingency theory, the behaviour of a company appears to be contingent on contextual factors and the measurement of sustainability performance is expected to reflect the specific configuration of contextual conditions in which a company operates.

In this context, the present research, grounded in contingency theory, investigates the two points above, specifically examining how SMEs measure their sustainability performance and how contextual factors influence the measurement. To address these research questions, the present study collected empirical data from 150 Italian manufacturing SMEs regarding their measurement of sustainability performance.

The remainder of the paper follows. Section 2 offers an overview of the literature background and presents the research questions. Section 3 reports on the method used for the empirical investigation. Section 4 reports and discusses the results obtained. Section 5 concludes the paper.

2 | Literature Background and Research Questions

2.1 | Measuring Industrial Sustainability Performance in Manufacturing Companies

Sustainability performance measurement refers to the use of indicators to assess environmental, social and economic performance using structured or semi-structured methods (Neri 2021).

Performance indicators enable performance measurement (Engida et al. 2018). Indicators can be evaluated as isolated indicators or arranged in a structured set, namely a performance measurement system (Neely et al. 1995). Compared to an isolated or unstructured list of indicators, a structured set of indicators might help companies in performing a precise and accurate evaluation of sustainability-related aspects (Damtoft et al. 2025). To allow a proper measurement of sustainability performance, a set of indicators should encompass the three sustainability pillars (Yip et al. 2023).

Previous literature has proposed or applied numerous sustainability sets or indicators at the company level. An overview of the literature from the past 15 years is presented in Table 1. The literature proposes sets for manufacturing companies in general, as Bernhard et al. (2024) or Cagno et al. (2019), but more broadly for specific contexts. For example, Córdova-Aguirre and Ramón-Jerónimo (2024) propose a tool for Peruvian manufacturing SMEs, Sureeyatanapas et al. (2015) for sugar production in Thailand, Feil et al. (2015) for micro and small companies operating in the furniture sector.

Empirical applications of these sets are present, but appear overall limited in terms of samples and contexts investigated, which limits the understanding of the suitability and appropriateness of the developed sets in real-world contexts (Neri 2021). Among the available empirical applications, Chen et al. (2014) provide an application of their indicators in one Swedish company, Garbie (2014) describes the application of the developed set in one large company in Oman, Ahmad (2023) applies their set in a Malaysian SME food manufacturer, Chourasiya et al. (2024) provide an application in one medium-sized textile company. A limited number of contributions offer broader empirical applications. For example, Mengistu and Panizzolo (2021) and Mengistu and Panizzolo (2023b) investigate 48 SMEs in the Italian footwear sector, whereas Chang and Cheng (2019) conduct an application study across 20 Taiwanese manufacturing SMEs. A broader sample is considered, for example, by Winroth

TABLE 1 | Overview of the literature. The table provides an overview of the literature of the last 15 years. For each of the contributions included, the following are reported. Information: authors and years, objective of the study; Theoretical development: sector, country and size for which the proposed/used set was developed; Characteristics of the set proposed/used: Categorization of indicators and number of indicators considered by the proposed/used set; Empirical application: method employed for the empirical investigation and dimension of the analysed sample, sector, country and size in which the empirical application took place.

Information		Theoretical development			Characteristics of the set proposed/used		Empirical application				
Authors and years	**Objective**	**Sector**	**Country**	**Size**	**Categories**	**Number**	**Method employed**	**Sample (dimension)**	**Sector**	**Country**	**Size**
(Delai and Takahashi 2011)	Develop of a reference model for measuring sustainability.	—	—	—	Economic, Environmental, Social	46					
(Lee and Farzipoor Saen 2012)	Develop of a model for the measurement of sustainability management.	—	—	—	Economic, Environmental, Social	12	Application	10	Electronics	Korea	Large
(Joung et al. 2013)	Provide a categorization of indicators to establish an integrated sustainability indicator repository.	Manufacturing	—	—	Economic, Environmental, Social, Technological, Performance management	212					
(Tseng 2013)	Develop of a hierarchical structure for sustainable production indicators, sufficiently general and can be applied in different firms.	Printed circuit board manufacturing	—	—	Sustainable production	21					
(Chen et al. 2014)	Develop of a holistic sustainability assessment tool.	Manufacturing	—	SMEs	Economic, Environmental, Social, Institutional	133	Application	1	Equipment assembly	Sweden	SME
(Garbie 2014)	Develop of a new assessment framework for manufacturing enterprises. The indicators are then incorporated into a general sustainable development index.	Manufacturing	—	—	Economic, Environmental, Social	83	Application	1	Extruders of aluminium profiles	Oman	Large
(Feil et al. 2015)	Develop of a set of indicators to measure industrial sustainability.	Furniture		Micro and Small	Economic, Environmental, Social	26					
(Harik et al. 2015)	Establish a framework to assess the performance of an industry.	Manufacturing	—	—	Economic, Environmental, Social, Manufacturing	45	Case study	6	Food manufacturing	MENA	

(Continues)

TABLE 1 | (Continued)

Information		Theoretical development			Characteristics of the set proposed/used		Empirical application				
Authors and years	**Objective**	**Sector**	**Country**	**Size**	**Categories**	**Number**	**Method employed**	**Sample (dimension)**	**Sector**	**Country**	**Size**
(Salvado et al. 2015)	Develop of a sustainability index to provide companies with information about their level of sustainability, allowing the evaluation of the firm as standalone and in the context of a supply chain.	Automotive	—	—	Economic, Environmental, Social	14	Case study	46 (1 supply chain)	Automotive	Portugal	
(Sureeyatanapas et al. 2015)	Develop of a framework for the assessment of corporate sustainability to address the lack of sector-specific tool and empirical research.	Sugar manufacturing	Thai	—	Economic, Environmental, Social, Quality	30					
(Long et al. 2016)	Develop a sustainable assessment system. The assessment allows for the evaluation of a sustainability performance index.	Iron and steel	China	—	Economic, Environmental, Social	17	Analysis of secondary data	3	Iron and steel	China	Large
(Winroth et al. 2016)	Identify a list of performance indicators relevant for a production manager.	Manufacturing			Economic, Environmental, Social	52	Survey	340	Different sectors (chemical polymers, metal, electronics, machinery, engines, vehicle).	Sweden	SMEs
(Hsu et al. 2017)	Develop of a methodology to select important elements in the available range of sustainability indicators.	Manufacturing	Taiwan	SMEs	Economic, Environmental, Social and BSC	28	Survey	5	Manufacturing	Taiwan	SMEs
(Chang and Cheng 2019)	Develop of an integrated multi-attribute decision analysis model to evaluate sustainability development.	Manufacturing	Taiwan	SMEs	Economic, Environmental, Social	31 (16 selected)	Survey	20	Manufacturing	Taiwan	SMEs
(Cagno et al. 2019)	Develop of a framework for evaluating industrial sustainability performance, proposing three different Industrial Sustainability Performance Measurement Systems (ISPMSs).	Manufacturing			Economic, Environmental, Social	104/76/44	—	—	—	—	—

(Continues)

TABLE 1 | (Continued)

Information		Theoretical development			Characteristics of the set proposed/used		Empirical application				
Authors and years	**Objective**	**Sector**	**Country**	**Size**	**Categories**	**Number**	**Method employed**	**Sample (dimension)**	**Sector**	**Country**	**Size**
(Trianni et al. 2019)	Understand the level of adoption of industrial sustainability indicators—based on the model of (Garbie 2014).				Economic, Environmental, Social—see (Garbie 2014)	80	Semi-structured interviews	26	Chemical and Metalworking	Germany; Italy	SMEs
(Mengistu and Panizzolo 2021)	Proposal of a methodological approach to identify, analyse and select sustainability indicators.	Footwear	Italy	SMEs	Economic, Environmental, Social	40	Delphi	48	Footwear	Italy	SMEs
(Rayhan Sarker et al. 2021)	Develop a sustainability performance measurement model.				Economic, Environmental, Social	21	Application	3	Leather	Bangladesh	
(Ahmad 2023)	Evaluate the sustainability performance of food manufacturing and packaging.				Economic, Environmental, Social	57	Application	1	Food manufacturing	Malaysia	SMEs
(Dewi et al. 2023)	Develop a novel approach for evaluating the performance of sustainable manufacturing.	Manufacturing			Economic, Environmental, Social	16	Application	1	Tyre manufacturing	Indonesia	NA
(Eslami et al. 2023)	Develop of a method for evaluating a composite sustainability index leveraging an already existing sustainability framework.	Manufacturing			Economic, Environmental, Social	38	Application	1	NA	NA	Large
(Mengistu and Panizzolo 2023a)	Identify useful and applicable sustainability indicators the context of SMEs—based on (Mengistu and Panizzolo 2021)				Economic, Environmental, Social	80	Case study	6	Footwear	Italy	SMEs
(Mengistu and Panizzolo 2023b)	Propose a method for analyse and select useful and applicable sustainability indicators.	Footwear	Italy	SMEs	Economic, Environmental, Social	40	Delphi	48	Footwear	Italy	SMEs
(Saad et al. 2023)	Develop of a sustainability rating tool for manufacturing organizations to selected appropriate indicators.	Manufacturing			Economic, Environmental, Social, Technology, Performance	12	Application	12	Aluminium	NA	NA

(Continues)

TABLE 1 | (Continued)

Information		Theoretical development			Characteristics of the set proposed/used		Empirical application				
Authors and years	**Objective**	**Sector**	**Country**	**Size**	**Categories**	**Number**	**Method employed**	**Sample (dimension)**	**Sector**	**Country**	**Size**
(Bernhard et al. 2024)	Develop of a model for sustainable production systems.	Manufacturing			Efficiency, Emissions, Employee, Circularity, Interaction with the environment, Organizational and business practices, Substitution, Waste.	40					
(Córdova-Aguirre and Ramón-Jerónimo 2024)	Develop of a holistic sustainability assessment framework to evaluate the integration of sustainability into business strategy.	Manufacturing	Peru	SMEs	Economic, Environmental, Social with elements of Balance Score Card	27					
(Dağıdır and Özkan 2024)	Propose an integrated approach for measuring performance in companies.				Sustainability Balance Score Card	34	Application	1	Glass industry	Turkey	SME
(Chourasiya et al. 2024)	Develop of a performance measurement framework for adopting sustainable manufacturing.	Textile	India		Economic, Environmental, Social with elements of Balance Score Card	29	Application	1	Textile	India	Medium[1]
(Silva et al. 2024)	Propose a model to measure activities of the organization to create a sustainability score for benchmarking.					96	Survey	4	Tea sector	UK; Sri Lanka	Medium; Large
(Sharma et al. 2024)	Propose a framework to evaluate the sustainability index.	Manufacturing			Economic, Environmental, Social	52 (45 selected)	Survey	444	Different sectors (automobile, sheet metal processing, iron and steel, chemical and industrial fertilizer, pharmaceutical, textile, electrical and electronics)	India	NA

(Continues)

TABLE 1 | (Continued)

Information		Theoretical development			Characteristics of the set proposed/used		Empirical application				
Authors and years	**Objective**	**Sector**	**Country**	**Size**	**Categories**	**Number**	**Method employed**	**Sample (dimension)**	**Sector**	**Country**	**Size**
(Gennitsaris and Sofianopoulou 2026)	Develop and validate a holistic and balanced sustainability indicator framework for manufacturing enterprises following the three-pillar approach.	Manufacturing			Economic, Environmental, Social	99					

[1]https://msme.gov.in.

et al. (2016), who investigated 340 Swedish SMEs and Sharma et al. (2024), who surveyed 444 large Indian manufacturers. Further, a few prior contributions are purely empirical and apply a previously developed framework to specific or varied contexts. Indeed, Mengistu and Panizzolo (2023a) provide an investigation of Italian footwear SMEs leveraging the framework proposed by Mengistu and Panizzolo (2021), whereas Trianni et al. (2019) provide empirical evidence on European SMEs based on Garbie (2014)'s set.

Despite these efforts, the real challenge lies not in the development of indicators (Singh et al. 2012) but in the selection of the right indicators to use (Hristov and Chirico 2019; Rojas-Lema et al. 2021). This aspect is particularly relevant for SMEs (Carlsson and Nevzorova 2025), as the correct selection and identification of indicators can help them achieve a new level of competitiveness as they move towards sustainability. Some studies in the literature focus on proposing methods for selecting appropriate indicators across different contexts. For example, Saad et al. (2023) provide a rating tool for manufacturing companies to help them select the right indicators, applying the method to 12 aluminium companies. Further, Cagno et al. (2019) propose a scalable framework of indicators to adapt to companies' characteristics in terms of resource availability, awareness and specific interest in sustainability. The use of a standard yet tailored set of indicators could also allow the benchmarking process, as stressed by Silva et al. (2024), focusing on the tea sector.

Although the current literature background focuses only on contributions that consider indicators spanning among the three pillars of sustainability, it is worth noting that not all of them consider the intersections among the pillars. In this regard, contributions such as Cagno et al. (2019) and Bernhard et al. (2024) provide interesting analyses of the indicators' coverage of the three pillars and their intersections.

For the sake of completeness, contributions addressing the sustainability of specific processes in the manufacturing sector have been developed, such as in the food process (Murad et al. 2021) or manufacturing cell (Zhang and Haapala 2015). However, these efforts do not appear to provide a scalable measurement to carry from the process to the entire company.

The literature analysis indicates that several contributions provide a set of indicators for manufacturing companies, specifically SMEs. Despite the large number of proposed indicators, there remains limited empirical evidence on which indicators SMEs actually adopt in practice and how these indicators reflect the real sustainability priorities perceived by companies. As discussed, most efforts are sector-specific or with a narrow empirical application, mainly limited to contexts characterised by specific contextual factors. Few empirical analyses are available, leaving it unclear how sustainability indicators are adopted across SMEs with different characteristics. Although undoubtedly leading the way for a better understanding of how manufacturing SMEs measure sustainability performance, the insights provided by the current literature are not enough. Gaining insight into the indicators effectively used by companies and specifically SMEs, is essential for bridging the gap between conceptual frameworks and real-world

sustainability implementation. This gap motivates our first research question:

> RQ1: How do manufacturing SMEs measure sustainability performance?

However, it is expected that not all SMEs measure sustainability performance in the same way. Consistent with contingency theory, specific contextual factors may influence the relevance of certain indicators relative to others or shape the overall approach to measuring sustainability. Therefore, while RQ1 provides insight into how SMEs measure their sustainability-related performance, it is also necessary to deepen the understanding of how different contexts shape the measurement.

2.2 | The Role of Contextual Factors

The behaviour of a company is contingent on contextual factors. This understanding underpins the contingency theory, which suggests that there is no single best way to organise and manage a company; rather, different approaches, depending on the specific situation, can be equally effective or useful (Brocke et al. 2016; Oyewo et al. 2025). Several contextual factors are critical to organisational structure, decision-making and behaviour (Brocke et al. 2016) and can influence the overall approach to sustainability (Cittadin et al. 2025; Osei and Amoah 2026). Accordingly, the adoption and prioritisation of sustainability performance indicators are expected to reflect the specific configuration of contextual conditions in which a company operates.

Among other applications, contingency theory has been applied to performance measurement (Viscardi et al. 2026). An interesting overview of contextual factors impacting performance measurement is offered by Jääskeläinen et al. (2012), who identify the relevance of contextual factors such as organisational size and structure, industrial sector, external factors, strategy, purpose and the need for measurement. Brocke et al. (2016), relating the adoption of business process management to performance evaluation, provide a classification of contextual factors. They categorise contextual factors in four dimensions, namely goal, process, organisation and environment. The factors related to the organisation dimension appear to be of interest in the context of performance measurement. In Brocke et al. (2016)'s view, the organisation dimension includes scope, industry, size, culture and resources.

Regarding company size, several authors have identified it as a relevant contextual factor that influences performance measurement. Company size can also serve as a proxy for a company's resources (Morioka and Carvalho 2014; Zharfpeykan and Akroyd 2022). From this line, Garengo et al. (2005) underline the need to tailor indicator sets to the specific needs of SMEs, which are significantly different from those of large companies. Previous research, however, showed contrasting results regarding size as a relevant contextual factor. For example, for Amhalhal et al. (2022) the size is not a relevant factor, whereas Trianni et al. (2019) point out significant differences between small and medium companies. These contrasting findings suggest that size may interact with other contextual factors in shaping the adoption of sustainability indicators.

The industry is another relevant contextual factor. Although Brocke et al. (2016) suggest a distinction between the product and service industry, further distinctions might apply in the same industry (Van Looy and Van den Bergh 2018). For example, Trianni et al. (2019) underline the significant differences between the chemical and metalworking sectors. This suggests that the sector may significantly influence the adoption of sustainability indicators.

In the context of sustainability, the culture of the organisation suggested by Brocke et al. (2016) can be related to the company's approach towards sustainability (Neri, Cagno, and Trianni 2021). The previous literature argued that the approach towards sustainability can be influenced by the understanding of sustainability (De Oliveira et al. 2018; Held et al. 2018) and the presence of certifications (Ben Arab 2020; May and Stahl 2017; Vieira Nunhes et al. 2022). In their empirical study, Trianni et al. (2019) underline the relevance of both certifications and understanding of sustainability for performance measurement, yet they call for more research on the topic. Such factors may shape distinct measurement patterns, leading companies to adopt different sustainability indicators.

Zharfpeykan and Akroyd (2022) remark that the industry, company size and perception of a sustainability aspect all influence the integration of indicators into a company's measuring system. However, to the best of our knowledge, a study evaluating how size, sector, certifications and understanding of sustainability influence the sustainability performance measurement in SMEs is still missing. These four factors represent key organisational contingencies because they directly influence companies' resource availability, operational constraints, strategic attention to sustainability and exposure to institutional pressures. Further, while some efforts moved in this direction (Trianni et al. 2019), they do not provide any indication of the relations among the contextual factors.

Following the contingency theory, we expect that the adoption and prioritisation of sustainability performance indicators vary across companies depending on their contextual characteristics. For instance, company size may be associated with differences in the breadth of indicator adoption; certified companies may emphasise environmental and social metrics; and companies with a stronger understanding of sustainability may implement more integrated measurement practices. Based on the above discussion, this study focuses on the organisational dimension, specifically on size, sector, certifications and understanding of sustainability and our second research question is:

> RQ2. How do contextual factors (size, sector, certifications and understanding of sustainability) shape the measurement of sustainability performance in manufacturing SMEs?

In line with contingency theory, this study employs it as an interpretative lens to investigate how contextual factors shape distinct approaches to sustainability performance measurement across SMEs. According to contingency theory, the fit between contextual conditions and managerial systems determines their effectiveness; thus, variations in company size, sector,

certifications and understanding of sustainability are expected to produce differentiated sustainability measurement aligned with companies' specific operating conditions. In addition to the individual effects of each factor, contingency theory suggests that these conditions may interact, such that specific configurations can lead to distinct patterns of sustainability measurement (Trianni et al. 2019). The study thus aims to explore the potential interplay between these contextual factors, acknowledging that different combinations may lead to distinct approaches to measuring sustainability performance.

3 | Methods

To answer the research questions, we collected data from 150 manufacturing SMEs using semi-structured interviews. Semi-structured interviews are a flexible tool for investigating the perspectives of industrial decision-makers, allowing for the immediate posing of follow-up questions when issues arise (W. C. Adams 2015). Thus, questions can also be adapted based on the informant's experience and knowledge (Bispo Júnior 2022).

3.1 | Sampling and Data Collection

We selected a purposive and convenience sample of Italian manufacturing SMEs (the unit of analysis) from the plastic and rubber, electronics, metalworking and textile sectors. Italian manufacturing SMEs, besides contributing significantly to the gross domestic product, are of interest for sustainability (Hristov et al. 2023). The four selected sub-sectors are among the most relevant to the Italian manufacturing sector in terms of both turnover and value added (Fornasiero and Tolio 2024).

SMEs were initially identified through the AIDA database (https://login.bvdinfo.com) and contacted via phone or mail to understand their availability to participate in the research. In case of acceptance, we organised an online or telephone meeting with people knowledgeable of the topic, such as a production manager or a sustainability/environmental manager. Data were collected through semi-structured interviews composed of three parts. The first was dedicated to collecting general information about the SME in terms of number of employees, context, sector, market, products, production process, certification, as well as about the interviewees; the second part was dedicated to exploring the interviewees' understanding of sustainability and the application of the paradigm within the SME; the third part focused on the sustainability performance measurement and the performance indicators adopted by the SME. The semi-structured interview protocol is available in Appendix S1. A total of 150 SMEs were interviewed, with a summary of information reported in Table 2 and details reported in Appendix S2.

3.2 | Data Analysis

Interviews were recorded (upon interviewees' agreement) and transcribed, resulting in 704 pages of transcripts. The analysis followed an abductive approach based on a coding process for content analysis (Kohlbacher 2006; Saldaña 2009). We specifically applied a structural coding scheme suitable for analysing semi-structured protocols (Saldaña 2009). Sustainability indicators were first identified inductively from interviews' transcripts, allowing respondents to describe the indicators adopted in their companies freely. In a second step, the identified indicators were deductively categorised according to the industrial sustainability performance measurement system (ISPMS) by Cagno et al. (2019), specifically the 'Full ISPMS' version. This procedure provided a common basis for analysing the performance indicators, enabling structured comparisons across companies while avoiding the imposition of a predefined framework during data collection. The structure of Cagno et al. (2019)'s ISPMS is reported in Table 3. The ISPMS is structured around the three sustainability pillars; each pillar has several performance dimensions, which in turn are linked to diverse performance indicators. The ISMPS contains 104 indicators in total.

TABLE 2 | General overview of the sample.

Sectors	Small	Medium	Total
Plastics and rubber	25	25	50
Textile	28	12	40
Metalworking	19	11	30
Electronics	19	11	30
Total	91	59	150

TABLE 3 | Sustainability pillars, performance dimensions and number of performance indicators of the Full ISPMS (Cagno et al. 2019).

		Number of performance indicators	
Sustainability pillar	Performance dimension	Performance dimension	Pillar
Economic	Investments	7	36
	Cost and Incomes	16	
	Production	10	
	Suppliers	3	
Social	Community	4	26
	Customers	3	
	Employees	8	
	OHS	11	
Environmental	Water	4	42
	Material	4	
	Energy	10	
	Air emissions	8	
	Waste	12	
	Environmental management	4	

The qualitative content analysis allowed us to understand the performance indicators adopted by each SME to measure sustainability performance for each specific pillar. Following our two research questions, besides focusing on the entire sample investigated, we also specifically focused on four contextual factors possibly shaping the measurement of sustainability performance, specifically the sector (plastic and rubber, textile, metalworking and electronics), SME size (small, medium), understanding of sustainability (based on the considered pillars) and certifications held (according to the three pillars of sustainability). Following the suggestions of W. C. Adams (2015) and Meredith (1998), descriptive statistics were employed to summarize the frequency and distribution of the indicators across SMEs, conveying the data's salient features concisely yet effectively (Green et al. 2023). This allowed for a structured comparison of patterns within the sample (Sheard 2018) and in graphical form (Gudivada 2017). To provide deeper insight into the findings, illustrative quotes from interviewees are reported alongside the quantitative summaries. The choice aligns with previous work that used semi-structured interviews as the research method and it is an interesting approach for capturing a snapshot of the overall results (Fallahi et al. 2023; Julkovski et al. 2023; Neri et al. 2023).

Methodological rigor was ensured by assessing the design tests suggested by Yin (2009). Given the exploratory nature of the present study, following Yin (2009)'s indications, we focused on construct validity, external validity and reliability (thus not focusing on internal validity) and assessed them against tactics suggested by the literature—please refer to Benbasat et al. (1987), Beverland and Lindgreen (2010), Barratt et al. (2011), Baškarada (2014). Construct validity was enhanced through careful interview techniques and the structured interview protocol. During the semi-structured interviews, immediate feedback and follow-up questions were used to clarify respondents' answers and reduce potential misunderstandings. A chain of evidence was also maintained by organizing the collected material. External validity was addressed by clearly defining the population of interest and by collecting data from a large sample of SMEs across different manufacturing sectors. Reliability was ensured using a consistent interview protocol and a transparent coding procedure. Additionally, the presence of multiple interviewers and multiple researchers conducting the coding (at least two for each interview) mitigated the risk of research bias.

4 | Results and Discussion

The section presents the results. The results for the total sample are presented first (4.1), followed by those for contextual factors (4.2). Leveraging the insights obtained, an analysis of the results according to the interplay between contextual factors is also presented (4.3).

4.1 | Sustainability Performance Measurement by SMEs

The 150 analysed SMEs measure on average 24.8 out of 104 sustainability indicators proposed by Cagno et al. (2019)'s ISPMS (24%) and specifically 11.4 out of 36 economic indicators (32%), 7.1 out of 26 social indicators (27%) and 6.1 out of 42 environmental indicators (14%) (Appendix S3). The number of measured sustainability indicators aligns with the range of 10–25 indicators reported in previous studies (Trianni et al. 2019; Zharfpeykan and Akroyd 2022).

To address RQ1, having Cagno et al. (2019)'s ISPMS as a reference, we performed two different analyses. First, we evaluated the coverage of each performance dimension. Second, we evaluated the most and least measured indicators by sampled SMEs.

4.1.1 | Coverage of Performance Dimensions According to Sustainability Pillars

To assess the coverage of performance dimensions, we evaluated the percentage of SMEs that measured at least one indicator for each performance dimension and the average number of indicators measured per dimension (Figure 1).

Performance dimensions related to the economic pillar emerge as the most frequently addressed, underscoring that sustainability is still potentially mainly seen in terms of economic implications, reinforcing previous studies (Sharma et al. 2024). Providing their definition of sustainability, many SMEs indeed focused on the economic pillar, specifically underlying how, in their perspective, the pursuit of sustainability has to deal with the need of being economically sustainable.

> An investment cannot be carried out solely because it meets sustainability criteria; an economic return is still required.
>
> (Plant manager, 22Nn)

> Financial sustainability is certainly the primary objective that must be pursued.
>
> (CEO, 26B)

> From a conceptual standpoint, when I think about sustainability, the first aspect a company must address is the economic one. If a company is not economically viable, everything else collapses.
>
> (CEO, 26C)

> Our policy is that anything requiring a cost for the company but failing to deliver tangible positive outcomes is not pursued.
>
> (Technical manager, 27D)

However, it is also worth noting that for some SMEs, sustainability can provide a competitive advantage.

> Since research activities aimed at improving sustainability do not provide immediate economic benefits, small and medium-sized companies often struggle to acknowledge that these initiatives involve considerable short-term costs but can produce long-term savings and tangible profitability.
>
> (CEO, 13I)

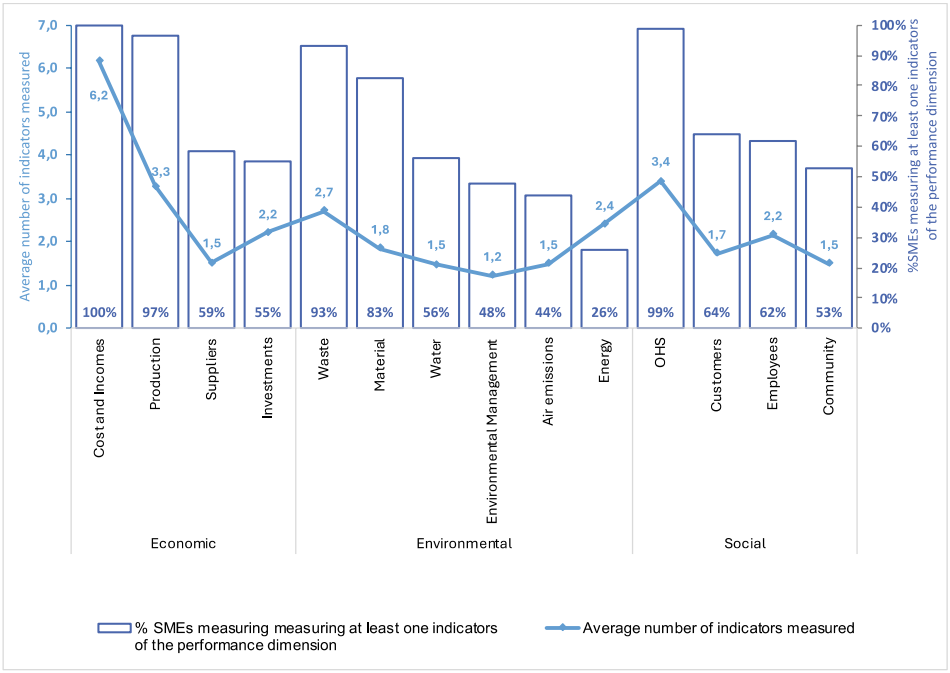

FIGURE 1 | Percentage of SMEs measuring at least one indicator belonging to each performance dimension and the average number of indicators measured.

> If pursued appropriately, sustainability can lead to a meaningful economic benefit.
>
> (Quality, safety and environmental manager; 22Ll)

> Sustainability is increasingly perceived as an advantage. In recent years, as market and consumers awareness has grown, sustainability has come to represent a clear commercial benefit.
>
> (Quality manager, 22J)

Focusing on the economic performance dimensions, *costs and incomes* emerges as the most frequently addressed, being considered by all 150 SMEs (100% coverage), with an average of 6.2 indicators measured by each SME, followed by *production* (97% coverage), with an average of 3.2 indicators. Interestingly, despite the high coverage of economic performance indicators, this process is not always well-structured for SMEs.

> I would say that processes are rather unstructured. As a result, we carry out an ex-post evaluation of the expenditures required for engine maintenance or repair and only afterwards do we determine the final margin.
>
> (Quality manager, 27B)

Interestingly, the *investment* performance dimension shows relatively low coverage (55.3%). The result contrasts with Chang and Cheng (2019) and Sharma et al. (2024), who consider investments among the most influential indicators of sustainability.

> When a new expenditure arises, we assess it and proceed only if deemed appropriate. [...] Our processes, however, remain poorly structured.
>
> (CEO, 26B)

> Concerning investments, we carry out periodic evaluations, but we do not have indicators in place to systematically monitor the situation.
>
> (Safety and quality manager, 28M)

The *suppliers'* performance dimension is not widely covered (58.7%), which likely underscores the need for additional efforts by SMEs to incorporate supply chain-related aspects. However, some SMEs underlined that the focal company in their supply chain and/or their customers are starting to move towards a more collaborative effort:

> Just ten or fifteen years ago, sustainability was treated merely as a label, with little relevance. We now see that some customers, particularly in the United States, view these aspects as targets and valuable supply chain requirements.
>
> (Accountability manager, 13V)

> At the moment, we are in a situation where the large companies we work for are beginning to move in this direction, increasingly requiring us to participate in webinars on the topic [sustainability].
>
> (Owner, 22Hh)

> We are aware of these topics also because our customers, especially the larger and more structured ones, who represent the majority, place requirements on us that we, in turn, pass on to our subcontractors.
>
> (Head of operations, 26M)

> We have been fortunate because, in our sector, these topics have always been driven by customers' requirements.
>
> (CEO, 27K)

As for the environmental pillar, *waste* is the most frequently addressed performance dimension (93% coverage), with an average of 2.7 indicators per SME, followed by *material* (83% coverage) with an average of 1.8 indicators. The focus on material and waste aligns with previous literature, e.g., Dewi et al. (2023), Winroth et al. (2016) and can be justified by the fact that these two performance dimensions have implications on the economic pillars (Söderholm and Tilton 2012).

> By reducing waste and scrap in production through targeted research and development efforts, we achieved benefits from both an environmental and an economic perspective.
>
> (CEO, 27K)

> It is a misconception to believe that renewable energy or efficiency measures can be pursued without considering their financial implications.
>
> (Quality manager, 28C)

> Environmental sustainability aims to promote economic growth that is compatible with the environment and the planet, reconciling diverse and sometimes competing needs.
>
> (Purchase manager, 28D)

Interestingly, *energy* is not among the most relevant environmental performance dimensions, despite being strongly connected to economic aspects—see, for example, Watanabe et al. (2016). The result contrasts previous evidence, e.g., Chang and Cheng (2019) and Saad et al. (2023), which considers energy consumption and emissions among the most relevant indicators, and goes against the indication of Sharma et al. (2024) who state that material and energy consumption aspects should be made mandatory for companies.

Regarding the social pillar, *occupational health and safety (OHS)* emerges as the most addressed performance dimension (99% coverage), with an average of 3.4 indicators measured by each SME. The result, consistent with Hsu et al. (2017) and Winroth et al. (2016), underscores the focus on legislative issues within the social pillar (Pawłowska 2015). The insight is further emphasised by the fact that the *employees*' performance dimension has much lower coverage (62%). Sharma et al. (2024) stressed that employees can significantly support the enhancement of sustainability in companies, as they are directly involved and responsible for the manufacturing activities. From this standpoint, indicators related to employees' safety, satisfaction and welfare should be properly assessed. The investigated SMEs employed diverse approaches to measuring employee-related indicators, with many viewing their employees as a sort of family.

> We maintain a relationship with our workers that goes beyond the typical employer–employee dynamic. We consider our company to be like a large family.
>
> (CEO, 22Gg)

> From a psychological perspective, it is essential to maintain high levels of motivation and enthusiasm among those who work for me within the company.
>
> (CEO, 22Aa)

> We try to keep our training activities constantly updated because worker training is what prevents injuries. Training is highly preventive by nature. Individual protective equipment is, of course, always available.
>
> (CEO, 25G)

Unexpectedly, the *customers*' performance dimension, linked to economic goals by the previous literature (Winroth et al. 2016), does not present a high level of coverage (64%), contrasting Rayhan Sarker et al. (2021) and despite the relevance attributed to the concept by previous literature (Mengistu and Panizzolo 2023b; Sharma et al. 2024). Although differences in the results could stem from variations in the sample, they could also be explained by the effort required to collect data beyond the SMEs' boundaries. Indeed, among the investigated SMEs, it emerged that attempts to collect customer satisfaction data failed due to a lack of customer engagement.

> For us, going on-site is not always feasible, as many customers are located far away. We attempted to collect feedback through a questionnaire, but the response rate has been consistently low.
>
> (Production manager, 28B)

> Some consultants have suggested that we should gather more direct feedback from clients through evaluation questionnaires. We have attempted this approach, but we now face some difficulties: when we send the questionnaires, they are rarely returned.
>
> (General manager, 28F)

Interestingly, community and political-social aspects are largely overlooked in our sample, in contrast to findings from Chang and Cheng (2019) and Sharma et al. (2024), despite many SMEs mentioning the community as a central stakeholder in their activities.

> A company should exist in symbiosis with its surrounding territory.
>
> (Production manager, 22T)

> We are deeply rooted in the local territory and we strive to involve the surrounding community.
>
> (Owner, 22D)

> Since we operate in a residential area, we pay close attention to avoiding disturbance and to integrating well within the community.
>
> (Co-owner, 13W)

The result indicates that the investigated SMEs are primarily focused on internal aspects and do not measure indicators of the relationship between the SME and its external context, thereby omitting a relevant aspect of sustainability.

4.1.2 | The Most and Least Measured Indicators

Focusing on the most measured indicators (Table 4), SMEs are mainly concerned with economic and regulation-related aspects. The top measured indicators are *injuries* and *production cost*, finding a correspondence with Chang and Cheng (2019). The interests of SMEs also emerged regarding environmental aspects, specifically, *total material used* (80%), *waste disposal* (74%) and *waste recycled* (65,3%), in line with Winroth et al. (2016).

Among the least measured indicators (Table 5) are several environmental indicators, including those related to emissions and energy use outside production processes. Similarly, social indicators such as *OHS citations*, *fatalities*, or *discrimination* are not widely measured. Integrating Table 5 with the information provided in Table D1, Table D2 and Table D3 in Appendix S4, it is evident that many environmental and social indicators are seldom measured. One explanation relates to the lower standardised way of measuring environmental aspects, as suggested by Cagno et al. (2019) and Gudmundsdottir and Sigurjonsson (2024), compared with economic (such as traditional financial accounting indicators) and mandatory social (i.e., injuries) aspects. Hsu et al. (2017) and Trianni et al. (2019) similarly report low concern among SMEs about social indicators, such as child labour and fair trading. Even though these are relevant aspects, their limited adoption indicates low interest in setting goals and taking action to address social issues. As for the environmental pillar, aspects related to environmental management are among the least measured. This aligns with Chang and Cheng (2019) who underline a limited interest in green supply chain and green image. This again stresses that companies and specifically SMEs, are still focused on environmental aspects related to production activities, leaving behind more proactive behaviour unless required by regulation or focal companies.

> External incentives are insufficient on their own; meaningful change requires an internal commitment.
>
> (CEO, 25E)

Overall, a limited interest in the implications for supply chains or industrial networks emerged. Specifically, the investigated SMEs underlined several difficulties, particularly on the downstream side.

> From an upstream supply chain perspective, we prefer suppliers that have adopted virtuous practices. In contrast, such behaviour is very rare on the downstream side.
>
> (CEO, 25B)

> We also work with large enterprises, yet none of them has ever asked for specific sustainability parameters.
>
> (CEO, 26O)

> We are among the smallest companies in our supply chain, yet we have never been asked for any certifications beyond product-related ones.
>
> (CEO, 27A)

TABLE 4 | Most measured indicators: used by at least 60% of the SMEs sample.

Pillar	Performance dimension	Performance indicators	% Sample performance dimension	%Sample indicator
Social	OHS	Injuries	98.7%	92.7%
Economic	Cost and incomes	Production cost	100.0%	90.7%
Environmental	Material	Total material use	82.7%	80.0%
Economic	Production	Quality	96.7%	79.3%
Economic	Production	Scrap	96.7%	76.0%
Environmental	Waste	Waste disposed	93.3%	74.0%
Economic	Cost and incomes	Sales	100.0%	69.3%
Environmental	Waste	Waste recycled	93.3%	65.3%
Social	OHS	Accidents	98.7%	62.0%
Economic	Production	Lead time	96.7%	60.0%

TABLE 5 | Least-measured indicators: used by 2% or fewer of the SME sample.

Pillar	Performance dimension	Performance indicators	% Sample performance dimension	%Sample Indicator
Environmental	Energy	Gas use not for production	26.0%	2.0%
Environmental	Air emissions	Metal emissions	44.0%	2.0%
Social	Employees	Ethnic group discrimination	62.0%	2.0%
Economic	Production	DFx (Design for X)	96.7%	2.0%
Environmental	Environmental management	Environmental fines	48.0%	2.0%
Environmental	Energy	Fuel use not for production	26.0%	1.3%
Environmental	Waste	COD (chemical oxygen demand)	93.3%	1.3%
Environmental	Waste	BOD (biochemical oxygen demand)	93.3%	1.3%
Economic	Investments	Ethics/philanthropy investment	55.3%	1.3%
Environmental	Air emissions	SO_2	44.0%	1.3%
Environmental	Energy	Coal use for production	26.0%	0.7%
Environmental	Air emissions	ODS (ozone-depleting substances)	44.0%	0.7%
Economic	Cost and Incomes	Turnover	100.0%	0.0%
Environmental	Energy	Coal use not for production	26.0%	0.0%
Social	OHS	Occupational health/safety administration citations	98.7%	0.0%
Economic	Cost and Incomes	Environmental, health and safety fines	100.0%	0.0%
Social	OHS	Fatalities	98.7%	0.0%

Environmental performance dimensions related to *water* and *air emissions* also appear to be overall limitedly addressed. Previous literature has indicated limited consideration of water consumption and greenhouse gas emissions among Italian footwear SMEs (Mengistu and Panizzolo 2021; Mengistu and Panizzolo 2023a, 2023b). Overall, some indicators in the *water* and *air emissions* performance dimensions, such as *metal emissions*, *coal used for production* and *wastewater quality*, may appear overly context-specific (Long et al. 2016). Interestingly, *CO_2 emissions* are not widely evaluated, possibly indicating that the path towards decarbonisation within the single SME and the supply chain could still be challenging. The results again underscore that SMEs are primarily interested in evaluating aspects directly related to an economic return.

Interestingly, *inventory cost* is among the least considered indicators. Although the adoption of this indicator is not extremely low (adopted by 20% of SMEs, Table D1, Appendix S4), indicators related to inventory and external logistics were not particularly considered of interest in the past literature. For example, Mengistu and Panizzolo (2021) underline that the inventory and delivery aspects were not widely considered among their sampled SMEs. Further, Hsu et al. (2017) underline that distribution costs are not among the most commonly measured indicators and the same applies to logistic costs according to Chang and Cheng (2019). AL-Shboul (2019) underlines how organisational and environmental factors can strongly influence the logistical advancements in SMEs. However, regarding logistics, some actions emerged from the investigation related to the willingness to make it greener.

> We are trying to introduce bar codes to replace traditional transportation documents.
>
> (Co-owner, 22I)

> We are working to promote rail-based logistics instead of relying on trucks.
>
> (Environmental and safety manager, 22Ee)

Overall, the investigated SMEs, while measuring the sustainability performance in different manners among the three sustainability pillars, tend to recognise the need for a structured performance measurement process to enable and support a systematic and coherent analysis of the performance.

> Having this information is like having an internal monitoring system that helps you understand where action is needed and where efforts should be concentrated. [...] You can only achieve meaningful results if something is measured beforehand; it is difficult to improve anything when relying solely on intuition.
>
> (CEO, 22K)

> Measurements are necessary because perceptions can often be misleading. Having objective data is essential.
>
> (Sales manager, 25M)

> When processes are properly structured, rather than relying on individual decisions, improvements naturally follow and mistakes are less likely to be repeated.
>
> (Sales manager, 27H)

> You cannot base your decisions on feelings. Today, we rely increasingly on data and information and the decision-making process is therefore far less improvised.
>
> (CEO, 28N)

However, based on the contingency theory, we expect that the adoption and prioritization of sustainability performance indicators vary across the investigated SMEs depending on their contextual characteristics. For this reason, the analysis of the adopted performance indicators from a general and aggregated perspective will be complemented in the following by an analysis of how selected contextual factors, namely size, sector, certifications and understanding of sustainability, shape the indicator adoption.

4.2 | Contextual Factors Shaping the Measurement of Sustainability Performance by Manufacturing SMEs

To investigate how contextual factors shape the performance measurement, we focused on the following. Dividing the SMEs according to specific contextual factors, first, we evaluated the ratio between the number of indicators measured by sampled SMEs over the total number of indicators available in Cagno et al. (2019), from both an aggregate perspective and considering each sustainability pillar: the analysis provides an indication of the relative priority given to one or another pillar. Second, we evaluated the coverage of performance dimensions by computing the percentage of SMEs that measured at least one indicator in each dimension; this analysis indicates SMEs' interest in each dimension. The results are reported while accounting for the influence of sector (4.2.1), size (4.2.2), understanding of sustainability (4.2.3) and certifications (4.2.4).

4.2.1 | Sector

4.2.1.1 | Analysis According to Sustainability Pillars. The analysis highlights differences in indicators measured by SMEs across sectors (Figure 2), as expected (Shaikh and Tripathy 2025). SMEs operating in the metalworking and electronics sectors tend to measure more indicators, particularly across the economic and social pillars. The result for the metalworking sector differs from previous insights, which found that the economic and environmental pillars were the most frequently addressed (Long et al. 2016; Strezov et al. 2013), possibly indicating a shift in the sector's focus. As proof, recently Krekel et al. (2024) underlined the need for the German metalworking sector to focus on both internal and external social aspects. Evidence of this emerged from our investigation, with a specific focus on employees' training.

> When it comes to employee training, everyone attends safety courses. It is an investment, but it also generates a return: our employees have never experienced any type of accident.
>
> (CEO, 25B)

> Our contract includes a fund dedicated to training. We have used it to offer courses in English, Incoterms, commercial communication and coaching, among others.
>
> (CEO, 25C)

> We try to invest in our staff with a long-term perspective.
>
> (CEO, 28E)

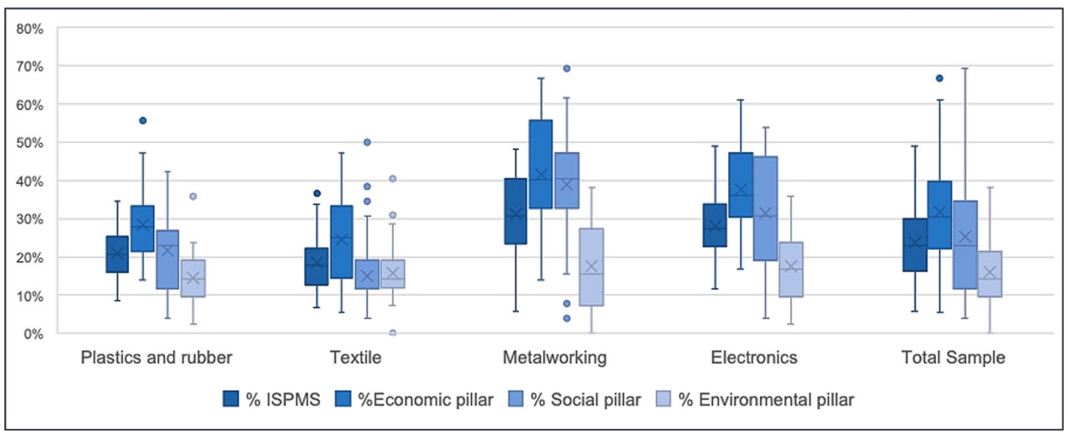

FIGURE 2 | Distribution of the percentage of the number indicators measured by the SMEs in relation to the total number of indicators in the Cagno et al. (2019)'s model (ISPMS) for each industrial sector.

Examples of safety-related overperformance relative to regulatory requirements were also highlighted.

> We believe workers should operate with maximum, not minimum, safety measures [...]. We consistently aim to exceed basic requirements, as ensuring the highest level of safety is essential.
>
> (Safety manager, 25D)

> We are delivering an additional safety training course not required by law, for personnel in the production department [...] we felt that the standard legally mandated course was insufficient.
>
> (Health, safety and environment manager, 25N)

Among the four sectors analysed, the textile sector appears to have the lowest adoption of sustainability indicators. This sector shows a higher percentage of economic indicators and a lower percentage of social and environmental indicators. This diverges from evidence collected from Dutch textile companies, whose websites showed a greater emphasis on communicating environmental and social factors than on economic ones (Tolentino-Zondervan and DiVito 2024). The result needs to be carefully analysed, as the textile sector is among the most polluting industries (Mousavi et al. 2024). There is a high risk of greenwashing in this industry (Tolentino-Zondervan and DiVito 2024) and the divergence between the performance measurement found in the present study and the externally communicated aspects identified by previous studies, e.g., Tolentino-Zondervan and DiVito (2024) could be a sign of misbehaviour. Indications of the limited relevance of sustainability to business competitiveness in the textile sector emerged in discussions with the investigated SMEs.

> For companies like ours, sustainability is not the core business.
>
> (Co-owner, 13Aa)

> Sustainability is an advantage when operating in a market that demands it. Now, the market does not. Currently, it offers more of an image-related advantage than a concrete market benefit.
>
> (Quality, environment, and safety manager, 13P)

However, contrasting results emerged, with other textile SMEs recognizing the relevance of sustainability.

> Companies will need to become sustainable to survive.
>
> (Commercial director, 13O)

4.2.1.2 | Analysis According to Performance Dimensions. Focusing on the performance dimensions for each pillar (Figure 3) highlights differences. The textile sector seems to have a specific focus on *environmental management* performance dimension, whereas the consideration of other environmental performance dimensions is overall aligned with those of other sectors. The result might underscore the need for the textile sector to comply with strict regulations and to have a clear and structured way to communicate with external stakeholders, given the pressure they exert (Tolentino-Zondervan and DiVito 2024).

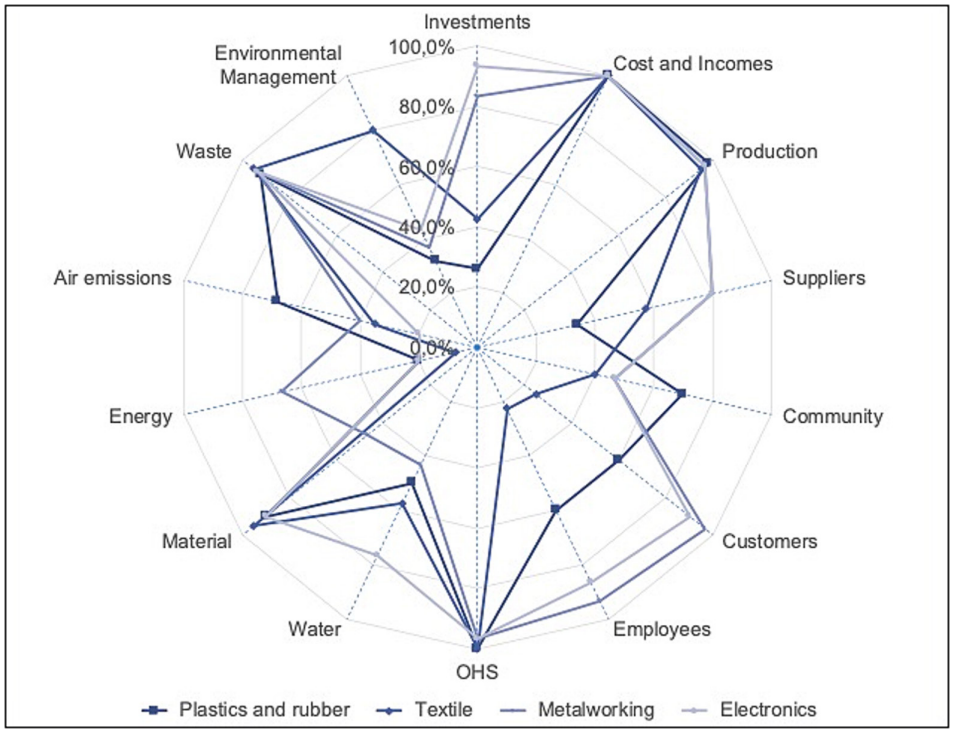

FIGURE 3 | Coverage of performance dimensions according to the sector.

> We conduct strict monitoring of environmental and safety regulations.
>
> (Safety and environment manager, 13Gg)

The need to comply with strict regulations is sometimes embedded directly in the textile SMEs' definition of sustainability, as it is seen as a way to remain in the market.

> For us, sustainability means energy saving, the use of non-polluting materials, and strict compliance with required protocols.
>
> (Safety and environment manager, 13Gg)

> To remain in the market, we are required to comply with a series of norms and protocols imposed by the industry. Brands demand absolute traceability.
>
> (CEO, 13Z)

Unlike in Chourasiya et al. (2024), the *energy*-related performance dimension did not emerge as central to the measurement.

> From an environmental perspective, our focus is on avoiding emissions, whether waste, fumes, or noise, that could negatively affect the surrounding area.
>
> (Accountability manager, 13V)

The result might be influenced by the specific characteristics of the company investigated by Chourasiya et al. (2024), a large company, according to the European Commission (2003) classification. Interestingly, the textile sector also does not measure many social indicators beyond *OHS* indicators, in line with Chourasiya et al. (2024).

The metalworking sector emerges as focused on the *energy* performance dimension and, to a lesser extent, on the *material* and *water* performance dimensions, confirming findings from Long et al. (2016). Specifically, several metalworking SMEs have installed photovoltaic systems to support the auto consumption of energy. The result, aligned with Saad et al. (2023), makes sense, as metalworking is an energy-intensive industry that contributes to climate change (Chou and Liou 2012; Gerres et al. 2019) and potentially offers a considerable economic advantage by monitoring the energy consumption.

> We carried out an energy analysis to identify measures capable of generating both economic and environmental benefits, which informed a three-year business plan. The program includes replacing outdated lighting systems and air conditioners, introducing machinery equipped with inverter motors, and renovating the roof with skylights to increase natural light and reduce electricity consumption.
>
> (Health, safety, and environment manager, 25I)

> We monitor the use of gas, electricity, and water, as well as the associated CO_2 emissions; in addition, we track the tons of CO_2 equivalents saved through sustainable technologies. Our emission indicators cover CO, CO_2, NO_x, particulate matter, and the cubic meters of methane consumed per ton of steel produced.
>
> (Health, safety, and environment manager, 25N)

> We place particular attention on reducing energy consumption. Last year, for example, we improved thermal insulation by replacing all window fixtures, which were outdated and caused substantial heat loss.
>
> (General manager, 28F)

> From an environmental perspective, our efforts focus on minimizing emissions and overall consumption, particularly electricity and gas.
>
> (Technical manager, 28O)

> All energy consumption is continuously monitored. We also assess the energy savings generated by the photovoltaic system and the economic return from the sale of surplus energy. These indicators are evaluated over time in relation to production levels.
>
> (Health, safety and environment manager, 28L)

The electronics sector emerges as focused on the *water* performance dimension. The result is supported by Madaka et al. (2022) who underline the relevance of the water footprint for the supply chain of consumer electronics.

> We have invested in systems for recovering coolants, allowing us to limit water consumption and ensure proper management of these liquids.
>
> (CEO, 26O)

> We introduced washing systems capable of retaining contaminated wastewater, which is subsequently collected by certified external companies for proper disposal, analysis, and reporting.
>
> (Quality manager, 27E)

> Our processes involve minimal direct water consumption. Water is primarily used for two purposes: to create emulsions by mixing it with the oils required for machining operations, and to operate the water-based braking systems in the test room. To reduce the environmental impact of these activities, we implemented a water-recycling system that enables the reuse of water employed during engine testing.
>
> (Sales manager, 27H)

The plastic and rubber sector emerged interested in *air emissions* and *community* performance dimensions, whereas aspects

related to *suppliers* and *investments* are not particularly considered. Emissions from the plastic sector are a relevant focus for academia and policymakers and the impact of plastic particles on human health, which raises concerns from communities (Maione et al. 2022; Mayer et al. 2024), might influence the community-related aspects. The investigated SMEs have also confirmed this aspect.

> Sustainability means complying with regulations concerning discharges, emissions, and waste disposal.
>
> (Owner, 22Q)

Concerning the focus on community, it indeed particularly emerged for SMEs belonging to the plastic and rubber sector.

> Taking care of the company's surroundings is part of the company's overall approach to sustainability.
>
> (Stamping division director, 22Uu)

4.2.1.3 | General Analysis Regarding the Sector. The sector appears as a relevant contextual factor influencing the measurement of sustainability performance. Differences emerged not only in the sustainability pillars considered but also in the performance dimensions within the same pillar. Differences might arise from the diverse characteristics of the processes performed within the specific sector, which can influence the specific aspects monitored or of interest. Further, the regulatory context might lead to different foci and interests, as is the case, for example, in the textile sector. Indeed, SMEs in the plastic and rubber sector and in electronics underlined that no incentives are available to them.

> There are no significant incentives to support us in improving our sustainability.
>
> (Production and maintenance manager, 22P)

Beyond formal institutions, sector-specific informal institutions, such as customers and other stakeholders, seem to influence the measurement of sustainability and SMEs possibly started measuring aspects monitored or of interest to the informal institutions. The lack of customers and market requests emerged as pivotal for different sectors.

> There is not a strong demand [for sustainability]
>
> (General manager, 22Y)

> At the moment we are very bound to customer requirements: if they ask for a large amount of plastic because they want everything packaged, we cannot refuse.
>
> (Sales manager, 25M)

> Since none of our clients has ever insisted on this, we have not pursued it. We do not invest where no feedback is received.
>
> (Production manager, 28B)

Given the sector's relevance, SMEs need to understand the most significant sustainability aspects of their processes and measure them effectively. In this manner, SMEs would also be better positioned to conduct benchmarking activities. Further, SMEs need to understand the formal and informal institutions specific to their sector, how to deal with them appropriately and possibly exploit institutional pressures to improve their measurement of sustainability performance.

4.2.2 | Company Size

4.2.2.1 | Analysis According to Sustainability Pillars. The analysis highlights differences in the indicators measured by SMEs of different sizes (Figure 4). Although the focus on the sustainability pillars is overall aligned, medium-sized companies tend to measure more indicators than small companies, supporting the findings of Trianni et al. (2019). It is worth noting the presence of two outliers among small companies. They are both metalworking companies and although they both have characteristics that might approximate them to medium-sized companies—one has a high annual revenue (€40MM), the other one counts 45 employees, the evidence seems to underline that smaller companies do not necessarily have less resources or less awareness, nor are they necessarily lagging compared to medium ones; rather, there could be very different situations.

4.2.2.2 | Analysis According to Performance Dimensions. Differences can be identified by focusing on the performance dimensions for each pillar (Figure 5). Small companies seem less focused on aspects related to *community* and the environment (*water, environmental management, emissions, energy*),

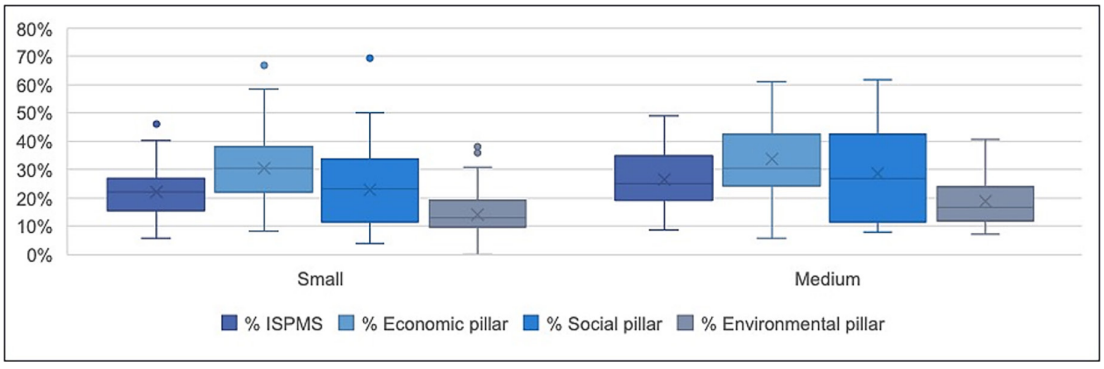

FIGURE 4 | Distribution of the percentage of the number indicators measured by the SMEs in relation to the total number of indicators in the Cagno et al. (2019)'s model (ISPMS) according to the companies' size (small and medium).

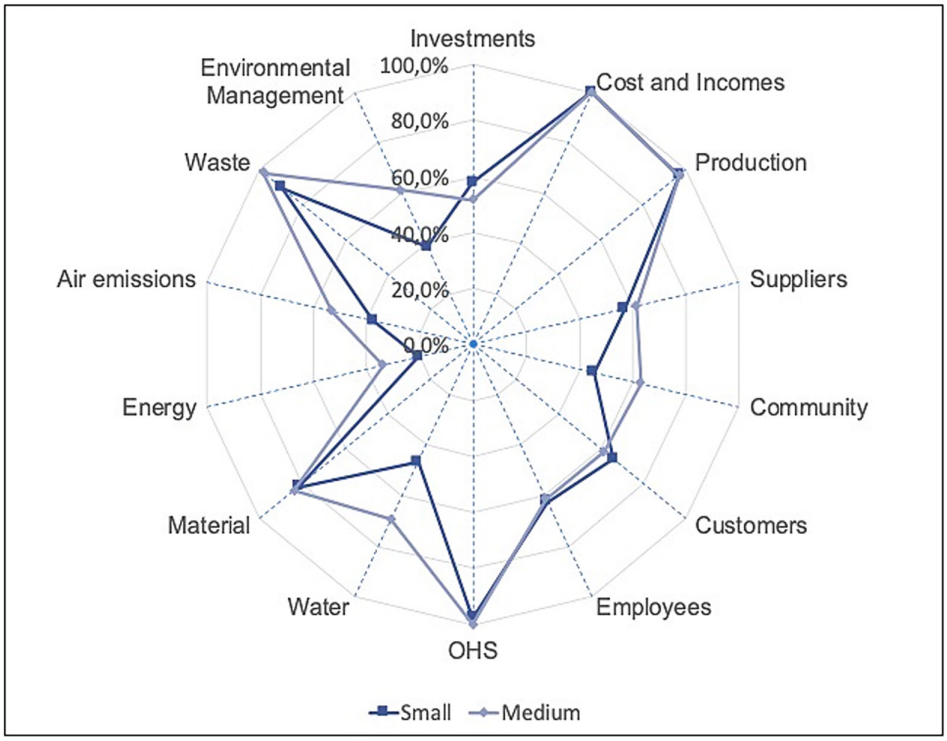

FIGURE 5 | Coverage of performance dimensions according to the size.

in line with Trianni et al. (2019). Further, Joy-Camacho and Thornhill (2024) note that *environmental management* is more effectively implemented in medium-sized companies than in smaller ones. Interestingly, smaller companies have a slightly higher adoption of indicators related to *customers* and *investments*. However, this result needs further investigation, as the difference is limited.

4.2.2.3 | General Analysis Regarding Company Size. The company size seems to influence the number of indicators more than the pillars or performance dimensions considered. Generally, smaller companies have fewer resources than medium-sized ones, which may lead them to focus their efforts on a limited number of aspects.

> The issue lies in determining who should perform these activities and when. Resources are limited, and we cannot afford dedicated personnel, as today the associated costs would be extremely high.
>
> (CEO, 25G)

Limited resources need to be prioritized and they might not necessarily be allocated to improving performance measurement. It remains open to discussion whether the aspects currently measured are also the best ones for the specific strategies and activities. Interestingly, Hassanein and Elmaghrabi (2024) underline that performance disclosure can hurt market competition for small companies, but not for medium and large companies.

Another point of interest that emerged during the interviews relates to the use of digital technologies. Trianni et al. (2019) underline that small companies measured fewer technology-related indicators than medium ones and that a digital divide is surely characterising small companies (Cagno et al. 2024). As digital technologies have also demonstrated strong potential for helping companies evaluate and map performance (Neri et al. 2023), the role of digital technologies in fostering the measurement of sustainability-related performance is worth investigating. Investigated SMEs and specifically small companies, realised the potential support offered by technology.

> Having information and technology tools to detect the facts is essential, because when you are dealing with a large amount of data, using an appropriate information system is the only way to manage it effectively.
>
> (Quality, safety and environmental manager, 22Ll)

> We would like to implement digital systems to monitor our processes better and to digitize data.
>
> (CEO, 25F)

> For data entry, it is always preferable to use digital methods. This is why we are currently investing in new software to bring digital transformation into the production area.
>
> (Technical manager, 25H)

> One thing that I believe will be particularly useful this year, and that I would like to implement, is a business intelligence system.
>
> (Head of operations, 26F)

Interestingly, a few small companies also highlighted the age of management as a determinant of overall behaviour and approach to sustainability measurement, with younger managers and employees more proactive in the activity.

> In fact, when company owners are young and up to date, it becomes much easier for them to understand that, for example, having an energy manager could be an advantage.
>
> (Sales manager, 27H)

> It is largely a cultural issue. In recent years, we have experienced some turnover: younger employees tend to be more attentive and express a stronger need for this type of initiative, whereas older employees struggle to understand these requirements.
>
> (General manager, 28F)

4.2.3 | Understanding of Sustainability

The SMEs' understanding of sustainability was evaluated based on the definition and interpretation of sustainability that emerged during the interviews (Table 6). The investigated SMEs have also recognised the understanding of the concept of sustainability as impacting their decision-making process.

> Sustainability is the combination of choices, decisions, and beliefs aimed at achieving balance, both at the company level and at the planetary level.
>
> (Quality manager, 22Rr)

Most SMEs interpret sustainability from a TBL perspective (44%) or as the intersection of environmental and economic pillars (27%). Plastic and rubber and textile sectors present a similar trend. At the same time, a few metalworking SMEs view sustainability as the intersection of environmental and social pillars. In contrast, some electronics SMEs view it solely as a matter of the environmental pillar. No differences emerged when comparing small and medium companies, except for a higher percentage of medium companies that understood sustainability as the intersection of the three pillars.

4.2.3.1 | Analysis According to Sustainability Pillars. The different understandings of sustainability seem to be reflected in the indicators measured by SMEs (Figure 6). At the same time, small differences emerged relative to the total number of indicators measured (Figure 6a). A focus on the single pillar offers more insights. SMEs with a greater emphasis on the economic pillar of sustainability show higher adoption of economically related indicators (Figure 6b); conversely, SMEs that view sustainability as the intersection of environmental and social pillars show higher adoption of social indicators, despite greater dispersion (Figure 6c). No differences seem to emerge when focusing on the indicators measured in the environmental pillar, as the average and median are aligned across all groups. Yet the high prevalence of outliers indicates low behavioural convergence (Figure 6d).

4.2.3.2 | Analysis According to Performance Dimensions. Differences can be spotted by focusing on the different performance dimensions (Figure 7). The results seem aligned across the different groups investigated. Yet, SMEs' understanding of sustainability mainly as economically related tends to measure more indicators linked to *material*, *water* and *customer* performance dimensions, but fewer indicators related to *energy* and *air emissions* performance dimensions. The result does not indicate a specific pattern. Interestingly, all SMEs in the group belong to the electronics sector, which might significantly shape the measured performance dimensions. SMEs including the social pillar in their interpretation of sustainability tend to measure more indicators related to community. Interestingly, although the expectation for SMEs with a TBL perspective on sustainability would have been greater coverage of the various performance dimensions, this difference was not evident in the data analysis.

4.2.3.3 | General Analysis Regarding the Understanding of Sustainability. The understanding of sustainability does not seem to be a relevant contextual factor in influencing the sustainability performance measurement. Interestingly,

TABLE 6 | Number of SMEs and percentage of the sample (in brackets) that consider respective sustainability pillars.

	Sector				Size		
Sustainability understanding	**Plastics and rubber**	**Textile**	**Metalworking**	**Electronics**	**Small**	**Medium**	**#SMEs**
Economic	0 (0%)	0 (0%)	0 (0%)	6 (20%)	5 (6%)	1 (2%)	6 (4%)
Environmental	5 (10%)	2 (5%)	5 (17%)	9 (30%)	12 (14%)	9 (15%)	21 (14%)
Environment and economic	12 (24%)	11 (28%)	14 (47%)	4 (13%)	30 (34%)	11 (18%)	41 (27%)
Environmental and social	6 (12%)	1 (3%)	6 (20%)	2 (7%)	8 (9%)	7 (11%)	15 (10%)
Social and economic	0 (0%)	0 (0%)	0 (0%)	1 (3%)	1 (1%)	0 (0%)	1 (1%)
TBL	27 (54%)	26 (65%)	5 (17%)	8 (27%)	32 (36%)	34 (55%)	66 (44%)
Total	50 (100%)	40 (100%)	30 (100%)	30 (100%)	88 (100%)	62 (100%)	150 (100%)

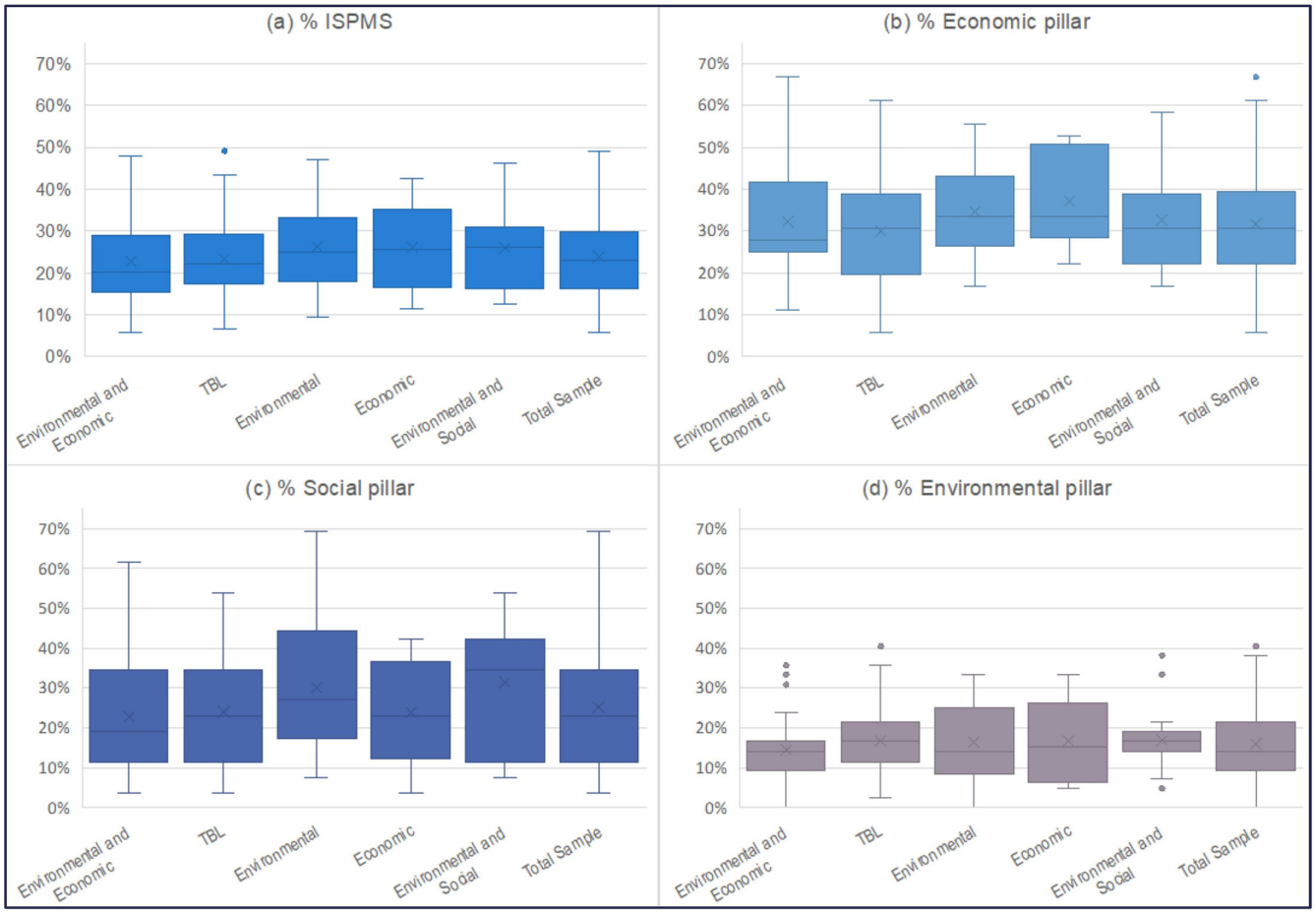

FIGURE 6 | Distribution of the percentage of the number indicators measured by the SMEs in relation to the total number of indicators in the Cagno et al. (2019)'s model (ISPMS) according to the sustainability understanding. Group 'Social and Economic' was excluded because it contains only one SME.

the understanding of sustainability appears to be linked to the sector to which the SME belongs. Further investigation is needed from this perspective.

4.2.4 | Certifications

A complete overview of the certifications held by the investigated SMEs is reported in Table 7. A large share of SMEs (98 out of 150; 65%) holds at least one economic certification. The most adopted one is the ISO 9001 (63%). Another significant portion of SMEs (73 out of 150; 49%) holds at least one environmental certification and ISO 14001 is the most widely adopted (25%). A limited group of SMEs holds at least one social certification (27 out of 150; 18%) and the most widely adopted are ISO 45001 (7%) and OHSAS 18001 (5%).

Interesting differences emerge when coupling the certifications held with the sector and the size (Table 8). Plastic and rubber, metalworking and electronics SMEs mostly hold economic certifications. At the same time, the textile sector shows significant adoption of environmental certifications, with a large share of textile SMEs holding only environmental certifications (among them, several sector-specific ones). From the investigation, certifications appeared to be requested by specific customers in some cases.

> In the medical sector, we were required to obtain specific certifications.
>
> (Head of operations, 25O)

> In the food and medical sectors, we are required to obtain additional types of certifications.
>
> (CEO, 26D)

> Some clients have asked us to provide plans related to our code of ethics or to environmental sustainability. [...] ISO 9001 is almost taken for granted in our industry. Our consultant recommended including key elements of our code of ethics in all our offers, such as ensuring safe working conditions, lawful employment, and related aspects.
>
> (CEO, 25E)

In the textile sector, the adoption of environmental certifications tends to be linked to rising market pressures.

> In market terms, adherence to environmental certification standards is set to become increasingly indispensable.
>
> (CEO's assistant, 13A)

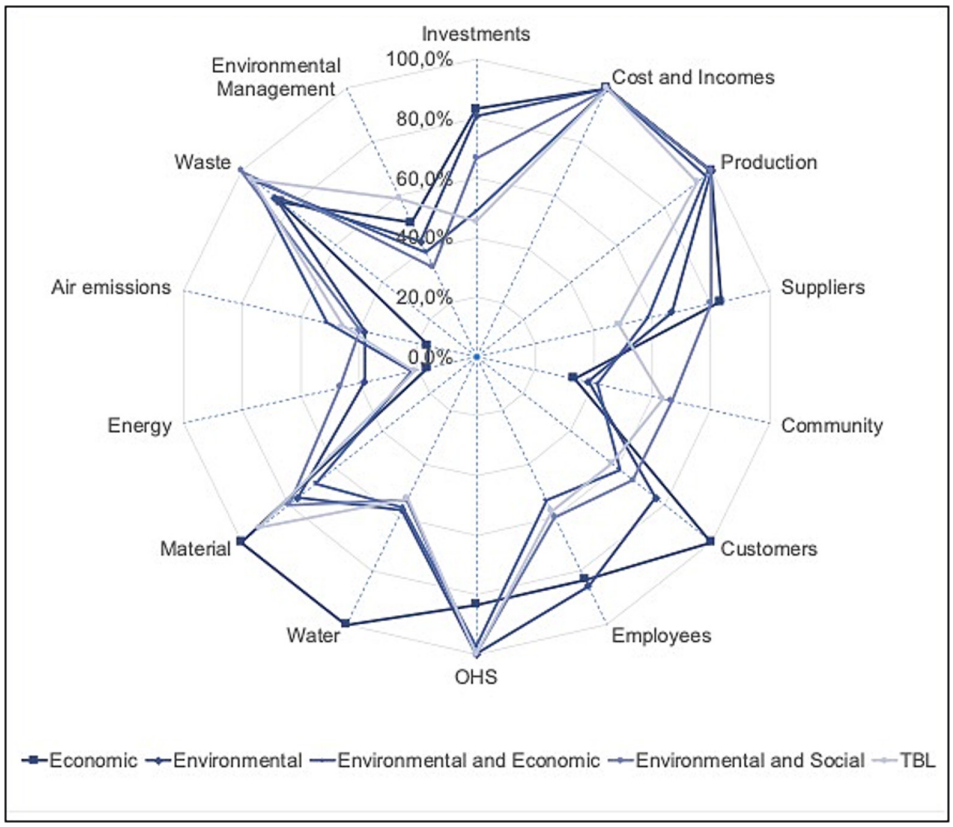

FIGURE 7 | Coverage of performance dimensions according to the sustainability understanding. Group 'Social and Economic' was excluded because it contains only one SME.

> We are working on certification projects related to the use of chemical substances that could harm people or the environment. These projects also influence the supply chain, prompting changes in protocols to reduce energy and water consumption.
>
> (Sales director, 13H)

Interestingly, the metalworking sector presents a relevant share of SMEs without certification. As for size, a large share of small companies does not hold any certification, possibly due to resource limitations.

4.2.4.1 | Analysis According to Sustainability Pillars. The certifications held seem to affect the indicators measured by SMEs (Figure 8), both in general and with respect to the different sustainability pillars. SMEs holding certifications related to the three pillars tend to measure more indicators (Figure 8a). This can lead either to a more structured measurement of indicators or to increased awareness of sustainability and the measurement of the related performance.

> If we want to evaluate the company, we must rely on a set of indicators. Moreover, this is precisely what the ISO 9001, 14001, and 45001 standards teach us.
>
> (Sustainability manager, 22Ii)

> I have worked for several years in other companies that held this type of certification, which can indeed represent additional workload and rules. However, it can also serve as an important vehicle for internal education within the company.
>
> (CEO, 25B)

SMEs without certifications and SMEs with only environmental certifications (both belonging to the textile sector) are associated with fewer indicators measured (Figure 8a). Combining different types of certifications appears to shape the number of indicators measured across the different pillars (Figure 8b, Figure 8c, Figure 8d).

4.2.4.2 | Analysis According to Performance Dimensions. The performance dimensions measured by each group appear similar (Figure 9). Still, some differences are worth noting. For example, SMEs with environmental and social certifications give significant consideration to *suppliers*; SMEs with only economic certifications largely consider *customers*-related aspects; SMEs holding only environmental certifications tend to have limited consideration of *energy* and *customers*' performance dimensions. Further on this, the *environmental management* performance dimension is mainly measured by SMEs with environmental certifications, in line with Sahoo (2024), who considers ISO 14001 necessary for an appropriate energy management system.

4.2.4.3 | General Analysis Regarding Certifications. Overall, certifications do not appear to be a relevant contextual factor shaping the sustainability performance

TABLE 7 | Certifications held by sampled SMEs.

Certification area	Certification	#SMEs	%SMEs
Economic certification	ISO 9001	95	63%
	IAFT 16949	5	3%
	Product specific	5	3%
	ISO 15001	3	1%
	Others (Econ.)	9	6%
	At least one economic certification	***98***	***65%***
Environmental certification	ISO 14001	38	25%
	OEKOTEX	26	17%
	GOTS	21	14%
	GRS	21	14%
	FSC	11	7%
	ZDHC	7	5%
	BCI	6	4%
	ISO 50001	4	3%
	Detox	3	2%
	OCS	3	2%
	Plastica Seconda Vita	2	1%
	BlueSign	2	1%
	Others (Env.)	6	4%
	At least one environmental certification	***73***	***49%***
Social certification	ISO 45001	11	7%
	OHSAS 18001	8	5%
	SERICO	4	3%
	Ecovadis	3	2%
	Others (Soc.)	3	2%
	At least one social certification	***27***	***18%***

measurement. The literature has underscored that certifications may be adopted to enhance brand image or from a 'greenwashing' perspective and may not be sufficient to prove sustainability claims (Tolentino-Zondervan and DiVito 2024).

> Large international fashion groups require these types of certifications, yet they do not purchase the corresponding products. Essentially, they want suppliers to be certified so that external organisations can verify compliance, but they do not actually engage with the certified output. In other words, greenwashing persists within the supply chain.
>
> (Sales director, 13H)

> We suffer from the competition of companies that engage in greenwashing: in our view, ninety percent of what is said about sustainability in the market is misleading or false.
>
> (Quality manager, 13S)

Further, Leimona et al. (2024) stress the relevance of a supply chain perspective for effective adoption of certifications. It must be noted that environmental certifications are held only by textile SMEs, suggesting a relationship between the sector and the certifications held, but further evaluations are needed.

4.3 | Interplay Between Contextual Factors

The previous sections suggested that the sector and the size could influence both the understanding of sustainability and certifications held. The present subsection evaluates in a more structured manner possible interplays between contextual factors.

4.3.1 | Sector, Understanding of Sustainability and Certifications

Table 9 provides a summary of a cross-analysis considering each industrial sector. A similarity emerges between the plastic and rubber sector and the textile sector, whereas the metalworking and electronics sectors tend to have common profiles in terms of sustainability indicators adoption.

The plastic, rubber and textile sectors both understand sustainability mainly as the intersection of the three pillars. However, this broader perception does not seem to reflect SMEs' certifications, mainly economic (mostly ISO 9001) and environmental (especially in the textile sector). Both sectors show lower adoption of sustainability indicators than the total sample. The most-covered performance dimension across both sectors is *material*. Still, differences can be underlined for the other most covered performance dimensions.

The metalworking and electronics sectors both understand sustainability mainly in economic terms and hold economically related certifications. The two sectors mostly focused on the *investments* and *customers*' performance dimensions, whereas differing in aspects related to *materials* and *employees*.

4.3.2 | Size, Understanding of Sustainability and Certifications

Table 10 provides a summary of a cross-analysis according to size. Company size does not seem to affect understanding of sustainability, but it does appear to affect the certifications held. Further, compared to smaller companies, medium ones tend to adopt more indicators and focus more on *community* and *water* performance dimensions.

TABLE 8 | Number of SMEs and percentage of the sample (in brackets) with at least one certification related to each of the sustainability pillars.

	Sector				Size		
Certifications	**Plastics and rubber**	**Textile**	**Metalworking**	**Electronics**	**Small**	**Medium**	**Sample**
Economic certifications	15 (30%)	2 (5%)	11 (37%)	18 (60%)	27 (31%)	19 (31%)	**46 (31%)**
Economic and environmental certifications	12 (24%)	7 (18%)	5 (17%)	7 (23%)	17 (19%)	14 (23%)	**31 (21%)**
Economic, environmental and social certifications	8 (16%)	3 (8%)	4 (13%)	1 (3%)	4 (5%)	12 (19%)	**16 (11%)**
Economic and social certifications	3 (6%)	0 (0%)	2 (7%)	1 (3%)	2 (2%)	4 (6%)	**6 (4%)**
Environmental certifications	0 (0%)	22 (55%)	0 (0%)	0 (0%)	14 (15%)	8 (14%)	**22 (15%)**
Environmental and social certifications	0 (0%)	4 (10%)	0 (0%)	0 (0%)	3 (3%)	1 (2%)	**4 (3%)**
Social certifications	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (2%)	**1 (1%)**
No certification	11 (22%)	2 (5%)	8 (27%)	3 (10%)	23 (26%)	1 (2%)	**24 (16%)**
TOTAL	**50 (100%)**	**40 (100%)**	**30 (100%)**	**30 (100%)**	**91 (100%)**	**59 (100%)**	**150 (100%)**

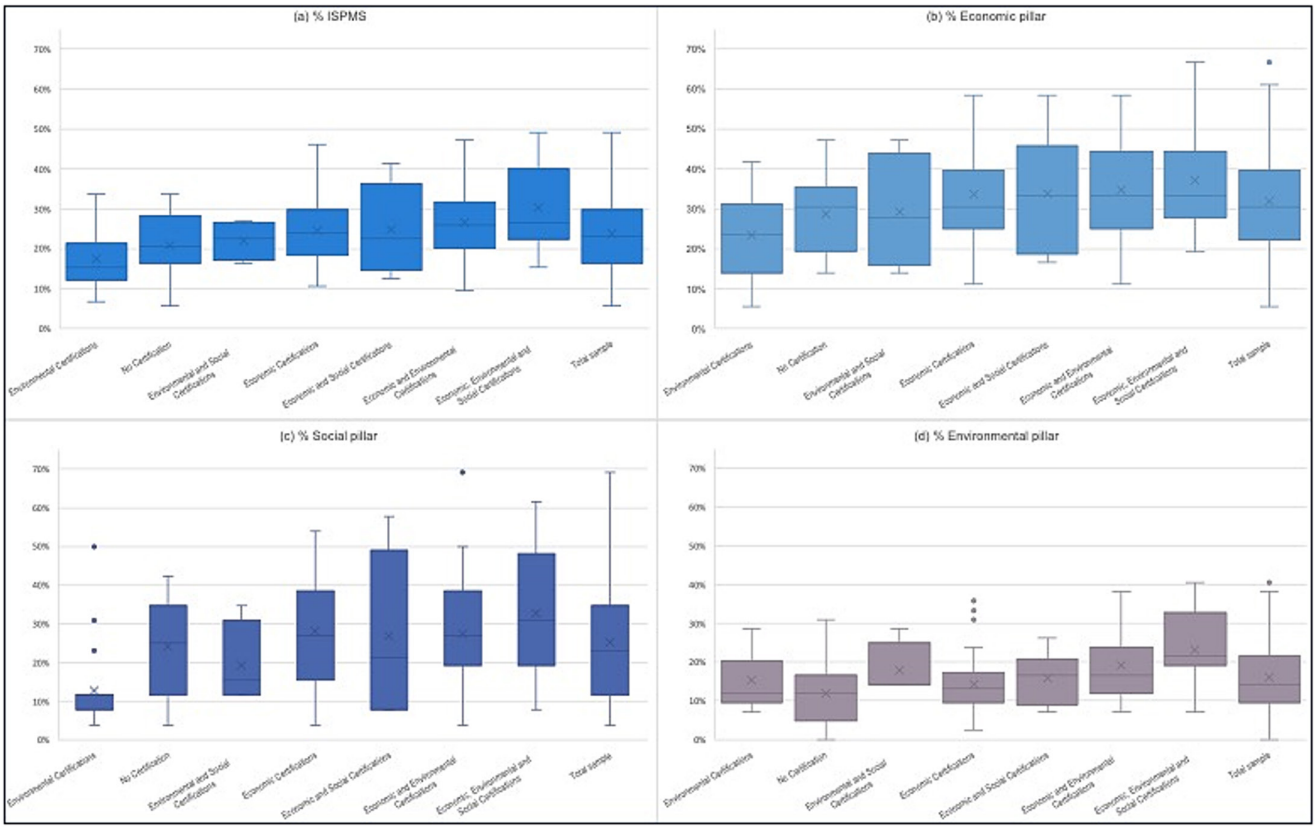

FIGURE 8 | Distribution of the percentage of the number indicators measured by the companies in relation to the total number of indicators in the Cagno et al. (2019)'s model (ISPMS) according to the sustainability understanding. Group 'Social certifications' was excluded because it contains only one SME.

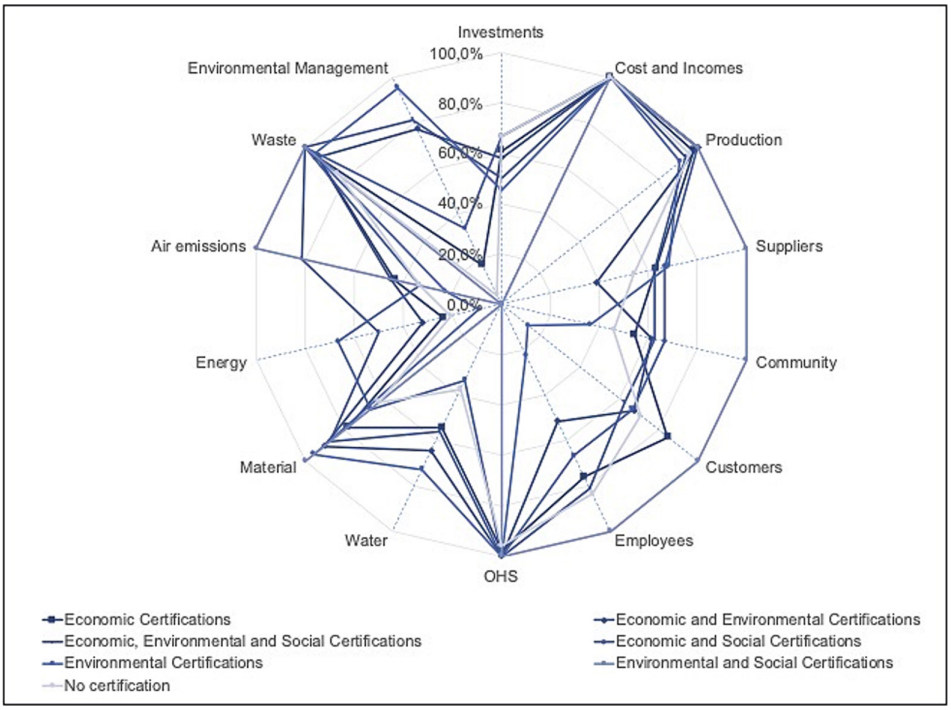

FIGURE 9 | Coverage of performance dimensions according to the sustainability understanding. Group 'Social Certification' was excluded because it contains only one SME.

TABLE 9 | Summary of the main results according to the sector.

Sector	Sustainability understanding[a]	Certification[b]	Sustainability indicators according to pillar[c]	Performance dimensions[d]
Plastic and rubber	TBL: 54% Environment and economic: 24%	Economic: 30% Economic + environment: 24%	Economic: 29% Social: 20% Environment: 14%	Environment—Material: 90% Social—Community: 70% Environment—Air emission: 68%
Textile	TBL: 65% Environment and economic: 28%	Environment: 55% Economic + environment: 18%	Economic: 24% Social: 16% Environment: 15%	Environment—Material: 95% Environment—Env. Management: 80% Economic—Suppliers: 58% Environment—Water: 58%
Metalworking	Environment and economic: 47% Environment and social: 20%	Economic: 37% No certification: 27%	Economic: 40% Social: 38% Environment: 18%	Social—Customers: 97% Social—Employees: 93% Economic—Investments: 83%
Electronics	Environment: 30% TBL: 27%	Economic: 60% Economic + environment: 23%	Economic: 38% Social: 34% Environment: 18%	Economic—Investment: 93% Social—Customers: 90% Environment—Material: 90%
Total sample	TBL: 44% Environment + economic: 27%	Economic: 31% Economic + environment: 21%	Economic: 32% Social: 25% Environment: 16%	Environment—Material: 82% Social—Customers: 64% Social—Employees: 62%

[a]Top 2 highest %SMEs in the sector that indicated the sustainability pillars when asked about the understanding of sustainability.
[b]Top 2 highest %SMEs in the sector with certifications related to each sustainability pillar.
[c]% of the number of indicators adopted for each sustainability pillar in relation to the total number of Full ISPMS versions.
[d]Top 3 highest %SMEs in the sector that measure at least one indicator belonging to the performance dimension. Please note that the following are excluded, as the most frequent ones common to all sectors: Economic – Cost; Economic—Income; Economic—Production; Social—OHS; Environmental—Waste.

TABLE 10 | Summary of the main results according to the size.

Size	Sustainability understanding[a]	Certification[b]	Sustainability indicators according to pillar[c]	Performance dimensions[d]
Small	TBL (36%) Environmental and economic (34%)	Economic: 31% No Certification: 26%	Economic: 30% Social: 23% Environmental: 14%	Environmental-Material: 82% Social—Customers: 66% Social—Employee: 62% Economic—Investment: 58%
Medium	TBL (55%)	Economic: 31% Economic + Environment: 23%	Economic: 34% Social: 29% Environmental: 19%	Environmental—Material: 84% Environmental—Water: 69% Social—Community: 63% Social—Customers: 61%
Total sample	***TBL: 44% Environmental and economic 27%***	***Economic: 31% Economic + environment: 21%***	***Economic: 32% Social: 25% Environmental: 16%***	***Environmental—Material: 82% Social—Customers: 64% Social—Employees: 62%***

[a]Top 2 highest %SMEs of the specific size that indicated the sustainability pillars when asked about the understanding of sustainability.
[b]Top 2 highest %SMEs of the specific size with certifications related to each sustainability pillar.
[c]% of the number of indicators adopted for each sustainability pillar in relation to total number of Full ISPMS version.
[d]Top 3 highest %SMEs in the sector that measure at least one indicator belonging to the performance dimension. Please note that the following are excluded, as the most frequent ones common to all sectors: Economic—Cost; Economic—Income; Economic—Production; Social—OHS; Environmental—Waste.

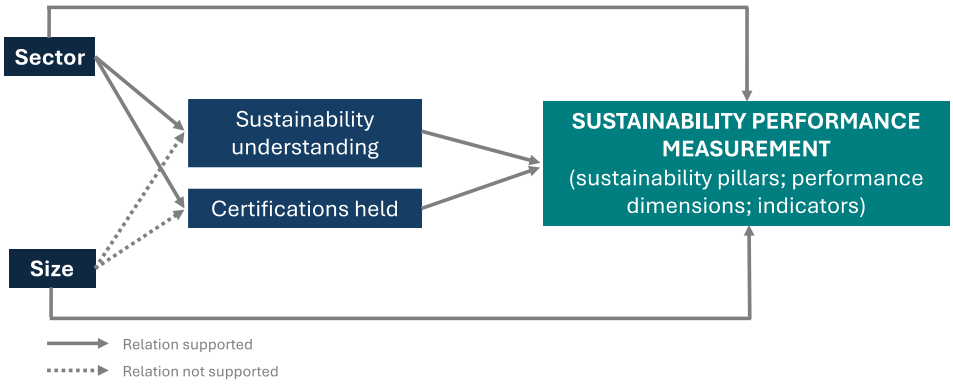

FIGURE 10 | Relations between analysed variables.

4.3.3 | General Analysis Regarding the Interplay Between Contextual Factors

The previous analyses showed an influence of size and sector on the indicators measured by manufacturing SMEs. They presented possible relations between sector and size and the understanding of sustainability and certifications. Further, the previous analyses highlighted the influence of certifications and understanding of sustainability on the measured performance. For example, SMEs that perceive the economic pillar as more relevant make a greater effort to measure economic and social-related indicators (Figure 6a and Figure 6c). As another example, the results underscore that SMEs with a broader range of certifications across the economic, social and environmental pillars do seem to be more interested in sustainability (Figure 8). In contrast, non-certified SMEs are relatively less concerned with the environmental pillar of sustainability (Figure 8d).

Overall, the evidence from the present study suggests that the industrial sector influences the measured indicators. Still, it can also shape the understanding of sustainability and the certification held by an SME, which mediates the measurement of sustainability indicators. The impact of size on performance measurement seems more related to the number of indicators than to the type of indicators measured. However, measuring additional indicators leads medium-sized companies to incorporate more social aspects and shift from an internal perspective to a more external perspective of sustainability. The identified relations are reported in Figure 10.

Overall, as expected under contingency theory, the study shows that the adoption and prioritisation of sustainability performance indicators vary across companies depending on their contextual characteristics and it provides insights into differences across the contextual factors investigated. Significantly, by going beyond a single-context-factor perspective, the analysis

provides a preliminary understanding of the possible interplay between these contextual factors, acknowledging that different combinations may lead to distinct sustainability performance measurement approaches.

5 | Conclusions

The present study brings novel empirical evidence that helps to answer the following research questions:

RQ1: How do manufacturing SMEs measure sustainability performance?

RQ2. How do contextual factors (size, sector, certifications and understanding of sustainability) shape the measurement of sustainability performance in manufacturing SMEs?

Overall, SMEs tend to measure sustainability from an economic perspective, followed by the social and environmental ones (Figure 1, Table 4 and Table 5). SMEs appear to be primarily driven by production-related factors, with economic and financial implications and regulatory mandates rather than by a comprehensive sustainability strategy, thereby neglecting broader environmental and social impacts, especially those extending beyond the SME's boundaries. Economic performance dimensions such as *costs* and *income* are largely measured, whereas *investments* and *supplier*-related aspects receive surprisingly little attention. In terms of environmental performance dimensions, *waste* and *material* use are the primary concerns, often due to their economic implications, yet *energy* use, *water* and *air emissions* are frequently overlooked. As for the social performance dimensions, *OHS*-related aspects are addressed across all SMEs, likely driven by legislation. Still, broader *employee welfare* and *customer*-related metrics are measured less frequently and *community* involvement is largely ignored, emphasising a prevalent internal operational focus.

However, the way SMEs approach sustainability measurement appears to be shaped by their contextual characteristics. Specifically, from our investigation, the sector and the size emerged as particularly relevant. The sector appears to shape SMEs' interest in sustainability measurement (Figure 2 and Figure 3). This is clearly seen for the economic and social pillars, but less evident for the environmental pillar (Figure 2). However, for example, the metalworking sector shows higher levels of *energy*-related aspects and the electronics sector shows higher levels of *water*-related aspects. The present study also provides evidence that different sectors have distinct understandings of sustainability (Table 6 and Table 9) and hold different types of certifications (Table 8 and Table 9). Further, consistent with previous studies, the present study indicates that smaller companies show less interest in sustainability measurement (Figure 3 and Figure 4) and hold fewer certifications than medium-sized companies (Table 8 and Table 10). Yet, there is no clear evidence relating company size to the understanding of sustainability (Table 6 and Table 10). Interestingly, unlike previous studies, the present research investigated four contextual factors. The results show that sector and size can influence performance measurement, but, as noted before, so can certifications held and understanding of sustainability, albeit to different extents, which in turn might lead to differences in the measurement of sustainability performance.

5.1 | Contributions of the Study

The present study, by providing empirical evidence on how manufacturing SMEs measure sustainability performance, adds to current knowledge on sustainability performance measurement in manufacturing SMEs. Indeed, although the sustainability performance literature is not new, only a few studies have empirically evaluated the sustainability performance indicators adopted. This is a novel contribution, as it provides robust data on SMEs' interest in sustainability and reflects the sustainability performance dimensions covered by the individual performance indicators used by manufacturing SMEs. The evidence provided is further enriched by adopting a contingency perspective and evaluating the influence of four contextual factors on performance measurement in manufacturing SMEs. Contingency theory has been successfully applied in sustainability studies across various areas, such as sustainable supply chain management (Donkor et al. 2024), sustainability strategy and eco-innovation (Tsai and Liao 2017). Still, it has had limited application to sustainable performance measurement (Ong et al. 2019). The present study successfully extends the empirical application of this theory to the measurement of sustainability performance. Leveraging Zharfpeykan and Akroyd (2022) and Trianni et al. (2019), and grounded in contingency theory, the study thus confirms that the adoption of sustainability performance indicators by manufacturing SMEs is contingent on certain factors, namely: industrial sector, company size, understanding of sustainability and certifications held. In fact, the present study not only indicates that they are indeed contingent factors but also provides empirical evidence on how these factors affect industrial sustainability performance measurement. Furthermore, the study makes a new contribution by providing a preliminary overview of the possible interplay among different contextual factors. The results provide further understanding of the mechanisms underlying contextual factors, preliminarily showing their connection and advancing knowledge of contingencies. Specifically, as also discussed before, our results refine contingency theory by showing that, in SMEs, the effect of contextual factors on sustainability measurement is not uniform: some factors (e.g., sector) exert a stronger and more consistent influence than others (e.g., size), suggesting a differentiated and configuration-dependent pattern. The influence of each investigated factor differs from that of the others and it appears a potential interplay with other contextual factors. This provides clear practical implications for manufacturers and policy decision-makers.

Based on the study's findings, several contributions and implications can be highlighted. Practitioners and industrial decision-makers are provided with an overview of the current measurement of sustainability performance by a significant group of heterogeneous manufacturing SMEs and of the selected contextual factors that shape the measurement. In this manner, they can benchmark their performance and potentially practice with peers and SMEs with similar characteristics. Indeed, practices and performances are so closely interrelated that Zaman

et al. (2025) identify sustainability in SMEs as the combination of sustainability practices and sustainability performance.

Based on the results, the measurement of sustainability performance and the company's sustainability priorities are clearly influenced by the sector. Sector-based industrial practices recommendations or practices, thus, might be more effective than general ones. Knowing how to focus efforts to improve sustainability integration within manufacturing companies, given previous practical implications, can help address resource constraints typical of manufacturing SMEs. Therefore, a widespread sustainability culture involving industrial decision-makers could lead to greater interest and associated effort towards sustainability performance.

In combination with the industrial sector and size contingent factors, sector-specific and size-specific initiatives are to be implemented to translate sustainability performance and understanding into the specific industrial context.

Policymakers and industrial associations are advised to develop sector-specific recommendations, since the sector affects not only the adoption of sustainability indicators but also the understanding of sustainability and the certifications held. From this perspective, Shaikh and Tripathy (2025) warn that, in assessing the sustainability performance of companies, differences across sectors and countries should be considered, as they directly translate into variability in sustainability reporting. The contributions offered to both practitioners and policymakers can help foster the evaluation of Scope 3 emissions by SMEs, encouraging a more proactive approach towards possible future legislation (European Commission 2025a, 2025b). Incentives for further certifications can also be an effective way to promote interest in sustainability issues among manufacturing companies. Thus, external sector-specific stakeholders, such as clients, the government and competitors demanding further certifications, were also shown to be effective in driving manufacturing interest in sustainability. Policymakers should thus avoid a standard approach to regulation and norm development in favour of a contingency-based approach grounded in behavioural patterns, interests and constraints.

5.2 | Limitations and Future Research

The study is not exempt from caveats. Data were collected primarily using a single informant per SME, which may have introduced personal bias. The number of sampled SMEs mitigates this limitation. Besides, the sample comprises only SMEs in Italy's Northern regions; manufacturing SMEs in other countries may yield different results.

Further studies are called for to deepen the understanding of sustainability measurement in SMEs. Measuring sustainability is the first step toward more mature sustainability integration in SMEs (Carlsson and Nevzorova 2025). Specifically, future studies can investigate additional factors influencing the measurement of sustainability performance, such as the internal organization of companies (Zharfpeykan and Akroyd 2022) or the characterization as family or non-family business (Herrero et al. 2024). This is critical to provide practice-oriented recommendations to support sustainability measurement and, in turn, improve sustainability performance. Future studies could also investigate differences in these results for larger companies. The difference between small and medium-sized companies was not as evident in the present study. However, the leap to large multinational incumbents could make the size difference in sustainability measurement more evident.

Leveraging prior literature and the results obtained, we suggest future research investigate the role of formal and informal institutions in shaping the measurement of sustainability performance by SMEs, as well as their relationship with the contextual factors examined in the present research. For example, Sharma et al. (2024) suggest that institutions can influence performance, whereas León-Bravo and Caniato (2024) underline that the institutional context can influence the presence of certifications. Interestingly, Xu et al. (2024) note that interest in sustainability might differ between formal and informal institutions and this aspect could be further investigated for its impact on companies.

Previous studies have also highlighted the importance of measuring sustainability in the supply chain (Negri et al. 2021; Neri, Cagno, Lepri, and Trianni 2021). We also suggest that further investigations be conducted into the sustainability indicators used to measure not only a company's sustainability performance but also the supply chain in which it is embedded.

Author Contributions

Alessandra Neri: conceptualization, data curation, formal analysis, investigation, methodology, project administration, supervision, validation, visualization, writing – review and editing, writing – original draft. **Enrico Cagno:** conceptualization, methodology, validation, writing – review and editing. **Sandra Naomi Morioka:** formal analysis, methodology, validation, visualization, writing – review and editing, writing – original draft. **Ivan Bolis:** methodology, formal analysis, validation, visualization, writing – review and editing, writing – original draft.

Acknowledgements

Open access publishing facilitated by Politecnico di Milano, as part of the Wiley - CRUI-CARE agreement.

Funding

The authors have nothing to report.

Ethics Statement

According to the Ethical Guidelines of Politecnico di Milano, the research design was such that no ethical approval was necessary.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data are not publicly available due to confidentiality.

References

Adams, D., J. Donovan, and C. Topple. 2021. "Achieving Sustainability in Food Manufacturing Operations and Their Supply Chains: Key Insights From a Systematic Literature Review." *Sustainable Production and Consumption* 28: 1491–1499. https://doi.org/10.1016/j.spc.2021.08.019.

Adams, W. C. 2015. "Conducting Semi-Structured Interviews." In *Handbook of Practical Program Evaluation*, edited by K. E. Newcomer, H. P. Hatry, J. S. Wholey, K. E. Newcomer, H. P. Hatry, and J. S. Wholey, 492–505. John Wiley & Sons, Inc. https://doi.org/10.1002/9781119171386.ch19.

Ahmad, S. 2023. "Triple Bottom Line-Based Sustainability Assessment of Tamar Cocoa Manufacturing and Packaging Activities by Using Comprehensive and Integrated Stochastic-Fuzzy Method." *International Journal of Life Cycle Assessment* 29: 2283–2304. https://doi.org/10.1007/s11367-023-02193-7.

AL-Shboul, M. A. 2019. "Towards Better Understanding of Determinants Logistical Factors in SMEs for Cloud ERP Adoption in Developing Economies." *Business Process Management Journal* 25, no. 5: 887–907. https://doi.org/10.1108/BPMJ-01-2018-0004.

Amhalhal, A., J. Anchor, N. S. Tipi, and S. Elgazzar. 2022. "The Impact of Contingency Fit on Organisational Performance: An Empirical Study." *International Journal of Productivity and Performance Management* 71, no. 6: 2214–2234. https://doi.org/10.1108/IJPPM-01-2021-0016.

Barratt, M., T. Y. Choi, and M. Li. 2011. "Qualitative Case Studies in Operations Management: Trends, Research Outcomes, and Future Research Implications." *Journal of Operations Management* 29, no. 4: 329–342. https://doi.org/10.1016/j.jom.2010.06.002.

Baškarada, S. 2014. "Qualitative Case Study Guidelines." *Qualitative Report* 19, no. 40: 1–25. https://doi.org/10.7748/nr2013.05.20.5.28.e327.

Ben Arab, S. D. 2020. "Quality Management Practices in SMEs: The Effects of Contextual Factors." *Quality Management Journal* 27, no. 4: 200–214. https://doi.org/10.1080/10686967.2020.1809583.

Benbasat, I., D. K. Goldstein, and M. Mead. 1987. "The Case Research Strategy in Studies of Information Systems." *MIS Quarterly* 11: 369–386. https://doi.org/10.2307/248684.

Bernhard, O., J. Brandstetter, and M. F. Zaeh. 2024. "A Multidimensional Holistic Sustainability Model for Production Systems." *Production & Manufacturing Research* 12, no. 1. https://doi.org/10.1080/21693277.2024.2423064.

Beverland, M., and A. Lindgreen. 2010. "What Makes a Good Case Study? A Positivist Review of Qualitative Case Research Published in Industrial Marketing Management, 1971–2006." *Industrial Marketing Management* 39, no. 1: 56–63. https://doi.org/10.1016/j.indmarman.2008.09.005.

Bispo Júnior, J. P. 2022. "Social Desirability Bias in Qualitative Health Research." *Revista de Saúde Pública* 56: 101. https://doi.org/10.11606/s1518-8787.2022056004164.

Brocke, J. V., S. Zelt, and T. Schmiedel. 2016. "On the Role of Context in Business Process Management." *International Journal of Information Management* 36, no. 3: 486–495. https://doi.org/10.1016/j.ijinfomgt.2015.10.002.

Cagno, E., D. Accordini, A. Neri, E. Negri, and M. Macchi. 2024. "Digital Solutions for Workplace Safety: An Empirical Study on Their Adoption in Italian Metalworking SMEs." *Safety Science* 177: 106598. https://doi.org/10.1016/j.ssci.2024.106598.

Cagno, E., A. Neri, M. Howard, G. Brenna, and A. Trianni. 2019. "Industrial Sustainability Performance Measurement Systems: A Novel Framework." *Journal of Cleaner Production* 230: 1354–1375. https://doi.org/10.1016/j.jclepro.2019.05.021.

Cantele, S., S. Landi, and S. Vernizzi. 2024. "Measuring Corporate Sustainability in Its Multidimensionality: A Formative Approach to Integrate ESG and Triple Bottom Line Approaches." *Business Strategy and the Environment* 33, no. 7: 7383–7408. https://doi.org/10.1002/bse.3872.

Carlsson, R., and T. Nevzorova. 2025. "Measuring Sustainable Transformation of Small and Medium-Sized Enterprises Using Management Systems Standards." *Business Strategy and the Environment* 34, no. 1: 708–723. https://doi.org/10.1002/bse.3995.

Chang, A. Y., and Y. T. Cheng. 2019. "Analysis Model of the Sustainability Development of Manufacturing Small and Medium-Sized Enterprises in Taiwan." *Journal of Cleaner Production* 207: 458–473. https://doi.org/10.1016/j.jclepro.2018.10.025.

Chen, D., S. Thiede, T. Schudeleit, and C. Herrmann. 2014. "A Holistic and Rapid Sustainability Assessment Tool for Manufacturing SMEs." *CIRP Annals - Manufacturing Technology* 63, no. 1: 437–440. https://doi.org/10.1016/j.cirp.2014.03.113.

Chou, K. T., and H. M. Liou. 2012. "Analysis on Energy Intensive Industries Under Taiwan's Climate Change Policy." *Renewable and Sustainable Energy Reviews* 16, no. 5: 2631–2642. https://doi.org/10.1016/j.rser.2012.01.057.

Chourasiya, R., S. Pandey, R. K. Malviya, and A. A. Pujara. 2024. "Towards Sustainable Success: A Framework for Assessing Performance of Sustainable Manufacturing Adoption in Indian Textile Industry." *Sustainable Futures* 7: 100216. https://doi.org/10.1016/j.sftr.2024.100216.

Cittadin, A., F. S. Da Rosa, and J. Monteiro. 2025. "Environmental Sustainability in Wineries: How Contingency Factors and Environmental Management Accounting Tools Influence Environmental Performance?" *Business Strategy and the Environment* 35: 5802–5822. https://doi.org/10.1002/bse.70437.

Córdova-Aguirre, L. J., and J. M. Ramón-Jerónimo. 2024. "Designing a Sustainability Assessment Framework for Peruvian Manufacturing Small and Medium Enterprises Applying the Stakeholder Theory Approach." *Sustainability* 16, no. 5: 1853. https://doi.org/10.3390/su16051853.

Cristofaro, M., P. L. Giardino, R. Camilli, and I. Hristov. 2024. "Unlocking the Sustainability of Medium Enterprises: A Framework for Reducing Cognitive Biases in Sustainable Performance Management." *Journal of Management & Organization* 30, no. 3: 490–520. https://doi.org/10.1017/jmo.2023.55.

Dağıdır, B. D., and B. Özkan. 2024. "A Comprehensive Evaluation of a Company Performance Using Sustainability Balanced Scorecard Based on Picture Fuzzy AHP." *Journal of Cleaner Production* 435: 140519. https://doi.org/10.1016/j.jclepro.2023.140519.

Damtoft, N. F., D. van Liempd, and R. Lueg. 2025. "Sustainability Performance Measurement – A Framework for Context-Specific Applications." *Journal of Global Responsibility* 16: 162–201. https://doi.org/10.1108/JGR-05-2023-0082.

De Oliveira, A. C., C. C. Sokulski, A. A. Da Silva Batista, and A. C. De Francisco. 2018. "Competencies for Sustainability: A Proposed Method for the Analysis of Their Interrelationships." *Sustainable Production and Consumption* 14: 82–94. https://doi.org/10.1016/j.spc.2018.01.005.

Delai, I., and S. Takahashi. 2011. "Sustainability Measurement System: A Reference Model Proposal." *Social Responsibility Journal* 7, no. 3: 438–471. https://doi.org/10.1108/17471111111154563.

Dewi, S. K., R. Febrianti, and D. M. Utama. 2023. "An Integrated Method for Manufacturing Sustainability Assessment in Tire Industry: A Case Study in Indonesian." *International Journal of Sustainable Engineering* 16, no. 1: 1–12. https://doi.org/10.1080/19397038.2023.2276936.

Donkor, F., T. Papadopoulos, and V. Spiegler. 2024. "Supply Chain Integration and Supply Chain Sustainability Relationship: A Qualitative Analysis of the UK and Ghana Pharmaceutical Industry." *Production Planning & Control* 35, no. 6: 535–558. https://doi.org/10.1080/09537287.2022.2105762.

Elkington, J. 1997. *Cannibals With Forks: The Triple Bottom Line of 21st Century Business*. Capstone.

Engida, T. G., X. Rao, P. B. M. Berentsen, and A. G. J. M. Oude Lansink. 2018. "Measuring Corporate Sustainability Performance—The Case of European Food and Beverage Companies." *Journal of Cleaner Production* 195: 734–743. https://doi.org/10.1016/j.jclepro.2018.05.095.

Eslami, Y., M. Lezoche, H. Panetto, and M. Dassisti. 2023. "An Indicator-Based Sustainability Assessment Framework in Manufacturing Organisations." *Journal of Industrial Information Integration* 36: 100516. https://doi.org/10.1016/j.jii.2023.100516.

European Commission. 2003. "What is a SME?" https://single-market-economy.ec.europa.eu/smes/sme-fundamentals/sme-definition_en.

European Commission. 2025a. "Proposal for a Directive of the European Parliament and of the Council Amending Directives (EU) 2022/2464 and (EU) 2024/1760 as Regards the Dates From Which Member States Are to Apply Certain Corporate Sustainability Reporting and Due Diligence Requirements." https://commission.europa.eu/document/download/0affa9a8-2ac5-46a9-98f8-19205bf61eb5_en?filename=COM_2025_80_EN.pdf.

European Commission. 2025b. "Proposal for a Regulation of the European Parliament and of the Council Amending Regulations (EU) 2015/1017, (EU) 2021/523, (EU) 2021/695 and (EU) 2021/1153 as Regards Increasing the Efficiency of the EU Guarantee Under Regulation (EU) 2021/523 and Simplifying Reporting Requirements." https://commission.europa.eu/document/download/58f5e2e3-e2c9-4149-9fd6-648490c9e7fe_en?filename=COM_2025_84_EN.pdf.

Eurostat. 2022. "EU Small and Medium-Sized Enterprises: An Overview." https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20220627-1.

Fallahi, S., A. Mellquist, O. Mogren, E. Listo Zec, P. Algurén, and L. Hallquist. 2023. "Financing Solutions for Circular Business Models: Exploring the Role of Business Ecosystems and Artificial Intelligence." *Business Strategy and the Environment* 32, no. 6: 3233–3248. https://doi.org/10.1002/bse.3297.

Feil, A. A., D. M. de Quevedo, and D. Schreiber. 2015. "Selection and Identification of the Indicators for Quickly Measuring Sustainability in Micro and Small Furniture Industries." *Sustainable Production and Consumption* 3: 34–44. https://doi.org/10.1016/j.spc.2015.08.006.

Fornasiero, R., and T. A. M. Tolio. 2024. "Analysis of the Italian Manufacturing Sector." In *The Future of Manufacturing: The Italian Roadmap*, edited by R. Fornasiero and T. A. M. Tolio, 15–34. Springer Nature. https://doi.org/10.1007/978-3-031-60560-4_2.

Garbie, I. H. 2014. "An Analytical Technique to Model and Assess Sustainable Development Index in Manufacturing Enterprises." *International Journal of Production Research* 52, no. 16: 4876–4915. https://doi.org/10.1080/00207543.2014.893066.

Garengo, P., S. Biazzo, and U. S. Bititci. 2005. "Performance Measurement Systems in SMEs: A Review for a Research Agenda." *International Journal of Management Reviews* 7, no. 1: 25–47. https://doi.org/10.1111/j.1468-2370.2005.00105.x.

Gennitsaris, S., and S. Sofianopoulou. 2026. "A Holistic Sustainability Assessment Framework for Industrial Enterprises: Development and Expert Validation of Balanced Environmental, Economic, and Social Indicators." *Circular Economy and Sustainability* 6, no. 2: 133. https://doi.org/10.1007/s43615-026-00906-2.

Gerres, T., J. P. Chaves Ávila, P. L. Llamas, and T. G. San Román. 2019. "A Review of Cross-Sector Decarbonisation Potentials in the European Energy Intensive Industry." *Journal of Cleaner Production* 210: 585–601. https://doi.org/10.1016/j.jclepro.2018.11.036.

Govindan, K., R. Khodaverdi, and A. Jafarian. 2013. "A Fuzzy Multi Criteria Approach for Measuring Sustainability Performance of a Supplier Based on Triple Bottom Line Approach." *Journal of Cleaner Production* 47: 345–354. https://doi.org/10.1016/j.jclepro.2012.04.014.

Green, J. L., S. E. Manski, T. A. Hansen, and J. E. Broatch. 2023. "Descriptive statistics." In *International Encyclopedia of Education*, Fourth ed., 723–733. Elsevier. https://doi.org/10.1016/B978-0-12-818630-5.10083-1.

Gudivada, V. N. 2017. "Data Analytics." *Data Analytics for Intelligent Transportation Systems* 31–67. https://doi.org/10.1016/b978-0-12-809715-1.00002-x.

Gudmundsdottir, S., and T. O. Sigurjonsson. 2024. "A Need for Standardized Approaches to Manage Sustainability Strategically." *Sustainability* 16, no. 6: 2319. https://doi.org/10.3390/su16062319.

Harik, R., W. El Hachem, K. Medini, and A. Bernard. 2015. "Towards a Holistic Sustainability Index for Measuring Sustainability of Manufacturing Companies." *International Journal of Production Research* 53, no. 13: 4117–4139. https://doi.org/10.1080/00207543.2014.993773.

Hassanein, A., and M. Elmaghrabi. 2024. "How Does Market Competition Affect the Reporting of Sustainability Practices? Insights From the UK and Germany." *International Journal of Productivity and Performance Management* 74: 1452–1474. https://doi.org/10.1108/IJPPM-07-2023-0369.

Held, M., D. Weidmann, D. Kammerl, et al. 2018. "Current Challenges for Sustainable Product Development in the German Automotive Sector: A Survey Based Status Assessment." *Journal of Cleaner Production* 195: 869–889. https://doi.org/10.1016/j.jclepro.2018.05.118.

Hemdi, A. R., M. Z. M. Saman, and S. Sharif. 2013. "Sustainability Evaluation Using Fuzzy Inference Methods." *International Journal of Sustainable Energy* 32, no. 3: 169–185. https://doi.org/10.1080/14786451.2011.605947.

Henao, R., and W. Sarache. 2022. "Sustainable Performance in Manufacturing Operations: The Cumulative Approach vs. Trade-Offs Approach." *International Journal of Production Economics* 244: 108385. https://doi.org/10.1016/j.ijpe.2021.108385.

Herrero, I., C. López, and R. Ruiz-Benítez. 2024. "So … Are Family Firms More Sustainable? On the Economic, Social and Environmental Sustainability of Family SMEs." *Business Strategy and the Environment* 33, no. 5: 4252–4270. https://doi.org/10.1002/bse.3699.

Hristov, I., A. Appolloni, W. Cheng, and M. Venditti. 2023. "Enhancing the Strategic Alignment Between Environmental Drivers of Sustainability and the Performance Management System in Italian Manufacturing Firms." *International Journal of Productivity and Performance Management* 72, no. 10: 2949–2976. https://doi.org/10.1108/IJPPM-11-2021-0643.

Hristov, I., and A. Chirico. 2019. "The Role of Sustainability Key Performance Indicators (KPIs) in Implementing Sustainable Strategies." *Sustainability* 11, no. 20: 5742. https://doi.org/10.3390/su11205742.

Hsu, C. H., A. Y. Chang, and W. Luo. 2017. "Identifying Key Performance Factors for Sustainability Development of SMEs – Integrating QFD and Fuzzy MADM Methods." *Journal of Cleaner Production* 161: 629–645. https://doi.org/10.1016/j.jclepro.2017.05.063.

Jääskeläinen, A., H. Laihonen, A. Lönnqvist, et al. 2012. "A Contingency Approach to Performance Measurement in Service Operations." *Measuring Business Excellence* 16, no. 1: 43–52. https://doi.org/10.1108/13683041211204662.

Joung, C. B., J. Carrell, P. Sarkar, and S. C. Feng. 2013. "Categorization of Indicators for Sustainable Manufacturing." *Ecological Indicators* 24: 148–157. https://doi.org/10.1016/j.ecolind.2012.05.030.

Joy-Camacho, W., and I. Thornhill. 2024. "Opportunities and Limitations to Environmental Management System (EMS) Implementation in UK Small and Medium Enterprises (SMEs) – A Systematic Review." *Journal of Environmental Management* 367: 121749. https://doi.org/10.1016/j.jenvman.2024.121749.

Julkovski, D. J., S. Sehnem, M. d. C. P. Ramos, and C. J. C. Jabbour. 2023. "Circular Business Models and the Environment: Maturity Levels of the Circular Economy and Innovation in Greener Craft Breweries." *Business Strategy and the Environment* 32, no. 6: 3465–3488. https://doi.org/10.1002/bse.3311.

Kohlbacher, F. 2006. "The Use of Qualitative Content Analysis in Case Study Research." *Forum: Qualitative Social Research* 7, no. 1: 21.

Krekel, G., J. Suer, and M. Traverso. 2024. "Identifying the Social Hotspots of German Steelmaking and Its Value Chain." *Sustainable Production and Consumption* 51: 222–235. https://doi.org/10.1016/j.spc.2024.09.013.

Lee, K. H., and R. Farzipoor Saen. 2012. "Measuring Corporate Sustainability Management: A Data Envelopment Analysis Approach." *International Journal of Production Economics* 140, no. 1: 219–226. https://doi.org/10.1016/j.ijpe.2011.08.024.

Leimona, B., D. Mithöfer, G. Wibawa, and M. van Noordwijk. 2024. "Sustainability Certification: Multiple Values of Nature Coexist in Value Chain Transformations Toward a Common but Differentiated Responsibility." *Current Opinion in Environmental Sustainability* 66: 101393. https://doi.org/10.1016/j.cosust.2023.101393.

León-Bravo, V., and F. Caniato. 2024. "Sustainability Performance Measurement in the Food Supply Chain: Trade-offs, Institutional Pressures, and Contextual Factors." *European Management Journal* 42, no. 4: 633–646. https://doi.org/10.1016/j.emj.2023.04.004.

Long, Y., J. Pan, S. Farooq, and H. Boer. 2016. "A Sustainability Assessment System for Chinese Iron and Steel Firms." *Journal of Cleaner Production* 125: 133–144. https://doi.org/10.1016/j.jclepro.2016.03.030.

Madaka, H., C. W. Babbitt, and E. G. Ryen. 2022. "Opportunities for Reducing the Supply Chain Water Footprint of Metals Used in Consumer Electronics." *Resources, Conservation and Recycling* 176: 105926. https://doi.org/10.1016/j.resconrec.2021.105926.

Madrid-Guijarro, A., and A. Duréndez. 2024. "Sustainable Development Barriers and Pressures in SMEs: The Mediating effect of Management Commitment to Environmental Practices." *Business Strategy and the Environment* 33, no. 2: 949–967. https://doi.org/10.1002/bse.3537.

Maione, C., Y. Lapko, and P. Trucco. 2022. "Towards a Circular Economy for the Plastic Packaging Sector: Insights From the Italian Case." *Sustainable Production and Consumption* 34: 78–89. https://doi.org/10.1016/j.spc.2022.09.002.

May, G., and B. Stahl. 2017. "The Significance of Organizational Change Management for Sustainable Competitiveness in Manufacturing: Exploring the Firm Archetypes." *International Journal of Production Research* 55, no. 15: 4450–4465. https://doi.org/10.1080/00207543.2016.1261197.

Mayer, P. M., K. D. Moran, E. L. Miller, et al. 2024. "Where the Rubber Meets the Road: Emerging Environmental Impacts of Tire Wear Particles and Their Chemical Cocktails." *Science of the Total Environment* 927: 171153. https://doi.org/10.1016/j.scitotenv.2024.171153.

Mengistu, A. T., and R. Panizzolo. 2021. "Indicators and Framework for Measuring Industrial Sustainability in Italian Footwear Small and Medium Enterprises." *Sustainability* 13, no. 10: 5472. https://doi.org/10.3390/su13105472.

Mengistu, A. T., and R. Panizzolo. 2023a. "Metrics for Measuring Industrial Sustainability Performance in Small and Medium-Sized Enterprises." *International Journal of Productivity and Performance Management* 73, no. 11: 46–68. https://doi.org/10.1108/IJPPM-04-2022-0200.

Mengistu, A. T., and R. Panizzolo. 2023b. "Tailoring Sustainability Indicators to Small and Medium Enterprises for Measuring Industrial Sustainability Performance." *Measuring Business Excellence* 27, no. 1: 54–70. https://doi.org/10.1108/MBE-10-2021-0126.

Meredith, J. 1998. "Building Operations Management Theory Through Case and Field Research." *Journal of Operations Management* 16, no. 4: 441–454. https://doi.org/10.1016/S0272-6963(98)00023-0.

Morioka, S. N., and M. M. Carvalho. 2014. "Measuring Sustainability in Practice: Exploring the Inclusion of Sustainability Into Corporate Performance Systems in Brazilian Case Studies." *Journal of Cleaner Production* 136: 123–133. https://doi.org/10.1016/j.jclepro.2016.01.103.

Morioka, S. N., and M. M. de Carvalho. 2016. "A Systematic Literature Review Towards a Conceptual Framework for Integrating Sustainability Performance Into Business." *Journal of Cleaner Production* 136: 134–146. https://doi.org/10.1016/j.jclepro.2016.01.104.

Mousavi, K., E. Kowsari, S. Ramakrishna, A. Chinnappan, and M. Gheibi. 2024. "A Comprehensive Review of Greenwashing in the Textile Industry (Life Cycle Assessment, Life Cycle Cost, and Eco-Labeling)." *Environment, Development and Sustainability* 27: 21737–21777. https://doi.org/10.1007/s10668-024-04508-6.

Murad, M. d. Q., W. F. Sales, and V. A. Feraressi. 2021. "Metric-Based Approach to Assess Sustainable Manufacturing Performance at Manufacturing Process Levels." *International Journal of Sustainable Engineering* 14, no. 6: 1342–1352. https://doi.org/10.1080/19397038.2021.1978588.

Neely, A., M. Gregory, and K. Platts. 1995. "Performance Measurement System Design: A Literature Review and Research Agenda." *International Journal of Operation Management & Production Management* 15, no. 4: 80–116. https://doi.org/10.1108/01443570010343708.

Negri, M., E. Cagno, C. Colicchia, and J. Sarkis. 2021. "Integrating Sustainability and Resilience in the Supply Chain: A Systematic Literature Review and a Research Agenda." *Business Strategy and the Environment* 30, no. 7: 2858–2886. https://doi.org/10.1002/bse.2776.

Neri, A. 2021. "Industrial Sustainability Performance Measurement System—Challenges for the Development." In *Methods in Sustainability Science*, edited by J. Ren, 87–104. Elsevier. https://doi.org/10.1016/B978-0-12-823987-2.00004-0.

Neri, A., E. Cagno, M. Lepri, and A. Trianni. 2021. "A Triple Bottom Line Balanced Set of Key Performance Indicators to Measure the Sustainability Performance of Industrial Supply Chains." *Sustainable Production and Consumption* 26: 648–689. https://doi.org/10.1016/j.spc.2020.12.018.

Neri, A., E. Cagno, and A. Trianni. 2021. "Barriers and Drivers for the Adoption of Industrial Sustainability Measure in European SMEs: Empirical Evidence from Chemical and Metalworking Sectors." *Sustainable Production and Consumption* 28: 1433–1464. https://doi.org/10.1016/j.spc.2021.08.018.

Neri, A., M. Negri, E. Cagno, et al. 2023. "The Role of Digital Technologies in Supporting the Implementation of Circular Economy Practices by Industrial Small and Medium Enterprises." *Business Strategy and the Environment* 32, no. 7: 4693–4718. https://doi.org/10.1002/bse.3388.

Nordheim, E., and G. Barrasso. 2007. "Sustainable Development Indicators of the European Aluminium Industry." *Journal of Cleaner Production* 15, no. 3: 275–279. https://doi.org/10.1016/j.jclepro.2006.02.004.

Ong, T. S., B. H. Teh, and A. S. Lee. 2019. "Contingent Factors and Sustainable Performance Measurement (SPM) Practices of Malaysian Electronics and Electrical Companies." *Sustainability* 11, no. 4: 1058. https://doi.org/10.3390/su11041058.

Osei, A., and J. O. Amoah. 2026. "Pathways to Sustainable Competitive Advantage: Integrating Firm-Level Sustainability Targets, Eco-Innovation, and Sustainable Governance for Circular Business Transformation." *Business Strategy and the Environment* 35: 7248–7274. https://doi.org/10.1002/bse.70531.

Osório De Andrade Guerra, J. B. S., J. Schneider, M. Andrade De Lima, et al. 2023. "Balanced Scorecard and Eco-Innovation in the Industrial Sector: A Strategic Map for Environmental Innovation." *Business*

Strategy and the Environment 32, no. 7: 4266–4281. https://doi.org/10.1002/bse.3364.

Oyewo, B., V. Tawiah, and M. Alta'any. 2025. "Determinants and Impact of Strategy-Driven Manufacturing Accounting Techniques on Organisational Competitiveness: A Structural Equation Modelling Approach." *Journal of Accounting & Organizational Change* 21, no. 1: 114–142. https://doi.org/10.1108/JAOC-10-2022-0165.

Pawłowska, Z. 2015. "Using Lagging and Leading Indicators for the Evaluation of Occupational Safety and Health Performance in Industry." *International Journal of Occupational Safety and Ergonomics* 21, no. 3: 284–290. https://doi.org/10.1080/10803548.2015.1081769.

Pazienza, M., M. de Jong, and D. Schoenmaker. 2026. "A Universal and Actionable Measure of Corporate Sustainability for Strategic Decision Making." *Business Strategy and the Environment*: 1–15. https://doi.org/10.1002/bse.70673.

Rayhan Sarker, M., S. Mithun Ali, S. Kumar Paul, and Z. Haque Munim. 2021. "Measuring Sustainability Performance Using an Integrated Model." *Measurement: Journal of the International Measurement Confederation* 184: 109931. https://doi.org/10.1016/j.measurement.2021.109931.

Rojas-Lema, X., J. J. Alfaro-Saiz, R. Rodríguez-Rodríguez, and M. J. Verdecho. 2021. "Performance Measurement in SMEs: Systematic Literature Review and Research Directions." *Total Quality Management and Business Excellence* 32, no. 15–16: 1803–1828. https://doi.org/10.1080/14783363.2020.1774357.

Saad, M. H., M. A. Nazzal, and B. M. Darras. 2023. "A Comprehensive Rating Tool for Sustainability Assessment of Manufacturing Organizations: A Step Towards Sustainable Manufacturing." *International Journal of Precision Engineering and Manufacturing - Green Technology* 10, no. 3: 835–850. https://doi.org/10.1007/s40684-022-00488-y.

Sahoo, S. 2024. "Assessing the Impact of Stakeholder Pressure and Green Data Analytics on Firm's Environmental Performance – Understanding the Role of Green Knowledge Management and Green Technological Innovativeness." *R and D Management* 54, no. 1: 3–20. https://doi.org/10.1111/radm.12602.

Saldaña, J. 2009. *The Coding Manual for Qualitative Researchers*. SAGE.

Salvado, M. F., S. G. Azevedo, J. C. O. Matias, and L. M. Ferreira. 2015. "Proposal of a Sustainability Index for the Automotive Industry." *Sustainability* 7, no. 2: 2113–2144. https://doi.org/10.3390/su7022113.

Salvador, R., P. V. Søberg, M. S. Jørgensen, L. L. Schmidt-Kallesøe, and S. B. Larsen. 2023. "Explaining Sustainability Performance and Maturity in SMEs – Learnings From a 100-Participant Sustainability Innovation Project." *Journal of Cleaner Production* 419: 138248. https://doi.org/10.1016/j.jclepro.2023.138248.

Searcy, C. 2016. "Measuring Enterprise Sustainability." *Business Strategy and the Environment* 25, no. 2: 120–133. https://doi.org/10.1002/bse.1861.

Setyaningsih, S., R. Widjojo, and P. Kelle. 2024. "Challenges and Opportunities in Sustainability Reporting: A Focus on Small and Medium Enterprises (SMEs)." *Cogent Business & Management* 11, no. 1: 2298215. https://doi.org/10.1080/23311975.2023.2298215.

Shaikh, I., and A. K. Tripathy. 2025. "Variability in Sustainability Reporting – A Multicountry Study." *Journal of Environmental Management* 373: 123851. https://doi.org/10.1016/j.jenvman.2024.123851.

Sharma, D., P. Kumar, and R. K. Singh. 2024. "Framework for Evaluating Sustainability Index of a Manufacturing System: A Case Illustration." *Operations Management Research* 17, no. 2: 569–595. https://doi.org/10.1007/s12063-023-00438-0.

Sheard, J. 2018. "Quantitative Data Analysis." In *Research Methods*, 429–452. Elsevier. https://doi.org/10.1016/B978-0-08-102220-7.00018-2.

Silva, D. N., W. Wehrmeyer, and R. Murphy. 2024. "Development of a Holistic Framework for Sustainability Measurement: A Case Study of the Tea Sector." *Cleaner Production Letters* 7: 100072. https://doi.org/10.1016/j.clpl.2024.100072.

Singh, R. K., H. R. Murty, S. K. Gupta, and A. K. Dikshit. 2012. "An Overview of Sustainability Assessment Methodologies." *Ecological Indicators* 15, no. 1: 281–299. https://doi.org/10.1016/j.ecolind.2011.01.007.

Söderholm, P., and J. E. Tilton. 2012. "Material Efficiency: An Economic Perspective." *Resources, Conservation and Recycling* 61: 75–82. https://doi.org/10.1016/j.resconrec.2012.01.003.

Strezov, V., A. Evans, and T. Evans. 2013. "Defining Sustainability Indicators of Iron and Steel Production." *Journal of Cleaner Production* 51: 66–70. https://doi.org/10.1016/j.jclepro.2013.01.016.

Sureeyatanapas, P., J. B. Yang, and D. Bamford. 2015. "The Sweet Spot in Sustainability: A Framework for Corporate Assessment in Sugar Manufacturing." *Production Planning and Control* 26, no. 13: 1128–1144. https://doi.org/10.1080/09537287.2015.1015470.

Tolentino-Zondervan, F., and L. DiVito. 2024. "Sustainability Performance of Dutch Firms and the Role of Digitalization: The Case of Textile and Apparel Industry." *Journal of Cleaner Production* 459: 142573. https://doi.org/10.1016/j.jclepro.2024.142573.

Trianni, A., E. Cagno, A. Neri, and M. Howard. 2019. "Measuring Industrial Sustainability Performance: Empirical Evidence From Italian and German Manufacturing Small and Medium Enterprises." *Journal of Cleaner Production* 229: 1355–1376. https://doi.org/10.1016/j.jclepro.2019.05.076.

Tsai, K., and Y. Liao. 2017. "Sustainability Strategy and Eco-Innovation: A Moderation Model." *Business Strategy and the Environment* 26, no. 4: 426–437. https://doi.org/10.1002/bse.1926.

Tseng, M. L. 2013. "Modeling Sustainable Production Indicators With Linguistic Preferences." *Journal of Cleaner Production* 40: 46–56. https://doi.org/10.1016/j.jclepro.2010.11.019.

Van Looy, A., and J. Van den Bergh. 2018. "The Effect of Organization Size and Sector on Adopting Business Process Management." *Business & Information Systems Engineering* 60, no. 6: 479–491. https://doi.org/10.1007/s12599-017-0491-3.

Vieira Nunhes, T., M. Espuny, T. Lauá Reis Campos, G. Santos, M. Bernardo, and O. J. Oliveira. 2022. "Guidelines to Build the Bridge Between Sustainability and Integrated Management Systems: A Way to Increase Stakeholder Engagement Toward Sustainable Development." *Corporate Social Responsibility and Environmental Management* 29, no. 5: 1617–1635. https://doi.org/10.1002/csr.2308.

Viscardi, S., C. Colicchia, and A. Creazza. 2026. "Preventing and Recovering Food Waste in Manufacturing Firms: A Contingency Perspective on Circular Economy Practices." *Business Strategy and the Environment* 35, no. 2: 1902–1929. https://doi.org/10.1002/bse.70261.

Watanabe, E. H., R. M. da Silva, M. S. G. Tsuzuki, F. Junqueira, D. J. dos Santos Filho, and P. E. Miyagi. 2016. "A Framework to Evaluate the Performance of a New Industrial Business Model." *IFAC-PapersOnLine* 49, no. 31: 61–66. https://doi.org/10.1016/j.ifacol.2016.12.162.

Winroth, M., P. Almström, and C. Andersson. 2016. "Sustainable Production Indicators at Factory Level." *Journal of Manufacturing Technology Management* 27, no. 6: 842–873.

Xu, S., T. M. Murugesan, A. A. A. Elfar, and M. P. R. Durairaj. 2024. "Evaluation of Sustainable Manufacturing Performance – A Case Illustration With Multistakeholder Perspective." *Journal of Cleaner Production* 458: 142368. https://doi.org/10.1016/j.jclepro.2024.142368.

Yin, R. K. 2009. *Case Study Research Design and Methods*. SAGE.

Yip, W. S., H. T. Zhou, and S. To. 2023. "A Critical Analysis on the Triple Bottom Line of Sustainable Manufacturing: Key Findings and Implications." *Environmental Science and Pollution Research* 30, no. 14: 41388–41404. https://doi.org/10.1007/s11356-022-25122-x.

Zaman, M., G. Tanewski, and G. Ekanayake. 2025. "What Does Sustainability Mean for Small and Medium Enterprises: A Systematic Literature Review." *Journal of Cleaner Production* 492: 144830. https://doi.org/10.1016/j.jclepro.2025.144830.

Zhang, H., and K. R. Haapala. 2015. "Integrating Sustainable Manufacturing Assessment Into Decision Making for a Production Work Cell." *Journal of Cleaner Production* 105: 52–63. https://doi.org/10.1016/j.jclepro.2014.01.038.

Zharfpeykan, R., and C. Akroyd. 2022. "Factors Influencing the Integration of Sustainability Indicators Into a Company's Performance Management System." *Journal of Cleaner Production* 331: 129988. https://doi.org/10.1016/j.jclepro.2021.129988.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Appendix S1:** Semi-structured interview protocol. **Appendix S2:** Description of the sample investigated. **Appendix S3:** General overview of sustainability indicators measured. **Appendix S4:** Performance indicators measured by sampled SMEs. **Table D1:** Percentage of SMEs from the sample that measure the economic pillar. Indicators are listed in decreasing order by the percentage of SMEs that measure each indicator. **Table D2:** Percentage of SMEs from the sample that measure the social pillar. Indicators are listed in decreasing order of the percentage of SMEs that measure the specific indicator. **Table D3:** Percentage of SMEs from the sample that measure the environmental pillar. Indicators are listed in decreasing order of the percentage of SMEs that measure the specific indicator.