Tailoring sustainability indicators to small and medium enterprises for measuring industrial sustainability performance

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Abstract

Purpose – *The lack of suitable indicators tailored to manufacturing industries' needs, particularly to small and medium enterprises (SMEs), has been the major challenge to measure and manage industrial sustainability performance. This paper aims to empirically analyze and select the useful and applicable indicators to measure sustainability performance in the context of SMEs.*

Design/methodology/approach – *A systematic review was carried out to identify potential sustainability indicators from the literature. A questionnaire was designed based on the identified indicators and then pretested with the selected industrial experts, scholars, and researchers to further refine the indicators before data collection from the Italian footwear SMEs. Fuzzy Delphi method with consistency aggregation method was applied to analyze and select the final indicators.*

Findings – *The study's findings show that the selected indicators emphasized measuring progress toward achieving industrial sustainability goals in terms of increasing financial benefits, reducing costs, improving market competitiveness, improving the effectiveness of resources utilization, and promoting the well-being of employees, customers and the community. In doing so, Italian footwear SMEs can contribute to achieving the Sustainable Development Goals (SDGs) by promoting health and well-being, promoting sustainable economic growth, providing productive employment and decent work, and ensuring responsible consumption and production.*

Social implications – *The results of this study have significant social implications in terms of promoting the well-being of employees, customers, and the community.*

Originality/value – *By providing empirically supported indicators tailored to measure and manage sustainability performance in the context of SMEs, this paper contributes to the existing knowledge in the field of industrial sustainability performance measurement. Furthermore, it links the selected indicators to their respective SDGs to provide policy implications.*

Keywords *Indicator, Performance measurement, Industrial sustainability, Sustainable Development Goals, Italian footwear SMEs, Fuzzy Delphi method*

Paper type *Research paper*

1. Introduction

Sustainable manufacturing has been given growing attention for managing the environmental and social impacts of manufacturing industries properly (Ahmad and Wong, 2019; Singh *et al.*, 2014). Manufacturing industries have a significant role in the sustainable development of society (Beekaroo *et al.*, 2019; Moldavska and Welo, 2019). Since manufacturing industries highly consume natural resources and moreover generate emissions and wastes, they should be considered to address sustainability issues (Hendiani *et al.*, 2020). Sustainable manufacturing has also become a key factor for manufacturing firms to stay relevant in the current competitive business environment (Singh *et al.*, 2019). Consequently, there is a need for transformation from the traditional manufacturing practices that focus on economic benefits to the state-of-the-art manufacturing that consider environmental and social responsibility in addition to pursuing the economic benefits (Shuaib *et al.*, 2014; Singh *et al.*, 2019). Adopting sustainability practices in manufacturing industries requires a holistic approach at different application scope that varies from the production line to the plant, the firm, and the supply chain (Huang and Badurdeen, 2018). Industrial sustainability considers the adoption of sustainability practices at the firm level (Trianni *et al.*, 2017).

Industrial sustainability has become an essential topic of discussion (Cagno *et al.*, 2019) and gains significant consideration among industrial decision-makers, policymakers, and scholars (Neri *et al.*, 2018; Trianni *et al.*, 2017). Manufacturing industries are the main driving force for the economic growth and social development of a country (Galal and Moneim, 2015; Zeng *et al.*, 2008). However, they are considered to be one of the main contributors to environmental and social concerns (Zeng *et al.*, 2008). Consequently, they are duly required to improve sustainability performance and to be transparent on their sustainability practices (Trianni *et al.*, 2019). Various stakeholders have put pressures on them to adopt sustainability practices (Huang and Badurdeen, 2018; Ocampo *et al.*, 2016; Zarte *et al.*, 2019) to address the growing concerns of environmental and social impacts (Beekaroo *et al.*, 2019; Samuel *et al.*, 2013; Wang *et al.*, 2018). The stakeholders of industrial sustainability include governments, investors, political groups, trade associations, suppliers, employees, customers and communities (Paramanathan *et al.*, 2004). Moreover, sustainability is adopted to get a competitive advantage (Tseng *et al.*, 2009; Veleva *et al.*, 2001; Wang *et al.*, 2018). To effectively adopt sustainability in industries, measuring its performance is crucial (Cagno *et al.*, 2019; Trianni *et al.*, 2019). The adoption of industrial sustainability considers actions that are taken at the levels of material, product, process, plant, and production system (Tonelli *et al.*, 2013).

The term industrial sustainability was coined by the Institute for Manufacturing at the University of Cambridge, and it defines industrial sustainability as "conceptualization, design and manufacture of goods and services that meet the needs of the present generation while not diminishing economic, social and environmental opportunity in the long-term" (Paramanathan *et al.*, 2004). Moreover, Zeng *et al.* (2008) defined industrial sustainability as "development that meets the needs of economic growth, social development, environmental protection and results in industrial advantage for the short- and long-term future of the region." From the concept of sustainability, there is a common understanding that sustainability considers economic, environmental, and social aspects (Paramanathan *et al.*, 2004; Zeng *et al.*, 2008). Elkington (1997) proposed the triple bottom line (TBL) approach that consists of three interrelated (economic, environmental, and social) dimensions of sustainability. TBL provides a comprehensive approach for measuring sustainability performance in manufacturing industries considering the three dimensions (Ahmad and Wong, 2019). To adequately address industrial sustainability, it is crucial to adopt a holistic approach based on TBL (Cagno *et al.*, 2019). Manufacturing industries have a significant impact on the three dimensions of sustainability (Ahmad *et al.*, 2019b; Ghadimi *et al.*, 2012). Subsequently, they should simultaneously consider economic, environmental, and social dimensions while producing their products and services (Eastwood and Haapala, 2015; Haapala *et al.*, 2013; Lacasa *et al.*, 2016; Watanabe *et al.*, 2016).

Although small and medium enterprises (SMEs) are contributing significantly to the economic growth of the country through innovation, production volume, and employment generation (Sajan *et al.*, 2017), they are less likely to address sustainability issues compared to large manufacturing industries (Mitchell *et al.*, 2020). Unlike large manufacturing industries, it is more difficult for SMEs to focus explicitly on sustainability since they have limited resources (Hsu *et al.*, 2017; Singh *et al.*, 2014; Trianni *et al.*, 2019; Winroth *et al.*, 2016) and lack the awareness and expertise required to effectively adopt sustainability (Singh *et al.*, 2014; Trianni *et al.*, 2019). Consequently, measuring sustainability performance in SMEs has been a major challenge (Trianni *et al.*, 2019). Furthermore, there has been a trend that SMEs primarily focus on the economic dimensions of sustainability, and they mainly address the environmental and social dimensions for compliance with regulations imposed by stakeholders (Choi and Lee, 2017; Trianni *et al.*, 2019).

There is still a need for suitable indicators tailored to different manufacturing industry contexts, especially to the context of SMEs, to effectively measure and manage industrial sustainability performance (Singh *et al.*, 2014; Winroth *et al.*, 2016). The lack of useful and applicable indicators has been the major challenge for measuring sustainability performance in manufacturing industries (Ahmad and Wong, 2019; Ocampo *et al.*, 2016). Contextual factors such as industry type, firm size and geographical area affect the use of indicators in measuring industrial sustainability performance (Cagno *et al.*, 2019; Trianni *et al.*, 2019). Thus, tailoring useful and applicable indicators to the industry context is essential to effectively measure sustainability performance in manufacturing industries (Medini *et al.*, 2015). In other words, it is essential to use a manageable number of indicators that are simple and easy to apply (Veleva and Ellenbecker, 2001). Furthermore, by analyzing and selecting indicators that are suitable to the industry context (Ahmad and Wong, 2019; Hsu *et al.*, 2017), the effectiveness of industrial sustainability performance measurement can be increased (Cagno *et al.*, 2019; Trianni *et al.*, 2019).

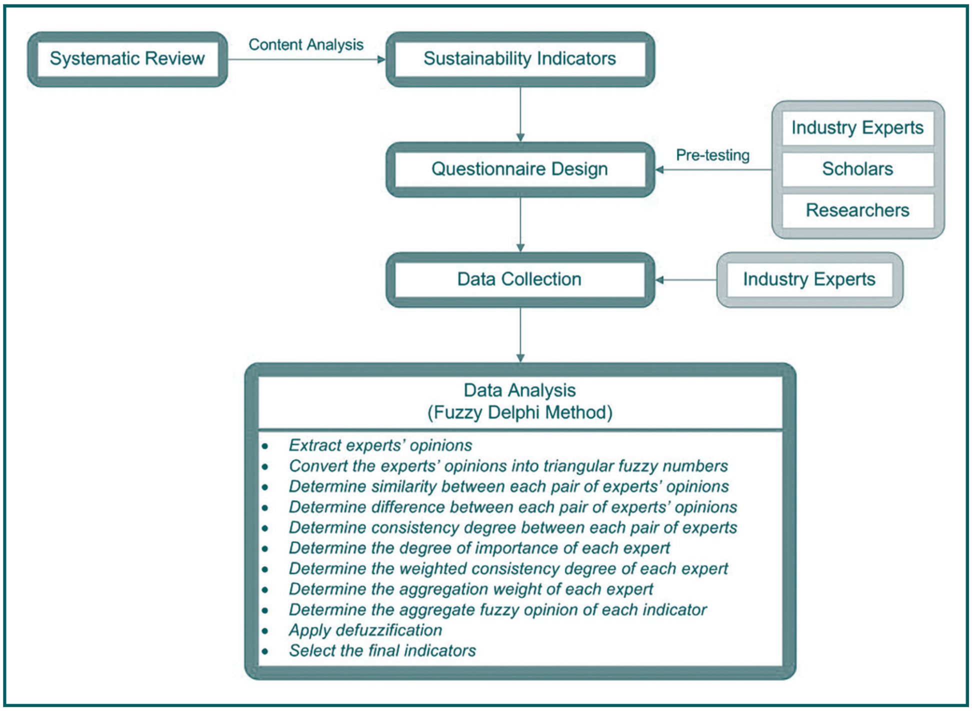
From the literature analysis, it is observed that the previous studies primarily focused on large manufacturing industries than SMEs. *Automotive* (Ghadimi *et al.*, 2012; Lee *et al.*, 2014; Moldavska and Welo, 2019; Singh *et al.*, 2018; Vinodh *et al.*, 2016), *food* (Ahmad and Wong, 2019; Harik *et al.*, 2015; Yakovleva and Flynn, 2004), and *electronics* (Huang and Badurdeen, 2017; Li *et al.*, 2012; Shuaib *et al.*, 2014) were the industrial sectors mostly used by previous research for conducting case studies. In this study, the Italian footwear SMEs were considered to conduct the empirical study since they are less researched. The footwear sector is one of the industrial sectors driving the economic growth and social development of Italy. According to Assocalzaturifici (2020), the sector had about 74,890 employees, a yearly turnover of about 14.3bn euros by 2019, and consumes a variety of input materials such as leather, synthetic, rubber, and textiles for production. These figures imply the economic, environmental, and social (TBL) implications of the sector that have a significant potential to address sustainability issues. However, the lack of suitable indicators is the major challenge of sustainability performance measurement of footwear firms, particularly SMEs. This study applied fuzzy Delphi method (FDM) with consistency aggregation method (CAM) to analyze and select useful and applicable indicators for measuring industrial sustainability in the SMEs. In the use of FDM based on CAM, all the experts' opinions are incorporated in one investigation to comprehensively consider the uncertainty and ambiguity of the experts to achieve a group consensus. Thus, the results obtained become objective and rational.

The rest of the work in this paper is divided into three sections. The research methodology applied in this study is described in Section 2. The results of the analysis are discussed in Section 3. Finally, our conclusions and future research work are described in Section 4.

2. Methodology

To achieve the aim of this paper (i.e. to select and prioritize suitable indicators tailored to SMEs for measuring their sustainability performance), the following methodological approach, as seen in Figure 1, was applied to carry out the empirical study for analyzing and selecting the useful and applicable indicators for measuring sustainability performance in the context of the Italian footwear SMEs. The main steps applied to select and prioritize indicators include conducting a systematic review to identify the potential sustainability indicators (step 1), designing a questionnaire (step 2), collecting data (step 3), and analyzing the data using FDM based on CAM (step 4).

Figure 1 Methodological approach for selecting and prioritizing indicators



2.1 Identification of potential sustainability indicators

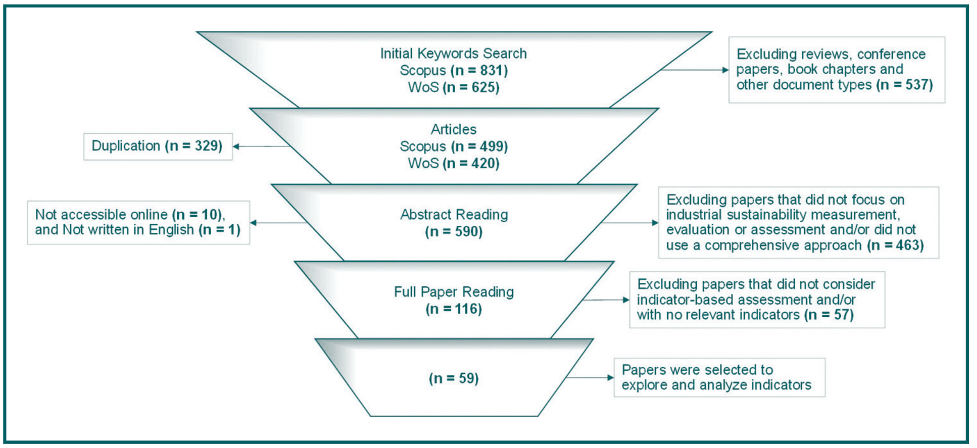
A systematic review was conducted to explore indicators within published peer-reviewed articles that are relevant to sustainability performance measurement of manufacturing industries. For this purpose, Scopus and Web of Science (WoS) were selected as search databases since they provide an extensive coverage of peer-reviewed journal articles (Ahi and Searcy, 2015). Two sets of keywords linked to the research topic of this paper were used for the search: "industrial sustainability" or "sustainable manufactur*" or "sustainable firm*" or "sustainable enterpri*" or "sustainable industr*" or "sustainable factory" or "sustainable production*" or "sustainable organi*" or "sustainable compan*" in the first set and "indicator*" or "metric*" or "performance measure*" in the second set. By applying the following approach to screen and select papers shown in Figure 2, a total of 1,456 papers were initially obtained using the keywords search in both Scopus and WoS databases published until 2020. Out of which, 59 papers were selected to identify and analyze the indicators.

A content analysis was conducted to identify the consistently and frequently used indicators (Ahi and Searcy, 2015; Ahmad *et al.*, 2019a). A total of 1,013 indicators (277 for economic, 402 environmental and 334 social dimensions) were explored. The majority (about 85%) of them appeared only once in the reviewed literature. This figure shows a lack of consistency in the use of indicators (i.e. lack of consensus on a single set of indicators) to measure sustainability performance in different industry contexts, and this invites an ongoing research debate on industrial sustainability performance measurement. On the other hand, few indicators (14 for economic, 18 for environmental and 12 for social dimensions) were consistently and frequently used to measure industrial sustainability.

2.2 Questionnaire design

Based on the consistently and frequently used indicators, a questionnaire was developed. Then, the pre-testing (i.e. pilot testing) of the questionnaire was conducted with selected

Figure 2 Approach used for screening and selecting papers



industry experts, scholars, and researchers (Forza, 2002; Padilla-Rivera *et al.*, 2021). The pre-testing was carried out to check clarity (language clarity, context clarity and content clarity), time (as much as possible to finish filling the questionnaire within a few minutes), redundancy (possibility of redundant questions), and relevance (being connected to the objective of the study). The feedback of the pretest was used to modify, add, and delete indicators so as to improve the questionnaire and increase its convergence (Padilla-Rivera *et al.*, 2021).

2.3 Data collection

A total of 48 valid responses were obtained after distributing the questionnaire to Italian footwear firms via email and linkedIn. In other words, experts' opinions on the sustainability indicators were collected from 48 Italian footwear SMEs. To get empirical evidence from the users of the final selected indicators and increase the reliability of the results, the data collection focused on industry experts. Table 1 summarizes the position and work experience of the experts.

As can be seen in Table 2, Chief Executive Officer/General Manager represents the highest percentage (44%) of the industry experts. Most of the industry experts (49%) have over 20 years of work experience.

A reliability analysis was conducted to check the consistency or repeatability of the questionnaire items (i.e. the indicators). The internal consistency method was applied for

Table 1 Profile of the experts by frequency

Variable	*Position*	*Frequency (#)*	*(%)*
Position	Chief Executive Officer/General Manager	21	44
	Production Manager	7	15
	Operation Manager	9	19
	Expert/Professional Employee of Sustainability	6	13
	Others	5	10
Work experience	Over 20 years	23	49
	15 to 20 years	4	9
	10 to 15 years	10	21
	5 to 10 years	6	13
	Below 5 years	4	9

Table 2 Linguistic variables with their corresponding fuzzy scales and triangular fuzzy numbers

Fuzzy scales	*Linguistic variables*	*Triangular fuzzy no. (*a,b,c*)*
1	Not important (NI)	(1,1,3)
3	Slightly important (SI)	(1,3,5)
5	Moderately important (MI)	(3,5,7)
7	Important (I)	(5,7,9)
9	Very important (VI)	(7,9,9)

testing the reliability (Forza, 2002). Cronbach's alpha, which is the most common test for internal consistency, was used to assess the reliability of the data. Cronbach's alpha (α) was calculated in IBM SPSS software (Version 26). The values of α were 0.710, 0.936 and 0.854 for economic, environmental and social dimensions, respectively, which are higher than the minimum acceptable value (0.7).

2.4 Data analysis: Fuzzy Delphi method

Fuzzy Delphi method (FDM) was applied to analyze the experts' opinions and select the most useful and applicable indicators for measuring industrial sustainability in Italian footwear SMEs. FDM integrates the traditional Delphi method and fuzzy theory to address the drawbacks of the traditional Delphi method (Tsai *et al.*, 2020). The use of fuzzy theory combined with the traditional Delphi method can solve the vagueness and ambiguity of expert judgments to improve efficiency and quality (Lee *et al.*, 2018; Padilla-Rivera *et al.*, 2021). In FDM, the linguistic variables (qualitative) converted into fuzzy membership functions (quantitative) for analysis of the indicators (Tsai *et al.*, 2020). Triangular fuzzy number, trapezoidal fuzzy number, and Gaussian fuzzy number are the membership functions that have been used by previous research (Hsu *et al.*, 2010). For this study, the triangular fuzzy number was applied as a fuzzy membership function (Hsu *et al.*, 2010; Zhang, 2017). FDM avoids the drawbacks of the traditional Delphi method such as low convergence of experts' opinions (Ma *et al.*, 2011), high cost and considerable time for collecting experts' opinions (Ma *et al.*, 2011; Padilla-Rivera *et al.*, 2021; Tsai *et al.*, 2020) due to the several rounds of a survey applied in the traditional Delphi method (Zhang, 2017). In FDM, all the experts' opinions are incorporated in one investigation (Kuo and Chen, 2008; Ma *et al.*, 2011) to comprehensively consider the uncertainty and ambiguity of the experts (Zhang, 2017) to achieve a consensus (Kuo and Chen, 2008). Thus, this method is considered to be robust (Padilla-Rivera *et al.*, 2021) and can create a better effect of data analysis (Ma *et al.*, 2011), and the results obtained are objective and rational (Zhang, 2017). More specifically, consistency aggregation method (CAM) was applied. In this method, the fuzzy individual expert's opinions are aggregated into a group consensus opinion for each indicator. To incorporate all the experts' opinions, both similarity and difference among the experts were considered to apply CAM (Lin *et al.*, 2019; Lu *et al.*, 2006). CAM was adopted through the following steps:

- *Extract experts' opinions*: Collect and organize the assessment scores given by each expert for each sustainability indicator from the returned questionnaire.
- *Convert the experts' opinions into triangular fuzzy numbers*: Translate the linguistic variables used by the experts to assess the sustainability indicators into triangular fuzzy numbers (Zhang, 2017) as shown in Table 2. The linguistic variables are used to express the experts' opinions on the importance (i.e., usefulness and applicability) of the indicator.

That is the triangular fuzzy numbers of the expert opinion is defined as $EPi = (ai, bi, ci)$, for $i = 1, 2, \ldots, n$.

where *EPi* is expert opinion of the i^{th} expert in the form of minimum (*a*), optimum (*b*) and maximum (*c*), and *n* is total number of experts.

- *Determine similarity (S) between each pair of experts' opinions*: The degree of similarity between each pair of experts' opinions was calculated as the proportion of intersection area (IntsArea) relative to the union area of each pair of experts' opinions *EPi = (ai, bi, ci)* and *EPj = (aj, bj, cj)* as follows:

$$S(EPi,\ EPj) = \frac{IntsArea\ (EPi,\ EPj)}{Area(EPi) + Area(EPj) - IntsArea\ (EPi,\ EPj)},\ for\ i = 1,\ 2,\ldots,\ n \tag{1}$$

For the same experts' opinions *S(EPi, EPj) = 1*, and if *IntsArea(EPi,EPj)* = 0, *S(EPi, EPj)* = 0.

$$S(EP_i,\ EP_j)\ =\ S(EPj,\ EPi)\ (i.e.\ S(EP_1,\ EP_2)\ =\ S(EP_2,\ EP_1)).$$

- *Determine difference (D) between each pair of experts' opinions*: Calculate the distance between each pair of experts' opinions *EPi = (ai, bi, ci)* and *EPj = (aj, bj, cj)* as shown below:

$$D(EPi,\ EPj) = \frac{1}{2}|bi - bj|,\ for\ i = 1,\ 2,\ldots,\ n \tag{2}$$

For identical experts' opinions, *D(EPi, EPj)* = 0.

Then, convert the absolute distance (D) into normalized distance (ND) using the following formula:

$$ND(EPi,\ EPj) = \frac{D(EPi,\ EPj)}{Max[D(EPi, EPj)]} \tag{3}$$

- *Determine consistency degree (r) between each pair of experts*: For *i = 1, 2,. . ., n*, the consistency degree of each pair of experts *EPi* was calculated as follows:

$$r(EPi,\ EPj) = \ \beta S(EPi,\ EPj) + (1 - \beta)ND(EPi,\ EPj) \tag{4}$$

For this study, considering equal importance for the similarity and difference among the experts, β = 0.5 was taken.

- *Determine degree of importance (e) for each expert*: The degree of importance (relative importance) of each expert (*ei*) is calculated based on their years of work experience. For this purpose, the following values of importance are assigned for the years of work experience categorized in this study. Accordingly, 5 for over 20 years of experience, 4 for 15 to 20 years, 3 for 10 to 15 years, 2 for 5 to 10 years and 1 for below 5 years. Table 3 summarizes the degree of importance (relative importance) of each expert (*ei*).
- *Determine the weighted consistency degree (C) of each expert*: For *i = 1, 2,. . ., n*, calculate the weighted consistency degree of each expert *Ei* as seen below:

$$C(Ei) = \sum_{i=1}^{n} r(EPi,\ EPj) * ei \tag{5}$$

- *Determine the aggregation weight (w) of each expert*: For *i = 1, 2,. . ., n*, the aggregation weight of each expert *Ei* was calculated as follows:

Table 3 Degrees of importance of the experts

Expert	Value	Relative importance	Expert	Value	Relative importance	Expert	Value	Relative importance
E1	5	0.0276	E17	3	0.0166	E33	1	0.0055
E2	2	0.0110	E18	5	0.0276	E34	1	0.0055
E3	5	0.0276	E19	2	0.0110	E35	5	0.0276
E4	5	0.0276	E20	5	0.0276	E36	3	0.0166
E5	4	0.0221	E21	3	0.0166	E37	3	0.0166
E6	5	0.0276	E22	3	0.0166	E38	5	0.0276
E7	5	0.0276	E23	5	0.0276	E39	5	0.0276
E8	5	0.0276	E24	5	0.0276	E40	1	0.0055
E9	5	0.0276	E25	3	0.0166	E41	1	0.0055
E10	4	0.0221	E26	5	0.0276	E42	3	0.0166
E11	2	0.0110	E27	5	0.0276	E43	4	0.0221
E12	5	0.0276	E28	4	0.0221	E44	5	0.0276
E13	5	0.0276	E29	3	0.0166	E45	5	0.0276
E14	2	0.0110	E30	4	0.0221	E46	5	0.0276
E15	3	0.0166	E31	2	0.0110	E47	5	0.0276
E16	5	0.0276	E32	2	0.0110	E48	3	0.0166

$$w(Ei) = \frac{C(Ei)}{\sum_{i=1}^{n} C(Ei)} \tag{6}$$

- *Determine the aggregate fuzzy opinion (R) for each indicator (k)*: For *k = 1, 2,..., N*, calculate the fuzzy opinion as shown below:

$$Rk = \sum_{k=1}^{N} w(Ei)_{(\cdot)} EPi \tag{7}$$

which implies the following:

$$\begin{aligned} R_k &= [(w(E_1) * a_1 + w(E_2) * a_2 + \ldots + w(E_n) * a_n), (w(E_1) * b_1 + w(E_2) * b_2 + \ldots \\ &\quad + \mathrm{w}(E_n) * b_n), (w(E_1) * c_1 + w(E_2) * c_2 + \ldots + w(E_n) * c_n)] \\ R_k &= (a_k, b_k, c_k), \text{ for } k = 1, 2, \ldots, N, \text{ where } N \text{ is number of indicators.} \end{aligned} \tag{8}$$

- *Defuzzification*: Determine the final score of each indicator. The center of gravity method was applied to defuzzify the aggregate fuzzy opinion of the indicator (R_k) as follows:

$$Sk = \frac{ak + bk + ck}{3} \tag{9}$$

where S_k is a final defuzzified score, which indicates the aggregate importance of each indicator (i).

- *Select indicators*: The final sustainability indicators were selected by setting a threshold value (T).

If $S_k \geq T$, the indicator is selected.

If $S_k < T$, the indicator is not selected.

Setting the threshold value depends on the fuzzy linguistic scale and user preference (Padilla-Rivera *et al.*, 2021; Zhang, 2017). If the users want more indicators, they can take a small value of the threshold and vice versa (Zhang, 2017). In this study, a threshold value (T = 6.2) was taken for a nine-fuzzy linguistic scale to select the indicators.

3. Results and discussion

In this section, the results of the analysis are presented with their discussion. In subsection 3.1, the potential sustainability indicators identified after conducting literature analysis and pre-testing and the final selected sustainability indicators are presented. The results are discussed in subsection 3.2.

3.1 Results

After conducting the systematic review and pre-testing the questionnaire with the selected industry experts, scholars and researcher, 40 potential sustainability indicators were identified and presented in Table 4. This study applied FDM based on CAM to incorporate experts' opinions with fuzzy logic for selecting the final suitable indicators. Through FDM, it is possible to analyze a group consensus by addressing the uncertainty and ambiguity of experts' judgment when evaluating each indicator (Padilla-Rivera *et al.*, 2021). Table 5 summarizes the results of the analysis based on the FDM.

For the selection of indicators, the final defuzzified scores (Table 5) are compared with the threshold value (T = 6.2). As a result, 25 indicators were selected and prioritized to measure sustainability performance in Italian footwear SMEs as shown in Figure 3. This does not mean that the unselected indicators are irrelevant, but they have, compared to the selected indicators, a lower priority to the SMEs. From the 25 selected indicators, product quality (8.091) was the top prioritized indicator for measuring the economic sustainability dimension followed by on-time delivery (7.978), profit (7.325), revenue (6.856), research & development (R&D) expenditure (6.747), labor cost (6.488), and material cost (6.380). Material consumption (6.944) followed by recycled material use (6.740), energy efficiency (6.688), and energy consumption (6.285) were found to be the most appropriate indicators for measuring the environmental sustainability dimension. Customer satisfaction (8.221) was given the top priority followed by working conditions (7.885), customer complaints (7.813), occupational health and safety (7.713), work-related injuries (7.644), employee satisfaction (7.630), customer health and safety (7.607), fair salary (7.352), employment/job opportunity (7.088) and training and development (7.020), working hours (6.833), lost working days (6.324), and employee turnover (6.323) for measuring the social sustainability dimension in the Italian footwear SMEs.

Table 4 Indicators identified after literature analysis and pre-testing

Indicators for economic dimension	*Indicators for environmental dimension*	*Indicators for social dimension*
Profit	Water consumption	Employment/Job opportunity
Revenue	Recycled water use	Fair salary
R&D expenditure	Energy consumption	Employee turnover
Material cost	Renewable energy use	Employee satisfaction
Labor cost	Energy efficiency	Occupational health and safety
Energy cost	Energy intensity	Training and development
Maintenance cost	Material consumption	Working conditions
Packaging cost	Recycled material use	Work-related injuries
Inventory cost	Packaging material consumption	Working hours
Product quality	Land use	Lost working days
Lead time	GHG emissions	Customer health and safety
On-time delivery	Wastewater discharge	Customer satisfaction
	Solid waste disposal	Customer complaints
	Recyclable waste	Corruption

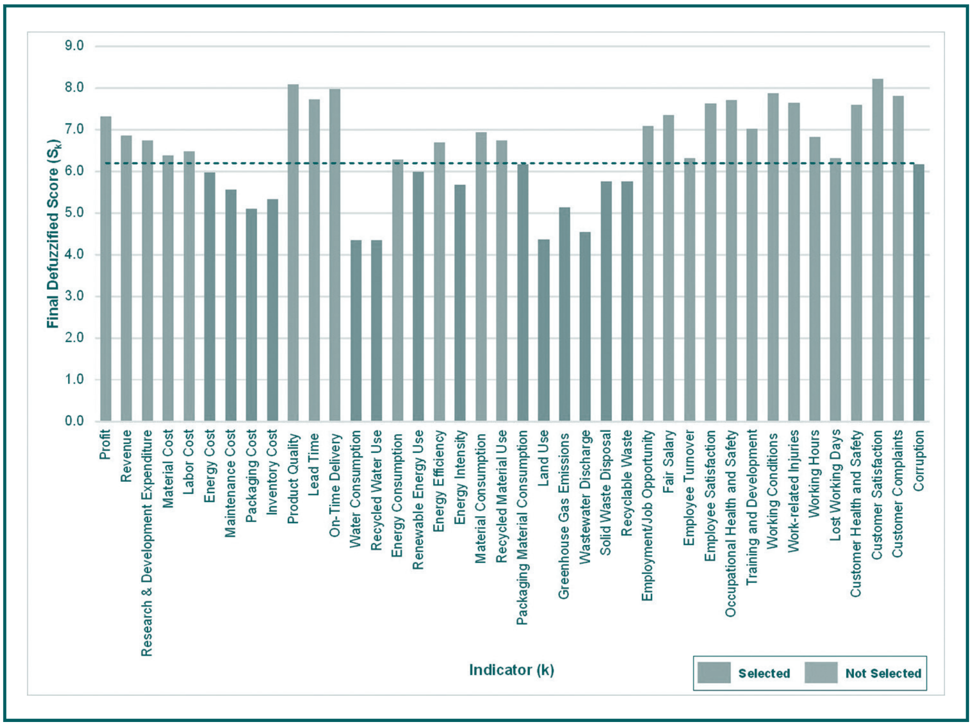
Table 5 Aggregate fuzzy opinion and defuzzified score

Sustainability dimensions	*Indicators (k)*	*Aggregate fuzzy opinion* Min (l_k)	Optimum (m_k)	Max (u_k)	*Defuzzified score* (S_k)	*Selected*
Economic	Profit	5.613	7.613	8.749	7.325	Y
	Revenue	4.962	6.962	8.642	6.856	Y
	R&D expenditure	4.978	6.965	8.297	6.747	Y
	Material cost	4.463	6.448	8.229	6.380	Y
	Labor cost	4.618	6.618	8.230	6.488	Y
	Energy cost	4.024	6.024	7.871	5.973	–
	Maintenance cost	3.645	5.561	7.469	5.559	–
	Packaging cost	3.150	5.097	7.071	5.106	–
	Inventory cost	3.422	5.316	7.289	5.342	–
	Product quality	6.642	8.642	8.987	8.091	Y
	Lead time	6.167	8.167	8.885	7.740	Y
	On-time delivery	6.480	8.480	8.972	7.978	Y
Environmental	Water consumption	2.852	4.265	5.954	4.357	–
	Recycled water use	2.909	4.193	5.939	4.347	–
	Energy consumption	4.435	6.376	8.043	6.285	Y
	Renewable energy use	4.162	6.121	7.674	5.986	–
	Energy efficiency	4.945	6.912	8.209	6.688	Y
	Energy intensity	3.795	5.722	7.505	5.674	–
	Material consumption	5.186	7.186	8.460	6.944	Y
	Recycled material use	4.943	6.928	8.351	6.740	Y
	Packaging material consumption	4.337	6.251	7.949	6.179	–
	Land use	2.652	4.332	6.143	4.376	–
	GHG emissions	3.406	5.250	6.755	5.137	–
	Wastewater discharge	2.844	4.534	6.247	4.542	–
	Solid waste disposal	3.880	5.834	7.575	5.763	–
	Recyclable waste	3.946	5.897	7.419	5.754	–
Social	Employment/Job opportunity	5.245	7.245	8.774	7.088	Y
	Fair salary	5.642	7.642	8.773	7.352	Y
	Employee turnover	4.465	6.448	8.056	6.323	Y
	Employee satisfaction	5.993	7.993	8.902	7.630	Y
	Occupational health and safety	6.133	8.133	8.873	7.713	Y
	Training and development	5.161	7.161	8.737	7.020	Y
	Working conditions	6.376	8.376	8.903	7.885	Y
	Work-related injuries	6.029	8.029	8.873	7.644	Y
	Working hours	5.001	7.001	8.497	6.833	Y
	Lost working days	4.449	6.449	8.074	6.324	Y
	Customer health and safety	6.001	7.994	8.824	7.607	Y
	Customer satisfaction	6.838	8.838	8.988	8.221	Y
	Customer complaints	6.252	8.252	8.934	7.813	Y
	Corruption	4.544	6.278	7.669	6.164	–

3.2 Discussion

From the empirical analysis, the results show that a few number of indicators (n = 25) were selected and prioritized to effectively measure and manage sustainability performance in Italian footwear SMEs. To measure the economic dimension of industrial sustainability, indicators linked to financial benefits (*profit* and *revenue*), costs (*labor cost* and *material cost*) and market competitiveness (*R&D expenditure, on-time delivery*, *lead time*, and *product quality*) were given high priority. On-time delivery, lead time, and product quality are crucial to ensure market competitiveness and financial performance of SMEs in the short run. Moreover, SMEs need to allocate reasonable expenditure to conduct R&D activities for promoting innovation for producing sustainable products and enhancing market competitiveness in the long run.

Figure 3 Final selected indicators



Although *water consumption* (Ahmad and Wong, 2019; Cagno *et al.*, 2019; Demartini *et al.*, 2018; Vitale *et al.*, 2019) and *greenhouse gas* (*GHG*) *emissions* (Abedini *et al.*, 2020; Beekaroo *et al.*, 2019; Cagno *et al.*, 2019; Zarte *et al.*, 2019) were frequently used by previous studies for measuring the environmental sustainability, this empirical study revealed that these indicators are less prioritized. This is due to the production process of footwear SMEs is not water-intensive unlike other industrial sectors such as food and beverage and produces fewer emissions. On the other hand, material consumption, recycled material use, energy efficiency, and energy consumption were prioritized over the other indicators of the environmental dimension. Different input materials are used by footwear industries to produce a range of products (Staikos and Rahimifard, 2007). Among which, leather, synthetics, plastic, rubber, and textiles are the most common input materials that are consumed by the footwear production process (Sellitto Miguel and Almeida Francieli Aparecida, 2019). The footwear industry has placed a significant effort in improving material efficiency and eliminating the use of hazardous materials during the production (Staikos and Rahimifard, 2007). The Italian footwear SMEs gave more attention to material consumption to measure their progress in terms of material efficiency improvement, hazardous materials reduction, and the use of eco-friendly and biodegradable materials. Subsequently, they can minimize waste generation by improving material efficiency. The safety of their products to the customers can be improved by reducing the use of hazardous materials in the production phase. Moreover, reducing the use of hazardous materials, increasing the use of eco-friendly and biodegradable materials, and promoting the use of recycled materials are crucial in minimizing growing concerns from environmental and social impacts of the end-of-life (EOL) products in the post-use phase. It is also essential for SMEs to measure their progress in energy saving and cost reduction using energy efficiency as one of the prioritized indicators.

In the social dimension of industrial sustainability, indicators that promote sustainability performance measurement related to employees, customers, and community were selected. The footwear industry is one of the industrial sectors that have low technology and are labor intensive (Scott, 2006). Since it is a labor-intensive industry, improving the well-being of the employees is required in the Italian footwear SMEs. To measure the progress towards this goal, working conditions, occupational health and safety, work-related injuries, fair salary, training and development, and employee satisfaction were the top prioritized indicators. SMEs also need to measure the progress in improving the well-being of their customers. To achieve this goal, customer satisfaction, customer complaints, and customer health and safety were found as more relevant indicators. High priority was given to employment/job opportunity to measure the progress toward community development. Moreover, working hours and lost working days were key indicators to measure performance associated with the working time management of employees.

Along with increasing pressure from stakeholders on footwear industries to be more transparent about their sustainability practices and improve sustainability performance, there is a growing interest in measuring and evaluating industrial sustainability performance. However, as SMEs have limited resources, they need to use a manageable number of suitable indicators to measure and report their sustainability performance effectively. The selected and prioritized indicators can be used to effectively measure and manage the sustainability performance of SMEs. Moreover, these indicators can also be applied to define, implement, evaluate and monitor policies to enhance sustainable manufacturing by considering economic, environmental, and social aspects while producing products and services, ensuring economic growth, conserving natural resources, minimizing negative environmental and social impacts, and meeting the requirements of stakeholders. Eventually, they can contribute to achieving the following Sustainable Development Goals (SDGs) such as promoting health, and well-being (SDG 3), promoting sustainable economic growth, productive employment and decent work (SDG 8), and ensuring sustainable consumption and production (SDG 12). Table 6 presents the link between the selected indicators and the SDGs.

4. Conclusions

This paper selected and prioritized sustainability indicators in the contexts of SMEs using fuzzy Delphi method (FDM) based on consistency aggregation method (CAM). The method combines the qualitative method (gathering experts' opinions using the questionnaire) and quantitative method (fuzzy analysis considering the ambiguity and subjectivity associated with the experts' opinions) to analyze and select the useful and applicable indicators for measuring industrial sustainability in the Italian footwear SMEs.

Our findings revealed that the selected indicators promote measuring and managing the progress towards achieving industrial sustainability goals in terms of increasing financial benefits, reducing costs, and market competitiveness for the economic sustainability dimension; improving the effectiveness of resources utilization for the environmental sustainability dimension; and promoting employees, customers, and the community for the social sustainability dimension. Therefore, SMEs need to focus and allocate their limited resources on effectively applying the selected indicators to measure and manage their sustainability performance. In doing so, they can contribute to achieving the SDGs by promoting health and well-being, promoting sustainable economic growth, providing productive employment, and decent work, and ensuring responsible consumption and production.

This paper has significant academic, practical, and policy implications. It will be a good theoretical base for future research in industrial sustainability performance measurement,

Table 6 Link between the selected indicators and their respective SDGs				
Sustainability dimensions	*Indicators*	*Sustainable Development Goals (SDGs)* SDG 3	*SDG 8*	*SDG 12*
Economic	Product quality		X	
	On-time delivery		X	
	Lead time		X	
	Profit		X	
	Revenue		X	
	R&D expenditure		X	X
	Labor cost		X	
	Material cost		X	
Environmental	Material consumption			X
	Recycled material use			X
	Energy efficiency			X
	Energy consumption			X
Social	Customer satisfaction	X		
	Working conditions	X	X	
	Customer complaints	X		
	Occupational health and safety	X		
	Work-related injuries	X		
	Employee satisfaction	X	X	
	Customer health and safety	X		
	Fair salary		X	
	Employment/Job opportunity		X	
	Training and development		X	
	Working hours	X	X	X
	Lost working days	X	X	X
	Employee turnover	X	X	X

primarily for the sustainability performance measurement of footwear industry. It provides a comprehensive methodological approach ranging from literature analysis to empirical analysis of sustainability indicators. Eventually, it can contribute to the existing theory and knowledge in the field of industrial sustainability performance measurement. From a practical viewpoint, it provides empirically supported indicators tailored to the context of SMEs to effectively measure and manage their sustainability performance. The methodological approach applied to tailor the indicators can easily be adapted to different manufacturing industry contexts. It also has policy implications by linking the selected indicators to industrial sustainability goals and their respective SDGs and can serve as a significant input for the policymakers in the field of industrial sustainability.

The scope of this paper was limited at the firm level to analyze TBL sustainability indicators. However, to get a more comprehensive view of sustainability by including the environment and social impacts of EOL products, it would be better to include additional indicators including governance indicators for measuring and managing sustainability performance at the supply chain level. Hence, it will be interesting for the future research to expand the approach applied in this paper to the entire supply chain consisting of supply, production, distribution, use, and post-use.

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