UNIVERSITÀ DEGLI STUDI DI PADOVA

Administrative Headquarters: Università degli Studi di Padova

Department of Management and Engineering

PhD Course: Management Engineering and Real Estate Economics
Curriculum: Management Engineering

XXXIV Cycle

Industrial sustainability: Context-tailored indicators and framework

Thesis written with the financial contribution of the Cassa di Risparmio di Padova e Rovigo (CARIPARO) Foundation

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Acknowledgements

First and foremost, let God the Almighty be praised for making me healthy and strong to carry out this PhD thesis work.

My deepest gratitude goes to my supervisors Prof. Roberto Panizzolo and Prof. Cipriano Forza for their invaluable guidance, support, and encouragement to carry out the thesis work. Their insightful comments and suggestions enable me to ensure the originality, rigor, and relevance of the thesis. Moreover, the great learning from them allows me to grow my academic career. All I learned from them is value-adding for my future career.

I would also like to extend my gratitude to the coordinators of the PhD program Prof. Anna Nosella and Prof. Lara Agostini for their commitment and dedication in coordinating and facilitating the doctoral program by creating a conducive environment to accomplish my thesis work.

My grateful thanks also goes to the faculty professors who gave me very crucial seminars and training, which provide valuable insights and research tools that I used for my thesis work and could also be helpful for my future academic career.

I would also like to thank those scholars and colleagues who participated in the pre-testing of the questionnaire. I also want to thank those industry experts who participated in the pre-testing of the questionnaire and those who gave me empirical evidence by responding to the final questionnaire and checklist. Without their participation, the empirical analysis of the thesis would not have been accomplished successfully.

I also gratefully thank the Cassa di Risparmio di Padova e Rovigo (CARIPARO) Foundation for its financial support.

Finally, my special thanks goes to my family, friends, and colleagues. Thank you, mom, for your love and care and all the sacrifices you have made for me. I couldn’t have accomplished everything without you; this thesis is dedicated to you.

Abstract

This thesis aims to empirically analyze and select useful and applicable indicators for measuring sustainability performance in Italian footwear small and medium-sized enterprises (SMEs) and develop a framework to put the selected indicators into practice. To achieve this objective, a comprehensive methodological approach, which includes a systematic review of the literature to identify sustainability indicators, an empirical analysis to select and prioritize the indicators and an indicator-based framework development, has been applied. The obtained findings indicate that out of 1013 indicators identified in the reviewed literature, 25 indicators were found to be more suitable for Italian footwear SMEs for measuring their sustainability performance. The 25 selected indicators emphasize measuring industrial sustainability performance associated with (1) increasing financial benefits, reducing costs, and improving market competitiveness for the economic sustainability dimension; (2) improving the effectiveness of resources utilization for the environmental sustainability dimension; and (3) improving the well-being of employees, customers, and the community for the social sustainability dimension. SMEs can also use these indicators to track their progress towards achieving sustainable development goals (SDGs). The developed framework provides a comprehensive view of the application of the indicators ranging from setting sustainability goals and targets to measuring, evaluating and interpreting sustainability performance. The metrics, which have been defined to make the indicators measurable and manageable, are a crucial aspects of the development framework. These metrics are supported by empirical evidence so that they can be used more easily and effectively in SMEs to measure and manage their sustainability performance. Furthermore, the thesis links the selected indicators to their respective SDGs to provide a broader view of sustainability to SMEs to ensure the well-being of stakeholders, sustainable economic growth and decent work, and sustainable consumption and production. Involving industry experts' opinions makes the thesis more solid and relates it to industrial reality. The provided set of suitable indicators and the related tailored framework should help Italian footwear SMEs to significantly improve the effectiveness of measuring and managing sustainability performance.

Sommario

L’obiettivo di questo lavoro di tesi è duplice. Da un lato, individuare un insieme di indicatori utili e applicabili per misurare le prestazioni di sostenibilità delle piccole e medie imprese (PMI) italiane appartenenti al settore della calzatura. Dall’altro lato, sviluppare un framework di riferimento idoneo a sostenere queste imprese nella pratica implementazione di questi indicatori. Dal punto di vista metodologico questo lavoro si basa innanzi tutto su una revisione sistematica della letteratura per identificare gli indicatori di sostenibilità proposti dagli studi scientifici internazionali. Successivamente è stata impostata una analisi empirica che ha visto il coinvolgimento di aziende ed esperti del mondo accademico e industriale al fine di selezionare gli indicatori più coerenti per il settore in esame, di stabilirne una priorità di rilevanza e le modalità di misura. L’analisi empirica è stata anche fondamentale per disegnare il framework di riferimento atto a sostenere l’implementazione degli indicatori selezionati nelle strategie e pratiche aziendali. I risultati ottenuti evidenziano che su 1013 indicatori individuati nella letteratura esaminata 25 sono risultati più adatti alle PMI calzaturiere italiane per misurare le loro prestazioni di sostenibilità. Gli 25 indicatori selezionati sottolineano che la misurazione delle prestazioni di sostenibilità industriale riguarda prioritariamente (1) l’aumento dei benefici finanziari, la riduzione dei costi e il miglioramento della competitività per la dimensione della sostenibilità economica; (2) il miglioramento dell'efficacia dell'utilizzo delle risorse per la dimensione della sostenibilità ambientale; e (3) il miglioramento del benessere dei dipendenti, dei clienti e della comunità per la dimensione della sostenibilità sociale. Gli indicatori selezionati e le relative modalità di misura consentono alle PMI del settore calzaturiero di monitorare i loro progressi nel tempo verso il raggiungimento degli obiettivi di sviluppo sostenibile (OSS). Il framework di riferimento sviluppato fornisce una visione completa dei vari aspetti legati alla pratica applicazione degli indicatori, dalla definizione di obiettivi e traguardi di sostenibilità alla misurazione, valutazione e interpretazione delle prestazioni di sostenibilità. Per lo sviluppo delle metriche e del framework di riferimento le risultanze empiriche sono state molto importanti per garantire semplicità di misurazione e facilità di implementazione dei vari indicatori in modo da rendere efficace nelle PMI del settore della calzatura il cammino verso la sostenibilità. Inoltre, il lavoro di tesi supporta l’integrazione tra indicatori con gli OSS quali il benessere di tutte le parti interessate, la crescita economica sostenibile e il lavoro dignitoso, nonché il consumo e la produzione sostenibili. Il coinvolgimento delle opinioni degli esperti del settore rende la tesi più solida e la mette in relazione con la realtà industriale. La serie fornita di indicatori adeguati e il relativo quadro su misura framework dovrebbero aiutare le PMI calzaturiere Italiane a migliorare significativamente l'efficacia della misurazione e della gestione delle prestazioni di sostenibilità.

Table of Contents

List of Figures

List of Tables

List of Acronyms

SMEs	Small and medium-sized enterprises
SDGs	Sustainable Development Goals
TBL	Triple bottom line
CO_2	Carbon dioxide
GHG	Greenhouse gas
OHS	Occupational health and safety
PCD	Performance and career development
R&D	Research and development
emp	Employee
h	Hour
kg	Kilogram
kWh	Kilowatt hour
L	Liter
m^3	Cubic meter
m^2	Square meter
pc	Piece
uop	Unit of product
USD	United States dollar
AFSS	Apparel and Footwear Sector Supplement
EC	European Commission
GRI	Global Reporting Initiative
ISO	International Organization for Standardization
LCSP	Lowell Center for Sustainable Production
NIST	National Institute of Standards and Technology
OECD	Organization for Economic Cooperation and Development
SAC	Sustainable Apparel Coalition
UN	United Nations

Chapter One

1 Introduction

1.1 Background

The issue of sustainability has been given increasing attention to deal with growing concerns of environmental and social impacts of development (Huang and Badurdeen, 2018). More specifically, sustainable manufacturing is increasingly being used to properly manage the environmental and social impacts of manufacturing companies (Ahmad and Wong, 2019; Singh S. et al., 2014); helping them to contribute to achieving the SDGs (Hashim et al., 2021). Sustainable manufacturing has also become a key factor enabling manufacturing firms to stay relevant in today's competitive business environment (Singh R.K. et al., 2019). Consequently, manufacturing companies need to transform their traditional manufacturing practices that focus primarily on the economic benefits into sustainable manufacturing practices that consider environmental and social responsibility in addition to pursuing their profitability (Shuaib et al., 2014; Singh R.K. et al., 2019). To effectively adopt sustainability in manufacturing companies, a comprehensive approach is required for measuring sustainability performance. The scope of sustainability performance measurement varies from production line to plant, firm, and supply chain (Huang and Badurdeen, 2018). Industrial sustainability involves adopting sustainability practices at the firm level (Trianni et al., 2017). In this research, the concept of industrial sustainability considers the sustainability of manufacturing industries at the firm level (Mengistu and Panizzolo, 2022a).

Along with the growing significance of sustainable development, the theories of industrial sustainability have evolved. The main theories linked to industrial sustainability are corporate social responsibility, stakeholder theory, and corporate sustainability (Chang et al., 2017). Corporate social responsibility refers to practices undertaken by companies to improve their performance so that they can achieve social responsibility and long-term sustainability and establish trust with stakeholders (Köseoglu et al., 2021). Stakeholder theory provides a rational perspective on how firms can manage their relationships with stakeholders to facilitate the development of competitive resources and achieve sustainable success. It also provides useful insights into the practices of sustainable and ethical value creation (Parmar et al., 2010). Corporate sustainability focuses not only on companies' economic aspects but also takes into account their environmental and social aspects. It helps companies to achieve economic growth while fulfilling their social responsibility and becoming more environmentally friendly (Aktaş and Demirel, 2021).

The manufacturing sector is one of the main drivers for a country's economic growth and social development (Galal and Moneim, 2015; Zeng et al., 2008). This sector, however, is considered to be one of the main causes contributing to environmental degradation and social impacts (Zeng et al., 2008). While the past few years have seen increasing emphasis placed on sustainability, there is still a need for more efforts to transform the traditional manufacturing practices, which focus primarily on economic benefits, into sustainable manufacturing practices that also consider environmental and social responsibility (Mengistu and Panizzolo, 2022a). Some of the sustainability challenges caused by the sector are an increase in pollution, greenhouse gas (GHG) emissions, global warming, and a decrease in biodiversity (Aktaş and Demirel, 2021). Various stakeholders have put pressure on manufacturing companies 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 of development (Beekaroo et al., 2019; Samuel et al., 2013; Wang et al., 2018). Stakeholders in industrial sustainability include governments, investors, political groups, trade associations, suppliers, employees, customers, and communities (Paramanathan et al., 2004; Veleva and Ellenbecker, 2001). Moreover, sustainability is adopted so that manufacturing companies can gain a competitive advantage (Tseng et al., 2009; Veleva et al., 2001; Wang et al., 2018).

To adequately address industrial sustainability, it is essential to adopt a holistic/comprehensive approach based on the triple bottom line (TBL) (Cagno et al., 2019). As was proposed by Elkington (1997), the TBL approach consists of three correlated dimensions of sustainability (i.e., economic, environmental, and social sustainability dimensions); and provides a comprehensive approach for measuring the sustainability performance of manufacturing companies (Ahmad and Wong, 2019). As manufacturing companies have a significant impact on the three sustainability dimensions (Ahmad, Wong, and Zaman, 2019; Ghadimi et al., 2012), they should simultaneously consider them while producing their products and services (Eastwood and Haapala, 2015; Haapala et al., 2013; Lacasa et al., 2016; Watanabe et al., 2016). For instance, the manufacturing sector in the European Union countries (EU-27) contributed a value-added of nearly 2.1 trillion euro to the gross domestic product (Eurostat, 2019); they generated about 370 million metric tons of CO_2 equivalent GHG emissions (Statista, 2019) in 2019; and the manufacturing sector employed nearly 35 million employees in the European Union, including the United Kingdom in 2020 (Statista, 2020). These figures imply that the manufacturing sector has a significant potential to address the issues of sustainability based on the TBL approach.

SMEs contribute significantly to a country's economic growth through innovation, production volume and job creation (Belas et al., 2019; Kassem and Trenz, 2020; Lopes de Sousa Jabbour et al., 2020; Sajan et al., 2017). Although SMEs have important economic, environmental and social implications, they are not effectively addressing the environmental and social sustainability dimensions to measure and manage their sustainability performance (Journeault et al., 2021; Mitchell et al., 2020); and they focus primarily on the economic dimension of sustainability (Choi and Lee, 2017; Trianni et al., 2019). This is due to limited resources (Hsu C.H. et al., 2017; Journeault et al., 2021; Singh S. et al., 2014; Trianni et al., 2019; Winroth et al., 2016), lack of awareness about impacts and benefits related to sustainability (Journeault et al., 2021; Singh S. et al., 2014), and a lack skills and expertise on sustainability performance measurement (Journeault et al., 2021; Singh S. et al., 2014; Trianni et al., 2019). In addition, the lack of suitable indicators tailored to the context of the manufacturing industry such as SMEs is a major challenge in measuring industrial sustainability performance (Ahmad and Wong, 2019; Ocampo et al., 2016).

The footwear sector is one of the leading industrial sectors driving the economic growth and social development of Italy. According to Assocalzaturifici Assocalzaturifici (2020), the sector created job opportunities for around 75000 employees, generated a yearly turnover of 14.3 billion euro in 2019, and consume a variety of input materials such as leather, synthetic, rubber, and textiles for production. These figures indicate that the sector has a significant potential to address issues of sustainability. However, the lack of clear sustainability goals, suitable indicators and frameworks, as well as limited resources are considerable challenges in measuring and managing the sustainability performance of footwear firms, especially SMEs. The present literature analysis performed for this thesis (see chapter four) points out that there is a need for research on the footwear sector regarding sustainability. More specifically, research is needed on measuring the sustainability performance of the footwear sector (SMEs in particular) based on the TBL approach. Previous research regarding the sustainability performance of the footwear industry is limited and focuses primarily on the environmental dimension (Deselnicu et al., 2014; Subic et al., 2013).

There is also a need for research on context-tailored indicators and frameworks for measuring and managing the sustainability performance of SMEs. These rationales pushed to consider the footwear sector, particularly Italian footwear SMEs as the research context to carry out an empirical study. This research focuses on Italian footwear SMEs than large firms. This is mainly due to, unlike large firms, SMEs have limited resources for measuring and managing sustainability performance. Consequently, they need a manageable number of sustainability indicators that are simple and easy to use. Moreover, the Italian footwear sector consists of a large number of SMEs, which have a significant impact on the sustainable development of Italy.

1.2 Research objectives and research questions

Manufacturing companies need to improve sustainability performance and be transparent about their sustainability practices (Trianni et al., 2019). For this purpose, they need to use suitable indicators and frameworks tailored to their needs. In order effectively adopt sustainability practices in a manufacturing firm, measuring its sustainability performance is essential (Cagno et al., 2019; Trianni et al., 2019). Industrial sustainability cannot be properly managed if it is not effectively measured using suitable indicators (Feil et al., 2015; Huang and Badurdeen, 2018; Trianni et al., 2019). To achieve this, manufacturing companies need to use multidimensional indicators for measuring their sustainability performance (Moldavska and Welo, 2019). The TBL approach provides multidimensional indicators based on the economic, environmental, and social sustainability dimensions (Ahmad and Wong, 2019; Trianni et al., 2019; Wang et al., 2018; Winroth et al., 2016). Furthermore, since 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), selecting and prioritizing suitable indicators tailored to the context of a manufacturing firm is essential (Medini et al., 2015). As SMEs have limited resources, they need to use a manageable number of indicators that are simple and easy to apply (Veleva and Ellenbecker, 2001).

This research has been conducted to fill gaps identified in the literature that are practically relevant in relation to what has been mentioned above. The gaps identified after the literature analysis are associated with the need for a comprehensive approach based on TBL, context-tailored indicators, and a comprehensive framework to apply the indicators in SMEs. Consequently, the main objective of the present research has been set to empirically analyze and select useful and applicable indicators for measuring sustainability performance in Italian footwear SMEs and develop a framework to put the selected indicators into practice. The specific objectives of this research are described as follows:

- To conduct a systematic review to identify indicators from the literature related to the sustainable performance measurement of manufacturing companies
- To carry out empirical analysis for selecting and prioritizing indicators tailored to the needs of SMEs for measuring their sustainability performance
- To develop a framework that guides SMEs to apply the selected indicators
- To carry out empirical analysis on the applicability of metrics, which are the crucial aspects of the framework

The present research is, therefore, positioned on industrial sustainability performance measurement. Industrial sustainability is becoming the main driver of the long-term business success of manufacturing companies by fulfilling stakeholders' requirements. To do research with high significant implications for academics, practice, and policymakers, more attention has been paid to selecting and prioritizing suitable indicators for the three sustainability dimensions (economic, environmental, and social) to properly address the gaps identified in the literature and the challenges of sustainability performance measurement in SMEs. In addition to selecting and prioritizing indicators, the scope of this research included developing a framework that can help SMEs put the selected indicators into practice. This research focuses on a specific country, namely Italy, to provide results more directly usable in practice. More specifically, it focuses on a specific context, namely Italian footwear SMEs, a sector that can take high advantages from the present research and a sector which is highly present in the region covered by the financer of the present research. To achieve the research objectives, the following two research questions were formulated and examined:

- *RQ1: What are the suitable indicators for measuring sustainability performance in Italian footwear SMEs?*
- *RQ2: How can the selected indicators be applied to measure sustainability performance in SMEs?*

1.3 Organization of the thesis

The remaining work of the thesis is organized into five chapters. Chapter 2 describes the theoretical framework that supports the research. It covers an overview of industrial sustainability, sustainability indicators, frameworks for measuring industrial sustainability, and an overview of the sustainable development goals. It also highlights sustainability in the footwear industry and describes the gaps identified in the literature. Chapter 3 describes the research methodology applied to conduct this research (i.e., to address the research questions). It includes the approach for conducting a systematic review and content analysis, questionnaire design and pre-testing, data collection and analysis, and indicator-based framework development. Chapter 4 presents and discusses the results of the literature analysis and the empirical analysis used to address research one (RQ1). It includes the most consistently and frequently used indicators, categorization of indicators, the refined indicators after pre-testing, selected and prioritized indicators, and linking the indicators into their respective SDGs. The indicator-based framework developed to address research question two (RQ2) is described in Chapter 5. It covers the overall structure of the framework, the metrics defined for the framework, and a detailed guideline for applying the indicators. Moreover, Chapter 6 presents the discussion and conclusions, implications, and limitations of the research and avenues for future research. Finally, the thesis ended up with the references used and appendices. Figure 1 presents the organization of the thesis.

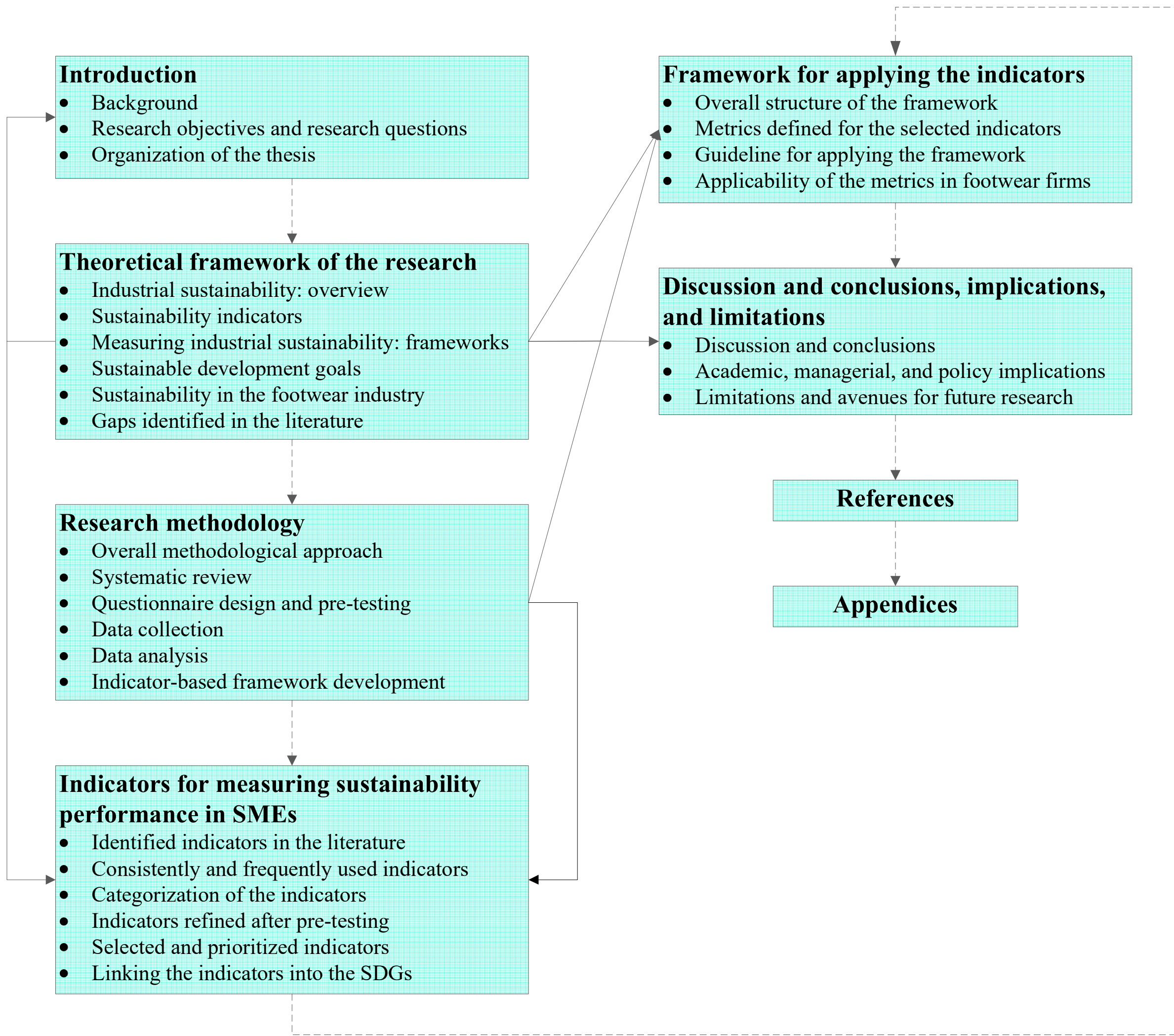

Figure 1. Organization of the thesis

Chapter Two

2 Theoretical framework of the research

2.1 Industrial sustainability: overview

In response to the excessive exploitation of natural resources, the growing consequences of environmental degradation, and considerable social impacts, the concept of sustainable development has been introduced and incorporated into several areas (Wang et al., 2018), including manufacturing. The manufacturing sector has been considered as one of the main causes that have created significant sustainability challenges such as pollution, global warming, waste production, climate change, resource scarcity, etc. Manufacturing companies, in order to reduce these challenges, need to apply sustainable practices in their day-to-day business activities (Muhardi et al., 2020), review their production strategies and develop innovative technologies for using the resources in a sustainable way (Bork et al., 2016).

The manufacturing sector can play a significant role in achieving sustainable development by creating jobs, improving social well-being, and reducing environmental impact (Moldavska and Welo, 2019). The sustainability of the manufacturing sector considers economic activities which could continue without long-term damage to the natural environment and social well-being. However, economic growth requires the consumption of natural resources and human resources. In order to effectively address economic growth, natural resources, and human resources in a sustainable way, manufacturing companies need to measure and manage their sustainability performance considering the economic, environmental, and social dimensions of sustainability (Beekaroo et al., 2019). The concept of sustainable manufacturing essentially consists of the selection of suitable indicators for assessing sustainability performance, identifying areas for improvement, and taking improvement actions (Hashim et al., 2021). These can be considered as the activities being carried out in industrial sustainability performance measurement.

Industrial sustainability has become an essential subject of discussion among (Cagno et al., 2019; Smart et al., 2017) and has gained relevance by industrial decision-makers, policymakers, and scholars (Neri et al., 2018; Trianni et al., 2017). It accounts for 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 defined 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). According to this definition, industrial sustainability should promote the production of goods and services that fulfills the needs of the current generation while not compromising economic, environmental, and social opportunity in the long-term. 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". According to Zeng et al. (2008) industrial sustainability should support economic growth, environmental protection, and social development to bring industrial advantage for the short- and long-term future. In this research, industrial sustainability is defined as a set of activities that includes all of the following: simultaneous consideration of economic, environmental, and social aspects while producing products and services; ensuring sustainable economic growth, conserving resources, and minimizing negative environmental and social impacts; and meeting stakeholder requirements in the short- to long-term (Mengistu and Panizzolo, 2021).

2.2 Sustainability indicators

Indicators provide information about physical, economic or social issues (Veleva and Ellenbecker, 2001) by translating complex issues into manageable and easily understood information for decision-making (Samuel et al., 2013). In particular, sustainability indicators are used to measure and evaluate progress towards achieving sustainability goals and targets (Ahi and Searcy, 2015). More specifically, they are used to raise awareness and understanding, inform decision-making, and measure progress toward established sustainability goals (Veleva et al., 2001). Sustainability indicators can be used to measure both quantitative and qualitative sustainability performance (Ahi and Searcy, 2015; Veleva and Ellenbecker, 2001). Both absolute and relative indicators are used to measure sustainability performance in manufacturing companies (Ahi and Searcy, 2015). Absolute indicators measure sustainability performance in terms of overall performance levels in specific areas of interest (e.g., water consumption) of a company as a whole. On the other hand, relative indicators measure a company's sustainability performance in one area (e.g., water consumption) with respect to the performance in another area (e.g., total production). (Ahi and

Searcy, 2015; Haffar and Searcy, 2018). As desired qualities, sustainability indicators should be *measurable* (simple and easy to measure either quantitatively or qualitatively), *relevant* (related to a purposeful aspect of sustainability), *understandable* (easily interpreted), *reliable* (provide trusted and accurate information), *accessible* (based on easily accessible data), *timely* (based on data that are available within a reasonable time frame), and *long-term oriented* (ensure its future use, development and adoption) (Hasan et al., 2017; Joung et al., 2013).

Sustainability indicators are used to operationalize economic, environmental, and social sustainability goals into practice (Samuel et al., 2013) and help manufacturing companies to report their contribution to achieving the SDGs (Moldavska and Welo, 2019). The economic dimension is the most crucial goal that manufacturing companies want to achieve (Wang et al., 2018; Zarte et al., 2019). In the economic sustainability dimension, the indicators are used to measure the economic sustainability performance of manufacturing companies linked mainly to *profit* (Ahmad, Wong, and Rajoo, 2019; Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019), *costs* (Ahmad, Wong, and Rajoo, 2019; Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019; Wang et al., 2018), *investment* (Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019). The environmental dimension considers the impacts on the environment resulting from the production processes and products of manufacturing companies (Wang et al., 2018; Zarte et al., 2019). The environmental indicators are used for measuring environmental sustainability performance of manufacturing companies related to *resources* (Ahmad, Wong, and Rajoo, 2019; Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019), *emissions* (Ahmad, Wong, and Rajoo, 2019; Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019; Wang et al., 2018), *wastes* (Ahmad, Wong, and Rajoo, 2019; Hasan et al., 2017; Song and Moon, 2019; Wang et al., 2018), *pollution* (Hasan et al., 2017; Joung et al., 2013), and *natural habitat conservation* (Joung et al., 2013). The social dimension considers human needs and well-being (Zarte et al., 2019). From the perspective of the manufacturing industry, the indicators in the social dimension address issues associated with employees, customers, and the community (Ahmad, Wong, and Rajoo, 2019; Joung et al., 2013). Indicators related to employees, for instance, include *income (wage or salary)* (Ahmad, Wong, and Rajoo, 2019; Wang et al., 2018), *occupational health and safety* (Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019), *employee development* (Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019), and *employee satisfaction* (Joung et al., 2013; Song and Moon, 2019); those related to customers consist of *customer health and safety* (Ahmad, Wong, and Rajoo, 2019;

Hasan et al., 2017; Joung et al., 2013; Song and Moon, 2019) and *customer satisfaction* (Ahmad, Wong, and Rajoo, 2019; Joung et al., 2013; Song and Moon, 2019); and those related to the community include *job opportunity* (Ahmad, Wong, and Rajoo, 2019; Hasan et al., 2017; Song and Moon, 2019), *corruption* (Ahmad, Wong, and Rajoo, 2019; Joung et al., 2013), and *community development* (Ahmad, Wong, and Rajoo, 2019; Joung et al., 2013).

2.3 Measuring industrial sustainability: frameworks

Measuring the sustainability performance of manufacturing firms is crucial for sustainable economic growth and promoting environmental protection and social responsibility (Trianni et al., 2019). Appropriate indicator-based frameworks enable manufacturing companies to effectively measure and manage sustainability performance and report their contribution towards achieving sustainability goals. Several frameworks have been proposed by previous research for measuring the sustainability performance of manufacturing companies. *For example*, Abedini et al. (2020) present a metric-based model to systematically and holistically evaluate the sustainability of the production schedules. On the other hand, Song and Moon (2019) provide an improved assessment framework for evaluating the sustainability performance of manufacturing systems against sustainability targets. Cagno et al. (2019) develop a framework for the assessment of industrial sustainability performance to provide industrial decision-makers with a scalable framework applicable in different contexts. Singh S. et al. (2018) propose a balanced scorecard-based framework for the sustainability performance evaluation of manufacturing SMEs. Li et al. (2012) develop a comprehensive and effective quantitative method to measure the overall sustainability performance of manufacturing companies. Huang and Badurdeen (2017) provide a framework to aggregate the indicators into index-based and value-based to measure sustainability at the enterprise level. Veleva and Ellenbecker (2001) propose a framework for promoting and measuring companies' achievements based on a set of indicators of sustainable production. Their framework identified a set of indicators and provided detailed guidance for the application of the indicators.

The indicator-based frameworks by previous research focused primarily on the measurement aspect of industrial sustainability performance mostly without providing a detailed guideline for sustainability performance evaluation (i.e., comparing the actual sustainability performance with respect to the predefined sustainability targets) and interpretation of the results (i.e., checking whether the performance is sustainable or needs improvement actions).

Moreover, there are several frameworks developed by sustainability standards and guidelines, which include Global Reporting Initiative (GRI) standards, ISO standards, and guidelines by organizations engaged in the sustainability performance measurement. Some sustainability standards and guidelines, which are closely connected to industrial sustainability performance measurement, are highlighted below.

GRI Standards: They create a common framework for organizations and stakeholders through which the economic, environmental, and social impacts of organizations can be communicated and understood. More specifically, they are designed to improve global comparability and the quality of information about these impacts, thereby allowing organizations to be more transparent and accountable. The GRI standards are structured as a set of the following interrelated standards (GRI, 2016):

- GRI 101 – Foundation
- GRI 102 – General disclosures
- GRI 103 – Management approach
- GRI 200 – Economic aspects of sustainability
- GRI 300 – Environmental aspects of sustainability
- GRI 400 – Social aspects of sustainability
- G4 – Sustainability reporting guidelines

ISO 26000 - Social Responsibility: It provides guidance to help organizations effectively assess and address social responsibilities relevant to their stakeholders and overall performance. The following are the core subjects of ISO 26000 for addressing social responsibility (ISO, 2010):

- Organizational governance
- Human rights
- Labor practices
- The environment
- Fair operating practices

- Consumer issues
- Community involvement and development

ISO 14031 - Environmental Performance Evaluation: It enables organizations to measure, evaluate and communicate their environmental performance using key performance indicators. It provides guidance for evaluating the environmental performance of an organization according to the PDCA cycle (ISO, 2021).

OECD Sustainable Manufacturing Toolkit: It provides a toolkit that includes a set of indicators helping business organizations measure their environmental performance at the plant or facility level. It defined the following seven steps to put the toolkit into practice (OECD, 2011):

1. Map your impact and set priorities
2. Select useful performance indicators
3. Measure the inputs used in production
4. Assess operations of your facility
5. Evaluate your products
6. Understand measured results
7. Take action to improve performance

NIST-Sustainable Manufacturing Indicators Repository: It provides an organized set of indicators used to measure the sustainability performance of manufacturing companies. The indicators are based on the following aspects of sustainability (Joung et al., 2013):

- Environmental stewardship
- Economic growth
- Social well-being
- Technological advancement
- Performance management

LSCP Indicator Framework: It is an indicator-based framework to promote sustainable production. The framework has the following five levels, which represent the progression of an organization towards advancement in doing its operations sustainably (Samuel et al., 2013):

- Level 1 – Facility compliance/conformance indicators
- Level 2 – Facility material use and performance indicators
- Level 3 – Facility effect indicators
- Level 4 – Supply chain and product life cycle indicators
- Level 5 – Sustainable systems indicators

Sustainability Reporting Guideline and AFSS: It is based on the GRI sustainability reporting guideline and focuses on supplementary indicators for the apparel and footwear sector to report their sustainability performance (GRI, 2008).

The Higg Index - SAC: It is a group of tools for the assessment of environmental and social sustainability throughout the value chain of the apparel, textile and footwear industry. It consists of the following core set of five tools that assess the environmental and social sustainability performance of the value chain (SAC, 2021):

- Higg Facility Environmental Module (FEM)
- Higg Facility Social and Labor Module (FSLM)
- Higg Brand and Retail Module (BRM),
- Higg Materials Sustainability Index (MSI)
- Higg Product Module (PM)

Some key features (i.e., TBL of sustainability, context-tailored/industry-specific, and sustainability performance evaluation and interpretation guideline) that describe the aforementioned sustainability standards and guidelines are summarized in Table 1.

Table 1. Description of the sustainability standards and guidelines according to some key features

Sustainability standards and guidelines	**TBL of sustainability**	**Context-tailored**	**Sustainability performance evaluation and interpretation guideline**
GRI Standards	• It considers the TBL of sustainability	• It is not context-tailored (industry-specific)	• Did not provide a detailed guideline for evaluating and interpreting sustainability performance.

Sustainability standards and guidelines	TBL of sustainability	Context-tailored	Sustainability performance evaluation and interpretation guideline
ISO 26000 - Social Responsibility	• It focuses on the environmental and social sustainability dimensions	• It is not industry-specific	• Did not provide a detailed guideline for evaluating and interpreting sustainability performance.
ISO 14031- Environmental Performance Evaluation	• It addresses the environmental sustainability dimension	• It is not industry-specific	• It considers the evaluation of the environmental performance according to PDCA cycle.
OECD Sustainable Manufacturing Toolkit	• It focuses on the environmental sustainability dimension	• It is not industry-specific	• Did not provide a detailed guideline for evaluating and interpreting sustainability performance.
NIST-Sustainable Manufacturing Indicators Repository	• It is based on the TBL of sustainability	• It is not industry-specific	• Did not provide a detailed guideline for evaluating and interpreting sustainability performance.
LSCP Indicator Framework	• It addresses the environmental and social sustainability	• It is not industry-specific	• Did not provide a detailed guideline for evaluating and interpreting sustainability performance.
Sustainability Reporting Guidelines and AFSS	• It considers the TBL of sustainability	• It is industry-specific (considers the apparel and footwear sector), but not context-tailored from the perspective of firm size	• Did not provide a detailed guideline for evaluating and interpreting sustainability performance.
The Higg Index - SAQ	• It focuses on the environmental and social sustainability dimensions	• It is industry-specific (considers the apparel, textile and footwear sector), but not context-tailored from the perspective of firm size	• Did not provide a detailed guideline for evaluating and interpreting sustainability performance.

As can be seen in Table 1, most of the sustainability standards and guidelines were not context-tailored to provide suitable indicators and frameworks tailored to measure the sustainability performance of a specific industry. Moreover, they focused mainly on the measurement aspect of sustainability performance and mostly did not provide a detailed guideline for sustainability performance evaluation (i.e., comparing the actual sustainability performance with respect to a predefined sustainability target) and interpretation of the results (i.e., checking whether the performance is sustainable or needs improvement actions).

2.4 Sustainable development goals

The UN set 17 sustainable development goals[1] in 2015 to push forward the 2030 agenda of sustainable development, which is a plan of action for people, the planet, and prosperity (UN, 2015, 2018). The agenda for *people* considers ending poverty and hunger in all their forms and dimensions and ensuring that all human beings can realize their potential with dignity and equality and in a healthy environment. The agenda for the *planet* focuses on protecting the planet from degradation, including through sustainable consumption and production, sustainable management of its natural resources, and taking action on climate change. Moreover, the agenda for *prosperity* includes ensuring that all human beings can enjoy prosperous and fulfilling lives and that economic, social, and technological progress occurs in harmony with nature.

Goal 1 – No Poverty: End poverty in all its forms everywhere.
Goal 2 – Zero Hunger: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
Goal 3 – Good Health and Well-being: Ensure healthy lives and promote well-being for all at all ages.
Goal 4 – Quality Education: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
Goal 5 – Gender Equality: Achieve gender equality and empower all women and girls.
Goal 6 – Clean Water and Sanitation: Ensure availability and sustainable management of water and sanitation for all.

[1] More information regarding the SDGs can be found in https://sdgs.un.org/goals

Goal 7 – Affordable and Clean Energy: Ensure access to affordable, reliable, sustainable and modern energy for all.

Goal 8 – Decent Work and Economic Growth: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Goal 9 – Industry, Innovation and Infrastructure: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

Goal 10 – Reducing Inequality: Reduce inequality within and among countries.

Goal 11 – Sustainable Cities and Communities: Make cities and human settlements inclusive, safe, resilient, and sustainable.

Goal 12 – Responsible Consumption and Production: Ensure sustainable consumption and production patterns.

Goal 13 – Climate Action: Take urgent action to combat climate change and its impacts.

Goal 14 – Life below Water: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

Goal 15 – Life on Land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Goal 16 – Peace, Justice, and Strong Institutions: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels.

Goal 17 – Partnerships for the Goals: Strengthen the means of implementation and revitalize the global partnership for sustainable development.

After UN set the 17 SDGs, the need to report on organizations' contribution to and impact on the SDGs has been advocated by the sustainability society and stakeholders (Moldavska and Welo, 2019). In response to this need, manufacturing companies need to assess their contribution to and impact on achieving the SDGs. Measuring sustainability performance using suitable indicators and frameworks can assist manufacturing companies in evaluating their contribution towards achieving the SDGs (Beekaroo et al., 2019). Furthermore, the adoption of sustainable manufacturing practices is in line with the implementation of the 2030 agenda of sustainable development, which is based on the SDGs (Muhardi et al., 2020).

2.5 Sustainability in the footwear industry

In the era of sustainability, consideration of environmental and social issues in the footwear sector is critical (Ciasullo et al., 2017) since it has significant economic, environmental, and social implications. Sustainability is a relevant topic in the footwear sector mainly for the following reasons: the short and seasonal product lifecycle, the high volatility and low predictability of products, the high purchasing impulse, and the complexity of consumer behavior and preference that affects factors such as quality, price, and attitude towards sustainability (Ciasullo et al., 2017). All these reasons are pushing the footwear industry towards more responsible and sustainable manufacturing practices, which go beyond the management of internal processes to fulfill the requirements of stakeholders (Ciasullo et al., 2018). Moreover, the footwear industry uses a lot of materials that are critical for environmental sustainability, and it is a labor-intensive sector with all the issues associated with social sustainability.

The footwear industry is characterized by many SMEs. In particular, the European footwear industry comprises of tens of thousands of SMEs, employing on average 10-15 employees (Ciasullo et al., 2017; EC, 2012). The production of the European footwear industry is mainly concentrated in Italy, which is responsible for around 50% of the total production (Ciasullo et al., 2017). SMEs often encounter challenges in responding to the issues of sustainability (Karaosman et al., 2020). In addition, the conscious level of customers and stakeholders on footwear sustainability has been increasing. Consequently, the footwear industry needs to consider the environmental and social sustainability issues to stay relevant in today's competitive business environment (Moktadir et al., 2018).

The footwear sector plays a considerable role in the development of a country by generating income and creating job opportunities (Bezerra et al., 2021). Hence, the sector needs to consider the issues of sustainability in its day-to-day business activities to sustain its role in driving the economic growth and social development of the country (e.g., Italy). The use of recycled waste materials and eco-friendly and biodegradable materials are some of the sustainability practices applied in the footwear sector, especially in large footwear companies. However, research is still needed in the footwear sector (in particular SMEs) regarding the sustainability performance measurement based on the TBL.

2.6 Gaps identified in the literature

The gaps identified in the literature are linked to the need for a comprehensive approach based on TBL, context-tailored indicators and a comprehensive framework to apply the indicators in SMEs. The gaps identified in the literature are described as follows:

- ***Need for a comprehensive approach based on the triple bottom line (gap 1)***: The triple bottom line (TBL) provides a comprehensive approach for measuring the sustainability performance of manufacturing companies (Ahmad and Wong, 2019) to adequately address industrial sustainability performance (Cagno et al., 2019). The TBL approach consists of three interconnected dimensions of sustainability, namely economic, environmental and social (Elkington, 1997). Manufacturing companies have a significant impact on the three dimensions of sustainability (Ahmad, Wong, and Zaman, 2019; Ghadimi et al., 2012). Hence, they should simultaneously consider economic, environmental, and social sustainability dimensions while producing their products and services (Watanabe et al., 2016; Lacasa et al., 2016; Eastwood and Haapala, 2015; Haapala et al., 2013). Even though SMEs have significant economic, environmental, and social implications, they still struggle to measure and manage their the environmental and social sustainability dimensions (Mitchell et al., 2020; Journeault et al., 2021) and focus primarily on the economic dimension (Trianni et al., 2019; Choi and Lee, 2017). This is because of limited resources (Trianni et al., 2019; Journeault et al., 2021; Hsu C.H. et al., 2017; Singh S. et al., 2014; Winroth et al., 2016), lack of awareness of the impacts and benefits of adopting sustainability practices (Journeault et al., 2021; Singh S. et al., 2014), and lack of skills and expertise to execute sustainability practices (Trianni et al., 2019; Journeault et al., 2021; Singh S. et al., 2014). Furthermore, there is a lack of research on sustainability performance measurement based on the TBL approach in the case of the footwear industry. Previous research on the footwear industry is limited and primarily addresses the environmental dimension (Deselnicu et al., 2014; Subic et al., 2013).
- ***Need for context-tailored indicators (gap 2)***: In order to effectively measure and manage industrial sustainability performance, there is a need for suitable indicators tailored to the different contexts of manufacturing industry (Singh S. et al., 2014; Winroth et al., 2016). Contextual factors like industry type, firm size, and geographical area affect the use of

indicators for measuring industrial sustainability performance (Cagno et al., 2019; Trianni et al., 2019). As SMEs have limited resources, they need to use a manageable number of indicators that are simple and easy to apply (Veleva and Ellenbecker, 2001). However, the lack of suitable indicators tailored to the needs of manufacturing firms, specifically SMEs, has been the major challenge in measuring industrial sustainability performance (Ahmad and Wong, 2019; Ocampo et al., 2016). The Italian footwear sector has significant economic, environmental and social implications for addressing the issues of sustainability. However, the lack of suitable indicators tailored to its needs (more specifically tailored to SMEs' needs) has been one of the major challenges in measuring and managing their sustainability performance.

- ***Need for a comprehensive framework suitable for applying the indicators (gap 3)***: A framework for putting the indicators into practice in a comprehensive manner in the context of SMEs is crucial. There is a need for measuring, evaluating and interpreting the sustainability performance of manufacturing companies to continuously improve their sustainability performance against predefined sustainability targets. Previous research and sustainability standards and guidelines focused primarily on the measurement aspect of industrial sustainability performance. They mostly did not provide a guideline for sustainability performance evaluation (i.e., comparing the actual sustainability performance with the predefined sustainability targets) and interpretation of the results (i.e., checking whether the performance is sustainable or needs improvement actions).

Chapter Three

3 Research methodology

3.1 Overall methodological approach

To address the formulated research questions, the methodological approach shown in Figure 2 was applied. To address RQ1, *First*, a systematic review was carried out (Ahi and Searcy, 2015; Ahmad, Wong, and Rajoo, 2019; Feil et al., 2019) to explore the indicators described in peer-reviewed articles that are relevant to the sustainability performance measurement of manufacturing companies. A content analysis was conducted to analyze and identify the potential sustainability indicators (Ahi and Searcy, 2015; Ahmad, Wong, and Rajoo, 2019). *Second*, based on the identified potential sustainability indicators, a questionnaire was developed. Subsequently, it was pre-tested (i.e., pilot-tested) with selected industry experts, scholars, and researchers (Forza, 2002; Padilla-Rivera et al., 2021). *Third*, data (i.e., empirical evidence on the suitability of the indicators) were collected from the footwear firms in Italy. *Fourth*, the collected data were analyzed by applying the fuzzy Delphi method (FDM) to select and prioritize the indicators (Mengistu and Panizzolo, 2022b). *Finally*, an indicator-based framework was developed to address RQ2 (i.e., to put the selected indicators into practice). The framework includes a number of specific metrics; a structured questionnaire was used to collect experts' opinions (empirical evidence) from the selected footwear firms for checking the applicability of the considered metrics.

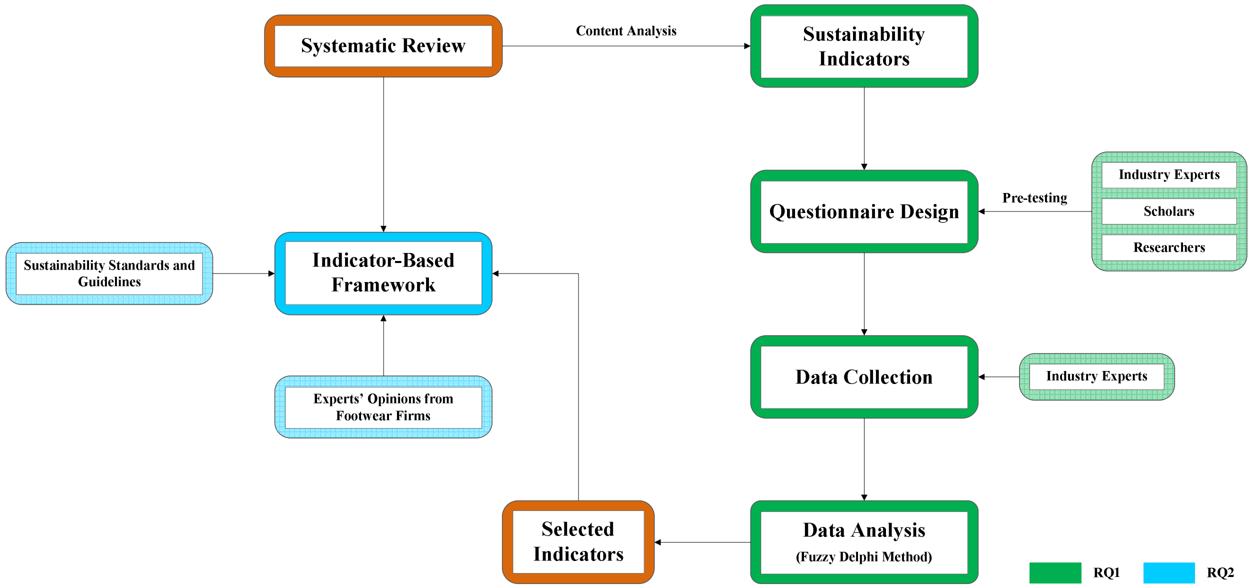

Figure 2. Methodological approach used to conduct the research

3.2 Systematic review

A systematic review of the literature related to the sustainable performance measurement of manufacturing companies was carried out. For this purpose, academic papers were searched in Scopus and WoS databases using two sets of keywords that are linked to the topic of the present research by adapting the approach used by Ahi and Searcy (2015). The keywords used for searching are "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 (Mengistu and Panizzolo, 2021). By the applying the approach shown in Figure 3, a total of 1456 papers were initially obtained using the keywords search in Scopus and WoS published until 2020. Considering the list of 919 peer-reviewed articles, a total of 598 papers reviews, conference papers, book chapters, and other document types were excluded. Out of the 919 articles, 329 were duplicated. In addition, 10 full-text articles were not accessible in the online search, and 1 article was not written in English. In the reading of the abstracts, 463 papers that did not focus on measuring, evaluating, or assessing the sustainability performance of manufacturing industries and did not use a comprehensive approach, such as the TBL of sustainability, were excluded after examining the purpose, methodology and/or scope of the paper. Following the full-text papers reading, 57 papers that did not consider indicator-based sustainability performance assessment of manufacturing companies and/or did not use indicators relevant to the purpose of this research were excluded after analyzing the detailed contents (i.e. methodology, results/findings, discussion and conclusions) of the paper. Finally, 59 papers were selected to explore and analyze the indicators.

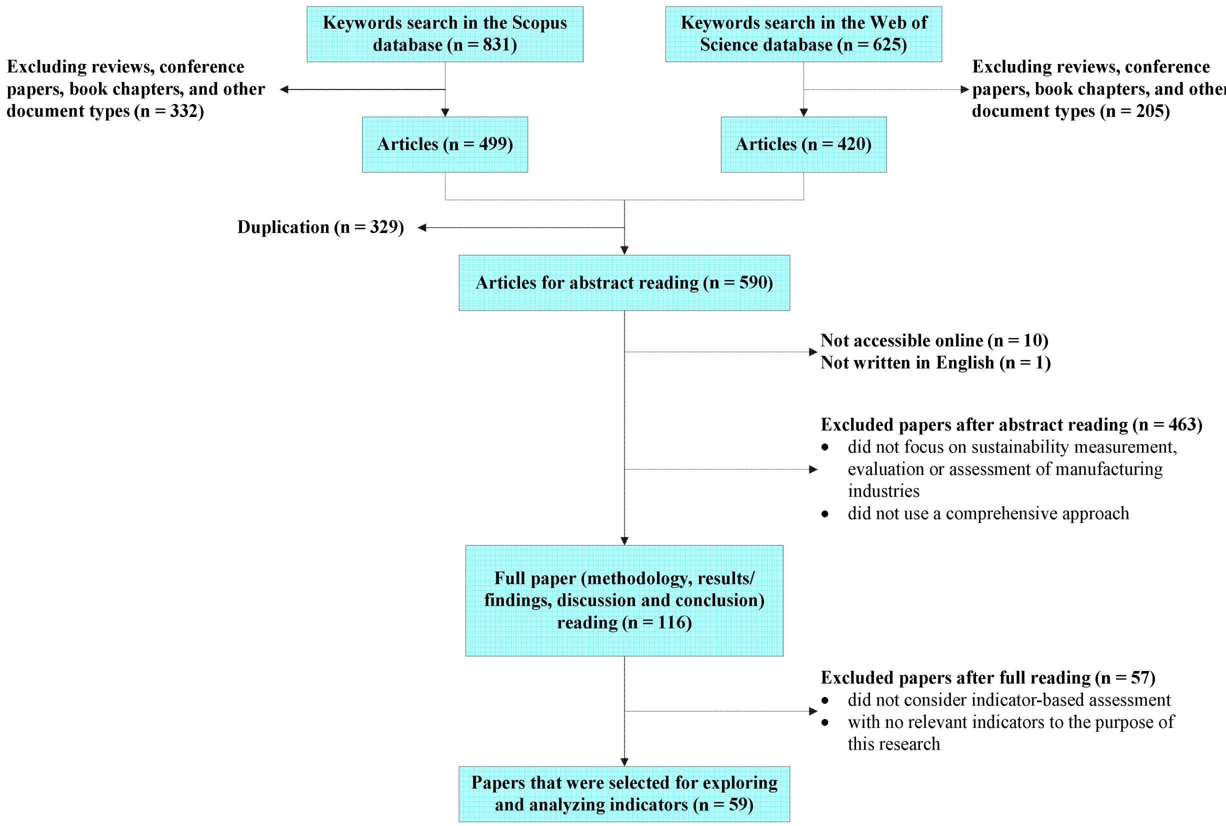

Figure 3. Approach used for screening and selecting papers

Then, a content analysis was conducted to analyze and identify the potential sustainability indicators from the selected papers. In the content analysis, all indicators described in the papers were recorded in Microsoft Excel. Afterward, the identified indicators were coded into either economic, environmental, or social dimensions of sustainability based on their concept, context, and purpose. Eventually, a frequency count was carried out to determine how many times (i.e., by how many papers) each indicator was used. In the frequency count, word-by-word and phrase-by-phrase analyses were performed to determine the indicators' consistency and frequency of use. Indicators considered to be essentially the same were counted together. In contrast, indicators that were different were considered to be unique indicators (Ahi and Searcy, 2015; Ahmad, Wong, and Rajoo, 2019).

3.3 Questionnaire design and pre-testing

Based on the identified indicators from the reviewed literature, a questionnaire was developed to collect empirical evidence from footwear firms on the suitability of the indicators. Then, pre-testing (pilot testing) of the questionnaire was conducted with selected industry experts, scholars, and researchers (Forza, 2002; Padilla-Rivera et al., 2021). The purpose of the pre-test was to check clarity (clarity of language, context, and content), time (to complete the questionnaire in a few minutes if possible), level of redundancy (possibility of redundant questions) and relevance (link to the objective of the research and the appropriateness of the identified indicators) (Mengistu and Panizzolo, 2021). In addition, the feedback of the pre-testing was used to modify, add, and delete indicators in order to improve the questionnaire and increase its convergence (Padilla-Rivera et al., 2021).

3.4 Data collection

For the empirical analysis of RQ1 (i.e., for empirically selecting and prioritizing the indicators), data were collected from Italian footwear firms using the questionnaire developed (see Appendix A). Furthermore, data were collected from the selected footwear firms for the empirical analysis of RQ2 (mainly to check the applicability of the metrics in practice) using a structured questionnaire (see Appendix B).

In the case of the FDM that has been applied for selecting and prioritizing the indicators, a small survey sample can be sufficient to obtain objective and reasonable results (Tahriri et al., 2014). Research trends also show that the use of small sample sizes for FDM applications is acceptable. Padilla-Rivera et al. (2021) applied the FDM by gathering opinions from 45 experts to select the social indicators for assessing the impacts of circular economy strategies. Lin et al. (2019) analyzed the importance levels of the ergonomics-based factors defined for evaluating product sustainability by involving 35 experts in their FDM application. Zhang (2017) collected opinions from 5 experts to apply the FDM for evaluating the low-carbon tourism strategies in Chengguan District-China using the evaluation indicators based on the TBL approach. Liu and Ho (2016) used 28 experts for their FDM application to assess the key factors affecting the application and promotion of small wind energy systems in Taiwan by defining twenty-four criteria in eight major objectives.

There are no standards or guidelines for an appropriate sample size for the Delphi method. However, the general rule-of-thumb is to have a sample size of 15 to 30 for a homogeneous population (i.e., experts from the same profession) and 5 to 10 for a heterogeneous population (i.e., experts from the different profession) (Clayton, 1997). In the present research, to get the required sample size, the questionnaire was randomly distributed via email and LinkedIn to the footwear firms in Italy. A total of 53 responses were collected, and of these, 5 responses were excluded for various reasons, such as missing data or coming were from large firms. Subsequently, the data analysis was performed based on valid responses from 48 Italian footwear SMEs. The data collection focused on industry experts of footwear firms so as to get empirical evidence from the direct users of the final selected indicators and increase the reliability of the results. Table 2 summarizes the position and work experience of the experts.

Table 2. Profile of the experts by participation frequency

Variable	**Position**	**Frequency (#)**	**Percentage (%)**
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%
	Less than 5 years	4	9%

As shown in Table 2, Chief Executive Officer/General Manager represents the highest percentage (44%) of the industrial experts. In addition, most of the industry experts (49%) have over 20 years of work experience.

A reliability analysis was performed to check for the consistency or repeatability of the questionnaire items (i.e., the indicators). The internal consistency method was applied to check the reliability (Carmines and Zeller, 1979). Cronbach's alpha, which is the most common internal consistency test (Forza, 2002), was used to evaluate the reliability of the collected data. The IBM SPSS software (Version 26) was used to calculate Cronbach's alpha (α). The value of α was 0.710

for the economic sustainability indicators, 0.936 for the environmental sustainability indicators, and 0.854 for the social sustainability indicators, which are higher than the minimum acceptable value (0.7) (Nunnally, 1978).

3.5 Data analysis

To address RQ1 (i.e., to select and prioritize indicators for measuring sustainability performance in Italian footwear SMEs), the fuzzy Delphi method (FDM) was applied. The FDM combines the traditional Delphi method with the fuzzy theory to address the drawbacks of the former (Tsai et al., 2020), by solving the vagueness and ambiguity of expert judgments in the traditional Delphi method to improve efficiency and quality (Lee C.-H. et al., 2018; Padilla-Rivera et al., 2021). In the FDM, the linguistic variables (qualitative) are converted into fuzzy membership functions (quantitative) for the analysis of the indicators (Tsai et al., 2020). The triangular fuzzy number, trapezoidal fuzzy number, and Gaussian fuzzy number are the membership functions that have been used by previous research (Hsu Y.-L. et al., 2010). In the present research, the triangular fuzzy number was applied as a fuzzy membership function (Hsu Y.-L. et al., 2010; Zhang, 2017). The FDM, as applied in this research, avoided the drawbacks of the traditional Delphi method. These include low convergence of experts' opinions (Ma et al., 2011) and 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 carried out using the traditional Delphi method (Zhang, 2017). In this research's use of the FDM, all the experts' opinions obtained in one round of survey are incorporated (Kuo and Chen, 2008; Ma et al., 2011) to consider the uncertainty and ambiguity of experts (Zhang, 2017) to achieve a consensus (Kuo and Chen, 2008). In doing so, this method is considered to be robust (Padilla-Rivera et al., 2021) and creates a better effect of data analysis (Ma et al., 2011); and the results obtained are objective and rational (Zhang, 2017). More specifically, the consistency aggregation method was applied to aggregate the fuzzy individual expert's opinions into a group consensus opinion for each indicator (Lin et al., 2019; Lu et al., 2006; Mengistu and Panizzolo, 2022b). In the consistency aggregation method, unlike the traditional Delphi method, both the similarity and difference between each pairs of experts' opinions were considered in order not to lose information and make an inadequate decision on the indicator. Figure 4 presents the steps for applying the FDM.

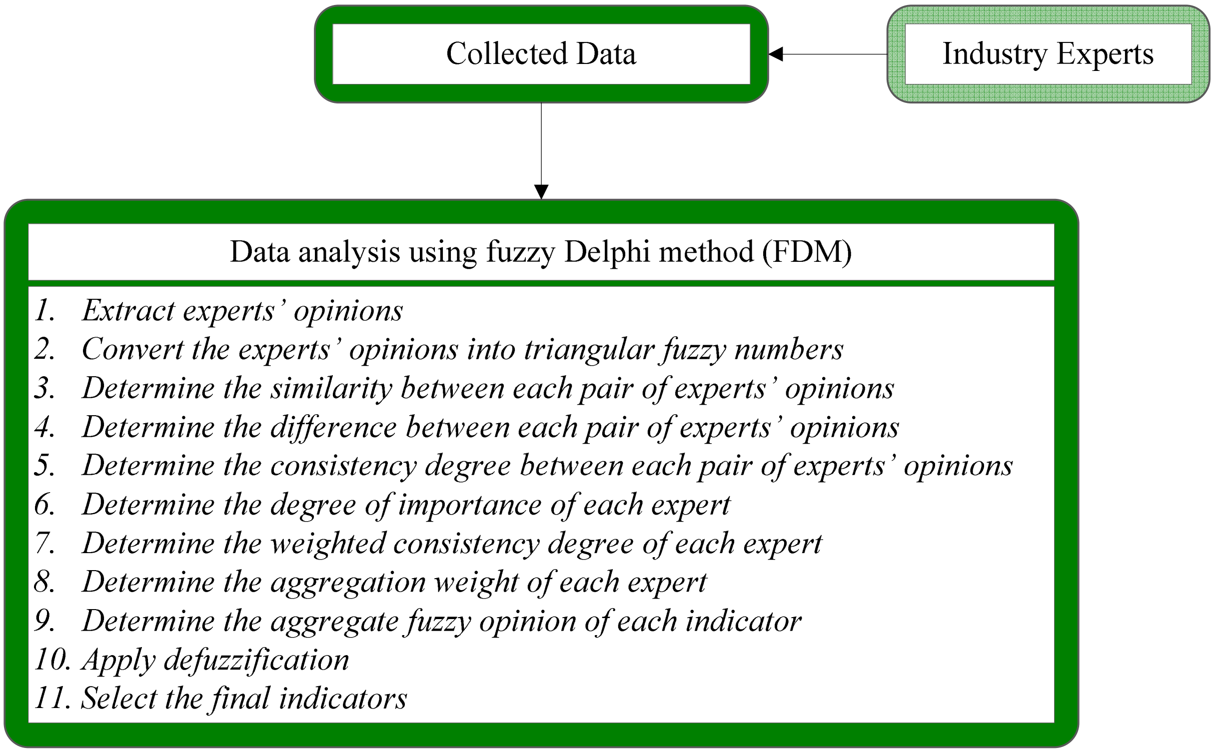

Figure 4. Steps for applying the FDM

1. *Extract experts' opinions:* The assessment scores given by each expert for each indicator were collected and organized from the returned questionnaire.
2. *Convert the experts' opinions into triangular fuzzy numbers:* The linguistic variables used to assess the indicators were translated into their respective triangular fuzzy numbers (Zhang, 2017), as shown in Table 3. The linguistic variables were used to describe an expert's opinions on the importance (i.e., usefulness and applicability) of the indicator.

Table 3. Linguistic variables with their corresponding fuzzy scales and triangular fuzzy numbers

Linguistic variables	**Fuzzy scales**	**Triangular fuzzy numbers (*a,b,c*)**
Not important (NI)	1	(1,1,3)
Slightly important (SI)	4	(1,3,5)
Moderately important (MI)	5	(3,5,7)
Important (I)	7	(5,7,9)
Very important (VI)	9	(7,9,9)

For the analysis, the triangular fuzzy numbers is denoted as $EPi = (ai, bi, ci)$, for $i = 1, 2, \ldots, n$, which represents the expert opinion of the i^{th} expert in the form of minimum (a), optimum (b) and maximum (c) values, and n is the total number of experts.

3. *Determine the similarity (S) between each pair of experts' opinions*: The degree of similarity between each pair of experts' opinions is calculated as proportion of the intersection area (IntsArea) between each pair of experts' opinions in relation to the union area between each pair of experts' opinions (*EPi = (ai, bi, ci), EPj = (aj, bj, cj)*) as follows, which is shown in Figure 5:

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

For the same experts' opinions *S(EPi, EPj) = 1*, and if *IntsArea(EPi,EPj)* = 0, *S(EPi, EPj)* = 0. *S(EPi, EPj) = S(EPj, EPi)* (i.e., $S(EP_1, EP_2) = S(EP_2, EP_1)$).

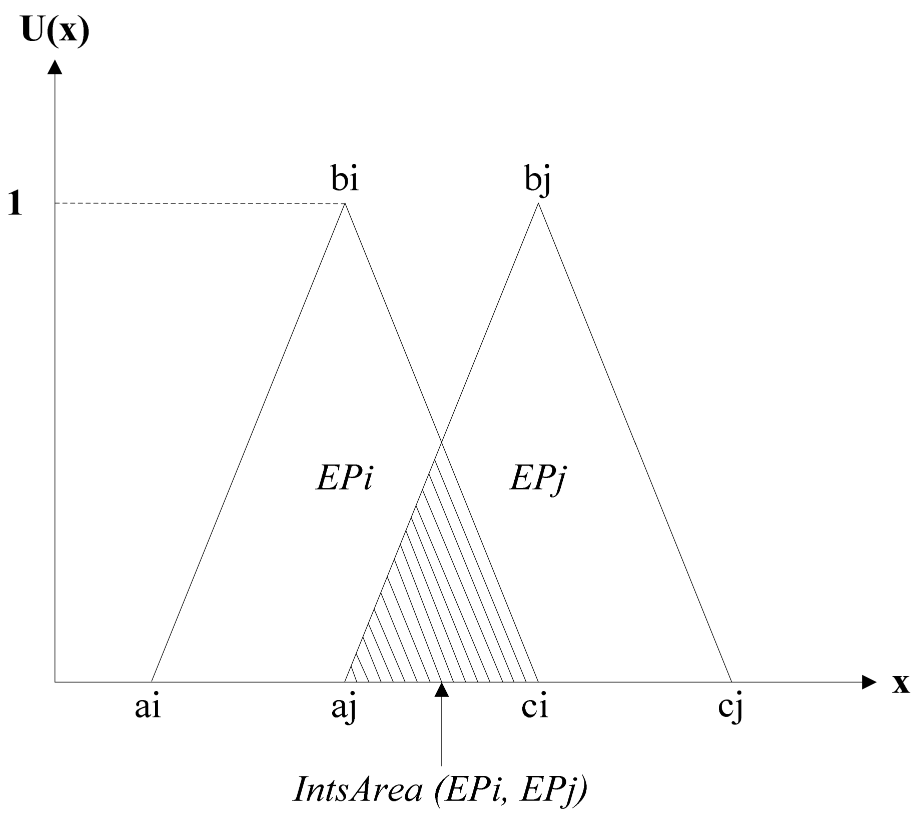

Figure 5. Representing a pair of experts' opinions

4. *Determine the difference (D) between each pair of experts' opinions*: In this step, the distance (difference) between each pair of experts' opinions (*EPi = (ai, bi, ci), EPj = (aj, bj, cj)*), as seen in Figure 5, was calculated by applying the following formula:

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

If there is no difference between experts' opinions, *D(EPi, EPj)* was taken as 0.

For the subsequent analysis, the absolute distance (D) was converted into the normalized distance (ND) as follows:

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

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

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

In this research, considering equal importance for the similarity and difference among the experts, the value of β was taken as 0.5 (Lin et al., 2019).

6. *Determine the degree of importance (e) for each expert*: The degree of importance of each expert (*ei*) was determined based on their years of work experience (Lin et al., 2019). For this purpose, values ranging from 1 to 5 was assigned to the work experience categories defined in the questionnaire to describe the importance of the experts. Accordingly, 5 was assigned for experts that have over 20 years of work experience, 4 for 15 to 20 years, 3 for 10 to 15 years, 2 for 5 to 10 years, and 1 for less than 5 years. The degree of importance of each expert was obtained by calculating the relative importance of each expert. Table 4 summarizes the degree of importance (relative importance) of each expert (*ei)*.

Table 4. Degrees of importance of the experts

Expert	Value assigned	Degree of importance	Expert	Value assigned	Degree of importance
E1	5	0.0276	E25	3	0.0166
E2	2	0.011	E26	5	0.0276
E3	5	0.0276	E27	5	0.0276
E4	5	0.0276	E28	4	0.0221
E5	4	0.0221	E29	3	0.0166
E6	5	0.0276	E30	4	0.0221

Expert	Value assigned	Degree of importance	Expert	Value assigned	Degree of importance
E7	5	0.0276	E31	2	0.011
E8	5	0.0276	E32	2	0.011
E9	5	0.0276	E33	1	0.0055
E10	4	0.0221	E34	1	0.0055
E11	2	0.011	E35	5	0.0276
E12	5	0.0276	E36	3	0.0166
E13	5	0.0276	E37	3	0.0166
E14	2	0.011	E38	5	0.0276
E15	3	0.0166	E39	5	0.0276
E16	5	0.0276	E40	1	0.0055
E17	3	0.0166	E41	1	0.0055
E18	5	0.0276	E42	3	0.0166
E19	2	0.011	E43	4	0.0221
E20	5	0.0276	E44	5	0.0276
E21	3	0.0166	E45	5	0.0276
E22	3	0.0166	E46	5	0.0276
E23	5	0.0276	E47	5	0.0276
E24	5	0.0276	E48	3	0.0166

7. *Determine the weighted consistency degree (C) of each expert*: For *i = 1, 2,…, n*, the weighted consistency degree of each expert (*C(Ei)*) was calculated using the following formula:

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

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

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

9. *Determine the aggregate fuzzy opinion (R) for each indicator (k)*: The aggregate fuzzy opinion (*Rk*) was calculated by applying the following formula:

$$Rk = \sum_{k=1}^{N} w(Ei)(.)EPi \quad (7)$$

Expanding the dot product:

$$R_k = [(w(E_1)*a_1 + w(E_2)*a_2 + \ldots + w(E_n)*a_n), (w(E_1)*b_1 + w(E_2)* b_2 + \ldots + w(E_n)*b_n), (w(E_1)*c_1 + w(E_2)*c_2 + \ldots + w(E_n)*c_n)] \quad (8)$$

$R_k = (a_k, b_k, c_k)$, *for* $k = 1, 2, \ldots, N$, where N is number of indicators.

10. *Apply defuzzification to determine the defuzzified score of each indicator* (S_k)*:* The center of gravity method was applied to defuzzify the aggregate fuzzy opinion of each indicator as follows:

$$Sk = \frac{ak + bk + ck}{3} \quad (9)$$

11. *Select the final indicators*: The final sustainability indicators were selected by setting a threshold value (T) for comparison. Accordingly, if $S_k \geq T$, the indicator is selected and if $S_k < T$, the indicator is not selected.

Setting a threshold value depends on the fuzzy linguistic scale and user preference (Padilla-Rivera et al., 2021; Zhang, 2017). If the users need more indicators, they can take a small threshold value and vice versa (Zhang, 2017). In this research, a threshold value of 6.2 was taken for a 9-fuzzy linguistic scale to select the final indicators. Therefore, the T value taken as 6.2 can be considered as a representative of the fuzzy experts' opinions.

3.6 Indicator-based framework development

Finally, as shown in Figure 6, after analyzing the frameworks used by previous research and sustainability standards and guidelines, an indicator-based framework was developed to address RQ2 (i.e., for applying the selected indicators in SMEs). Furthermore, to support the framework with empirical evidence (mainly the metrics, which are the crucial aspects of the framework), a structured questionnaire (see Appendix B) was used to collect data (experts' opinions) on the applicability of the metrics from the selected footwear firms (SMEs).

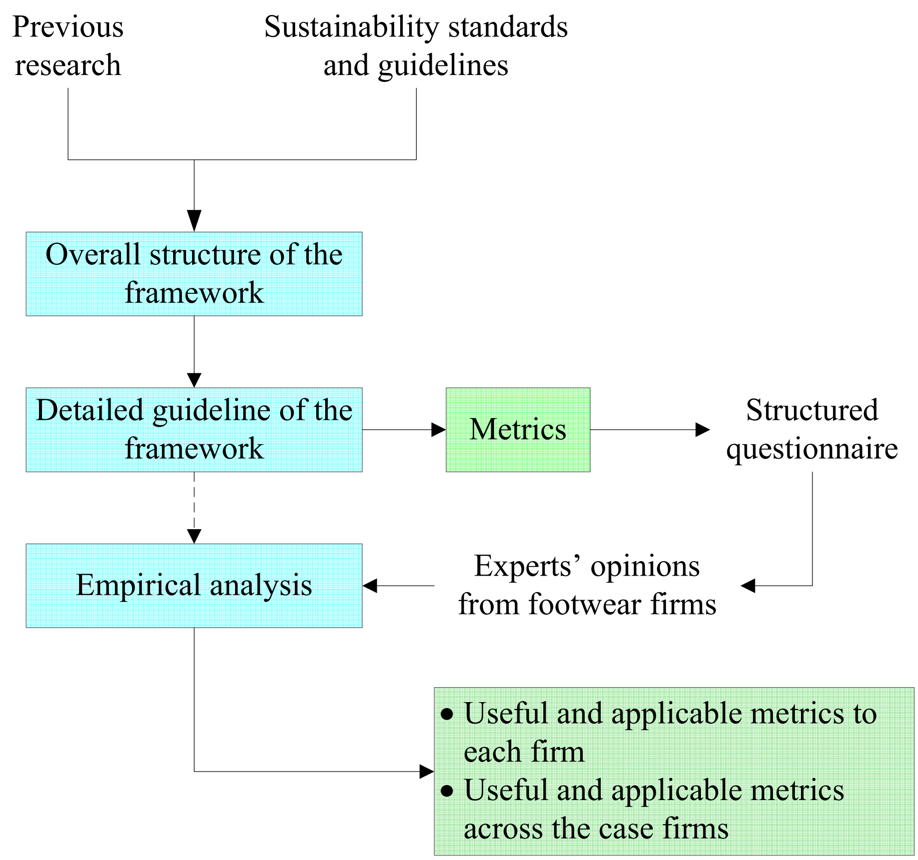

Figure 6. Approach used to develop the framework

Chapter Four

4 Indicators for measuring sustainability performance in SMEs

4.1 Indicators identified in the literature

Identifying the indicators in the literature is the initial step to address RQ1. In the reviewed literature, a total number of 1013 indicators (277 for the economic, 402 for the environmental, and 334 for the social sustainability dimensions) were identified. Table 5 presents the total number of indicators identified from the literature according to their frequency of use (i.e., by how many papers they were used in) after conducting a content analysis (Ahi and Searcy, 2015; Ahmad, Wong, and Rajoo, 2019).

Table 5. The indicators identified according to their frequency of use

Frequency of use	Identified indicators (#)
1	860
2	58
3	35
4	16
5	13
6	10
7	6
8	1
9	1
10	1
11	4
12	1
13	1
14	2
17	1
18	1
26	1
27	1
Total	**1013**

As seen in Table 5, the majority of indicators (860 out of 1013) appeared only once in the reviewed literature (i.e., they were not used by more than paper). The availability of this wide range of indicators could be due to the lack of consensus regarding how sustainability performance should be measured in manufacturing companies (Ahi and Searcy, 2015; Ahmad, Wong, and Rajoo, 2019). The differences in the manufacturing companies' contexts also affect the use of indicators for measuring sustainability performance (Cagno et al., 2019; Trianni et al., 2019). Moreover, a lack of consensus regarding the definition of sustainability in the manufacturing industry context, the research purpose, and the methodological approach differences of the authors can contribute to a wide range of indicators. On the other hand, few indicators have been consistently and frequently used for measuring industrial sustainability performance in the reviewed literature.

4.2 Consistently and frequently used indicators

The content analysis results show that 44 indicators (14 for the economic, 18 for the environmental, and 12 for the social sustainability dimensions) were used at least five times (i.e., by at least five papers) in the reviewed literature. The consistently[2] and frequently[3] used indicator for the environmental, economic, and social sustainability dimensions are presented in Tables 6, 7, and 8, respectively. In addition, the following are the list of papers from which the consistently and frequently used indicators were explored:

1-Abedini et al. (2020)
2-Agrawal and Vinodh (2020)
3-Ahmad and Wong (2019)
4-Ahmad, Wong, and Rajoo (2019)
5-Ahmad, Wong, and Zaman (2019)
6-Beekaroo et al. (2019)
7-Cagno et al. (2019)
8-Singh R.K. et al. (2019)
27-Pires et al. (2016)
28-Vinodh et al. (2016)
29-Watanabe et al. (2016)
30-Winroth et al. (2016)
31-Eastwood and Haapala (2015)
32-Feil et al. (2015)
33-Galal and Moneim (2015)
34-Harik et al. (2015)

[2] Consistency of indicators refers to the frequent use of indicators in the reviewed literature over a period of time (e.g., the past 20 years). Also, it refers to the applicability of indicators in various industry contexts.
[3] Frequency of indicators refers to the frequent use of indicators in the reviewed literature regardless time and industry contexts.

9-Song and Moon (2019)
10-Trianni et al. (2019)
11-Vitale et al. (2019)
12-Wu et al. (2019)
13-Zarte et al. (2019)
14-Demartini et al. (2018)
15-Huang and Badurdeen (2018)
16-Moldavska and Welo (2018)
17-Raj and Srivastava (2018)
18-Singh S. et al. (2018)
19-Wang et al. (2018)
20-Elhuni and Ahmad (2017)
21-Hasan et al. (2017)
22-Huang and Badurdeen (2017)
23-Hsu C.H. et al. (2017)
24-Bork et al. (2016)
25-Lacasa et al. (2016)
26-Ocampo et al. (2016)
35-Jakhar (2015)
36-Medini et al. (2015)
37-Lee J.Y. et al. (2014)
38-Shuaib et al. (2014)
39-Singh S. et al. (2014)
40-Haapala et al. (2013)
41-Linke et al. (2013)
42-Joung et al. (2013)
43-Samuel et al. (2013)
44-Tseng (2013)
45-De Araujo and De Oliveira (2012)
46-Ghadimi et al. (2012)
47-Li et al. (2012)
48-Traverso et al. (2012)
49-Jayal et al. (2010)
50-Yakovleva and Flynn (2004)
51-Veleva and Ellenbecker (2001)

Table 6. Frequently used economic sustainability indicators in the reviewed literature

Indicators for economic dimension	Frequency of use	Authors
Profit	14	3, 4, 5, 7, 11, 17, 21, 26, 32, 33, 36, 39, 42, 50
R&D expenditure	14	3, 4, 5, 6, 7, 11, 17, 19, 22, 26, 34, 36, 38, 47
Product quality	13	2, 7, 10, 12, 14, 16, 17, 18, 21, 23, 24, 35, 39
Revenue	12	3, 4, 5, 9, 7, 11, 17, 20, 22, 26, 47, 48
Material cost	11	2, 3, 4, 5, 8, 15, 22, 29, 38, 46, 49
Labor cost	11	1, 3, 4, 5, 8, 7, 22, 29, 38, 40, 49

Indicators for economic dimension	Frequency of use	Authors
Energy cost	8	1, 2, 15, 22, 29, 38, 40, 49
Operating/Operational cost	7	4, 7, 21, 31, 32, 38, 46
Maintenance cost	6	4, 5, 7, 15, 40, 49
Production cost	6	1, 7, 26, 36, 42, 49
Packaging cost	6	3, 4, 5, 15, 46, 49
Lead time	6	7, 10, 15, 28, 30, 36
Inventory cost	5	1, 7, 8, 22, 46
On-time delivery	5	8, 17, 20, 22, 20

Table 6 presents the most consistently and frequently used indicators in the literature for measuring economic sustainability performance. These indicators placed more emphasis on measuring progress in obtaining high financial benefits, which include *profit* (Ahmad and Wong, 2019; Cagno et al., 2019; Vitale et al., 2019) and *revenue* (Ahmad and Wong, 2019; Cagno et al., 2019; Song and Moon, 2019) from business activities; allocating reasonable *expenditure to R&D activities* (Ahmad and Wong, 2019; Beekaroo et al., 2019; Cagno et al., 2019); reducing costs such as *material* (Agrawal and Vinodh, 2020; Ahmad and Wong, 2019; Singh R.K. et al., 2019), *labor* (Abedini et al., 2020; Ahmad and Wong, 2019; Singh R.K. et al., 2019), *energy* (Abedini et al., 2020; Agrawal and Vinodh, 2020; Huang and Badurdeen, 2018), *operating/operational* (Ahmad, Wong, and Rajoo, 2019; Cagno et al., 2019; Hasan et al., 2017), *maintenance* (Ahmad, Wong, and Rajoo, 2019; Cagno et al., 2019; Huang and Badurdeen, 2018), *production* (Abedini et al., 2020; Cagno et al., 2019; Ocampo et al., 2016), *packaging* (Ahmad and Wong, 2019; Ghadimi et al., 2012; Huang and Badurdeen, 2018) and *inventory* (Abedini et al., 2020; Cagno et al., 2019; Singh R.K. et al., 2019) costs; improving *product quality* (Agrawal and Vinodh, 2020; Cagno et al., 2019; Wu et al., 2019); and adequately managing *lead tim*e (Cagno et al., 2019; Huang and Badurdeen, 2018; Trianni et al., 2019) and *delivery time* (Hsu C.H. et al., 2017; Raj and Srivastava, 2018; Singh R.K. et al., 2019).

Table 7. Frequently used environmental sustainability indicators in the reviewed literature

Indicators for environmental dimension	Frequency of use	Authors
Water consumption	27	3, 4, 5, 7, 11, 14, 15, 17, 20, 21, 22, 24, 26, 29, 31, 32, 34, 37, 38,

Indicators for environmental dimension	Frequency of use	Authors
		40, 42, 43, 44, 45, 47, 50, 51
Energy consumption	26	1, 2, 4, 7, 8, 9, 13, 14, 15, 17, 21, 26, 28, 29, 30, 31, 35, 37, 40, 42, 44, 47, 48, 49, 50, 51
GHG emissions	18	1, 6, 7, 9, 13, 15, 20, 22, 26, 27, 29, 31, 34, 40, 42, 43, 44, 47
Material consumption	17	2, 3, 4, 7, 8, 14, 15, 21, 22, 26, 30, 37, 38, 42, 43, 45, 51
Renewable energy use	9	6, 7, 15, 21, 22, 32, 33, 40, 49
Recycled water use	7	7, 13, 15, 17, 22, 38, 43
Recycled material use	7	13, 19, 21, 29, 31, 43, 45
Wastewater discharge	7	7, 13, 21, 22, 31, 34, 45
Hazardous waste	7	21, 22, 30, 31, 44, 47, 49
Land use	6	21, 23, 26, 34, 37, 42
Solid waste	6	5, 6, 14, 15, 21, 38
Recyclable waste	6	7, 10, 14, 31, 32, 47
Packaging material consumption	5	15, 29, 37, 43, 50
Electricity consumption	5	3, 4, 5, 11, 21
Air emissions	5	8, 16, 21, 26, 42,
Global warming potential	5	2, 25, 36, 48, 51
Energy efficiency	5	9, 15, 24, 38, 45
Energy intensity	5	6, 17, 22, 33, 41

In the environmental sustainability dimension as shown in Table 7, more weight was given to indicators that are used for measuring progress in the efficient use of input resources such as *water* (Ahmad and Wong, 2019; Cagno et al., 2019; Vitale et al., 2019), *energy* (Abedini et al., 2020; Agrawal and Vinodh, 2020; Song and Moon, 2019) and *material* (Agrawal and Vinodh, 2020; Ahmad and Wong, 2019; Cagno et al., 2019) consumption; the use of recycled resources which include *recycled water* (Cagno et al., 2019; Huang and Badurdeen, 2018; Zarte et al., 2019) and *recycled material* (Cagno et al., 2019; Huang and Badurdeen, 2017; Zarte et al., 2019); the *use of renewable energy* (Beekaroo et al., 2019; Cagno et al., 2019; Huang and Badurdeen, 2018); reduction of emissions consisting of *GHG* (Abedini et al., 2020; Beekaroo et al., 2019; Zarte et al., 2019) and *air* (Hasan et al., 2017; Moldavska and Welo, 2018; Singh R.K. et al., 2019); and the proper management of wastes including *wastewater discharge* (Hasan et al., 2017; Wang et al., 2018; Zarte et al., 2019) and *hazardous* (Hasan et al., 2017; Huang and Badurdeen, 2017; Winroth et al., 2016), *solid* (Ahmad, Wong, and Rajoo, 2019; Beekaroo et al., 2019; Demartini et al., 2018) and *recyclable* (Cagno et al., 2019; Demartini et al., 2018; Trianni et al., 2019) wastes.

Table 8. Frequently used social sustainability indicators in the reviewed literature

Indicators for social dimension	Frequency of use	Authors
Employment/Job opportunity	11	2, 4, 5, 7, 10, 15, 19, 21, 22, 44, 50
Employee turnover	11	3, 5, 11, 14, 21, 22, 30, 36, 43, 45, 51
Work-related injuries	10	4, 7, 11, 15, 20, 22, 31, 36, 40, 47
Customer satisfaction	7	7, 9, 16, 18, 26, 32, 42
Employee satisfaction	6	4, 9, 26, 30, 32, 42
Working hours	6	3, 4, 5, 17, 25, 36
Corruption	6	4, 5, 17, 20, 42, 43
Occupational health and safety	5	3, 4, 5, 8, 17
Training and development	5	3, 4, 5, 20, 32
Fair salary	5	3, 4, 5, 34, 43
Customer complaints	5	5, 22, 29, 44, 51
Lost working days	5	4, 11, 31, 44, 51

Regarding the social sustainability dimension as can be seen in Table 8, the focus was on indicators that are used to measure progress in creating *employment/job opportunities* (Agrawal and Vinodh, 2020; Ahmad, Wong, and Rajoo, 2019; Cagno et al., 2019) improving the well-being of employees by minimizing *employee turnover* (Ahmad and Wong, 2019; Demartini et al., 2018; Vitale et al., 2019), minimizing *work-related injuries* (Ahmad, Wong, and Rajoo, 2019; Cagno et al., 2019; Vitale et al., 2019), ensuring *employee satisfaction* (Ahmad, Wong, and Rajoo, 2019;

Ocampo et al., 2016; Song and Moon, 2019) and *occupational health and safety* (Ahmad and Wong, 2019; Raj and Srivastava, 2018; Singh R.K. et al., 2019), providing *training and development* (Ahmad and Wong, 2019; Elhuni and Ahmad, 2017; Feil et al., 2015) and a *fair salary* (Ahmad and Wong, 2019; Harik et al., 2015; Samuel et al., 2013); improving the well-being of customers in terms of *customer satisfaction* (Cagno et al., 2019; Moldavska and Welo, 2018; Song and Moon, 2019) and minimizing *customer complaints* (Ahmad, Wong, and Zaman, 2019; Huang and Badurdeen, 2017; Watanabe et al., 2016); properly managing employee working time such as *working hours* (Ahmad and Wong, 2019; Lacasa et al., 2016; Raj and Srivastava, 2018) and *lost working days* (Ahmad, Wong, and Rajoo, 2019; Eastwood and Haapala, 2015; Vitale et al., 2019); and reducing *corruption* (Ahmad, Wong, and Rajoo, 2019; Elhuni and Ahmad, 2017; Raj and Srivastava, 2018).

The present analysis of the indicators identified in the literature found that *automotive* (Ghadimi et al., 2012; Lee J.Y. et al., 2014; Moldavska and Welo, 2019; Singh S. et al., 2018; Vinodh et al., 2016), *food* (Ahmad and Wong, 2019; Harik et al., 2015; Yakovleva and Flynn, 2004), *electronics* (Huang and Badurdeen, 2017; Li et al., 2012; Shuaib et al., 2014) and *plastic* (Ocampo et al., 2016; Song and Moon, 2019) were the industrial sectors most often used by previous research for conducting case studies regarding sustainability performance measurement. However, this literature analysis shows a lack of research on the analysis and selection of indicators for the footwear industry.

4.3 Categorization of the indicators

To provide a broader view of indicators from the perspective of the themes linked to industrial sustainability, the consistently and frequently used indicators identified in the literature were categorized. As can be seen in Figure 7, the indicators can logically be categorized for measuring industrial sustainability performance related to financial benefits, costs, and market competitiveness in the economic dimension; resources, emissions, and wastes in the environmental dimension; and employees, customers, and community in the social dimension. Most of the proposed categories (themes) are in line with the categories of the NIST's sustainability manufacturing indicator repository (Joung et al., 2013).

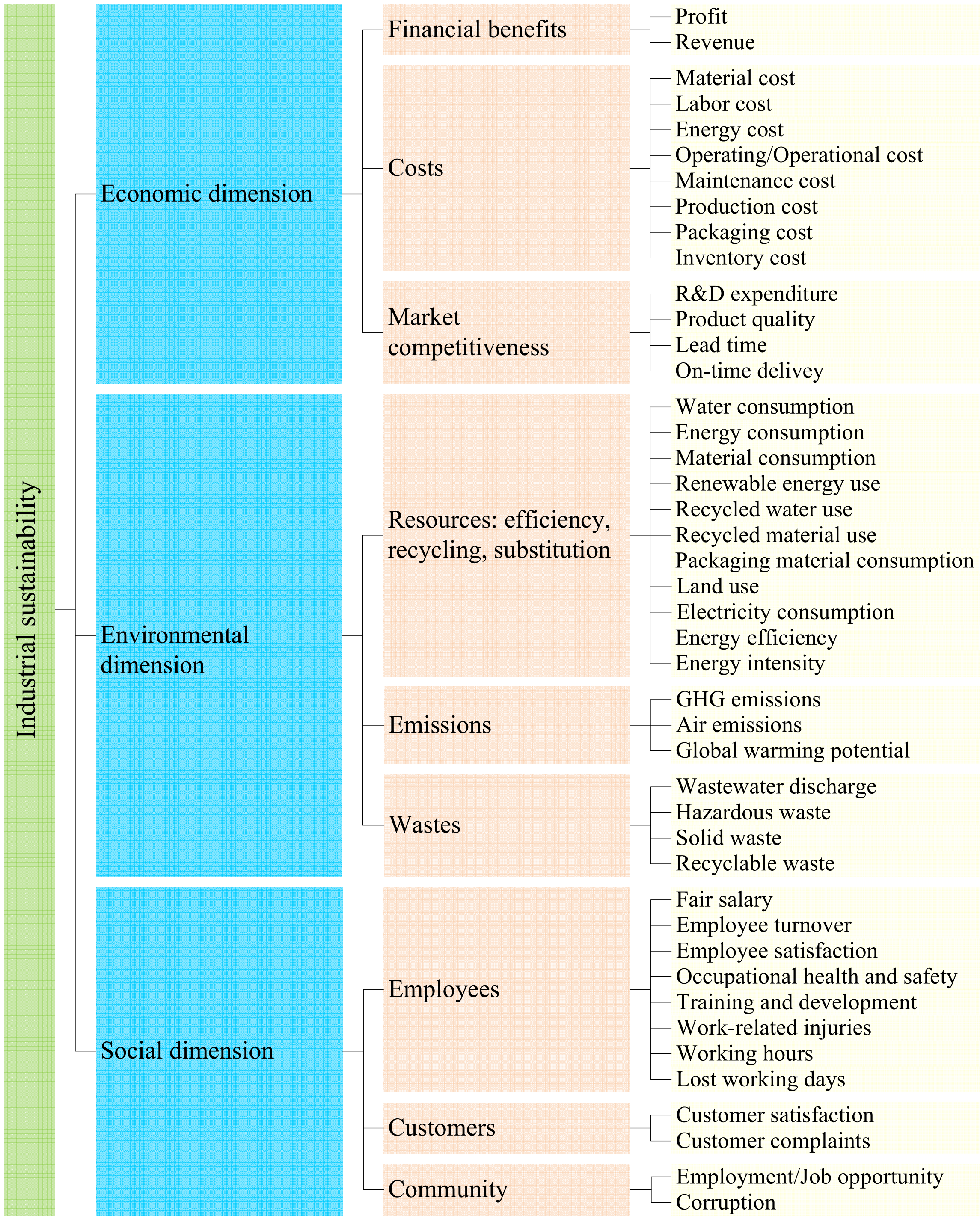

Figure 7. Hierarchical structure of indicator categorization

The hierarchical structure of indicator categorization demonstrates that manufacturing industries always need to increase their financial benefits to maintain their existence in the market. They should also improve their market competitiveness, employ cost reduction strategies, efficiently use resources, conserve resources, properly manage wastes, and apply emissions reduction strategies while producing their products and services. In addition, they need to promote the well-being of their employees and customers and fulfill other stakeholders' needs (such as the community). The synergistic effect of these efforts can lead to achieving industrial sustainability (economic, environmental, and social sustainability) goals. Hence, manufacturing companies need to use suitable indicators in order to effectively measure and manage their progress towards attaining sustainability goals (Ahmad and Wong, 2019; Hendiani et al., 2020; Wang et al., 2018).

4.4 Indicators refined after pre-testing

The indicators in Tables 6, 7, and 8 were initially used to develop the questionnaire for pre-testing. Because of their high consistency and frequency of use, these indicators can be considered to be more understandable and relevant to manufacturing companies (Ahmad, Wong, and Rajoo, 2019); and they can be taken as potential indicators for measuring industrial sustainability performance. Furthermore, to refine the indicators (i.e., modify, add, and delete), the pre-testing of the questionnaire was carried out with selected industry experts from Italian footwear SMEs, scholars, and researchers. Finally, 40 sustainability indicators (12 for the economic, 14 for environmental, and 14 for social sustainability dimensions) were identified and used to develop the final questionnaire used for data collection (Mengistu and Panizzolo, 2021), as shown in Table 9.

Table 9. Indicators refined after pre-testing

Sustainability dimensions	Indicators	Short descriptions
Economic	Profit	• Excess revenue over the cost of producing the product (OECD, 2008).
	Revenue	• Value of output (product) sold, i.e., number of products sold times unit price (OECD, 2008)
	Material cost	• Cost of input materials used to produce the product (OECD, 2008)
	Labor cost	• Salaries and wages of active employees, pensions, various social charges, and related (OECD, 2008)
	Energy cost	• Cost allocated for quantity of energy consumed (OECD, 2008)
	Maintenance cost	• Costs (such as expenses for lubricants, spare parts, tools and equipment, and maintenance crew) incurred to carry-out maintenance activities (OECD, 2008).

Sustainability dimensions	Indicators	Short descriptions
	Packaging cost	• Cost allocated for packaging material
	Inventory cost	• Expenses associated with holding and storing raw materials and products.
	R&D expenditure	• Expenses allocated to carry out research and development (R&D) activities (OECD, 2008)
	Product quality	• Features incorporated that can meet customer needs
	Lead time	• Time between order placement and shipment
	On-time delivery	• Delivery of finished products on time.
Environmental	Water consumption	• Use of water for processing, washing, drinking and related (OECD, 2008)
	Recycled water use	• Reuse of wastewater after treatment (Zarte et al., 2019)
	Energy consumption	• Use of energy (electricity, fuel) for manufacturing process, lighting, heating and other purposes (OECD, 2008)
	Renewable energy use	• Use of energy comes from renewable sources such as solar, wind, hydro, biomass and others (GRI, 2020)
	Energy efficiency	• Ratio of energy used in manufacturing process, heating, lighting and other purposes to input energy (Song and Moon, 2019)
	Material consumption	• Input materials consumed to produce output (product) (Ahmad, Wong, and Zaman, 2019)
	Recycled material use	• Use of recycled input materials by replacing virgin materials (GRI, 2020)
	Packaging material consumption	• Use of materials as containers or wrapping for handling, protecting and marketing product (Ahmad, Wong, and Zaman, 2019)
	Land use	• Use of land for industrial activities (OECD, 2008)
	GHG emissions	• Release of GHGs such as Carbon dioxide (CO_2), Nitrous oxide (N_2O), Methane (CH_4), Chlorofluorocarbons (CFCs) and others contributing to greenhouse effect/ global warming (OECD, 2008)
	Wastewater discharge	• Industrial sewage (used water) released to surface water, groundwater, seawater, or third party (GRI, 2020)
	Hazardous waste	• Waste with toxic, infectious, radioactive or flammable properties that pose a potential hazard to human health, other living organisms and environment (OECD, 2008)

Sustainability dimensions	Indicators	Short descriptions
	Solid waste disposal	• Disposal of solid waste (waste with low liquid content) that is not recycled (OECD, 2008)
	Recyclable waste	• Waste that can be used in production and consumption processes (OECD, 2008)
Social	Employment/Job opportunity	• Opportunities created for employment (OECD, 2008)
	Fair salary	• Regular fair payments to employees their service (OECD, 2008)
	Employee turnover	• Employees leaving the organization voluntarily or due to dismissal, retirement, or death (GRI, 2020)
	Employee satisfaction	• Happiness of employees with their job
	Occupational health and safety	• Promotion of employee health and safety by preventing work-related injuries and illnesses (GRI, 2020)
	Training and development	• Organizational activities to enhance employees' knowledge and skills for better performance of specific tasks
	Working conditions	• Promoting a safe working environment by preventing work-related injuries and illnesses due to exposure to hazardous substances, dust, high temperature, loud noise and other risk factors
	Work-related injuries	• Injuries arising from exposure to hazards and accidents at work (GRI, 2020)
	Working hours	• Hours that employees spend doing paid work (OECD, 2008)
	Lost working days	• Lost days due to work-related injuries and illnesses (Tseng, 2013; Veleva and Ellenbecker, 2001)
	Customer health and safety	• Systematic efforts to address incidents concerning health and safety impacts of products and services on customers (GRI, 2016)
	Customer satisfaction	• How well customers' needs are met by products and services offered.
	Customer complaints	• Customers' feedback on the products and services that did not meet their needs
	Corruption	• Abuse of power in leadership for personal financial or other benefits (GRI, 2020; OECD, 2008)

4.5 Selected and prioritized indicators

The FDM was applied to address RQ1 empirically. Table 10 summarizes the results of the empirical analysis that includes the aggregate fuzzy opinion and the defuzzified score of each indicator. The defuzzified score compared with the previously defined threshold for selecting and prioritizing the indicators, as shown in Figure 8. As a result, 25 indicators were selected and prioritized for measuring sustainability performance in Italian footwear SMEs. This does not imply that the unselected indicators are irrelevant, but they have a lower priority than the selected indicators. As SMEs have limited resources, they need to use a manageable number of indicators (Veleva and Ellenbecker, 2001). From the selected indicators, *product quality* was the top prioritized indicator for measuring the economic sustainability performance of SMEs, followed by *on-time delivery*, *lead time*, *profit*, *revenue*, *R&D expenditure*, *labor cost*, and *material cost*. *Material consumption* followed by *recycled material use*, *energy efficiency*, and *energy consumption* were found to be the most appropriate indicators for measuring the environmental sustainability performance of SMEs. *Customer satisfaction* was given the top priority followed by *working conditions*, *customer complaints*, *occupational health and safety*, *work-related injuries*, *employee satisfaction*, *customer health and safety*, *fair salary*, *employment/job opportunity*, *training and development*, *working hours*, *lost working days*, and *employee turnover* for measuring the social sustainability performance.

Table 10. Aggregate fuzzy opinion and defuzzified score

Sustainability Dimensions	Indicators (k)	Aggregate fuzzy opinion			Defuzzified score (S_k)
		Min (l_k)	Optimum (m_k)	Max (u_k)	
Economic	Profit	5.613	7.613	8.749	7.325
	Revenue	4.962	6.962	8.642	6.856
	Material cost	4.463	6.448	8.229	6.380
	Labor cost	4.618	6.618	8.230	6.488
	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
	R&D expenditure	4.978	6.965	8.297	6.747
	Product quality	6.642	8.642	8.987	8.091
	Lead time	6.167	8.167	8.885	7.740

Sustainability Dimensions	Indicators (k)	Aggregate fuzzy opinion			Defuzzified score (S_k)
		Min (l_k)	Optimum (m_k)	Max (u_k)	
	On-time delivery	6.480	8.480	8.972	7.978
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
	Renewable energy use	4.162	6.121	7.674	5.986
	Energy efficiency	4.945	6.912	8.209	6.688
	Energy intensity	3.795	5.722	7.505	5.674
	Material consumption	5.186	7.186	8.460	6.944
	Recycled material use	4.943	6.928	8.351	6.740
	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
	Fair salary	5.642	7.642	8.773	7.352
	Employee turnover	4.465	6.448	8.056	6.323
	Employee satisfaction	5.993	7.993	8.902	7.630
	Occupational health and safety	6.133	8.133	8.873	7.713
	Training and development	5.161	7.161	8.737	7.020
	Working conditions	6.376	8.376	8.903	7.885
	Work-related injuries	6.029	8.029	8.873	7.644
	Working hours	5.001	7.001	8.497	6.833
	Lost working days	4.449	6.449	8.074	6.324
	Customer health and safety	6.001	7.994	8.824	7.607
	Customer satisfaction	6.838	8.838	8.988	8.221
	Customer complaints	6.252	8.252	8.934	7.813
	Corruption	4.544	6.278	7.669	6.164

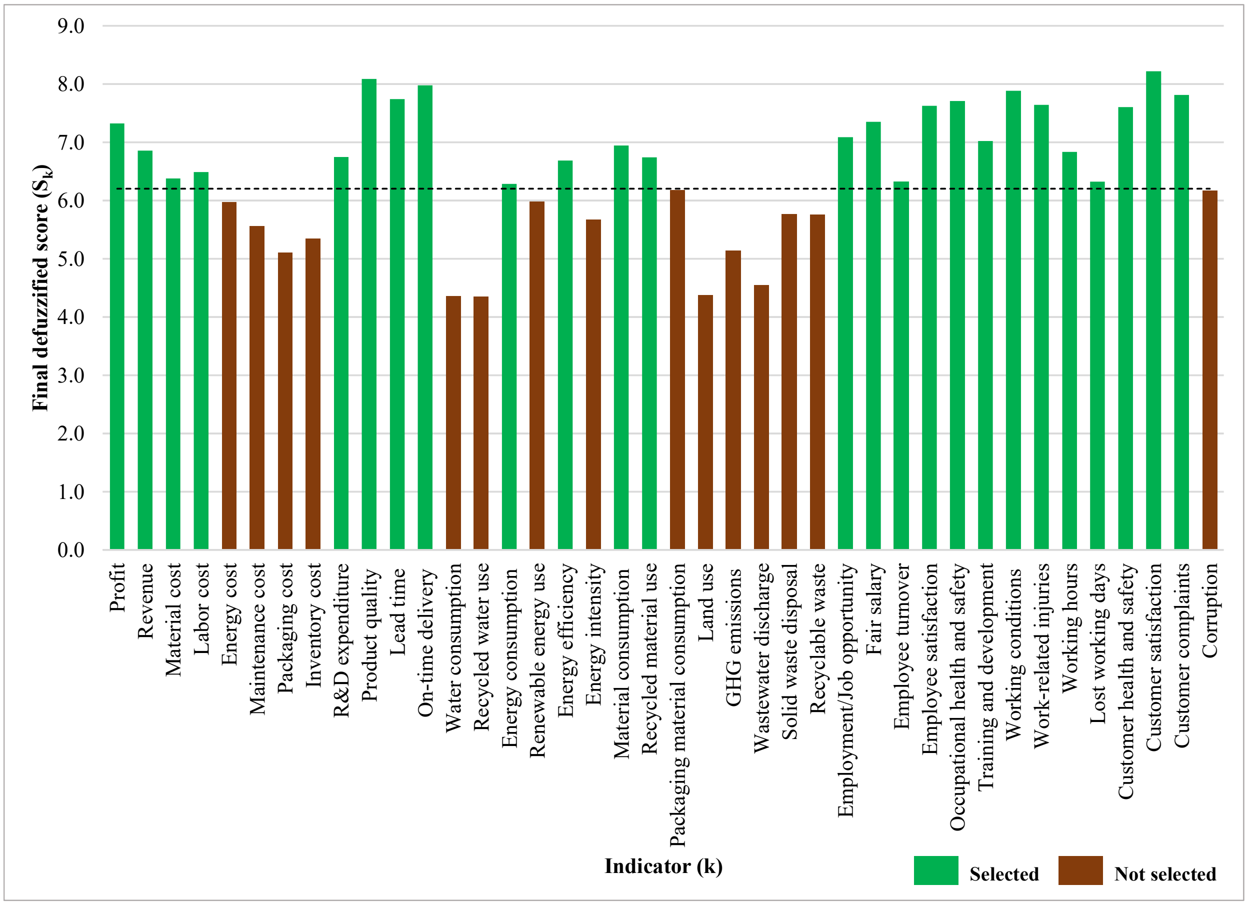

Figure 8. Final selected indicators

4.6 Linking the selected indicators to the SDGs

With increasing pressure from stakeholders on manufacturing companies for more transparency about their sustainability practices and improving sustainability performance, there is a growing interest in measuring and managing industrial sustainability performance. The selected indicators can help the Italian footwear SMEs to effectively measure and manage their sustainability performance. Moreover, these indicators can also be applied to define, implement, evaluate and monitor policies to enhance sustainable manufacturing by considering the economic, environmental, and social aspects simultaneously while producing products and services, ensuring economic growth, conserving natural resources, minimizing negative environmental and social impacts, and meeting the requirements of stakeholders. In doing so, SMEs can contribute to achieving the SDGs (presented in chapter two section 2.4) such as promoting health and well-being (Goal 3), promoting sustainable economic growth, productive employment, and decent work

(Goal 8), and ensuring sustainable consumption and production (Goal 12). Table 11 presents the link between the selected indicators and their respective SDGs. By linking the indicators to the SDGs, this research addresses the shortcoming of previous research to incorporate the SDGs into their analyses of sustainability indicators. The link between the selected indicators and their respective SDGs is carried out mainly based on the purpose of each indicator and the categories of the indicators (presented in section 4.3). In this regard, the purpose of the selected economic sustainability indicators in measuring and managing towards increasing financial benefits, reducing costs, and improving market competitiveness is mostly linked to the purpose of Goal 8. And, the purpose of the selected environmental sustainability indicators in measuring and managing progress towards the effectiveness of resources utilization is linked to the purpose of Goal 12. Furthermore, the purpose of the selected social sustainability indicators in measuring and managing progress towards promoting the well-being of employees, customers, and the community is linked to the purpose of Goal 3, Goal 8, and Goal 12. An indicator, depending on its purpose, can be linked to more than one SDG, as shown in Table 11.

Table 11. The link between the selected indicators and their respective SDGs

Sustainability dimensions	Indicators	SDGs		
		Goal 3	Goal 8	Goal 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		

Sustainability dimensions	Indicators	SDGs		
		Goal 3	Goal 8	Goal 12
	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

Chapter Five

5 Framework for applying indicators

To address RQ2 (i.e., to put the selected indicators into practice), an indicator-based framework based on previous research and sustainability standards and guidelines was developed to guide SMEs in using the selected indicators to measure sustainability performance.

5.1 Overall structure of the framework

The framework, as shown in Figure 9, has four stages (i.e., sustainability plan, sustainability apply, sustainability check, and sustainability action) defined according to the well-known PDCA cycle (ISO, 2021; Venkatraman and Nayak, 2010). The functions under each stage of the framework were defined by adapting the continuous-loop model for defining and measuring the sustainability performance of organizations proposed by Veleva and Ellenbecker (2001).

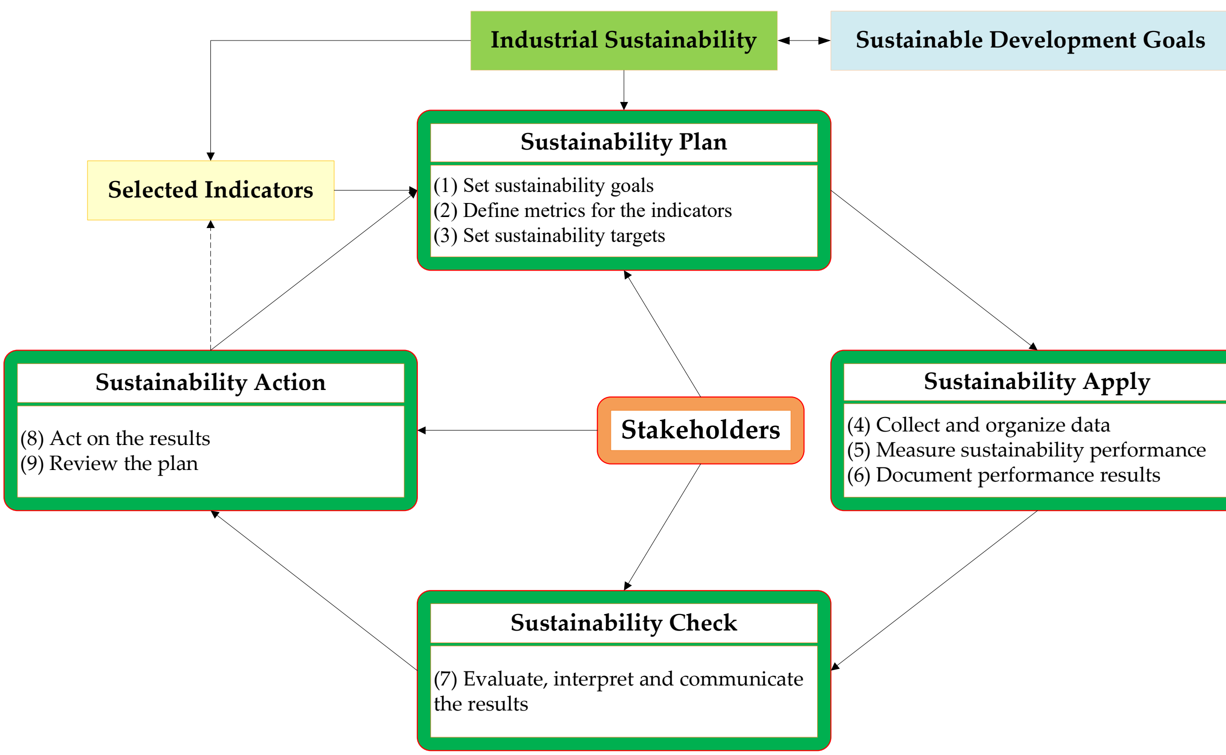

Figure 9. The overall structure of the framework

Stage 1 – Sustainability Plan: This stage includes (1) setting sustainability goals achieved by the selected indicators, (2) defining metrics for the selected indicators for measuring and managing progress towards sustainability goals, and (3) setting sustainability targets based on the specified metrics. SMEs can set the sustainability targets in consultation with stakeholders (Veleva and Ellenbecker, 2001). The targets could be acceptable limits, critical loads, or standards set by governmental and non-governmental organizations (Song and Moon, 2019). *For instance*, the targets include acceptable limits of renewable, eco-friendly and biodegradable or hazardous materials use, critical loads related to working conditions, and standards linked to labor and occupational health and safety (OHS).

Stage 2 – Sustainability Apply: It involves (4) collecting and organizing the required data, (5) measuring sustainability performance for the reporting period, which can be fiscal year, calendar year, six months, quarter, month (Veleva and Ellenbecker, 2001), and (6) documenting the performance results so that they can be properly reported.

Stage 3 – Sustainability Check: It focuses on (7) comparing the sustainability performance results obtained with their respective sustainability targets, interpreting the results to check whether the performance of SMEs is sustainable or not, and communicating the results to the managers and the stakeholders to have a shared understanding and for taking improvement actions.

Stage 4 – Sustainability Action: It consists of (8) actions to be taken on the sustainability performance that needs improvement, and (9) reviewing the plan for continuous sustainable performance improvement.

The framework provides a comprehensive view of indicators application ranging from setting sustainability goals to defining metrics, setting sustainability targets, measuring, evaluating and interpreting sustainability performance, taking actions on the performance results, and reviewing for continuous improvement. Furthermore, it promotes stakeholder engagement mainly in setting sustainability goals and targets, interpreting sustainability performance, taking improvement actions, and reviewing the plan. This ultimately creates a high level of trust between SMEs and their stakeholders. It can also act as a reporting mechanism and a continuous improvement tool of industrial sustainability performance. Subsequently, SMEs can contribute to achieving the SDGs.

5.2 Metrics defined for the selected indicators

Defining quantifiable metrics is crucial (Shuaib et al., 2014) in order to measure and continuously improve industrial sustainability performance. As shown in Tables 12, 13, and 14, both absolute and relative metrics were defined for the selected economic, environmental, and social indicators, respectively (Mengistu and Panizzolo, 2021). The absolute metrics help SMEs to measure their sustainability performance as a whole. On the other hand, the relative metrics can be used to measure the sustainability performance of SMEs in one area with respect to the performance in another area (Ahi and Searcy, 2015). The metrics[4] defined for the indicators can enable SMEs to carry out their sustainability performance measurement using data science. By providing a predefined list of indicators and their metrics, manufacturing industries will not be overloaded with information whose utility is uncertain. Additionally, this improves the effectiveness of sustainability performance measurement in SMEs. The metrics are the crucial aspect of the framework, which are used as the basis for setting sustainability targets and measuring, evaluating and interpreting the sustainability performance of SMEs. For this purpose, defining appropriate metrics supported by empirical evidence is essential and will improve the practical relevance of the framework.

Table 12. Metrics defined for the economic sustainability dimension indicators

Indicators	Metrics		Adapted from
	Absolute	**Relative**	
Profit	Net profit gained (Euro, USD)	Net profit to total revenue ratio (%)	Elhuni and Ahmad (2017)
Revenue	Total revenue generated (Euro, USD)	Revenue generated per unit of product sold (Euro, USD/uop)	Ahmad, Wong, and Zaman (2019)
Material cost	Total material cost (Euro, USD)	Percentage of material cost relative to total revenue (%)	Ahmad, Wong, and Zaman (2019)
Labor cost	Total labor cost (Euro, USD)	Percentage of labor cost relative to total revenue (%)	Ahmad, Wong, and Zaman (2019)
R&D expenditure	R&D spending (Euro, USD)	R&D spending to total revenue ratio (%)	Ahmad, Wong, and Zaman (2019); Grecu et al. (2020)
Product quality	Total number of products that met customer requirements (#)	Percentage of products that met customer requirements (%)	Proposed metrics

[4] The terms 'metrics' and 'indicators' are often used interchangeably. However, in this research, metrics refer to quantifiable measures of sustainability performance. And, indicators refer to performance measures used to measure progress towards achieving sustainability goals. An indicator consists of one or more metrics to be measurable.

Indicators	Metrics		Adapted from
	Absolute	Relative	
Lead time	Total number of products produced within the required lead time (#)	Percentage of products produced within the required lead time (%)	Proposed metrics
On-time delivery	Total number of products delivered on time (#)	Percentage of products delivered on time (%)	Proposed metrics

As shown in Table 12, the economic metrics can be used to properly measure and manage the economic sustainability performance of SMEs associated with financial benefits (profit and revenue), costs (material, labor, energy, operating, maintenance, production, packaging, and inventory), and market competitiveness (R&D expenditure, on-time delivery, lead time, and product quality). Measuring and managing cost reduction, on-time delivery, lead time, and product quality is essential in order to maintain market competitiveness and financial benefits in the short run. Moreover, it is crucial to determine the reasonable expenditure levels for carrying out R&D activities to promote sustainable products and processes and enhance market competitiveness in the long run.

Table 13. Metrics defined for the environmental sustainability dimension indicators

Indicators	Metrics		Adapted from
	Absolute	Relative	
Energy consumption	Total electricity consumed (kWh); total amount of fuel consumed (L, m^3, tonne)	Electricity consumption per unit of product produced (kWh/uop); fuel consumption per unit of product produced (L, m^3, tonne/uop)	Veleva and Ellenbecker (2001)
Energy efficiency	******	Ratio of energy used for production to the total input energy (%)	Song and Moon (2019)
Material consumption	Total weight or volume of materials consumed (kg, m^3, L, m^2, pc)	Material consumption per unit of product produced (kg, m^3, L, m^2, pc/uop); material efficiency (%); percentage of biodegradable materials used (%); percentage of renewable materials used (%); percentage	Huang and Badurdeen (2018); Veleva and Ellenbecker (2001)

Indicators	Metrics		Adapted from
	Absolute	Relative	
		of hazardous materials used (%)	
Recycled material use	Total weight or volume of recycled materials used (kg, m^3, L, m^2, pc)	Percentage of recycled materials used (%)	Huang and Badurdeen (2018)

From Table 13, it can be seen that the environmental metrics are defined to effectively measure and manage the environmental sustainability performance of SMEs related to resources (energy and material). More specifically, the metrics can be used for measuring progress towards improving the effectiveness of resources utilization such as energy consumption, material efficiency, material consumption, and the use of recycled materials.

Table 14. Metrics defined for the social sustainability dimension indicators

Indicators	Metrics		Adapted from
	Absolute	Relative	
Employment/Job opportunity	Total number of new employees hired (#)	Recruitment efficiency (%)	GRI (2016)
Fair salary	******	Average salary per employee (Euro, USD/emp)	Ahmad, Wong, and Zaman (2019)
Employee turnover	Total number of employee turnover (#)	Percentage of employee turnover (%)	Huang and Badurdeen (2018); GRI (2016)
Employee satisfaction	Total number of employees who reported job satisfaction (#)	Percentage of employees who reported job satisfaction (%)	Huang and Badurdeen (2018); Veleva and Ellenbecker (2001)
Occupational health and safety	Total number of employees covered by OHS program (#); total number of fatalities as a result of work-related injuries (#); total number of fatalities as a result of work-related illnesses (#); total number of cases of work-related illnesses (#)	Percentage of employees covered by OHS program (%); percentage of fatalities as a result of work-related injuries (%); percentage of fatalities as a result of work-related illnesses (%); percentage of cases of work-related illnesses (%)	GRI (2016)

Indicators	Metrics		Adapted from
	Absolute	Relative	
Training and development	Total number of employees who received a regular performance and career development (PCD) review (#); total training hours (h)	Percentage of employees who received a regular PCD review (%); average training hours per employee (h/emp)	GRI (2016)
Working conditions	Total number of employees working in decent conditions (#)	Percentage of employees working in decent conditions (%)	Proposed metrics
Work-related injuries	Total number of work-related injuries (#)	Work-related injuries per employee (#/emp)	GRI (2016)
Working hours	Total working hours (h)	Average working hours per employee (h/emp)	Zarte et al. (2019)
Lost working days	Total lost working days due to injuries and illnesses (day)	Percentage of lost working days due to injuries and illnesses (%)	Tseng (2013); Veleva and Ellenbecker (2001)
Customer health and safety	Total number of incidents concerning the health and safety impacts of products and services provided (#)	Number of health and safety incidents per unit of product sold (#/uop)	GRI (2016)
Customer satisfaction	Total number of customers who reported satisfaction with the products and services offered (#)	Percentage of customers who reported satisfaction with the products and services offered (%)	Ahmad, Wong, and Zaman (2019)
Customer complaints	Total number of customer complaints (#)	Customer complaints per unit of product sold (#/uop)	Ahmad, Wong, and Zaman (2019); Veleva and Ellenbecker (2001)

Table 14 shows the metrics defined to measure and manage the social sustainability performance of SMEs. Measuring the social sustainability performance has been difficult compared to the economic and environmental sustainability dimensions (Ahmad, Wong, and Rajoo, 2019). The metrics shown in Table 14 will help to easily measure the social sustainability performance of SMEs associated with the well-being of their employees, customers, and the community. The metrics defined for employee turnover, employee satisfaction, occupational health and safety, training and development, fair salary, and work-related injuries can be used for measuring progress in improving employee well-being. It is also essential to measure progress in promoting customer well-being. For this purpose, the metrics defined for customer satisfaction and customer complaints are helpful. The metrics defined for employment/job opportunity can be used for measuring progress towards community development. Moreover, the metrics defined for working hours and lost working days can be used for measuring performance associated with employees' time management.

5.3 Guideline for applying the indicators

In order to effectively apply the selected indicators for measuring sustainability performance in SMEs, a detailed guideline was developed as shown below. The following key elements (Veleva and Ellenbecker, 2001) shown in Table 15 were used to develop the guideline.

Table 15. Key elements of the guideline

Key elements	Description
Goal	• The objective that states the progress towards sustainability to be achieved by the indicator. It can be an improvement objective for positive sustainability impact and a reduction objective for negative sustainability impact.
Level of application	• Scope of application of the indicators that could be at the material level, product level, process level, and/or firm level.
Reporting period	• The time span for which sustainability performance measurement is carried out and reported by SMEs.
Metrics	• Quantifiable measures of the indicators.
Target (T)	• Represents the tolerable value (plan, threshold, standard, or norm) of the sustainability performance to be measured.
Actual performance (P)	• The actual sustainability performance of SMEs during the reporting period.
Evaluation	• Comparing the actual sustainability performance (P) with the respective predefined sustainability target (T). The evaluation can be carried out by calculating ratio (W), i.e., $W = P / T$ if $T > 0$, or distance (D), i.e., $D = T – P$ if $T = 0$.
Interpretation	• Based on the evaluation result, deciding whether the performance of SMEs is sustainable or needs improvement.

The aforementioned vital elements of the guideline were detailed for each indicator depending on its nature and purpose to help the SMEs effectively apply the indicators for measuring, evaluating and interpreting their sustainability performance as described below.

The detailed guideline for applying the indicators:

INDICATOR: Profit (I_P)

Goal: Increase profit

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Net profit gained (Euro, USD)	Net profit to total revenue ratio (%)
Target (T):	The planned net profit (Euro, USD)	Target net profit to total revenue ratio (%)
Actual performance (P):	1)-Determine the total revenue during the reporting period 2)-Determine the total expenses of the same period 3)-Apply *[Total revenue – Total expenses]* formula to determine the absolute measured value of this metric (PA)	1)-Take the net profit of the same period 2)-Take the total revenue of the same period 3)-Apply *[Net profit / Total revenue]*100* formula to determine the relative measured value of this metrics (PR)
Evaluation:	WI_P = [PA / TA]	WI_P = [PR / TR]
Interpretation:	$WI_P > 1.1$: Sustainable, $WI_P = 1$ to 1.1: Marginally sustainable, $WI_P < 1$: Needs improvement	$WI_P > 1.1$: Sustainable, $WI_P = 1$ to 1.1: Marginally sustainable, $WI_P < 1$: Needs improvement

INDICATOR: Revenue (I_R)

Goal: Increase revenue

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**

Metrics:	Total revenue generated (Euro, USD)	Revenue generated per unit of product sold (Euro, USD/uop)
Target (T):	The planned revenue (Euro, USD)	Revenue generated per unit of a benchmark product (Euro, USD/uop)
Actual performance (P):	1)-Determine the total revenue during the reporting period	1)-Take the total revenue of the same period 2)-Take the total number of products sold during the same period 3) Apply *[Total revenue / Total number of products sold]*100* formula
Evaluation:	WI_R = [PA / TA]	WI_R = [PR / TR]
Interpretation:	WI_R > 1.1: Sustainable, WI_R = 1 to 1.1: Marginally sustainable, WI_R < 1: Needs improvement	WI_R > 1.1: Sustainable, WI_R = 1 to 1.1: Marginally sustainable, WI_R < 1: Needs improvement

INDICATOR: Material cost (I_{MC})

Goal: Reduce material cost

Level of application: Material level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total material cost (Euro, USD)	Percentage of material cost relative to total revenue (%)
Target (T):	TMC*the planned revenue (Euro, USD)	TMC – Target percentage of material cost relative to total revenue (%)
Actual performance (P):	1)-Determine the total cost of materials consumed to produce the product during the reporting period	1)-Take the total cost of materials consumed of the same period 2)-Take the total revenue of the same period

		3)-Apply *[Total cost of materials consumed / Total revenue]*100* formula
Evaluation:	$WI_{MC} = [PA / TA]$	$WI_{MC} = [PR / TR]$
Interpretation:	$WI_{MC} < 0.9$: Sustainable, $WI_{MC} = 0.9$ to 1: Marginally sustainable, $WI_{MC} > 1$: Needs improvement	$WI_{MC} < 0.9$: Sustainable, $WI_{MC} = 0.9$ to 1: Marginally sustainable, $WI_{MC} > 1$: Needs improvement
INDICATOR: Labor cost (I_{LC})		
Goal: Reduce labor cost		
Level of application: Firm level		
Reporting period: Fiscal year, Six months, Quarter year, Month		
	Absolute (A)	**Relative (R)**
Metrics:	Total labor cost (Euro, USD)	Percentage of labor cost relative to total revenue (%)
Target (T):	TLC*the planed revenue (Euro, USD)	TLC – Target percentage of labor cost relative to total revenue (%)
Actual performance (P):	1)-Determine the total labor cost (both direct and indirect) during the reporting period	1)-Take the total labor cost of the same period 2)-Take the total revenue of the same period 3)-Apply *[Total labor cost / Total revenue]*100* formula
Evaluation:	$WI_{LC} = [PA / TA]$	$WI_{LC} = [PR / TR]$
Interpretation:	$WI_{LC} < 0.9$: Sustainable, $WI_{LC} = 0.9$ to 1: Marginally sustainable, $WI_{LC} > 1$: Needs improvement	$WI_{LC} < 0.9$: Sustainable, $WI_{LC} = 0.9$ to 1: Marginally sustainable, $WI_{LC} > 1$: Needs improvement
INDICATOR: R&D expenditure (I_{RD})		
Goal: Allocate optimal R&D expenditure		
Level of application: Product level, Firm level		
Reporting period: Fiscal year, Six months, Quarter year, Month		
	Absolute (A)	**Relative (R)**

Metrics:	R&D spending (Euro, USD)	R&D spending to total revenue ratio (%)
Target (T):	TRD*the planned revenue (Euro, USD)	TRD – Target R&D spending to total revenue ratio (%)
Actual performance (P):	1)-Determine the marginal R&D expenditure allocated during the reporting period	1)-Take the marginal R&D expenditure of the same period 2)-Take the total revenue of the same period 3)-Apply *[Marginal R&D expenditure / Total revenue]*100* formula
Evaluation:	I_{RD} = [PA / TA]	I_{RD} = [PR / TR]
Interpretation:	WI_{RD} > 1.1: Sustainable, WI_{RD} = 1 to 1.1: Marginally sustainable, WI_{RD} < 1: Needs improvement	WI_{RD} > 1.1: Sustainable, WI_{RD} = 1 to 1.1: Marginally sustainable, WI_{RD} < 1: Needs improvement

INDICATOR: Product quality (I_{PQ})

Goal: Improve product quality

Level of application: Product level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total number of products that met customer requirements (#)	Percentage of products that met customer requirements (%)
Target (T):	The total number of products produced as per the quality plan (#)	100%
Actual performance (P):	1)-Determine the total number of products produced during the reporting period 2)-Determine number the defective products of the same period	1)-Take the total number of products that met customer specification of the same period 2)-Take the total number products produced during the same period 3)-Apply *[Total number of products that meet customer specification /*

	3)-Apply *[Total number of products produced – Number of defective products]* formula	*Total number of products produced]*100* formula
Evaluation:	WI_{PQ} = [PA / TA]	WI_{PQ} = [PR / TR]
Interpretation:	WI_{PQ} = 1: Sustainable, WI_{PQ} < 1: Needs improvement	WI_{PQ} = 1: Sustainable, WI_{PQ} < 1: Needs improvement
INDICATOR: Lead time (I_{LT})		
Goal: Reduce lead time		
Level of application: Product level, Firm level		
Reporting period: Fiscal year, Six months, Quarter year, Month		
	Absolute (A)	**Relative (R)**
Metrics:	Total number of products produced within the required lead time (#)	Percentage of products produced within the required lead time (%)
Target (T):	The total number of products to be produced as per the production plan (#)	100%
Actual performance (P):	1)-Determine the total number of products produced within the required lead time	1)-Take the total number of products produced within the required lead time 2)-Take the total number of products from customer order or production plan 3)-Apply *[Total number of products produced within the required lead time / Total number of products from customer order or production plan]*100* formula
Evaluation:	WI_{LT} = [PA / TA]	WI_{LT} = [PR / TR]
Interpretation:	WI_{LT} = 1: Sustainable, WI_{LT} < 1: Needs improvement	WI_{LT} = 1: Sustainable, WI_{LT} < 1: Needs improvement
INDICATOR: On-time delivery (I_{OTD})		

Goal: Maintain on-time delivery

Level of application: Product level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total number of products delivered on-time (#)	Percentage of products delivered on-time (%)
Target (T):	The total number products to be sold as per the sales plan (#)	100%
Actual performance (P):	1)-Determine the total number of products delivered on-time during the reporting period	1)-Take the total number of products delivered on-time during the same period 2)-Take the total number of products from customer order or sales plan of the same period 3)-Apply *[Total number of products delivered / Total number of products from customer order or production plan]*100* formula
Evaluation:	WI_{OTD} = [PA / TA]	WI_{OTD} = [PR / TR]
Interpretation:	$WI_{OTD} = 1$: Sustainable, $WI_{OTD} < 1$: Needs improvement	$WI_{OTD} = 1$: Sustainable, $WI_{OTD} < 1$: Needs improvement

Indicator: Energy consumption (I_{EC})

Goal: Reduce energy consumption

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	1-Total electricity consumed (kWh); 2-Total amount of fuel consumed (L, m^3, tonne)	4-Electricity consumption per unit of product produced (kWh/uop); 5-Fuel consumption per unit of product produced (L, m^3, tonne/uop)

Target (T):	The planned electricity demand (kWh) for 1; and the planned fuel demand (L, m^3, tonne) for 2	Electricity consumption per unit of a benchmark product for 4; and fuel consumption per unit of a benchmark product for 5
Actual performance (P):	1)-Determine the total electricity consumed during the reporting period 2)-Determine the total amount of fuel consumed during the same period	1)-Take the total electricity consumed during the same period 2)-Take the total amount of fuel consumed during the same period 3)-Take total number of products produced during the same period 4)-Apply *[Total electricity consumed / Total number of products produced]* formula 5- Apply *[Total amount of fuel consumed / Total number of products produced]* formula
Evaluation:	WI_{EC} = [PA / TA]	WI_{EC} = [PR / TR]
Interpretation:	$WI_{EC} < 0.9$: Sustainable, WI_{EC} = 0.9 to 1: Marginally sustainable, $WI_{EC} > 1$: Needs improvement	$WI_{EC} < 0.9$: Sustainable, WI_{EC} = 0.9 to 1: Marginally sustainable, $WI_{EC} > 1$: Needs improvement

INDICATOR: Energy efficiency (I_{EE})

Goal: Improve energy efficiency

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	******	Ratio of final energy used for production to the total input energy (%)
Target (T):	******	Target energy efficiency (%)

Actual performance (P):	******	1)-Determine the total input energy during the reporting period 2)-Determine the final energy used for manufacturing process, heating, lighting and others during the same period 3) Apply *[Final energy used / Total input energy]*100* formula
Evaluation:	******	WI_{EE} = [PR / TR]
Interpretation:	******	WI_{EE} > 1.1: Sustainable, WI_{EE} = 1 to 1.1: Marginally sustainable, WI_{EE} < 1: Needs improvement

INDICATOR: Material consumption (I_{MtC})

Goal: Reduce material consumption

Level of application: Material level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total weight or volume of materials consumed (kg, m^3, L, m^2, pc)	7-Material consumption per unit of product produced (kg, m^3, L, m^2, pc/uop); 8-Material efficiency (%); 9-Percentage of biodegradable materials used (%); 10-Percentage of renewable materials used (%); 11-Percentage of hazardous materials used (%)
Target (T):	The planned consumption of materials (kg, m^3, L, m^2, pc)	The optimum material consumption per unit of benchmarked product for 7; Target material efficiency (%) for 8; Target percentage of biodegradable materials use (%) for 9; 100% for 10; and 0% for 11

Actual performance (P):	1)-Determine the total weight or volume of materials consumed to produce the product during the reporting period	1)-Take the total weight or volume of materials consumed during the same period 2)-Take the total number of products produced during the same period 3)-Determine the total weight or volume of materials waste during the same period 4)-Determine the total weight or volume of biodegradable materials consumed during the same period 5)-Determine the total weight or volume of renewable materials consumed during the same period 6)-Determine the total weight or volume of hazardous materials consumed during the same period 7)-Apply *[Total weight or volume of materials consumed / Total number of products produced]* formula 8)-Apply [(*Total weight or volume of materials consumed – Total weight or volume of materials waste) / Total weight or volume of materials consumed]*100* formula 9)-Apply *[Total weight or volume of biodegradable materials consumed / Total weight or volume of materials consumed]*100* formula 10)-Apply *[Total weight or volume of renewable materials consumed /*

		*Total weight or volume of materials consumed]*100* formula 11)-Apply *[Total weight or volume of hazardous materials consumed / Total weight or volume of materials consumed]*100* formula
Evaluation:	WI_{MtC} = [PA / TA]	WI_{MtC} = [PR / TR] for TR > 0, and DI_{MtC} = [TR – PR] for TR = 0
Interpretation:	WI_{MtC} < 0.9: Sustainable, WI_{MtC} = 0.9 to 1: Marginally sustainable, WI_{MtC} > 1: Needs improvement	WI_{MC} < 0.9: Sustainable, WI_{MtC} = 0.9 to 1: Marginally sustainable, WI_{MtC} > 1: Needs improvement for 7, 11 and if TR for 11 > 0 DI_{MtC} = 0: Sustainable, DI_{MtC} < 0: Needs improvement for if TR for 11 = 0 WI_{MtC} > 1.1: Sustainable, WI_{MtC} = 1 to 1.1: Marginally sustainable, WI_{MtC} < 1: Needs improvement for 8, 9 WI_{MtC} = 1: Sustainable; WI_{MtC} < 1: Needs improvement for 10

INDICATOR: Recycled material use (I_{RM})

Goal: Increase the use of recycled materials

Level of application: Material level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total weight or volume of recycled materials used (kg, m^3, L, m^2, pc)	Percentage of recycled materials used (%)
Target (T):	The planned consumption of recycled materials (kg, m^3, L, m^2, pc)	Target percentage of recycled materials use (%)

Actual performance (P):	1)-Determine the total weight or volume of recycled materials used during the reported period	1)-Take the total weight or volume of recycled materials used during the same period 2)-Take the total weight or volume of materials consumed during the same period 3)-Apply *[Total weight or volume of recycled materials used / Total weight or volume of materials consumed]*100* formula
Evaluation:	WI_{RM} = [PA / TA]	WI_{RM} = [PR / TR]
Interpretation:	WI_{RM} > 1.1: Sustainable, WI_{RM} = 1 to 1.1: Marginally sustainable, WI_{RM} < 1: Needs improvement	WI_{RM} > 1.1: Sustainable, WI_{RM} = 1 to 1.1: Marginally sustainable, WI_{RM} < 1: Needs improvement

INDICATOR: Employment/Job opportunity (I_{JO})

Goal: Increase employment/job opportunity

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total number of new employees hired (#)	Recruitment efficiency (%)
Target (T):	The total number of new employees to be hired as per the recruitment plan (#)	100%
Actual performance (P):	1)-Determine the total number of new employees hired during the reporting period	1)-Take the total number of new employees hired during the same period 2)-Take the total number of new employees from recruitment plan of the same period

		3)-Apply *[Total number of new employees hired / Total number of new employees from recruitment plan]*100* formula
Evaluation:	WI_{JO} = [PA / TA]	WI_{JO} = [PR / TR]
Interpretation:	$WI_{JO} > 1.1$: Sustainable, $WI_{JO} = 1$ to 1.1: Marginally sustainable, $WI_{JO} <$ 1: Needs improvement	$WI_{JO} > 1$: Sustainable, $WI_{JO} < 1$: Needs improvement

INDICATOR: Fair salary (I_{FS})

Goal: Set fair salary

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	******	Average salary per employee (Euro, USD/emp)
Target (T):	******	The average salary scale of the industry (Euro, USD/emp)
Actual performance (P):	******	1)-Determine the total amount of salary paid during the reporting period 2)-Take the total number of employees during the same period 3)-Apply *[Total amount of salary paid / Total number of employees]* formula
Evaluation:	******	WI_{FS} = [PR / TR]
Interpretation:	******	$WI_{FS} > 1.1$: Sustainable, $WI_{FS} = 1$ to 1.1: Marginally sustainable, $WI_{FS} <$ 1: Needs improvement

INDICATOR: Employee turnover (I_{ET})

Goal: Reduce employee turnover

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total number of employee turnover (#)	Percentage of employee turnover (%)
Target (T):	0	0
Actual performance (P):	1)-Determine the total number of employee turnover during the reporting period	1)-Take the total number of employee turnover during the same period 2)-Take the total number of new employees during the same period 3)-Apply *[Total number of employee turnover / Total number of new employees]*100* formula
Evaluation:	DI_{ET} = [TA – PA] for TA = 0, and WI_{ET} = [PA / TA] for TA > 0	DI_{ET} = [TR – PR] for TR = 0, and WI_{ET} = [PR / TR] for TR > 0
Interpretation:	DI_{ET} = 0: Sustainable, DI_{ET} < 0: Needs improvement for TA = 0 WI_{ET} < 0.9: Sustainable, WI_{ET} = 0.9 to 1: Marginally sustainable, WI_{ET} > 1: Needs improvement in case SMEs set TA > 0	DI_{ET} = 0: Sustainable, DI_{ET} < 0: Needs improvement for TR = 0 WI_{ET} < 0.9: Sustainable, WI_{ET} = 0.9 to 1: Marginally sustainable, WI_{ET} > 1: Needs improvement in case SMEs set TR > 0

INDICATOR: Employee satisfaction (I_{ES})

Goal: Improve employee satisfaction

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total number of employees who reported job satisfaction (#)	Percentage of employees who reported job satisfaction (%)
Target (T):	The total number of employees (#)	100%

	Absolute (A)	Relative (R)
Actual performance (P):	1)-Determine the total number of employees who reported job satisfaction during the reporting period	1)-Take the total number of employees who reported job satisfaction during the same period 2)-Take the total number of employees during the same period 3)-Apply *[Total number of employees who reported job satisfaction / Total number of employees]*100* formula
Evaluation:	WI_{ES} = [PA / TA]	WI_{ES}= [PR / TR]
Interpretation:	WI_{ES} = 1: Sustainable, $WI_{ES} < 1$: Needs improvement	WI_{ES} = 1: Sustainable, $WI_{ES} < 1$: Needs improvement

INDICATOR: Occupational health and safety (I_{OHS})

Goal: Improve occupational health and safety

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	Relative (R)
Metrics:	1-Total number of employees covered by OHS program (#); 2-Total number of fatalities as a result of work-related injuries (#); 3-Total number of fatalities as a result of work-related illnesses (#); 4-Total number of cases of work-related illnesses during the reported period (#)	6-Percentage of employees covered by OHS program (%); 7-Percentage of fatalities as a result of work-related injuries (%); 8-Percentage of fatalities as a result of work-related illnesses (%); 9-Percentage of cases of work-related illnesses (%)
Target (T):	The total number of employees (#) for 1; and 0 for 2, 3, 4	100% for 6; and 0 for 7, 8, 9
Actual performance (P):	1)-Determine the total number of employees covered by OHS program during the reporting period	1)-Take the total number of employees covered by OHS program during the reporting period

	2)-Determine the total number of fatalities as a result of work-related injuries during the same period 3)-Determine the total number of fatalities as a result of work-related illnesses during the same period 4)-Determine the total number of cases of work-related illnesses during the same period	2)-Take the total number of fatalities as a result of work-related injuries during the same period 3)-Take the total number of fatalities as a result of work-related illnesses during the same period 4)-Take the total number of cases of work-related illnesses during the same period 5)-Take the total number of employees during the same period 6)-Apply *[Total number of employees covered by OHS program / Total number of employees]*100* formula 7)-Apply *[Total number of fatalities as a result of work-related injuries / Total number of employees]*100* formula 8)-Apply *[Total number of fatalities as a result of work-related illnesses / Total number of employees]*100* formula 9)-Apply *[Total number of cases work-related illnesses / Total number of employees]*100* formula
Evaluation:	WI_{OHS} = [PA / TA] for TA > 0, and DI_{OHS} = [TA – PA] for TA = 0	WI_{OHS} = [PR / TR] for TR > 0, and DI_{OHS} = [TR – PR] for TR = 0
Interpretation:	WI_{OHS} = 1: Sustainable, WI_{OHS} < 1: Needs improvement for l	WI_{OHS} = 1: Sustainable, WI_{OHS} < 1: Needs improvement for 6

	$DI_{OHS} = 0$: Sustainable, $DI_{OHS} < 0$: Needs improvement for 2, 3, 4	$DI_{OHS} = 0$: Sustainable, $DI_{OHS} < 0$: Needs improvement for 7, 8, 9
INDICATOR: Training and development (I_{TD})		
Goal: Improve training and development		
Level of application: Firm level		
Reporting period: Fiscal year, Six months, Quarter year, Month		
	Absolute (A)	**Relative (R)**
Metrics:	1-Total number of total employees who received a regular performance and career development (PCD) review (#); 2-Total training hours (h)	4-Percentage of employees who received a regular PCD review (%); 5-Average training hours per employee (h/emp)
Target (T):	The total number of employees to receive PCD review as per the training and development plan (#) for 1; and the planned training hours (h) for 2	Target percentage of employees to receive a regular PCD review (%) for 4; and the planned training hours per employee for 5
Actual performance (P):	1)-Determine the total number of total employees who received a regular performance and career development review during the same period 2)-Determine the total training hours of the employees during the reporting period	1)-Take the total number of total employees who received a regular performance and career development review during the same period 2)-Take the total training hours of the employees during the same period 3)-Take the total number of employees during the same period 4)-Apply *[Total number of total employees who received a regular performance and career development review / Total number of employees]*100* formula

		5)-Apply *[Total training hours / Total number of employees]* formula
Evaluation:	WI_{TD} = [PA / TA]	WI_{TD} = [PR / TR]
Interpretation:	$WI_{TD} > 1.1$: Sustainable, $WI_{TD} = 1$ to 1.1: Marginally sustainable, $WI_{TD} < 1$: Needs improvement for 1, 2	$WI_{TD} > 1.1$: Sustainable, $WI_{TD} = 1$ to 1.1: Marginally sustainable, $WI_{TD} < 1$: Needs improvement for 4, 5

INDICATOR: Working conditions (I_{WC})

Goal: Improve working conditions

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total number of employees working in decent conditions (#)	Percentage of employees working in decent conditions (%)
Target (T):	The total number of employees (#)	100%
Actual performance (P):	1)-Determine the total number of employees working in decent conditions during the reporting period	1)-Take the total number of employees working in decent conditions during the same period 2)-Take the total number of employees during the same period 3)-Apply *[Total number of employees working in decent conditions / Total number of employees]*100* formula
Evaluation:	WI_{WC} = [PA / TA]	WI_{WC} = [PR / TR]
Interpretation:	$WI_{WC} = 1$: Sustainable, $WI_{WC} < 1$: Needs improvement	$WI_{WC} = 1$: Sustainable, $WI_{WC} < 1$: Needs improvement

INDICATOR: Work-related injuries (I_{WI})

Goal: Reduce work-related injuries

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**

Metrics:	Total number of work-related injuries (#)	Work-related injuries per employee (#/emp)
Target (T):	0	0
Actual performance (P):	1)-Determine the total number of work-related injuries during the reporting period	1)-Take the total number of work-related injuries during the same period 2)-Take the total number of employees during the same period 3)-Apply *[Total number of work-related injuries / Total number of employees]* formula
Evaluation:	$DI_{WI} = [TA – PA]$	$DI_{WI} = [TR – PR]$
Interpretation:	$DI_{WI} = 0$: Sustainable, $DI_{WI} < 0$: Needs improvement	$DI_{WI} = 0$: Sustainable, $DI_{WI} < 0$: Needs improvement

INDICATOR: Working hours (I_{WH})

Goal: Increase working hours

Level of application: Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total working hours (h)	Average working hours per employee (h/emp)
Target (T):	The planned working hours of employees (h)	8*the total working days (h/emp)
Actual performance (P):	1)-Determine the total working hours of employees during the reporting period	1)-Take the total working hours of employees during the same period 2)-Take the total number of employees during the same period 3)-Apply *[Total working hours of employees / Total number of employees]* formula
Evaluation:	$WI_{WH} = [PA / TA]$	$WI_{WH} = [PR / TR]$

Interpretation:	$WI_{WH} > 1.1$: Sustainable, $WI_{WH} = 1$ to 1.1: Marginally sustainable, $WI_{WH} < 1$: Needs improvement	$WI_{WH} > 1.1$: Sustainable, $WI_{WH} = 1$ to 1.1: Marginally sustainable, $WI_{WH} < 1$: Needs improvement
INDICATOR: Lost working days (I_{LWD})		
Goal: Reduce lost working days		
Level of application: Firm level		
Reporting period: Fiscal year, Six months, Quarter year, Month		
	Absolute (A)	**Relative (R)**
Metrics:	Total lost working days due to injuries and illnesses (day)	Percentage of lost working days due to injuries and illnesses (%)
Target (T):	0	0
Actual performance (P):	1)-Determine the total lost working days of employees due to injuries and illnesses during the reporting period	1)-Take the total lost working days of employees due to injuries and illnesses during the same period 2)-Determine total working days of employees 3)-Apply *[Total lost working days of employees due to injuries and illnesses / Total working days of employees]* formula
Evaluation:	$DI_{LWD} = [TA – PA]$ for $TA = 0$, and $WI_{LWD} = [PA / TA]$ for $TA > 0$	$DI_{LWD} = [TR – PR]$ for $TR = 0$, and $WI_{LWD} = [PR / TR]$ for $TR > 0$
Interpretation:	$DI_{LWD} = 0$: Sustainable, $DI_{LWD} < 0$: Needs improvement for $TA = 0$ $WI_{LWD} < 0.9$: Sustainable, $WI_{LWD} = 0.9$ to 1: Marginally sustainable, $WI_{LWD} > 1$: Needs improvement in case SMEs set $TA > 0$	$DI_{LWD} = 0$: Sustainable, $DI_{LWD} < 0$: Needs improvement for $TR = 0$ $WI_{LWD} < 0.9$: Sustainable, $WI_{LWD} = 0.9$ to 1: Marginally sustainable, $WI_{LWD} > 1$: Needs improvement in case SMES set $TR > 0$
INDICATOR: Customer health and safety (I_{CHS})		
Goal: Improve customer health and safety		

Level of application: Product level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	Relative (R)
Metrics:	Total number of incidents concerning the health and safety impacts of products and services provided (#)	Customer health and safety incidents per unit of product sold (#/uop)
Target (T):	0	0
Actual performance (P):	1)-Determine the total number of incidents concerning the health and safety impacts of products and services provided during the reporting period	1)-Take the total number of incidents concerning the health and safety impacts of products and services provided during the same period 2)-Take the total number of products sold during the same period 3)-Apply *[Total number of incidents concerning the health and safety impacts of products and services provided / Total number of products sold]* formula
Evaluation:	$DI_{CHS} = [TA – PA]$	$DI_{CHS} = [TR – PR]$
Interpretation:	$DI_{CHS} = 0$: Sustainable, $DI_{CHS} < 0$: Needs improvement	$DI_{CHS} = 0$: Sustainable, $DI_{CHS} < 0$: Needs improvement

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INDICATOR: Customer satisfaction (I_{CS})

Goal: Improve customer satisfaction

Level of application: Product level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	Relative (R)
Metrics:	Total number of customers who reported satisfaction with products and services offered (#)	Percentage of customers who reported satisfaction with products and services offered (%)
Target (T):	The total number of customers (#)	100%

Actual performance (P):	1)-Determine the total number of customers who reported satisfaction with the products and services offered during the reporting period	1)-Take the total number of customers who reported satisfaction with the products and services offered during the same period 2)-Take the total number of customers during the same period 3)-Apply *[Total number of customers who reported satisfaction with the products and services offered / Total number of customers]*100* formula
Evaluation:	WI_{CS} = [PA / TA]	WI_{CS} = [PR / TR]
Interpretation:	WI_{CS} = 1: Sustainable; WI_{CS} < 1: Needs improvement	WI_{CS} = 1: Sustainable; WI_{CS} < 1: Needs improvement

INDICATOR: Customer complaints (I_{CC})

Goal: Reduce customer complaints

Level of application: Product level, Firm level

Reporting period: Fiscal year, Six months, Quarter year, Month

	Absolute (A)	**Relative (R)**
Metrics:	Total number of customer complaints (#)	Customer complaints per unit of product sold (#/uop)
Target (T):	0	0
Actual performance (P):	1)-Determine the total number of customer complaints during the reporting period	1)-Take the total number of customer complaints during the same period 2)-Take the total number of products sold during the same period 3)-Apply *[Total number of customer complaints / Total number of products sold]* formula
Evaluation:	DI_{CC} = [TA – PA]	DI_{CC} = [TR – PR]

Interpretation:	$DI_{CC} = 0$: Sustainable, $DI_{CC} < 0$: Needs improvement	$DI_{CC} = 0$: Sustainable, $DI_{CC} < 0$: Needs improvement

Table 16 presents a summary of the selected indicators with their respective metrics. As shown in the table, a total of 16 metrics were defined for economic sustainability indicators (4 metrics for indicators related to financial benefits, 4 metrics for indicators related to costs, and 8 metrics for indicators related to market competitiveness). For the environmental sustainability indicators, a total of 13 metrics were considered (5 metrics for indicators associated with resources: energy and 8 metrics for indicators associated with resources: materials). In addition, a total of 33 metrics were identified for the social sustainability indicators (25 metrics for indicators linked to employees, 6 metrics for indicators linked to customers, and 2 metrics for indicators linked to community).

Table 16. Summary of the selected indicators with their respective metrics

Sustainability dimensions	**Categories**	**Indicators**	**Metrics**
Economic	Financial benefits	Profit	Net profit gained (Euro, USD)
			Net profit to total revenue ratio (%)
		Revenue	Total revenue generated (Euro, USD)
			Revenue generated per unit of product sold (Euro, USD/uop)
	Costs	Material cost	Total material cost (Euro, USD)
			Percentage of material cost relative to total revenue (%)
		Labor cost	Total labor cost (Euro, USD)
			Percentage of labor cost relative to total revenue (%)
	Market competitiveness	R&D expenditure	R&D spending (Euro, USD)
			R&D spending to total revenue ratio (%)
		Product quality	Total number of products that met customer requirements (#)
			Percentage of products that met customer requirements (%)
		Lead time	Total number of products produced within the required lead time (#)

Sustainability dimensions	Categories	Indicators	Metrics
			Percentage of products produced within the required lead time (%)
		On-time delivery	Total number of products delivered on-time (#)
			Percentage of products delivered on-time (%)
Environmental	Resources (energy)	Energy consumption	Total electricity consumed (kWh)
			Total amount of fuel consumed (L, m^3, tonne)
			Electricity consumption per unit of product produced (kWh/uop)
			Fuel consumption per unit of product produced (L, m^3, tonne/uop)
		Energy efficiency	Ratio of final energy used for production to the total input energy (%)
	Resources (materials)	Material consumption	Total weight or volume of materials consumed (kg, m^3, L, m^2, pc)
			Material consumption per unit of product produced (kg, m^3, L, m^2, pc /uop)
			Material efficiency (%)
			Percentage of biodegradable materials used (%)
			Percentage of renewable materials used (%)
			Percentage of hazardous materials used (%)
		Recycled materials use	Total weight or volume of recycled materials used (kg, m^3, L, m^2, pc)
			Percentage of recycled materials used (%)
Social	Employees	Fair salary	Average salary per employee (Euro, USD/emp)
		Employee turnover	Total number of employee turnover (#)
			Percentage of employee turnover (%)
		Employee satisfaction	Total number of employees who reported job satisfaction (#)
			Percentage of employees who reported job satisfaction (%)
		Occupational health and safety	Total number of employees covered by OHS program (#)
			Total number of fatalities as a result of work-related injuries (#)

Sustainability dimensions	Categories	Indicators	Metrics
			Total number of fatalities as a result of work-related illnesses (#)
			Total number of cases of work-related illnesses (#)
			Percentage of employees covered by OHS program (%)
			Percentage of fatalities as a result of work-related injuries (%)
			Percentage of fatalities as a result of work-related illnesses (%)
			Percentage of cases of work-related illnesses (%)
		Training and development	Total number of total employees who received a regular PCD review (#)
			Total training hours (h)
			Percentage of employees who received a regular PCD review (%)
			Average training hours per employee (h/emp)
		Working conditions	Total number of employees working in decent conditions (#)
			Percentage employees working in decent conditions (%)
		Work-related injuries	Total number of work-related injuries (#)
			Work-related injuries per employee (#/emp)
		Working hours	Total working hours (h)
			Average working hours per employee (h/emp)
		Lost working days	Total lost working days due to injuries and illnesses (day)
			Percentage of lost working days due to injuries and illnesses (%)
	Customers	Customer health and safety	Total number of incidents concerning the health and safety impacts of products and services provided (#)
			Customer health and safety incidents per unit of product sold (#/uop)
		Customer satisfaction	Total number of customers who reported satisfaction with products and services offered (#)

Sustainability dimensions	Categories	Indicators	Metrics
			Percentage of customers who reported satisfaction with products and services offered (%)
		Customer complaints	Total number of customer complaints (#) Customer complaints per unit of product sold (#/uop)
	Community	Employment/Job opportunity	Total number of new employees hired (#) Recruitment efficiency (%)

5.4 Applicability of the metrics in footwear firms: within-case analysis

The empirical analysis of RQ2 focuses primarily on the metrics since they are the crucial aspects of the framework (i.e., the pillars to carry out the main functions of the framework: measurement, evaluation and interpretation of sustainability performance). Hence, supporting the applicability of the metrics[5] with empirical evidence will be helpful to effectively apply the selected indicators in SMEs using the framework. Table 17 presents the list of footwear firms (SMEs) involved in assessing the applicability of the metrics.

Table 17. List of firms involved in assessing the applicability of the metrics

Firms[6]	Year of establishment	Number of employees	Market segment
A	1947	172	Local and export
B	1987	86	Local and export
C	1975	40	Local
D	1960	76	Local and export
E	1959	44	Local and export
F	1947	53	Local and export

The results of the empirical analysis on applicability metrics to each firm are described as follows:

[5] In the present research, metrics refer to quantifiable measures of sustainability performance. And, indicators refer to performance measures used to measure progress towards achieving sustainability goals. An indicator consists of one or more metrics to be measurable.
[6] The letters A, B, C, D, E, and F were used to represent the six firms from which empirical evidence regarding the applicability of the metrics was collected, as the names of the firms should remain anonymous.

Applicability of the metrics in firm A

Metrics for economic dimension	Metrics for environmental dimension	Metrics for social dimension
All the metrics mentioned in Table 12 were found to be applicable to firm A, except: • Revenue generated per unit of product sold (Euro, USD/uop)	All the metrics mentioned in Table 13 were applicable, except the following: • Total electricity consumed (kWh) • Total amount of fuel consumed (L, m^3, tonne) • Electricity consumption per unit of product produced (kWh/uop) • Fuel consumption per unit of product produced (L, m^3, tonne/uop) • Ratio of final energy used for production to the total input energy (%) • Material consumption per unit of product produced (kg, m^3, L, m^2, pc /uop)	All the metrics mentioned in Table 14 were applicable to this firm.

The empirical analysis revealed that the vast majority of the metrics (i.e., 55 metrics out of 62) were found to be useful and applicable to firm A to measure its sustainability performance. Out of these applicable metrics, 31 metrics are currently used by this firm and the remaining 24 metrics are contributed to firm A by this research. As shown in Figure 10, firm A currently uses 12 metrics for measuring the economic sustainability performance related to financial benefits, costs, and market competitiveness, and 3 metrics associated with market competitiveness were found to be applicable in the future. Furthermore, a total of 7 metrics were useful and applicable for measuring the environmental sustainability performance linked to resources (materials); out of which, 2 metrics are currently used by this firm. It is also seen that firm A currently uses 17 metrics for measuring the social sustainability performance related to employees, customers, and the community, and 16 metrics linked to employees and customers were considered to be applicable in the future.

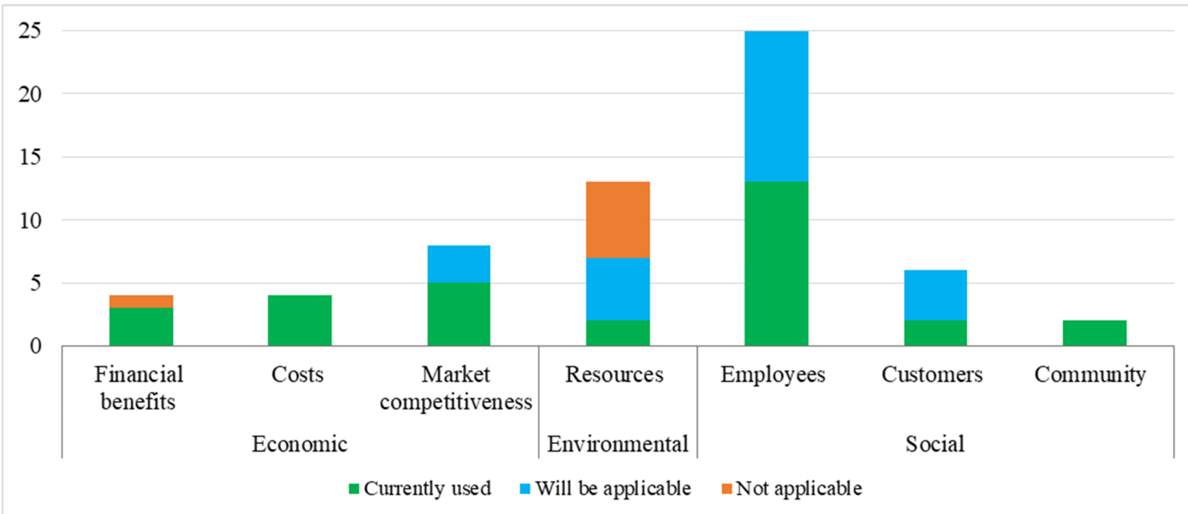

Figure 10. Applicability of metrics in firm A by category

Applicability of the metrics in firm B

Metrics for economic dimension

All the metrics were applicable to firm B, except the following:

- Revenue generated per unit of product sold (Euro, USD/uop)
- Percentage of material cost relative to total revenue (%)
- Percentage of labor cost relative to total revenue (%)

Metrics for environmental dimension

All the metrics were found to be applicable, except the following:

- Total electricity consumed (kWh)
- Total amount of fuel consumed (L, m^3, tonne)
- Electricity consumption per unit of product produced (kWh/uop)

Metrics for social dimension

All the metrics were applicable to this firm, except the following:

- Total number of employee turnover (#)
- Customer health and safety incidents per unit of product sold (#/uop)

- Total number of products that met customer requirements (#)
- Total number of products produced within the required lead time (#)
- Fuel consumption per unit of product produced (L, m^3, tonne/uop)
- Ratio of final energy used for production to the total input energy (%)
- Material efficiency (%)

In the case of firm B, 49 metrics out of 62 were useful and applicable. Of these applicable metrics, 22 metrics are being used by this firm and the additional 27 metrics are provided to firm B by this research. From Figure 11, it is seen that a total of 11 metrics were found to be useful and applicable to firm B for measuring the economic sustainability performance associated with financial benefits, costs, and market competitiveness; from which, 3 metrics related to financial benefits and market competitiveness were considered to be applicable in the future. Moreover, this firm currently uses 2 metrics for measuring the environmental sustainability performance related to resources (materials), and 5 metrics were applicable in the future. In addition, 31 metrics were useful and applicable for measuring the social sustainability performance related to employees, customers, and the community; out of which, 12 metrics related to employees and customers are currently used by firm B.

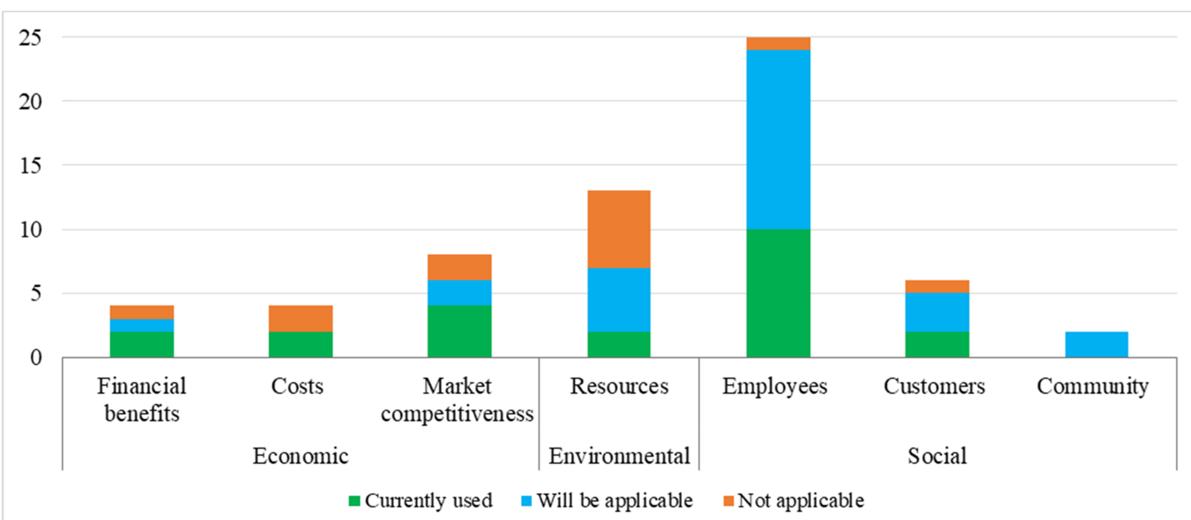

Figure 11. Applicability of metrics in firm B by category

Applicability of the metrics in firm C

Metrics for economic dimension	Metrics for environmental dimension	Metrics for social dimension
All the metrics were found to be applicable to firm C	All the metrics were applicable, except the following metrics: • Total electricity consumed (kWh) • Total amount of fuel consumed (L, m^3, tonne) • Electricity consumption per unit of product produced (kWh/uop) • Fuel consumption per unit of product produced (L, m^3, tonne/uop) • Ratio of final energy used for production to the total input energy (%) • Material consumption per unit of product produced (kg, m^3, L, m^2, pc /uop) • Material efficiency (%) • Percentage of biodegradable materials used (%) • Percentage of hazardous materials used (%)	All the metrics were applicable to this firm, except the following: • Recruitment efficiency (%)

The overwhelming majority of the metrics (i.e., 52 out of 62) were found to be useful and applicable to firm C. Out of these relevant metrics, 20 metrics are currently used by this firm and this research contributes the remaining 32 metrics that can be applied by firm C for measuring its sustainability performance. As can be seen in Figure 12, a total of 16 metrics were useful and applicable to firm C for measuring the economic sustainability performance linked to financial benefits, costs, and market competitiveness; of which, 8 metrics are currently used by this firm. It also seen that firm C currently uses 3 metrics for measuring the environmental sustainability performance associated with resources (materials), and 1 metric was found to be applicable in the future. Additionally, 32 metrics were useful and applicable for measuring the social sustainability performance linked to employees, customers, and the community; from which, 9 metrics associated with employees and customers are currently used by this firm.

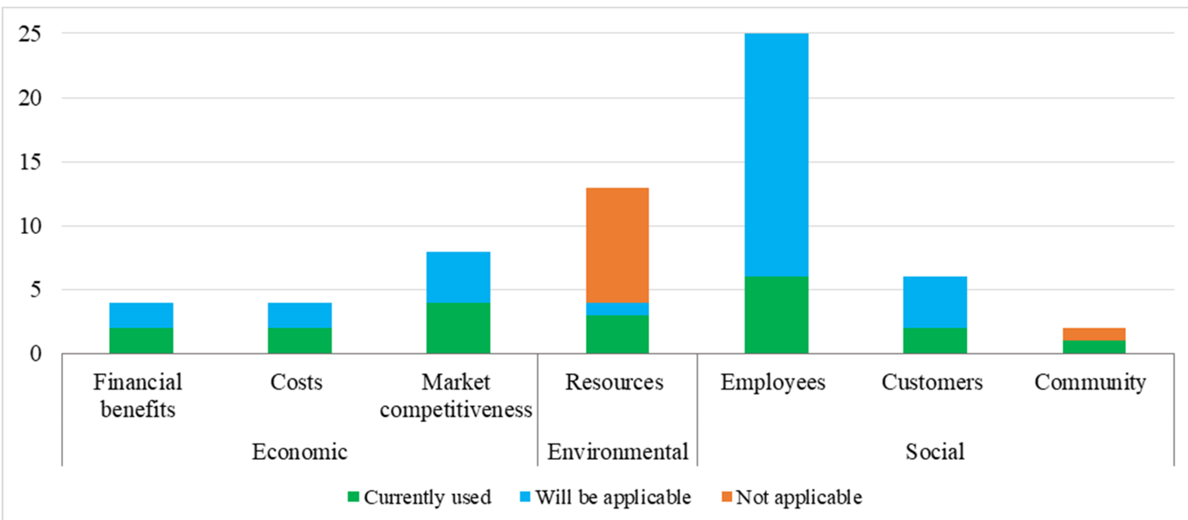

Figure 12. Applicability of metrics in firm C by category

Applicability of the metrics in firm D

Metrics for economic dimension

All the metrics were applicable to firm D, except the following:

- Revenue generated per unit of product sold (Euro, USD/uop)

Metrics for environmental dimension

All the metrics were found to be applicable, except the following:

- Total electricity consumed (kWh)

Metrics for social dimension

All the metrics were applicable to this firm, except the following:

- Total number of new employees hired (#)
- Recruitment efficiency (%)

- Total amount of fuel consumed (L, m^3, tonne)
- Electricity consumption per unit of product produced (kWh/uop)
- Fuel consumption per unit of product produced (L, m^3, tonne/uop)
- Ratio of final energy used for production to the total input energy (%)
- Material efficiency (%)
- Percentage of biodegradable materials used (%)

- Total number of employees covered by the OHS program (#)
- Percentage of employees covered by OHS program (%)
- Total number of employees who received a regular PCD review (#)
- Total number of employees working in decent conditions (#)
- Percentage of employees working in decent conditions (%)
- Total lost working days due to injuries and illnesses (day)
- Percentage of lost working days due to injuries and illnesses (%)

For firm D, 45 metrics out of 62 were useful and applicable. From these applicable metrics, 40 metrics are being used by this firm and this research provides the additional 5 metrics that can be applied by firm D to measure its sustainability performance. As shown in Figure 13, firm D currently uses 15 metrics for measuring the economic sustainability performance related to financial benefits, costs, and market competitiveness. In addition, a total of 6 metrics are currently used by this firm for measuring the environmental sustainability performance linked to resources (materials). It is also seen that firm D currently uses 19 metrics for measuring the social sustainability performance related to employees and customers, and 5 metrics linked to employees were considered to be applicable in the future.

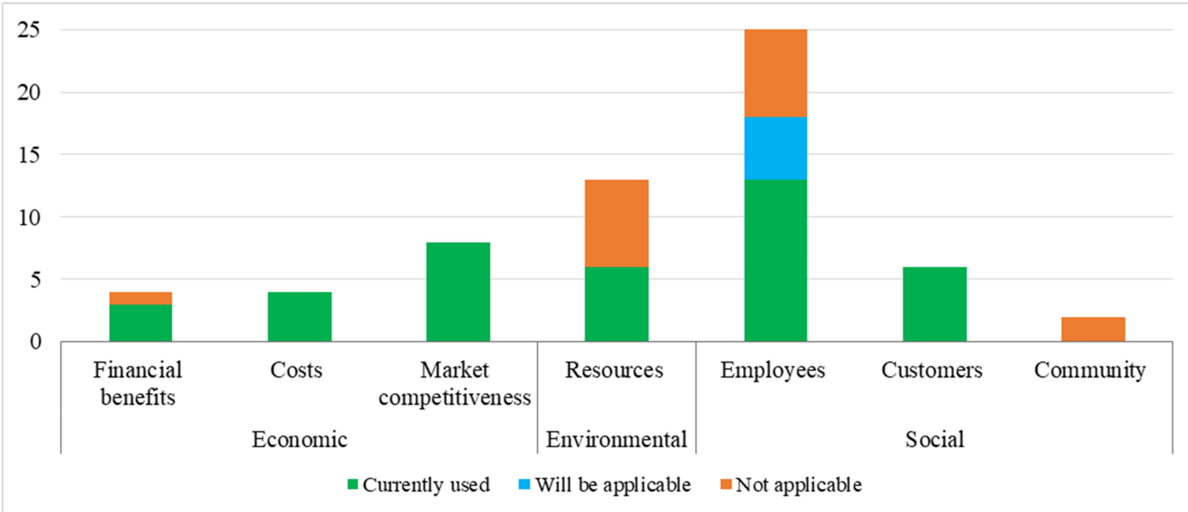

Figure 13. Applicability of metrics in firm D by category

Applicability of the metrics in Firm E

Metrics for economic dimension

All the metrics were found to be applicable to Firm E.

Metrics for environmental dimension

All the metrics were applicable, except the following metrics:

- Total electricity consumed (kWh)
- Total amount of fuel consumed (L, m^3, tonne)
- Electricity consumption per unit of product produced (kWh/uop)
- Fuel consumption per unit of product produced (L, m^3, tonne/uop)
- Ratio of final energy used for production to the total input energy (%)

Metrics for social dimension

All the metrics were applicable to this firm, except the following:

- Total number of employees working in decent conditions (#)
- Percentage of employees working in decent conditions (%)

- Material consumption per unit of product produced (kg, m^3, L, m^2, pc /uop)
- Percentage of biodegradable materials used (%)
- Percentage of renewable materials used (%)
- Percentage of hazardous materials used (%)
- Total weight or volume of recycled materials used (kg, m^3, L, m^2, pc)
- Percentage of recycled materials used (%)

The majority of the metrics (i.e., 49 metrics out of 62) were found to be useful and applicable to firm E. Out of these relevant metrics, 33 metrics are currently used by this firm and the remaining 16 metrics are provided to firm E by this research. From Figure 14, it is seen that a total of 16 metrics were found to be useful and applicable to firm E for measuring the economic sustainability performance associated with financial benefits, costs, and market competitiveness; from which, 5 metrics related to financial benefits and market competitiveness were considered to be applicable in the future. In addition, this firm currently uses 2 metrics for measuring the environmental sustainability performance related to resources (materials). Furthermore, 31 metrics were useful and applicable for measuring the social sustainability performance related to employees, customers, and the community; out of which, 20 metrics related to employees and customers are currently used by firm E.

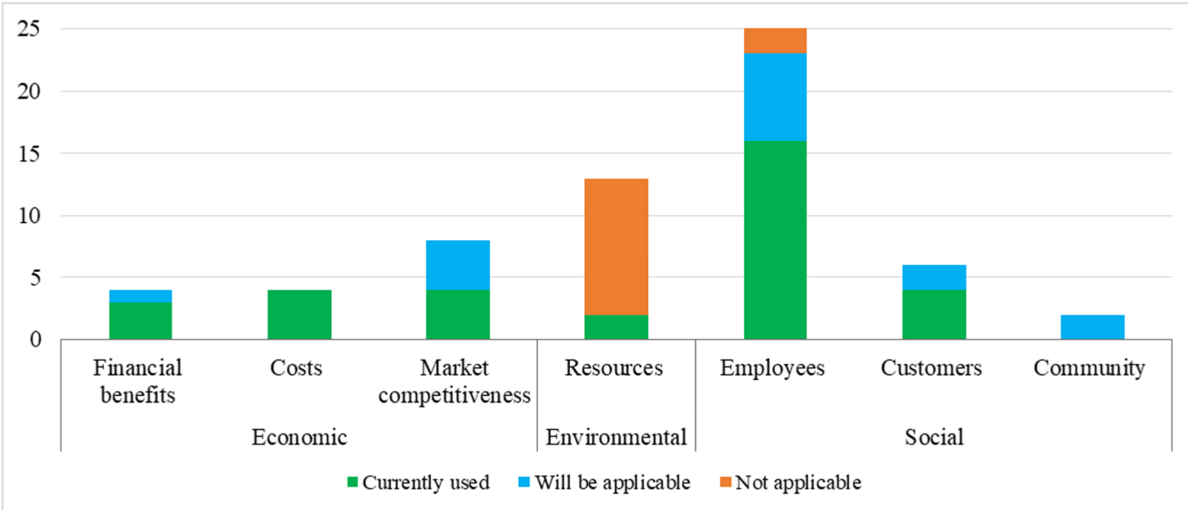

Figure 14. Applicability of metrics in firm E by category

Applicability of the metrics in firm F

Metrics for economic dimension

All the metrics were applicable to firm F, except the following:

- Revenue generated per unit of product sold (Euro, USD/uop)

Metrics for environmental dimension

All the metrics were found to be applicable, except the following:

- Total electricity consumed (kWh)
- Total amount of fuel consumed (L, m^3, tonne)
- Electricity consumption per unit of product produced (kWh/uop)
- Fuel consumption per unit of product produced (L, m^3, tonne/uop)
- Ratio of final energy used for production to the total input energy (%)

Metrics for social dimension

All the metrics were applicable to this firm.

- Material consumption per unit of product produced (kg, m^3, L, m^2, pc /uop)

In the case of firm F, 55 metrics out of 62 were useful and applicable. Of these applicable metrics, 31 metrics are being used by this firm and the additional 24 metrics are contributed to firm F by this research. As can be seen in Figure 15, a total of 15 metrics were useful and applicable to firm F for measuring the economic sustainability performance linked to financial benefits, costs, and market competitiveness; of which, 4 metrics related to market competitiveness are currently used by this firm. It is also seen that firm F currently uses 4 metrics for measuring the environmental sustainability performance associated with resources (materials), and 3 metrics were found to be applicable in the future. Moreover, 33 metrics were useful and applicable for measuring the social sustainability performance linked to employees, customers, and the community; from which, 16 metrics associated with employees, customers, and the community are currently used by this firm.

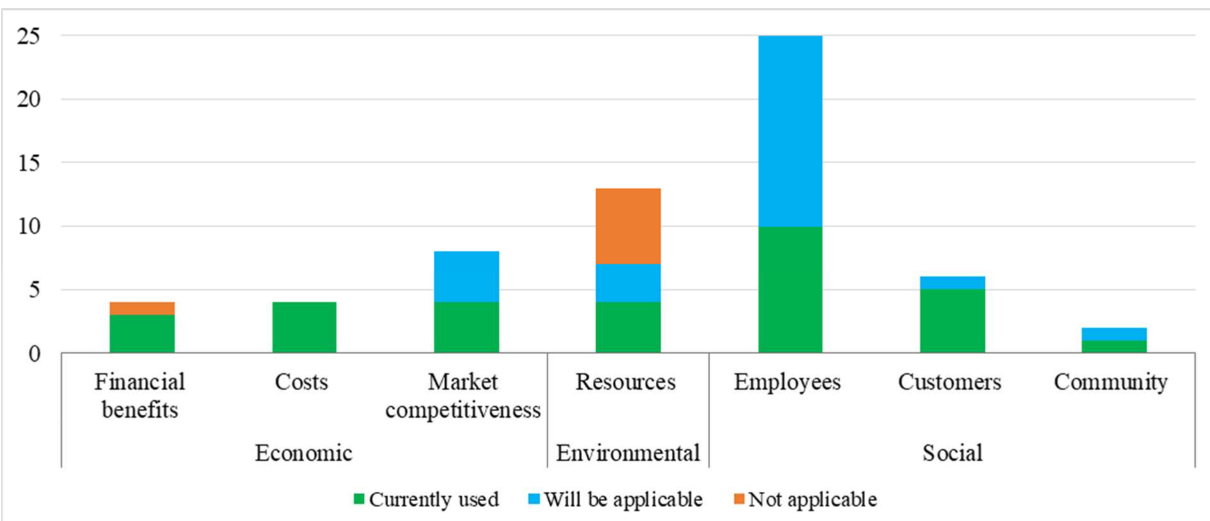

Figure 15. Applicability of metrics in firm F by category

5.5 Applicability of the metrics across footwear firms: cross-case analysis

The cross-case analysis was conducted mainly to identify the metrics applicable across the footwear firms (SMEs). These metrics can be considered as core metrics used across the footwear SMEs for measuring and managing sustainability performance.

5.5.1 Economic metrics applicable across footwear firms

All the 16 metrics defined for the economic dimension were found to be applicable across at least two footwear firms (SMEs) for measuring and managing the economic sustainability performance associated with economic benefits, costs, and market competitiveness. Of these metrics, 11 metrics were applicable across all six firms, as seen in Figure 16.

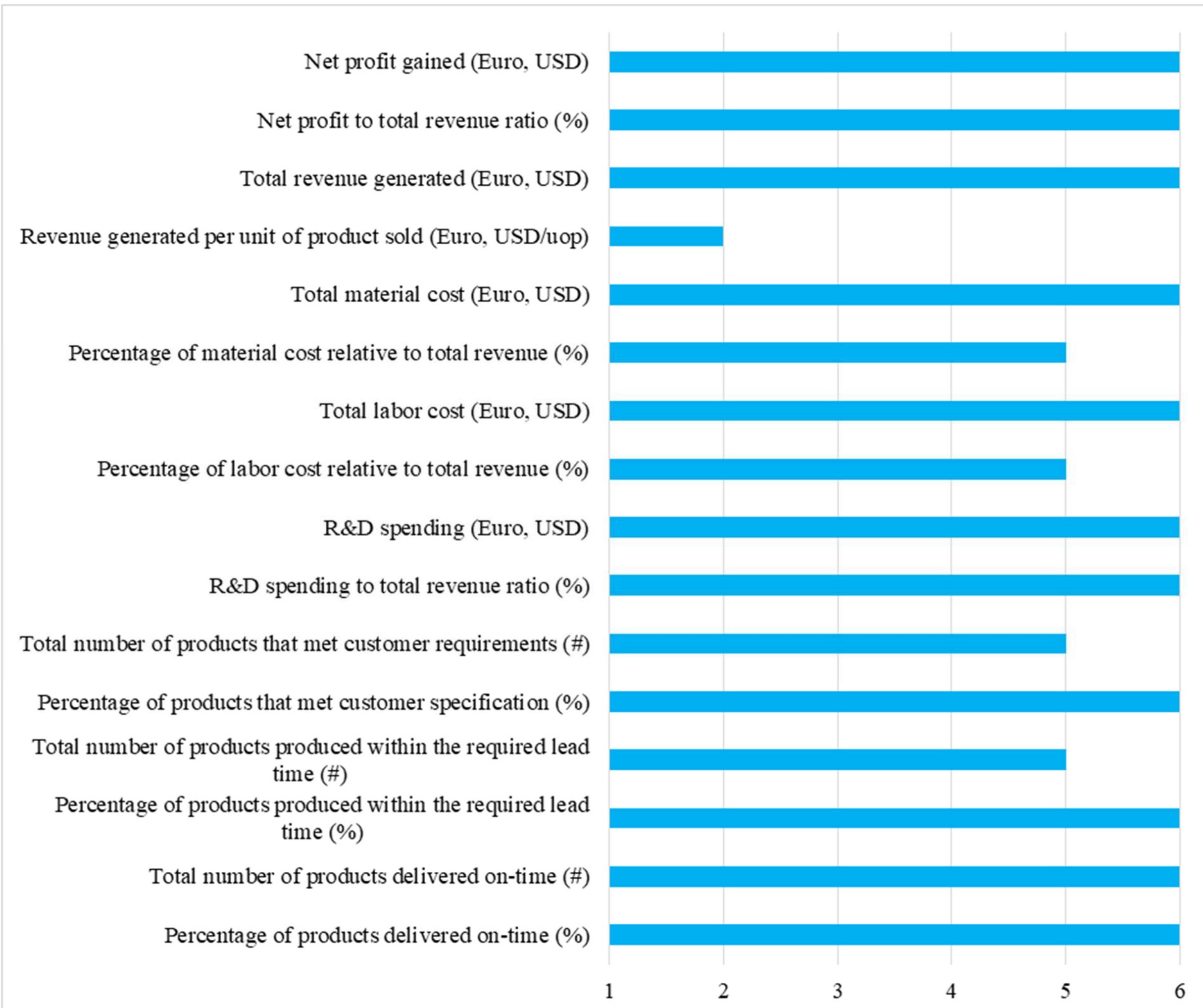

Figure 16. Economic metrics applicable across the firms

5.5.2 Environmental metrics applicable across footwear firms

As shown in Figure 17, the environmental metrics related to the effective utilization of materials were applicable across at least three firms (SMEs) for measuring and managing the environmental sustainability performance. From these metrics, the total weight or volume of materials consumed (kg, m^3, L, m^2, pc) were applicable across all six firms.

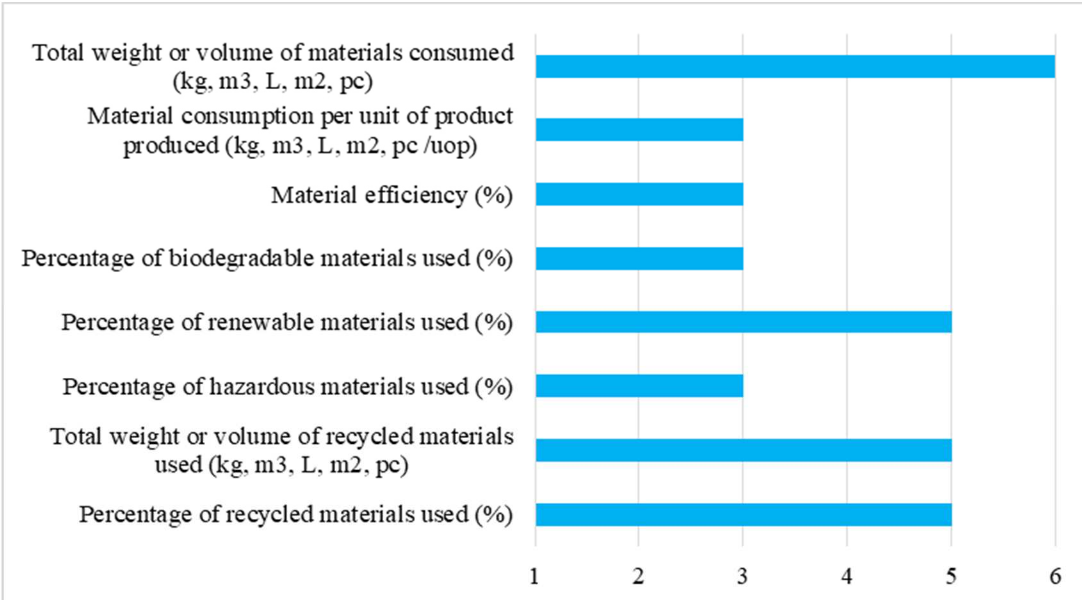

Figure 17. Environmental metrics applicable across the firms

5.5.3 Social metrics applicable across footwear firms

As can be seen in Figure 18, all the 33 metrics defined for the social dimension were found to be applicable across at least four firms for measuring and managing the social sustainability performance linked to employees, customers, and the community. Out of these metrics, 22 metrics were found to be applicable across all six firms.

Figure 18. Social metrics applicable across the firms

Table 18 summarizes the common (core) economic, environmental, and social metrics, which were found to be applicable across all six firms after the cross-case analysis.

Table 18. Common metrics (core metrics) applicable across all six firms

Sustainability dimensions	Common metrics (core metrics)
Economic	Net profit gained (Euro, USD)
	Net profit to total revenue ratio (%)
	Total revenue generated (Euro, USD)
	Total material cost (Euro, USD)
	Total labor cost (Euro, USD)
	R&D spending (Euro, USD)
	R&D spending to total revenue ratio (%)
	Percentage of products that met customer requirements (%)
	Percentage of products produced within the required lead time (%)
	Total number of products delivered on-time (#)
	Percentage of products delivered on-time (%)
Environmental	Total weight or volume of materials consumed (kg, m^3, L, m^2, pc)
Social	Average salary per employee (Euro, USD/emp)
	Percentage of employee turnover (%)
	Total number of employees who reported job satisfaction (#)
	Percentage of employees who reported job satisfaction (%)
	Total number of fatalities as a result of work-related injuries (#)
	Total number of fatalities as a result of work-related illnesses (#)
	Total number of cases of work-related illnesses (#)
	Percentage of fatalities as a result of work-related injuries (%)
	Percentage of fatalities as a result of work-related illnesses (%)
	Percentage of cases of work-related illnesses (%)
	Total training hours (h)
	Percentage of employees who received a regular PCD review (%)
	Average training hours per employee (h/emp)
	Total number of work-related injuries (#)
	Work-related injuries per employee (#/emp)
	Total working hours (h)
	Average working hours per employee (h/emp)
	Total number of incidents concerning the health and safety impacts of products and services provided (#)

Sustainability dimensions	Common metrics (core metrics)
	Total number of customers who reported satisfaction with products and services offered (#)
	Percentage of customers who reported satisfaction with products and services offered (%)
	Total number of customer complaints (#)
	Customer complaints per unit of product sold (#/uop)

Chapter Six

6 Discussion and conclusions, implications, and limitations

6.1 Discussion and conclusions

This research provides specifically for Italian footwear SMEs a set of suitable indicators and a tailored framework to measure and manage the economic, environmental, and social sustainability performance. To achieve this, a comprehensive methodological approach was applied, which includes (1) conducting an in-depth analysis of sustainability indicators available in the literature using a systematic review (Ahi and Searcy, 2015; Ahmad, Wong, and Rajoo, 2019; Feil et al., 2019), (2) carrying out an empirical study to select and prioritize the indicators by applying the FDM (Lin et al., 2019; Lu et al., 2006; Mengistu and Panizzolo, 2022b) and (3) developing a framework, based on previous research (Veleva and Ellenbecker, 2001) and sustainability standards and guidelines (GRI, 2016; ISO, 2021), to put the selected indicator into practice in the context of Italian footwear SMEs.

The results of the literature analysis indicate that the majority of the indicators available in the literature (i.e., 85% of the indicators identified in the reviewed literature) have only been used once, showing a lack of consistency in the use of indicators (i.e., the lack of consensus on a single set of indicators) for measuring sustainability performance in various manufacturing industry contexts (Ahi and Searcy, 2015; Ahmad, Wong, and Rajoo, 2019). On the other hand, a few of the indicators were consistently and frequently used in the reviewed literature. These indicators can be considered as potential indicators for measuring industrial sustainability performance due to their high consistency and frequency of use.

The results of the empirical analysis indicate that out of 1013 indicators identified in the reviewed literature, 25 indicators (i.e., 8 for the economic sustainability dimension, 4 for the environmental sustainability dimension, and 13 for the social sustainability dimension) were found to be more suitable for Italian footwear SMEs to measure their sustainability performance. The 25 selected indicators emphasized measuring industrial sustainability performance associated with financial benefits, costs, and market competitiveness for the economic sustainability dimension; resources for the environmental sustainability dimension; and employees, customers, and the community for the social sustainability dimension.

Product quality, material consumption, and customer satisfaction were given a higher priority than other selected economic, environmental, and social sustainability indictors, respectively. As customers want to play a significant role in the transition towards a sustainable lifestyle, SMEs need to respond by producing sustainable products (eco-friendly products). The use of renewable materials, eco-friendly and biodegradable materials, and non-hazardous materials for production promotes product quality in terms of a sustainable product.

To measure the economic sustainability performance of SMEs, 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. Product quality, on-time delivery, and lead time are crucial to ensure market competitiveness and financial performance of SMEs in the short run. Moreover, SMEs need to allocate appropriate spending for conducting R&D activities to promote innovation, produce sustainable products and enhance market competitiveness in the long run. More specifically, the R&D department needs to investigate innovative production technology and engage in new product development (Demartini et al., 2018) to enhance sustainable manufacturing. Due to the introduction of new laws and policies for sustainability manufacturing, the development of innovative technologies, processes, applications, and products considering the environmental and social sustainability aspects are becoming more essential for manufacturing companies (Zarte et al., 2019).

Water consumption (Ahmad and Wong, 2019; Cagno et al., 2019; Vitale et al., 2019) (Demartini et al., 2018) and *GHG emissions* (Abedini et al., 2020; Beekaroo et al., 2019; Cagno et al., 2019; Zarte et al., 2019) were consistently and frequently used by previous research for measuring the environmental sustainability performance of manufacturing companies. Our empirical analysis, however, revealed that these indicators are less prioritized than other environmental sustainability indicators. This is due to, unlike other industrial sectors such as food and beverage, the manufacturing process of footwear SMEs does not consume a large amount of water and emits less. On the other hand, indicators such as material consumption, recycled material use, and energy efficiency were prioritized for measuring the environmental sustainability performance of SMEs. Different input materials are utilized by the footwear industry to produce a range of products (Staikos and Rahimifard, 2007). Among which, leather, synthetics, plastic, rubber, textiles are the most common input materials consumed by the footwear industry for its production process (Sellitto and Almeida, 2019). The footwear industry has placed a significant effort in improving material efficiency and eliminating the use of hazardous materials during 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. Moreover, they can minimize waste generation by improving material efficiency. Consumer product safety can be improved by reducing the use of hazardous materials in the production phase. In addition, increasing the use of eco-friendly and biodegradable materials, promoting the use of recycled materials, and reducing the use of hazardous materials are crucial in minimizing growing concerns from environmental and social impacts of the end-of-life 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 a prioritized indicators.

In the social sustainability dimension, the selected indicators that promote sustainability performance measurement related to employees, customers, and the community were selected. The footwear industry is one of the industrial sectors with low-technology and that are labor-intensive (Scott, 2006). Since it is a labor-intensive industry, ensuring the well-being of the employees is essential 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 created for measuring the progress towards community development. Moreover, working hours and lost-working days were crucial indicators to measure performance associated with the working time management of employees.

The results suggest that SMEs need to allocate their limited resources for applying the selected indicators for measuring and managing progress towards achieving industrial sustainability goals, which includes (1) increasing financial benefits, reducing costs, improving market competitiveness for the economic sustainability dimension; (2) improving the effectiveness of resources utilization for the environmental sustainability dimension; and (3) promoting the well-being of stakeholders (employees, customers, and the community) for the social sustainability dimension. In doing so, SMEs can contribute to achieving the SDGs by promoting health and well-being, promoting sustainable economic growth, providing productive employment and decent work, ensuring responsible consumption and production, and combating climate change and its impacts. Moreover, as long as SMEs are not facing scarcity of resources and other challenges, they are recommended to use the other potential sustainability indicators.

The framework developed for applying the indicators is goal-driven, target-based, continuously improving, with a detailed guideline for measuring, evaluating and interpreting sustainability performance, flexible to implement, and promoting stakeholder engagement. These give the framework a comprehensive feature to effectively measure and manage the sustainability performance of SMEs. Following the framework, SMEs need to start by setting sustainability goals and targets and measuring the actual sustainability performance. Then, they need to conduct sustainability performance evaluation by comparing the actual sustainability performance with the predefined sustainability targets, interpret the results, and finally, act on the performance results and review to bring continuous sustainability performance improvements. At the heart of these core functions of the framework are the metrics[7] defined to make the indicators measurable and manageable. Thus, the metrics are the main elements of the framework that enable SMEs to set sustainability targets and measure, evaluate and interpret sustainability performance.

This research provides valuable and applicable metrics supported by empirical evidence, which can effectively be used in practice with the support of the framework. These metrics help SMEs to measure, evaluate and interpret their sustainability performance effectively. The results show that the metrics linked to economic benefits, costs, and market competitiveness were useful and applicable for measuring and managing the economic sustainability performance of SMEs. Those metrics associated with the effective utilization of materials were found to be useful and applicable for measuring and managing the environmental sustainability performance; and those metrics related to the well-being of employees, customers, and the community were useful and applicable for measuring and managing the social sustainability performance of SMEs. The developed framework includes a list of indicators and metrics that have been selected based on

[7] In this research, metrics refer to quantifiable measures of sustainability performance. And, indicators refer to performance measures used to measure progress towards achieving sustainability goals. An indicator consists of one or more metrics to be measurable.

their suitability for Italian footwear SMEs. It, therefore, does not overload Italian footwear SMEs with information whose utility is uncertain or less prioritized.

6.2 Academic, managerial, and policy implications

The present research has significant implications for academics, managers, and policymakers. From an academic viewpoint, this research provides a strong theoretical basis for future research on measuring the sustainability performance of the footwear industry. More specifically, future research on industrial sustainability performance measurement can adapt the comprehensive methodological approach used in this research to other industrial sectors in order to select appropriate indicators tailored to the industries' needs and develop frameworks for applying the selected indicators. It will also encourage further discussions on the sustainability performance of the footwear industry by providing avenues for future research. The potential feature research areas include supply chain sustainability of the footwear industry to further address supplier sustainability and end-of-life product management, the impact of geographical or national diversity on indicators' similarity and difference in footwear firms from various countries, identification of indicators (including governance indicators) for emerging sustainability trends considering digitization of the footwear industry, and the impact of the footwear industry sustainability towards achieving the national sustainable development goals of a country.

From a managerial viewpoint, by providing appropriate indicators supported by empirical evidence and a framework to put these indicators into practice, this research can be used as a managerial tool to assess and improve the sustainability performance of the footwear industry so that it can fulfill the requirements of stakeholders regarding sustainable manufacturing practices. Footwear SMEs can use the framework developed by this research for applying the indicators for measuring and managing their sustainability performance. The detailed guideline of the framework can be used by SMEs' managers to set sustainability goals and targets, measure their actual sustainability performance, evaluate their performance by comparing the actual sustainability performance with the predefined sustainability targets, interpret to check whether their performance is sustainable or needs improvement actions, encourage stakeholder involvement (Elhuni and Ahmad, 2017; Huang and Badurdeen, 2018; Veleva and Ellenbecker, 2001), and report their sustainability performance. Consequently, SMEs can build a high level of trust with their stakeholders and enhance their business reputation (Hsu C.H. et al., 2017; Song and Moon, 2019; Trianni et al., 2019), whereby they can improve their competitive performance to stay relevant in today's competitive business environment in which customers seek firms to operate sustainably (Eastwood and Haapala, 2015; Joung et al., 2013; Pires et al., 2016; Singh S. et al., 2014; Watanabe et al., 2016) by placing more attention on economic, environmental and social responsibility (Eastwood and Haapala, 2015). In addition to the footwear industry, the framework can easily be adapted to other manufacturing industry sectors for measuring and managing their sustainability performance.

This research also has policy implications. It addresses the economic, environmental, and social sustainability issues that can influence policies such as environmental policy (Beekaroo et al., 2019; Tseng, 2013; Watanabe et al., 2016), socio-economic (Ahmad and Wong, 2019; Lacasa et al., 2016; Ocampo et al., 2016), and social responsibility (Lee J.Y. et al., 2014; Samuel et al., 2013; Zarte et al., 2019). This research will help footwear SMEs to contribute to the environmental policy by improving energy efficiency and material efficiency, by increasing the use of renewable materials, eco-friendly and biodegradable materials, recycled materials, and reducing the use of hazardous materials. In addition, the results of this research will be used to enhance socio-economic development by addressing the economic sustainability issues (financial benefits, costs, and market competitiveness) and the social sustainability issues (the well-being of employees, customers, and the community). It will also help SMEs to address social responsibility by promoting the well-being of employees, customers, and the community. Moreover, by linking the indicators to their respective SDGs, the results of this research can be used as input for policymakers for assessing how footwear firms can contribute towards achieving the SDGs.

6.3 Limitations and avenues for future research

By providing suitable sustainability indicators supported by empirical evidence and a framework to put these indicators into practice in the context of SMEs, the present research contributes to the existing knowledge in the field of industrial sustainability performance measurement. However, it is subjected to the following limitations, which open opportunities for future research. Some of these limitations are due to the exceptional COVID 19 pandemic that has struck the world and which has made it impossible for months to involve companies in research activities and to have direct contact with them.

- The scope of this research was limited at the firm level. However, it would be helpful to determine additional indicators that could be used to measure sustainability performance at the supply chain level to obtain a more comprehensive view of sustainable manufacturing. Hence, it would be interesting for future research to expand the scope to the entire supply chain in the stages of supply, production, distribution, use, and post-use.
- It focused on the indicators that have been used by scientific papers (i.e., academic papers). Therefore, as an additional avenue, future research could consider analyzing indicators used by the sustainability documents of organizations engaged in the sustainability performance measurement. Furthermore, future research could also consider governance indicators in addition to TBL indicators.
- In addition to Italian footwear firms, it would also be interesting for future research to conduct a comparative analysis considering the footwear firms of various countries (e.g., European countries) to identify the similarities and differences in the indicators from the perspective of geographical or national diversity.
- The four-stage framework developed to address the second research question was not fully considered in the empirical analysis. This is because carrying out the test of each of the four stages of the developed framework would have required more time than what was available to finish the PhD thesis. Specifically, it requires considerable time to collect intensive data from footwear firms and various stakeholders for measuring, evaluating and interpreting sustainability performance, and taking improvement actions. Thus, the empirical analysis was limited to the first stage of the framework. The first stage of the framework, which involves setting sustainability goals, defining metrics for the indicators, and setting sustainability targets, is the basis and crucial aspect for the subsequent stages of the framework. The subsequent stages, which focus mainly on measuring, evaluating and interpreting sustainability performance, and taking improvement actions, require considerable time and resources to carry out an empirical analysis. Hence, the empirical analysis of these stages of the framework could be considered in future research.

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Appendices

Appendix A. Questionnaire for collecting empirical evidence from footwear firms to address RQ1

Respondent and Company Profiles Information

Position:	**Tick**
Chief Executive Officer/General Manager	O
Production Manager	O
Operation Manager	O
Expert/Professional Employee of Sustainability	O
If it is **Other Position**, please write below:	
Qualification:	**Tick**
Doctorate Degree (PhD)	O
Master Degree (MSc, MA, ...)	O
Bachelor Degree (BSc, BA, ...)	O
Diploma (Certificate, ...)	O
Experience:	**Tick**
Below 5 Years	O
5 to 10 Years	O
10 to 15 Years	O
15 to 20 Years	O
Over 20 Years	O
Name of the Firm:	
Firm Size Category:	**Tick**
Large (250 and more employees)	O
Medium (50 – 249 employees)	O

Small (10 – 49 employees)	O

Assessment of Indicators

Assessment 1: Please rate the importance (usefulness and applicability) of the following indicators for measuring 'economic dimension' of sustainability in your firm:

	Not Important	Slightly important	Moderately important	Important	Very important
Profit	O	O	O	O	O
Revenue	O	O	O	O	O
Research & Development Expenditure	O	O	O	O	O
Material Cost	O	O	O	O	O
Labor Cost	O	O	O	O	O
Energy Cost	O	O	O	O	O
Maintenance Cost	O	O	O	O	O
Packaging Cost	O	O	O	O	O
Inventory Cost	O	O	O	O	O
Product Quality (features that meet customer needs)	O	O	O	O	O
Lead Time (time between order placement and shipment)	O	O	O	O	O
On-Time Delivery (delivery of finished products carried-out on time)	O	O	O	O	O

Assessment 2: Please rate the importance (usefulness and applicability) of the following indicators for measuring 'environmental dimension' of sustainability in your firm:

	Not Important	Slightly important	Moderately important	Important	Very important

Water Consumption	O	O	O	O	O
Recycled Water Use	O	O	O	O	O
Energy Consumption (electricity, fuel, ……)	O	O	O	O	O
Renewable Energy Use	O	O	O	O	O
Energy Efficiency	O	O	O	O	O
Energy Intensity	O	O	O	O	O
Material Consumption (leather, fabric, rubber, plastic, ……)	O	O	O	O	O
Recycled Material Use	O	O	O	O	O
Packaging Material Consumption	O	O	O	O	O
Land Use	O	O	O	O	O
Greenhouse Gas Emissions (CO2, CH4, CFCs, ……)	O	O	O	O	O
Wastewater Discharge	O	O	O	O	O
Solid Waste Disposal	O	O	O	O	O
Recyclable Waste	O	O	O	O	O

Assessment 3: Please rate the importance (usefulness and applicability) of the following indicators for measuring 'social dimension' of sustainability in your firm:

	Not Important	**Slightly important**	**Moderately important**	**Important**	**Very important**
Employment/Job Opportunity	O	O	O	O	O
Fair Salary	O	O	O	O	O
Employee Turnover	O	O	O	O	O
Employee Satisfaction	O	O	O	O	O

Occupational Health and Safety	O	O	O	O	O
Training and Development	O	O	O	O	O
Working Conditions (prevent exposure to dust, chemicals, heat, ……)	O	O	O	O	O
Work-related Injuries	O	O	O	O	O
Working Hours	O	O	O	O	O
Lost Working Days	O	O	O	O	O
Customer Health and Safety	O	O	O	O	O
Customer Satisfaction	O	O	O	O	O
Customer Complaints	O	O	O	O	O
Corruption	O	O	O	O	O

Appendix B. Structured questionnaire (checklist) for collecting empirical evidence from footwear SMEs to address RQ2 (mainly for checking the applicability of the metrics)

Name of the firm:				
Year of establishment:				
Market segment: Local ( ) Export ( ) Local and export ( )				
Number of employees		**Performance reporting period, please tick (X)**		
Male (#)	**Female (#)**	**Reporting period**	**Yes**	**No**
		Fiscal year		
		Six months		
		Quarter year		
		Month		

Indicator	**Metrics**	**Please tick (X) one of the three**		
		Can be applicable (useful) in the future	**Our firm currently uses this metric**	**Not applicable (not useful)**
Profit	Net profit gained (Euro, USD)			
	Net profit to total revenue ratio (%)			
Revenue	Total revenue generated (Euro, USD)			
	Revenue generated per unit of product sold (Euro, USD/uop)			
Research & development expenditure	R&D spending (Euro, USD)			
	R&D spending to total revenue ratio (%)			

Material cost	Total material cost (Euro, USD)			
	Percentage of material cost relative to total revenue (%)			
Labor cost	Total labor cost (Euro, USD)			
	Percentage of labor cost relative to total revenue (%)			
Product quality	Total number of products that meet customer specification (#)			
	Percentage of products that meet customer specification (%)			
Lead time	Total number of products produced within the required lead time (#)			
	Percentage of products produced within the required lead time (%)			
On-time delivery	Total number of products delivered on-time (#)			
	Percentage of products delivered on-time (%)			
Energy consumption	Total electricity consumed (kWh)			
	Total amount of fuel consumed (L, m^3, tonne)			

	Electricity consumption per unit of product produced (kWh/uop)			
	Fuel consumption per unit of product produced (L, m^3, tonne/uop)			
Energy efficiency	Ratio of final energy used for production to the total input energy (%)			
Material consumption	Total weight or volume of materials consumed (kg, m^3, L, m^2, pc)			
	Material consumption per unit of product produced (kg, m^3, L, m^2, pc /uop)			
	Material efficiency (%)			
	Percentage of biodegradable materials used (%)			
	Percentage of renewable materials used (%)			
	Percentage of hazardous materials used (%)			
Recycled material use	Total weight or volume of recycled materials used (kg, m^3, L, m^2, pc)			
	Percentage of recycled materials used (%)			
Employment/Job opportunity	Total number of new employees hired (#)			

	Recruitment efficiency (%)			
Fair salary	Average salary per employee (Euro, USD/emp)			
Employee turnover	Total number of employee turnover (#)			
	Percentage of employee turnover (%)			
Employee satisfaction	Total number of employees who reported job satisfaction (#)			
	Percentage of employees who reported job satisfaction (%)			
Occupational health and safety	Total number of employees covered by OHS program (#)			
	Total number of fatalities as a result of work-related injuries (#)			
	Total number of fatalities as a result of work-related illnesses (#)			
	Total number of cases of work-related illnesses (#)			
	Percentage of employees covered by OHS program (%)			

	Percentage of fatalities as a result of work-related injuries (%)			
	Percentage of fatalities as a result of work-related illnesses (%)			
	Percentage of cases of work-related illnesses (%)			
Training and development	Total number of employees who received a regular performance and career development (PCD) review (#)			
	Total training hours (h)			
	Percentage of employees who received a regular PCD review (%)			
	Average training hours per employee (h/emp)			
Working conditions	Total number of employees working in decent conditions (#)			
	Percentage employees working in decent conditions (%)			
Work-related injuries	Total number of work-related injuries (#)			
	Work-related injuries per employee (#/emp)			
Working hours	Total working hours (h)			

	Average working hours per employee (h/emp)			
Lost working days	Total lost working days due to injuries and illnesses (day)			
	Percentage of lost working days due to injuries and illnesses (%)			
Customer health and safety	Total number of incidents concerning the health and safety impacts of products and services provided (#)			
	Customer health and safety incidents per unit of product sold (#/uop)			
Customer satisfaction	Total number of customers who reported satisfaction with products and services offered (#)			
	Percentage of customers who reported satisfaction with products and services offered (%)			
Customer complaints	Total number of customer complaints (#)			
	Customer complaints per unit of product sold (#/uop)			