UNIVERSIDADE
BEIRA INTERIOR

Supply chain sustainability: towards a maturity model

Elisabete Maria da Fonseca Correia

Tese para obtenção do Grau de Doutor em
Gestão
(3º ciclo de estudos)

Orientadora: Prof. Doutora Susana Palavra Garrido
Coorientadora: Prof.ª Doutora Helena Maria Lourenço Carvalho Remigio
Coorientadora: Prof.ª Doutora Tânia Daniela Felgueiras Miranda Lima

Júri:
Prof Doutor António Manuel Cardoso Marques
Prof. Doutor José Luis Mexia Fraústo Crespo de Cravalho
Prof. ª Doutora Graça Maria de Oliveira Miranda Silva
Prof. Doutor Luis António Fonseca Mendes
Prof. ª Doutora Maria Margarida Serra Marques Martins de Moura Saraiva
Prof. ª Doutora Graça Maria de Oliveira Miranda Silva
Prof. ª Doutora Marta Alexandra da Costa Ferreira Dias
Prof. Doutor Luis Miguel Domingues Fernandes Ferreira

Covilhã, 17 de maio de 2023

Declaração de Integridade

Eu, Elisabete Maria da Fonseca Correia, que abaixo assino, estudante com o número de inscrição D1583 do Curso de Doutoramento em Gestão da Faculdade de Ciências Sociais e Humanas, declaro ter desenvolvido o presente trabalho e elaborado o presente texto em total consonância com o **Código de Integridades da Universidade da Beira Interior.**

Mais concretamente afirmo não ter incorrido em qualquer das variedades de Fraude Académica, e que aqui declaro conhecer, que em particular atendi à exigida referenciação de frases, extratos, imagens e outras formas de trabalho intelectual, e assumindo assim na íntegra as responsabilidades da autoria.

Universidade da Beira Interior, Covilhã maio de 2023

Assinado por: **ELISABETE MARIA DA FONSECA CORREIA**
Num. de Identificação: 08398236
Data: 2023.05.26 12:18:42+01'00'

Dedication

I dedicate this thesis to my beloved father.

Acknowledgments

The elaboration of this thesis was only possible with the collaboration, support and encouragement of several people who contributed to its conclusion. The personal enrichment resulting from contact with all of them far exceeds the scientific work that is now being presented. Here is my deep gratitude to all of them and particularly to the following people:

A special thanks to my supervisor, Professor Susana Garrido, for having followed me closely on this journey since the beginning and always being available to support me. Thank you for your generosity, rigor, and sharing of knowledge and experience. She is an inspiration to me as a professional and a person.

To Professor Helena Carvalho, for her availability, encouragement and always accurate and positive criticisms and suggestions throughout this work, which resulted in evident improvements in the final result.

To Professor Tânia Lima, who arrived later on in this project, but who always showed to be ready to collaborate.

To the people responsible for the companies that agreed to collaborate in this study, I want to thank for their time, patience, and the precious information indispensable for its realization.

To my family, without whom everything would have been more difficult, and especially to my mother and sisters, I thank them for always believing in me.

Finally, I want to thank Acácio, my life partner, and my children, Sofia and Filipe, who are my pillar, for always being there, for putting up with my absences many times and for their support and affection.

Resumo

A sustentabilidade tornou-se numa questão muito relevante devido a vários fatores como aumento da poluição, alterações climáticas, escassez de recursos, elevados desperdícios, problemas sociais, falta de respeito pelos direitos humanos, exploração do trabalho infantil, falta de aceitação da diversidade no local de trabalho, desigualdades salariais, problemas de segurança e saúde dos trabalhadores, entre outros. Neste contexto, aumentam também as pressões dos diferentes *stakeholders*, externos e internos, para as organizações alterarem o seu comportamento em relação à sustentabilidade. Tendo em atenção o seu papel nos sistemas de produção e consumo, considera-se que as organizações podem contribuir proactivamente para a sustentabilidade. A integração dos objetivos/princípios da sustentabilidade em todos os aspetos da organização, nas diferentes atividades e áreas funcionais, incluindo as que envolvem os seus parceiros da cadeia de abastecimento, e outros *stakeholders* como as organizações não governamentais são fatores críticos para melhorar a sustentabilidade.

A sustentabilidade requer pensar para além das fronteiras de uma entidade ou organização. Para gerir e melhorar a sustentabilidade nas cadeias de abastecimento é essencial considerar vários aspetos como: ter em conta uma perspetiva *Triple Bottom Line*, onde sejam contempladas as diversas dimensões da sustentabilidade (económica, ambiental e social); ter uma perspetiva de curto e longo prazo; considerar as expectativas e necessidades das organizações da cadeia de abastecimento e dos seus s*takeholders*; e, integrar os objetivos de sustentabilidade aos níveis intra e inter-organizacional na gestão dos diversos processos ou fluxos de materiais, de informação, e de capital entre as empresas ao longo da cadeia de abastecimento. Contudo, incorporar a sustentabilidade nas organizações e na cadeia de abastecimento exige o desenvolvimento de esforços e a implementação de práticas de sustentabilidade, e cria alguns desafios para as organizações.

O principal objetivo desta tese é propor um Modelo de Maturidade para a Sustentabilidade da Cadeia de Abastecimento que possa ser usado como: i) uma ferramenta de autoavaliação para fornecer um diagnóstico e ter uma compreensão mais ampla de como e quais práticas de sustentabilidade são implementadas nas organizações em termos individuais e na sua cadeia de abastecimento; ii) um instrumento para ajudar a desenvolver um *roadmap* para a melhoria do comportamento de sustentabilidade; e,

iii) uma ferramenta de *benchmarking* para avaliar e comparar *standards* e melhores práticas entre organizações e cadeias de abastecimento.

Para o desenvolvimento do modelo foi usada uma metodologia assente em seis passos, sugerida na literatura sobre desenvolvimento de modelos de maturidade. A construção do modelo de maturidade baseou-se numa revisão da literatura e contou com a participação de cinco empresas portuguesas do setor dos moldes para o seu aperfeiçoamento, aplicação e validação.

O modelo procura mitigar as insuficiências de modelos anteriores e oferecer uma perspetiva holística e alinhada com as componentes da sustentabilidade da cadeia de abastecimento. Assim, o modelo apresenta um carácter diferenciador ao considerar três perspetivas integradoras: Práticas de sustentabilidade intra e inter-organizacionais envolvendo diversos parceiros da cadeia de abastecimento; as dimensões económica, social e ambiental da sustentabilidade; e, diferentes áreas críticas para a sustentabilidade: governança da sustentabilidade, nível de produto e processo, gestão de clientes e fornecedores, e foco nos *stakeholders*. O modelo considera cinco níveis de maturidade, permitindo determinar o nível de maturidade para cada uma das áreas críticas, e considerando globalmente a empresa e a sua cadeia de abastecimento. Para acompanhar o progresso dos esforços em direção à sustentabilidade, o modelo inclui também uma dimensão temporal inerente ao conceito de sustentabilidade. Investigação futura pode ajudar a consolidar o modelo.

Palavras-chave

Modelo de Maturidade, Sustentabilidade, Cadeia de abastecimento, *Framework*, Práticas, Perspetiva Intra e inter-organizacional, Abordagem TBL, Governança da sustentabilidade, Nível do produto e do processo, Gestão de clientes e fornecedores, Foco nos *Stakeholders*, Revisão sistemática da literatura, Entrevistas, Estudo de caso.

Abstract

Sustainability has become a very relevant issue due to several factors such as increased pollution, climate change, scarcity of resources, high waste, social problems related to human rights such as exploitation of child labour, lack of acceptance of diversity in the workplace and wage inequalities, workers' health and safety problems, among others. In this context, pressures also increase from different stakeholders, external and internal, for organizations to change their behaviour concerning sustainability. Given its role in production and consumption systems, it is considered that organizations can proactively contribute to sustainability. The integration of sustainability objectives /principles in all aspects of the organization, in different activities and functional areas, including those involving its supply chain partners and other stakeholders such as non-governmental organizations, are critical factors for improving sustainability.

Sustainability requires thinking beyond the boundaries of an entity or organization. To manage and improve sustainability in supply chains is essential to consider several aspects such as: taking into account a Triple Bottom Line perspective, where the different dimensions of sustainability (economic, environmental and social) are considered; have a short-term and long-term perspective; consider the expectations and needs of supply chain organizations and their stakeholders; and, integrate sustainability objectives at intra and inter-organizational levels in the management of the different processes or flows of materials, information, and capital between companies along the supply chain. However, embedding sustainability in organizations and supply chain requires developing efforts and the implementation of sustainability practices and creates some challenges for organizations.

The main objective of this thesis is to propose a Supply Chain Sustainability Maturity Model that can be used as: i) a self-assessment tool to provide a diagnosis and broader understanding of how and which organizational sustainability practices are implemented in individual organizations and their supply chain; ii) an instrument to help develop a roadmap for sustainability behaviour improvement, and iii) a benchmarking tool to evaluate and compare standards and best practices among organizations and supply chains.

A methodology based on six steps, suggested in the literature on the development of maturity models, was used to develop the model. The construction of the maturity model

was based on a literature review and had the participation of five Portuguese companies in the mould sector for its improvement, application and validation.

The model aims to mitigate the shortcomings of previous models and offer a holistic perspective aligned with the supply chain sustainability components. Thus, the model presents a differentiating character when considering three integrative perspectives: Intra and inter-organizational sustainability practices involving different partners in the supply chain; the economic, social and environmental dimensions of sustainability; and other critical areas for sustainability: sustainability governance, product and process level, customer and supplier management, and focus on stakeholders. The model considers five maturity levels, making it possible to determine the maturity level for each critical area globally considering the company and its supply chain. As it makes it possible to monitor the progress of efforts towards sustainability, the model includes also a temporal dimension inherent to the concept of sustainability. Future research may help consolidate the model.

Keywords

Maturity model, Supply chain, Sustainability, Framework, Practices, Intra and Inter-Organizational Perspective, TBL approach, Sustainability governance, Product and process Level, Customer and supplier Management, Focus on stakeholders, Systematic literature review, Interviews, Case study.

Contents

List of Figures

List of Tables

List of Acronyms and Abbreviations

BSC	Balanced Scorecard
CMM	Capability Maturity Model
CSR	Corporate Social Responsibility
CS	Corporate sustainability
EFQM	European Foundation for Quality Management
GITO	Global Information Technologies Outsourcing
GRI	Global Reporting Initiative
GSCM	Green supply chain management
IL	Implementation level
IT	Information Technology
IATF	International Automotive Task Force
ISO	International Standard Organization
JIT	Just in Time
KLD	Kinder, Lydenberg and Domini Index
LCA	Life cycle analysis
MM	Maturity Model
MMs	Maturity Models
NGOs	Non-governmental organizations
NP	Norma Portuguesa
RBV	Resource-Based View
SME	Small and medium-sized enterprise
SMEs	Small and medium-sized enterprises
SA 8000	Social Accountability
SC	Supply chain
SCM	Supply chain management
SCOR	Supply chain operations reference
SCS	Supply chain sustainability
SCs	Supply chains
SD	Sustainable development
SSCM	Sustainable supply chain management
SLR	Systematic literature review
PRISMA	Transparent reporting of systematic reviews and meta-analyses
TBL	Triple Bottom Line
UN	United Nations

Chapter 1

Introduction

In this chapter, the background and motivation contextualization of the research work that is intended to be developed is presented, namely, the theme to be studied, its importance and what is intended to be added to the existing knowledge is identified. In the following sections, the defined objectives, the selected methodology and the structure of the thesis are also presented.

1. Background and motivation

The increasing socio-environmental problems such as climate change, air pollution, different pollution-related health diseases, and some industrial accidents contributed to the growing attention to sustainability. It has become an essential topic of discussion in major global forums such as the United Nations (Rajeev et al., 2017; Govindan et al., 2020; Shekarian et al., 2022). The need to change consumption patterns and production systems became evident (Rajeev et al., 2017; Santos et al., 2020), while the concept of Triple Bottom Line (TBL) was consolidated. TBL addresses the required balance between the economic, social, and environmental dimensions of sustainability (Elkington, 1998).

This attention and growing importance of sustainability has resulted in pressures created by consumers, regulatory authorities, and other stakeholders (workers, investors, etc.) on organisations to change their behaviour and transform their business activities (Mota et al., 2015; Santos et al., 2020). In addition to pressures from stakeholders, other factors highlighted the need for organisations to understand the importance of achieving sustainability, motivating the implementation of practices to respond to three dimensions of sustainability, whether in the company context (Labuschagne et al., 2005; Colicchia et al., 2011) or at Supply Chain (SC) level (Govindan et al., 2020). These factors are very diverse. Among them, the following stand out: the need for compliance with legal requirements established by governments; the desire to reduce costs, improve their organisational reputation and overall performance, and/or gain competitive advantage (Raut et al., 2019; Govindan et al., 2020; Santos et al., 2020; Khan et al., 2021; Dai et al., 2021).

The inter-organisational perspective associated with sustainability has gained increasing importance in an increasingly globalized world where no organisation exists in a closed system but must interact with various stakeholders and suppliers in an open system, or SC (Osland & Zhou, 2013). The management of Supply chains (SCs) has become increasingly complex, and sustainability in this context has become a very relevant issue for practitioners and researchers (Sánchez-Flores et al., 2020; Nimsai et al., 2020). For example, it has become increasingly common for organisations to acquire products from different countries. However,

nongovernmental organisations and regulatory entities often require these organisations to show that their products are being manufactured and processed according to acceptable social and environmental standards (Santos et al., 2020). On the other hand, complying with these standards does not always depend exclusively on the organisation but on other partners in your SC. As Tate et al. (2010) mentioned, high levels of sustainability performance from one company may be challenging due to poor performance levels from other SC partners, such as suppliers. Thus, as Seuring and Gold (2013) emphasize, organisations cannot address sustainability challenges alone.

The idea that sustainability requires thinking beyond the boundaries of a single entity or organisation to consider entire value chains and production and consumption systems (Lebel & Lorek, 2008) reinforced approaching sustainability in an SC context as a fundamental component of sustainable development (Tonelli et al., 2013). Supply chain management (SCM) is thus considered critical to sustainability policy and practice agenda.

The discussion around sustainability in the SC context made Sustainable supply chain management (SSCM) a focus of interest for business practitioners and academics (Ahi & Searcy, 2015; Dai et al., 2021). SSCM, or Supply chain sustainability, according to Chowdhury and Quaddus (2021), emerges as a management philosophy that integrates sustainability into the core business functions of SCM (Dai et al., 2021). Among others, authors like Carter and Rogers (2008), Seuring and Müller (2008), and Ahi and Searcy (2013) have defined SSCM. Seuring and Müller (2008) present one of the most cited definitions of SSCM. According to the authors, SSCM is: "The management of material, information, and capital flow as well as cooperation among companies along the SC while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account, which are derived from customer and stakeholder requirements" (Seuring & Müller, 2008, p. 1700).

Although there is some lack of clarity surrounding the concept of SSCM (Negri et al., 2021), some fundamental aspects must be considered in SCs' management to improve their sustainability (i.e., obtain sustainable supply chains). One of the main aspects highlighted by most SSCM definitions is the focus on the TBL approach, i.e., simultaneously considering the three sustainability dimensions (Carter & Rogers, 2008; Seuring & Müller, 2008; Ahi & Searcy, 2013). Some definitions of SSCM (Carter & Rogers, 2008; Ahi & Searcy, 2013; Stindt, 2017) converge on the importance of integrating sustainable initiatives with SCM for present and future improvements of organisations (time dimension). Another aspect to consider in the SSCM is the integration of sustainability in the organisation and SC, the expectations and needs of SC organisations, and their multiple stakeholders (Seuring & Müller, 2008; Ahi & Searcy, 2013). Finally, it is critical to integrate the objectives of sustainability at the intra-organisational and inter-organisational levels of management and in the various processes or flows of materials, information, and capital (Carter & Rogers, 2008; Wolf & Seuring, 2010; Ahi & Searcy, 2013; Negri et al., 2021).

Integrating sustainability in the organisation and SC contexts requires developing efforts and implementing practices. Sustainability practices help embed sustainability objectives in the various processes/activities (Govindan et al., 2015; Zhu et al., 2007), representing "tangible implementations of sustainability" (Sodhi & Tang, 2017; Arslan, 2020).

Many studies within the scope of the SSCM investigate sustainability practices, emerging different types of practices and their classification (Negri et al., 2021; Dai et al., 2021). In the literature, it is usual to distinguish sustainability practices between environmental, social and economic practices. This distinction is associated with the sustainability objectives (i.e., environmental, social, economic) that are intended to be achieved (Miemczyk & Luzzini, 2018).

Preuss (2005) points out that the literature highlights several practices that include sustainability objectives internally and beyond the organisation's boundaries and that are critical for the organisation's sustainability (Preuss, 2005) and a more sustainable SC (Pagell & Wu, 2008). However, while pressure from stakeholders has encouraged many organisations to implement these practices (Gopal & Thakkar, 2016), others are struggling to integrate these practices into their core business functions and the management of their SC (Carter & Rogers, 2008; Xie, 2016; Gold & Schleper, 2017; Kumar et al., 2019; Khan et al., 2021). One major reason for this could be the difficulty in understanding the issue of sustainability (Khan et al., 2021). The great diversity of practices and their classifications may contribute to difficulties in decision-making about their integration into companies and SC (Khan et al., 2021). For example, social sustainability practices have not been considered by many organisations. Even at the research level, the integration of social aspects in SC management, compared with environmental aspects, is understudied (Martins & Pato, 2020; Negri et al., 2021).

The type of practices suggested in the literature can be very diverse. For example, some researchers suggest environmental sustainability practices in the areas of design, production, distribution, and investment recovery (Esfahbodi et al., 2017); others, practices in terms of design, processes, collaboration with customers and suppliers (Paulraj et al., 2015); and, also environmental practices in the areas of packaging and purchasing (Zailani et al., 2012). Regarding the social dimension, the social practices related to workers and the community are suggested (Das, 2017). Carter and Jennings (2002) operationalize this type of practices regarding human rights, safety, diversity and philanthropy.

An approach regarding practices classification is to consider them in terms of SC tier (Negri et al., 2021). For example, practices can be regarded at the early stages of product development (e.g., green design), upstream SC practices (e.g., cooperation with suppliers), and internal and downstream SC practices (e.g., sustainable manufacturing, warehousing) (Azevedo et al., 2011; Negri et al., 2021). Wang and Dai (2018) and Dai et al. (2021) argue that sustainability practices in the SC context should be viewed from both internal and external perspectives. They operationalize internal practices in terms of environmental and social responsibility management and external ones in terms of supplier collaboration, monitoring and assessment.

Organisations may present different approaches to implementing sustainability practices : i) a more or less extensive and sophisticated way (Chardine-Baumann & Botta-Genoulaz, 2014); ii) practices related to one or more dimensions (environmental, social and economic) of sustainability (Marshall et al., 2014); iii) implement only internally practices in the various functions and processes of the organisation (or only in a specific function and process); iv) and, implement practices (or not) in the SC.

Incorporating sustainability in organisations and SC through implementing sustainability practices creates some challenges for organisations. Some instruments have been used to support companies in this process and demonstrate their commitment to sustainability concerns (Meza-Ruiz et al., 2017; Siew, 2015). For example, standardized management systems (e.g., ISO 14001; ISO 45001; SA8000), guidelines and official recommendations for environmental and social reporting (e.g. GRI standards), tools for the measurement of corporate sustainability, and applied concepts (e.g., Life Cycle Assessment, Sustainability balanced scorecard, Kinder, Lydenberg, and Domini (KLD) Index, Dow Jones Sustainability Index, Ethibel Sustainability Index, Calvert Social Index) (Hassini et al., 2012; Searcy & Elkhawas, 2012; Chardine-Baumann & Botta-Genoulaz, 2014; Müller & Pfleger, 2014; Siew, 2015; Meza-Ruiz et al., 2017). However, some of these instruments do not follow a TBL approach, focusing only on one dimension of sustainability; others focus on the organisation or just specific aspects and do not consider the SC.

Some models/frameworks designed to help improve SC management and assess its performance, such as the SCOR model, Odette EVALOG, Efficient Costumer response, Oliver Class A Checklist (Estampe et al., 2013) are identified as bringing together the potential to integrate sustainability in SCs (Estampe et al., 2013; Chardine-Baumann & Botta-Genoulaz, 2014).

Furthermore, most proposed tools and frameworks do not support companies in either identifying their sustainability profile and continuously implementing roadmaps. This aspect seems fundamental in incorporating sustainability in organisations and SC, as it is, likewise, the existence of these types of frameworks and models (Hepper et al., 2017). Therefore, Maturity Models (MMs) can be a tool that can support organisations and their SC in this process. Mani et al. (2010) suggest that MMs can assess the initial state and progress of organisations regarding sustainability. Some sustainability MMs have been suggested in the literature, but there is already much scope for research in this area.

This thesis fits into the study of these models and intends to propose an SC Sustainability MM.

This study seeks to contribute to the research in the field of Sustainable Supply Chain Management (SSCM), particularly in the area of developing instruments and methodologies for assessing the level of SC sustainability. This study may contribute to a better knowledge and understanding of Sustainability MMs and their application in the context of SCs. This thesis also seeks to contribute to developing and proposing a MM, which constitutes a tool that supports practitioners in incorporating sustainability in organisations and SCs. The proposed MM aims to

answer the need for managers to have instruments aligned with the main elements/components of sustainability, previously defined, which allows identifying the current profile in sustainability application and deploying implementation roadmaps in a continuous improvement context. These aspects seem to be fundamental in incorporating sustainability in organisations and SCs.

2. Review of research trends

The number of studies on maturity and the proposed MM has been increasing in different areas (Peña-Montoya et al., 2020). Through a systematic review of the literature, Wendler (2012) recognizes the use of MM in more than 20 domains, such as risk management, project management, new product development, human resources management, process management, and SCM. Sustainability was then presented as a marginal area. However, in recent years more studies have emerged and have addressed the use of MMs to assist the effort of integrating sustainability in specific processes, in the organisation, and in the SC. Yet, the number of Sustainability MMs is limited, even in the context of SC.

Regarding sustainability MMs at specific processes, for example, Pigosso et al. (2013) proposed a MM to support organisations in implementing ecodesign. Hynds et al. (2014) developed a tool to evaluate the maturity of an organisation in terms of its ability to create sustainable products. Xavier et al. (2020) proposed a framework to support eco-innovation integration.

Other proposed MMs are more comprehensive, referring to integrating sustainability throughout the organisation. In this context, Golinska & Kuebler (2014) develop an MM focusing on sustainability in re-manufacturing companies using the TBL approach. The purpose of the MM is to identify the potential for optimization of resource utilization in the re-manufacturing companies. Gouvinhas et al. (2016) presented a self-evaluation framework to classify organisations into six maturity levels regarding sustainability.

Considering the context of SC, the use of MM is not new and is a valuable tool used for its management (McCormack et al., 2008). Several MMs are proposed in the literature, focusing, among others: on aspects such as SC processes (e.g., Lockamy III & McCormack, 2004; Söderberg & Bengtsson, 2010); systems, and technologies (e.g., Simchi-Levi et al., 2003; Aryee et al., 2008); and, relationships in SC (e.g., Handfield & Straight, 2004; Meng et al., 2011). There are some proposals in the literature concerning the integration of sustainability in the context of SC. Reefke et al. (2014) suggest a MM for SC with six maturity levels providing an orientation towards the development of higher levels of SC sustainability. Likewise, Santos et al. (2020) propose a MM for the SC based on five maturity levels from an analysis of the previous MM.

However, as Reefke et al. (2014) highlighted, few models "that connect maturity considerations in SCs with sustainability imperatives," so developing such a model, can contribute to filling this research gap. Some MMs that cross these strands (sustainability and SC), even assuming a TBL approach have shortcomings/limitations that make them challenging to understand and use.

These limitations are highlighted in the literature. For example, Santos et al. (2020) pointed out that some sustainability maturity models focus on only one aspect of sustainability or are excessively broad and do not detail the elements necessary to measure the level of maturity. The lack of detail in guiding the MM application and the lack of validation of the MM in practice is another aspect highlighted by Tarhan et al. (2016). As proposed in this thesis, it reveals a need to propose an SC Sustainability MM that overcomes these limitations.

3. Research questions and objectives

Following the background set out above, the following five research questions (RQ) are proposed:

RQ1 - What is the meaning of Supply Chain Sustainability?

RQ2 - What are the existing Sustainability MMs in the literature and their main characteristics?

RQ3 - What approach/method to use to develop, validate and test an SC Sustainability MM?

RQ4 - What are the components to consider for the SC Sustainability MM, and in particular, what maturity levels to consider, and which critical areas and sustainability practices are most relevant to integrate as components of the MM?

RQ5 - What SC Sustainability MM should be proposed, and how can this model be applied and validated?

Based on these five research questions, this thesis presents five specific objectives that allow achieving its main objective, which is to propose an SC Sustainability MM that can be used as:

i) a self-assessment tool to provide a diagnosis and broader understanding of how and which organisational sustainability practices are implemented in individual organisations and their SC; ii) an instrument to help developing a roadmap for sustainability behaviour improvement, and iii) a benchmarking tool to evaluate and compare standards and best practices among organisations and supply chains.

The following five specific objectives were defined to attend to this main objective and achieve it.

Objective 1 - to propose a conceptual framework to help clarify the concept of supply chain sustainability since it represents the main topic focused on this thesis.

Objective 2 - to identify the various MM sustainability proposed in the literature and analyse their most relevant characteristics. The analysis of already existent Sustainability MMs allows the evaluation of other available solutions, which is essential before proposing new MMs. Identifying and analysing the existing MM is fundamental to determining the primary MM's shortcomings/limitations and tracing the investigation path. It is also essential to explore the MMs' key characteristics, such as their scope (regarding sustainability dimensions and unity of analysis) and their components (maturity levels and elements- areas and practices- considered for maturity analysis/evaluation).

Objective 3 - to define the approach/method to design the MM proposed. The following aspects were used to analyse sustainability MM studies: the research objectives and methods used to develop, validate and test the MMs.

Objective 4 - to identify and define the components of the MM: maturity levels and sustainability areas and practices. This thesis aims to present a comprehensive MM for SC that represents a holistic approach to sustainability. Thus, the components of the MM to be proposed have to be aligned with this perspective. Regarding sustainability areas and practices, the use of literature on sustainability MMs is not enough. Considering the quantity, diversity, and lack of consensus in the SSCM literature on the type of practices to implement, it is necessary to identify the most relevant practices to implement and proceed with their systematization and allocation by the critical areas.

Objective 5 - to propose the SC Sustainability MM and to apply and validate the MM. By opting for a combination of theory-driven and practitioner-based approaches, we seek to complement the insights of the literature with the collaboration of potential users of the MM. The case study method is essential in the MM improvement and validation process. The application of the MM in companies is essential to understand how the MM can be applied and used in practice. It also allows its validation regarding the following factors: the relevance, comprehensiveness and mutual exclusion of areas and practices of the MM; the sufficiency and the accuracy of maturity levels; the ease of understanding, and the level of usefulness and practicality.

4. Thesis design

This thesis seeks to propose an MM within the scope of Supply Chain Sustainability. The design and development of this research followed three phases, as illustrated in figure 1.

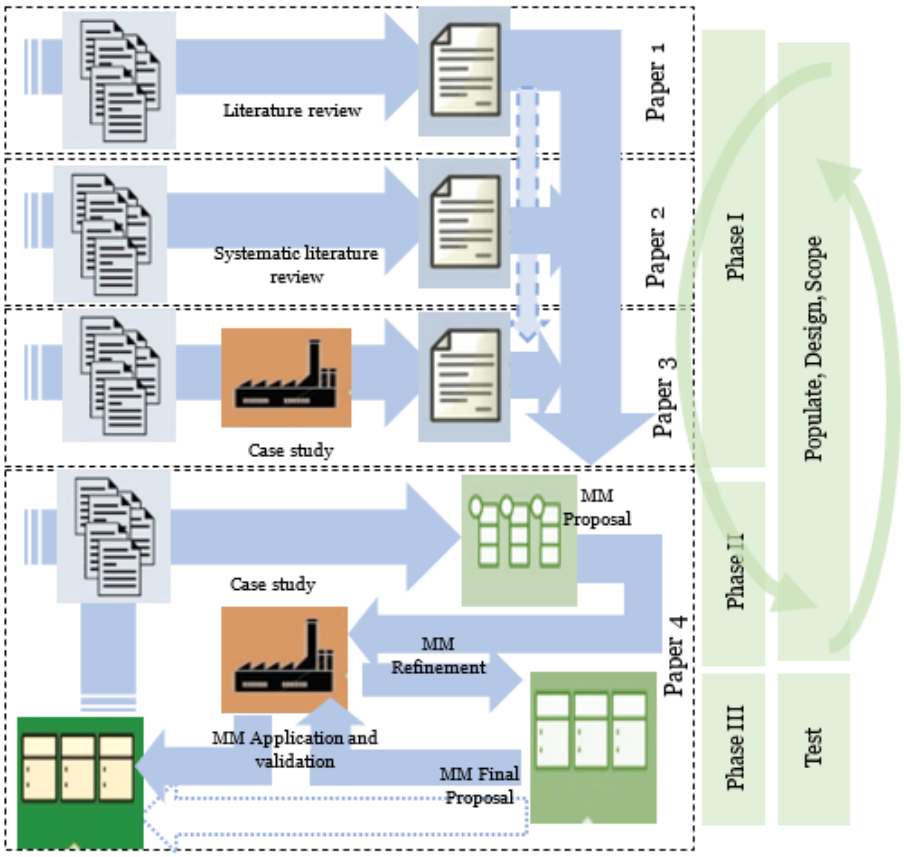


Figure 1. Thesis research design

Research is exploratory when the objective is investigating poorly understood phenomena, identifying important concepts and variables on the subject, and exploring the problem or situation to provide criteria and understanding, generating hypotheses for future research (Malhotra & Grover, 1998; Karlsson, 2009). The initial development phase of a knowledge area is characterised by exploratory research that will result in concepts, classifications and definitions. Since there are few theoretical developments in the SC Sustainability MM, this research initially adopts an exploratory character. Considering that this study also proposes a model that intends to support companies in integrating and managing sustainability in SC, this investigation can also be classified as prescriptive (Karlsson, 2009). For the development of the MM, the six-step methodology proposed by De Bruin et al. (2005) was followed: *Scope*, *Design*, *Populate*, *Test*, *Deploy* and *Maintain*. Considering the objective of this thesis, *Deploy* and *Maintain* are outside the scope of this research: *Deploy* deals with the extension of the MM to companies independent of the MM development, and *Maintain* deals with the conditions to assure the continued use of the model in the future. This research was developed following a set of phases:

Phase I - the literature review and the case study were used in the following MM development steps: *Scope*, *Design* and *Populate*. At this stage, the case study method was developed to identify and understand some of the main components of the SC Sustainability MM and its validation.

Companies from the mould industry were used to perform the case study method because, despite sustainability being one of the sector's main challenges (CEFAMOL, 2022), many of these companies appear to be at the beginning of this process. They must make significant efforts to integrate sustainability into their operations and SC and adopt a TBL approach (Correia et al., 2021). Thus, a sustainability MM could be an exciting instrument for these companies.

Phase II - the case study allowed refining of the MM resulting in an improved version of the MM.

Phase III - the SC Sustainability MM was applied and tested in the companies participating in the case study.

The different methodological procedures followed in this research are described in detail in the four papers associated with each of the previous phases resulting from the doctoral work. These papers represent the fundamental core of this thesis (Chapter 2 to Chapter 5) and corresponds to papers that have been submitted or to be submitted to international journals: one study was already published and awarded; two are currently undergoing peer reviews; and although the other one was published as a working paper, we intend to submit it as well to an international journal. Table 1 summarizes thesis papers (title, purpose, research methods, reference, and status).

Table 1. Some features associated to the scientific outputs of this thesis

Papers	Title	Purpose	Research Methods	Reference	Status
Paper 1	Supply chain sustainability: concept clarification and framework proposal	To define supply chain sustainability and propose a framework to help clarify the concept	Literature review	Garrido, S.; Correia, E., & Carvalho, H. (2022). Supply Chain Sustainability: Concept clarification and framework proposal. CeBER Working papers 6/2022, Faculdade de Economia, Universidade de Coimbra, Coimbra, Portugal	Published
Paper 2	Maturity models in supply chain sustainability: A systematic literature review	To give insights into methodological issues related to MMs, namely the research objectives; the research methods used to develop, validate and test them; the scope; and, the main characteristics associated with their design	Systematic literature review	Correia, E., Carvalho, H., Azevedo, S. G., & Govindan, K. (2017). Maturity models in supply chain sustainability: A systematic literature review. Sustainability, 9(1), 64. https://doi.org/10.3390/su9010064	Published (Best Paper Awards in the journal Sustainability in 2019)
Paper 3	Sustainability Supply Chain Practices: Proposal for a Framework	To propose a framework for the implementation of sustainability practices by individual companies and corresponding supply chains	Case study	Correia, E., Garrido, S., & Carvalho, H. Sustainability Supply Chain Practices: Proposal for a Framework. International Journal of Logistics Management	Undergoing peer review
Paper 4	Proposal of a Sustainability Maturity Model for Supply Chain	To propose a maturity model that helps individual companies and corresponding SCs to identify their level of engagement with the sustainability practices by giving information on how and which are already implemented and what is the correct path they must follow to reach a high level of commitment with the sustainability	Case study	Correia, E., Garrido, S., Carvalho, H., & Lima, T. Proposal of a Sustainability Maturity Model for Supply Chain. International Journal of Production Economics	Undergoing peer review

This thesis is organised into six chapters. In figure 2, the structure and rationale followed are described, highlighting the theoretical and methodological steps used to reach the thesis results.

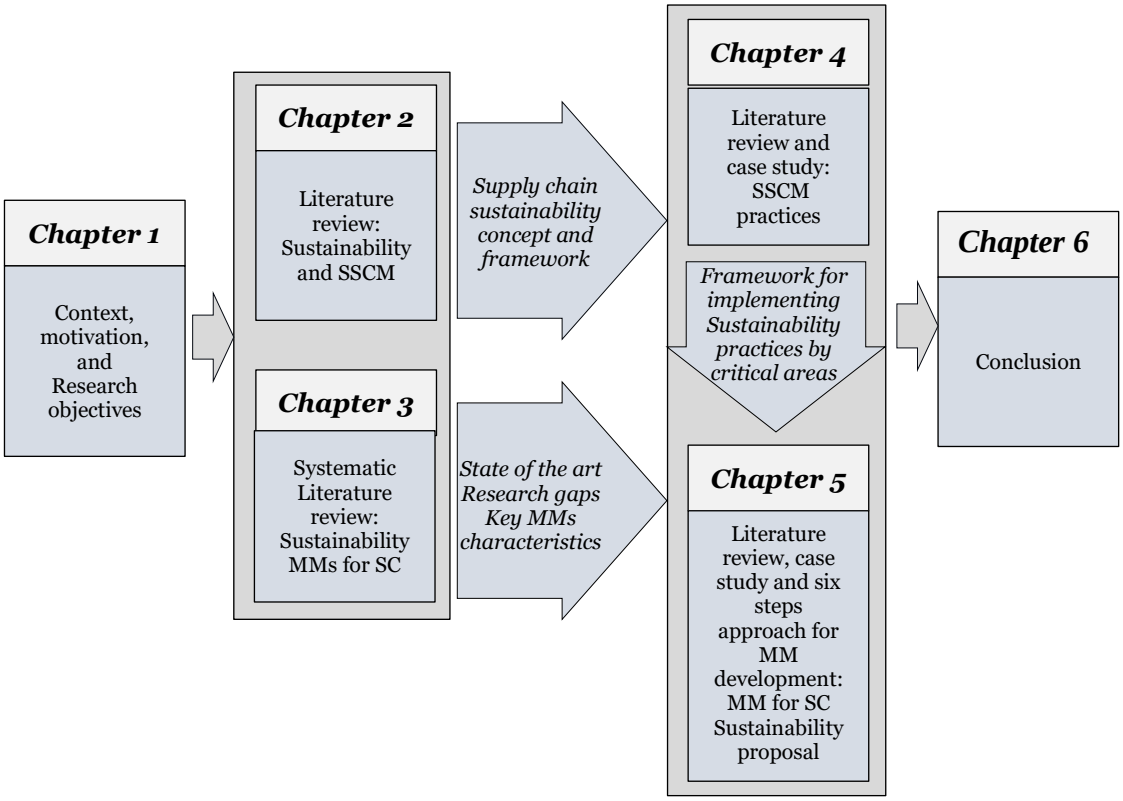


Figure 2. Organisation of the thesis

Chapter one presents the context and motivation of the thesis, a brief review of research trends, and the research objectives.

In chapter two, based on a literature review, some concepts such as sustainability, dimensions of sustainability and sustainable supply chain management are clarified. The importance of sustainability in SC is also discussed, and a framework presenting the main components to consider in Supply chain sustainability is proposed.

Chapter three contains a systematic review of the literature on MM in the SC Sustainability domain. The definition of the maturity model and the state of the art of sustainability MMs are presented. The analysis is extended to several application levels (process, company, SC). Here, the following are analysed: the main research objectives of the studies in the sustainability MM field; the research methods used to develop, validate and test MMs; the MM scope considering the sustainability dimensions and their application level; and the MMs' main characteristics. In this chapter, the gaps in the literature are also identified.

In chapter four, the sustainability practices present in the SSCM literature are identified and organised by the various dimensions of sustainability. The case study (five mouldmaking companies) proposes a framework for implementing sustainability practices by individual companies and corresponding SCs. Through the case study, sustainability practices that are the most important for practitioners are identified, thereby reducing the number of sustainability practices specified in the literature and giving insights regarding which should be used to address critical areas. Appendix A contains the tool used for the collection of empirical data.

Chapter five proposes the SC Sustainability MM based on theoretical contributions in SSCM and MMs, the previous chapter's results, and the case study method. A six-step methodology to develop MMs is followed for developing the model. The case study method (five mouldmaking companies) is used to improve, apply and validate the model. The chapter presents the different phases of model development and describes them in detail. The results of the MM application in the five mouldmaking companies and MM validation are also described in detail. In Appendix B, Appendix C, and Appendix D supplementary material to support the MM development and application is provided.

Finally, in chapter six, the main research conclusions are pointed out, and some paths for future research are indicated.

References

Ahi, P., & Searcy, C. (2015). Assessing sustainability in the supply chain: A triple bottom line approach. *Applied Mathematical Modelling*, *39*(10-11), 2882-2896. https://doi.org/10.1016/j.apm.2014.10.055

Arda, O. A., Montabon, F., Tatoglu, E., Golgeci, I., & Zaim, S. (2021). Toward a holistic understanding of sustainability in corporations: Resource-based view of sustainable supply chain management. *Supply Chain Management: An International Journal*. https://doi.org/10.1108/SCM-08-2021-0385

Arslan, M. (2020). Corporate social sustainability in supply chain management: a literature review. *Journal of Global Responsibility*, *11*(3), 233-255. https://doi.org/10.1108/JGR-11-2019-0108

Aryee, G., Naim, M. M., & Lalwani, C. (2008). Supply chain integration using a maturity scale. *Journal of Manufacturing Technology Management*, 19 (5), 559 – 575. https://doi.org/10.1108/17410380810877258

Azevedo, S. G., Carvalho, H., & Machado, V. C. (2011). The influence of green practices on supply chain performance: A case study approach. *Transportation research part E: logistics and transportation review*, *47*(6), 850-871. https://doi.org/10.1016/j.tre.2011.05.017

Becker, J., Knackstedt, R. & Pöppelbuß., J. (2009). Developing Maturity Models for IT Management – A Procedure Model and its Application. *Business & Information Systems Engineering*, 1(3), 212-222. https://doi.org/10.1007/s12599-009-0044-5

Carter, C., & Rogers, D.S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution & Logistics Management*, 38 (5), 360-387. https://doi.org/10.1108/09600030810882816

Carter, C.R.; & Jennings, M.M. (2002). Logistics social responsibility: an integrative framework. *Journal of Business Logistics*, 23 (1), 145-80. https://doi.org/10.1002/j.2158-1592.2002.tb00020.x

CEFAMOL (2022). Molde, 123, January 2022. Available at: https://www.cefamol.pt/index.php?id=85&idn=510 (accessed 05 May 2022)

Chardine-Baumann, E. & Botta-Genoulaz, V. (2014). A framework for sustainable performance assessment of supply chain management practices. *Computers & Industrial Engineering*, 76, 138–147. https://doi.org/10.1016/j.cie.2014.07.029

Chowdhury, M. M. H., & Quaddus, M. A. (2021). Supply chain sustainability practices and governance for mitigating sustainability risk and improving market performance: A dynamic capability perspective. *Journal of Cleaner Production*, *278*, 123521. https://doi.org/10.1016/j.jclepro.2020.123521

Colicchia, C., Melacini, M., & Perotti, S. (2011). Benchmarking supply chain sustainability: insights from a field study. *Benchmarking: An International Journal*, 18 (5), 705-732. https://doi.org/10.1108/14635771111166839

Correia, E., Garrido, S. & Carvalho, H. (2021). Online sustainability information disclosure of mould companies, *Corporate Communications: An International Journal*, 26(3), 557-588. https://doi.org/10.1108/CCIJ-05-2020-0085

Dai, J., Xie, L., & Chu, Z. (2021). Developing sustainable supply chain management: The interplay of institutional pressures and sustainability capabilities. *Sustainable Production and Consumption*, *28*, 254-268. https://doi.org/10.1016/j.spc.2021.04.017

Das, D. (2017). Development and validation of a scale for measuring Sustainable Supply Chain Management practices and performance. *Journal of Cleaner Production*, *164*, 1344-1362. https://doi.org/10.1016/j.jclepro.2017.07.006

De Bruin, T., Rosemann, M., Freeze, R. & Kaulkarni, U. (2005b). Understanding the main phases of developing a maturity assessment model. In Australasian Conference on Information Systems (ACIS) (pp. 8-19). Australasian Chapter of the Association for Information Systems.

Elkington, J. (1998). *Cannibals with folks: the triple bottom line of 21st century business*. Stony Creek, CT: New Society Publishers.

Esfahbodi, A., Zhang, Y., & Watson, G. (2016). Sustainable supply chain management in emerging economies: Trade-offs between environmental and cost performance. *International Journal of Production Economics*, *181*, 350-366. https://doi.org/10.1016/j.ijpe.2016.02.013

Estampe, D., Lamouri, S., Paris, J. & Brahim-Djelloul, S. (2013). A framework for analysing supply chain performance evaluation models. *International Journal of Production Economics*, 142 (2), 247-258. https://doi.org/10.1016/j.ijpe.2010.11.024

Estampe, D., Lamouri, S., Paris, J., & Brahim-Djelloul, S. (2013). A framework for analysing supply chain performance evaluation models. *International Journal of Production Economics*, 142, 247–258. https://doi.org/10.1016/j.ijpe.2010.11.024

Gold, S., & Schleper, M. C. (2017). A pathway towards true sustainability: A recognition foundation of sustainable supply chain management. *European Management Journal*, *35*(4), 425-429. https://doi.org/10.1016/j.emj.2017.06.008

Golinska, P., & Kuebler, F. (2014). The method for assessment of the sustainability maturity in remanufacturing companies. *Procedia Cirp*, *15*, 201-206. https://doi.org/10.1016/j.procir.2014.06.018

Gopal, P. R. C., & Thakkar, J. (2016). Sustainable supply chain practices: an empirical investigation on Indian automobile industry. *Production Planning & Control*, *27*(1), 49-64. https://doi.org/10.1080/09537287.2015.1060368

Gopal, P. R. C., & Thakkar, J. (2016). Sustainable supply chain practices: an empirical investigation on Indian automobile industry. *Production Planning & Control*, *27*(1), 49-64. https://doi.org/10.1080/09537287.2015.1060368

Gouvinhas, R. P., Reyes, T., Naveiro,R., M., Perry, N., & Filho, E. R., (2016). A proposed framework of sustainable self-evaluation maturity within companies: an exploratory study. *International Journal on Interactive Design and Manufacturing*, 10(3), 319-327. https://doi.org/10.1007/s12008-016-0322-7

Govindan, K., Azevedo, S.G., Carvalho, H. & Cruz-Machado, V., (2015). Lean, green and resilient practices influence on supply chain performance: interpretive structural modeling approach. *International Journal of Environmental Science and Technology*, 12(1), 15-34. https://doi.org/10.1007/s13762-013-0409-7

Govindan, K., Rajeev, A., Padhi, S. S., & Pati, R. K. (2020). Supply chain sustainability and performance of firms: A meta-analysis of the literature. *Transportation Research Part E: Logistics and Transportation Review*, *137*, 101923. https://doi.org/10.1016/j.tre.2020.101923

Handfield, R.B., & Straight, S.L. (2004). How mature is your supply chain? The SCRD capability maturity model, Proceedings of the ISM's 89th Annual International Supply Management Conference, Philadelphia, USA, pp.512–515.

Hassini, E., Surti, C., & Searcy, C. (2012). A literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics*, 140 (1), 69-82. https://doi.org/10.1016/j.ijpe.2012.01.042

Hepper, E. L, Souza, O. T., Petrini, M. C., & Silva; C. E. L. (2017). Proposição de um modelo de maturidade para sustentabilidade corporativa. *Acta Scientiarum. Human and Social Sciences*, 9(1), 43-53. https://doi.org/10.4025/actascihumansoc.v39i1.33127

Hynds, E. J., Brandt, V., Burek, S., Jager, W., Knox, P., Parker, J. P., ... & Zietlow, M. (2014). A maturity model for sustainability in new product development. *Research-Technology Management*, *57*(1), 50-57. https://doi.org/10.5437/08956308X5701143

Karlsson, C. (2009). *Researching operations management*. New York, EUA: Routledge.

Khan, S. A. R., Yu, Z., Golpira, H., Sharif, A., & Mardani, A. (2021). A state-of-the-art review and meta-analysis on sustainable supply chain management: Future research directions. *Journal of Cleaner Production*, *278*, 123357. https://doi.org/10.1016/j.jclepro.2020.123357

Klimko, G. (2001, November). Knowledge management and maturity models: Building common understanding. In *Proceedings of the 2nd European conference on knowledge management* (Vol. 2, pp. 269-278). Bled, Slovenia.

Kumar, A., Mangla, S. K., Luthra, S., & Ishizaka, A. (2019). Evaluating the human resource related soft dimensions in green supply chain management implementation. *Production Planning & Control*, *30*(9), 699-715. https://doi.org/10.1080/09537287.2018.1555342.

Labuschagne, C., Brent, A. C. & van Erck, R. P. G. (2005). Assessing the Sustainability Performances of Industries. *Journal of Cleaner Production,* 13(4), 373–385. doi:10.1016/j.jclepro.2003.10.007.

Lebel, L., & Lorek, S. (2008). Enabling sustainable production-consumption systems. *Annual Review of Environment and Resources*, *33*, 241-275. https://doi.org/10.1146/annurev.energy.33.022007.145734

Lockamy III, A., & McCormack, K. (2004). The development of a supply chain management process maturity model using the concepts of business process orientation. *Supply Chain Management: An International Journal*, 9(4), 272-278. https://doi.org/10.1108/13598540410550019

Malhotra, M. K., & Grover, V. (1998). An assessment of survey research in POM: from constructs to theory. *Journal of operations management*, *16*(4), 407-425. https://doi.org/10.1016/S0272-6963(98)00021-7

Mani. V, Agrawal, R., & Sharma, V. (2015). Social sustainability practices in the supply chain of Indian manufacturing industries. *International Journal of Automation and Logistics*, 1(3), 211–233. https://doi.org/10.1504/IJAL.2015.071721

Marshall, D., McCarthy, L., Heavey, C. & McGrath, P. (2014). Environmental and social supply chain management sustainability practices: construct development and measurement. *Production Planning & Control: The Management of Operations*, 26(8), 2-19. ttps://doi.org/10.1080/09537287.2014.963726

Martins, C. L., & Pato, M. V. (2019). Supply chain sustainability: A tertiary literature review. *Journal of Cleaner Production*, *225*, 995-1016. https://doi.org/10.1016/j.jclepro.2019.03.250

McCormack, K., Ladeira, M. B., & de Oliveira, M. P. V. (2008). Supply chain maturity and performance in Brazil. *Supply Chain Management: An International Journal*, 13(4), 272-282, https://doi.org/10.1108/13598540810882161

McCormack, K., Ladeira, M.B., & Oliveira, M.P.V. (2008). Supply chain maturity and performance in Brazil. *Supply Chain Management: An International Journal*, 13(4), 272-282. https://doi.org/10.1108/13598540810882161

Meng, X., Sun, M., & Jones, M. (2011). Maturity Model for Supply Chain Relationships in Construction. *Journal of Management in Engineering*, 27 (2), 97-105. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000035

Meng, X., Sun, M., & Jones, M. (2011). Maturity Model for Supply Chain Relationships in Construction. *Journal of Management in Engineering*, 27 (2), 97-105. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000035

Meza-Ruiz, I. D., Rocha-Lona, L., del Rocío Soto-Flores, M., Garza-Reyes, J. A., Kumar, V., & Lopez-Torres, G. C. (2017). Measuring business sustainability maturity-levels and best practices. *Procedia Manufacturing*, *11*, 751-759. https://doi.org/10.1016/j.promfg.2017.07.176.

Miemczyk, J. & Luzzini, D. (2018). Achieving triple bottom line sustainability in supply chains: The role of environmental, social and risk assessment practices. *International Journal of Operations & Production Management*, 39(2), 238-259. https://doi.org/10.1108/IJOPM-06-2017-0334

Mota, B., Gomes, M. I., Carvalho, A., & Barbosa-Povoa, A. P. (2015). Towards supply chain sustainability: economic, environmental and social design and planning. *Journal of cleaner production*, *105*, 14-27. https://doi.org/10.1016/j.jclepro.2014.07.052

Müller, A. & Pfleger, R. (2014). Business transformation towards sustainability. *Business Research*, 7, 313–350. https://doi.org/10.1007/s40685-014-0011-y

Negri, M., Cagno, E., Colicchia, C., & Sarkis, J. (2021). Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda. *Business Strategy and the environment*, *30*(7), 2858-2886. https://doi.org/10.1002/bse.2776

Nimsai, S., Yoopetch, C., & Lai, P. (2020). Mapping the knowledge base of sustainable supply chain management: A bibliometric literature review. *Sustainability*, *12*(18), 7348. https://doi.org/10.3390/su12187348

Osland, A., & Zhou, S. (2013, July). Sustainability in supply chain management how to execute the triple bottom line. In *2013 Suzhou-Silicon Valley-Beijing International Innovation Conference* (pp. 13-18). IEEE.

Pagell, M., & Wu, Z. (2009). Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *Journal of Supply Chain Management*, 45 (2), 30-56. https://doi.org/10.1111/j.1745-493X.2009.03162.x

Paulraj, A., Chen, I. J., & Blome, C. (2017). Motives and performance outcomes of sustainable supply chain management practices: A multi-theoretical perspective. *Journal of Business Ethics*, *145*(2), 239-258. https://doi.org/10.1007/s10551-015-2857-0

Peña-Montoya, C. C., Bouzon, M., Torres-Lozada, P., & Vidal-Holguin, C. J. (2020). Assessment of maturity of reverse logistics as a strategy to sustainable solid waste management. *Waste Management & Research*, *38*(1_suppl), 65-76. https://doi.org/10.1177/0734242X19897131

Pigosso, D.C. A., Rozenfeld, H. & McAloone, T. C. (2013). Eco-design maturity model: a management framework to support ecodesign implementation into manufacturing companies. *Journal of Cleaner Production*, 59, 160-173. https://doi.org/10.1016/j.jclepro.2013.06.040

Pöppelbuß, J., & Röglinger, M. (2011). What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in business process management. In: ECIS 2011 Proceedings, 28-40.

Preuss, L. (2005). Rhetoric and reality of corporate greening: a view from the supply chain management function. *Business Strategy and the Environment*, 14(2), 123–39. https://doi.org/10.1002/bse.435

Rajeev, A., Pati, R. K., & Govindan, K. (2017). Evolution of sustainability in supply chain management: A literature review. *Journal of cleaner Production*, 162, 299-314. https://doi.org/10.1016/j.jclepro.2017.05.026

Raut, R. D., Luthra, S., Narkhede, B. E., Mangla, S. K., Gardas, B. B., & Priyadarshinee, P. (2019). Examining the performance oriented indicators for implementing green management practices in the Indian agro sector. *Journal of Cleaner Production*, *215*, 926-943. https://doi.org/10.1016/j.jclepro.2019.01.139

Reefke, H., Ahmed, M. D., & Sundaram, D. (2014). Sustainable supply chain management—Decision making and support: The SSCM maturity model and system. *Global Business Review*, 15(4), 15(4), 1-12. https://doi.org/10.1177/0972150914550138

Sánchez-Flores, R. B., Cruz-Sotelo, S. E., Ojeda-Benitez, S., & Ramírez-Barreto, M. E. (2020). Sustainable supply chain management—a literature review on emerging economies. *Sustainability*, *12*(17), 6972. https://doi.org/10.3390/su12176972

Santos, D. A., Quelhas, O. L. G., Gomes, C., F.S., Zotes, L. P., França, S. L. B., Souza, G. V. P. S, & Santos, S. S.C. (2020). Proposal for a maturity model in sustainability in the supply chain. *Sustainability*, *12*(22), 9655. https://doi.org/10.3390/su12229655

Searcy, C., & Elkhawas, D. (2012). Corporate sustainability ratings: an investigation into how corporations use the Dow Jones Sustainability Index. *Journal of Cleaner Production*, *35*, 79-92. https://doi.org/10.1016/j.jclepro.2012.05.022

Seuring M. & Müller S. (2008). Core issues in sustainable supply chain management – a delphi study. *Business Strategy and the Environment*, 17 (8), 455-466. https://doi.org/10.1002/bse.607

Seuring, S., & Gold, S. (2013). Sustainability management beyond corporate boundaries: from stakeholders to performance. *Journal of Cleaner Production*, 56, 1-6. https://doi.org/10.1016/j.jclepro.2012.11.033

Shekarian, E., Ijadi, B., Zare, A., & Majava, J. (2022). Sustainable Supply Chain Management: A Comprehensive Systematic Review of Industrial Practices. *Sustainability*, *14*(13), 7892. https://doi.org/10.3390/su14137892

Siew, R. Y., Balatbat, M. C., & Carmichael, D. G. (2016). Measuring project sustainability maturity levela fuzzy-based approach. *International Journal of Sustainable Development*, *19*(1), 76-100. https://doi.org/10.1504/IJSD.2016.073680

Söderberg, L., & Bengtsson, L. (2010). Supply chain management maturity and performance in SMEs. *Operations Management Research*, *3*(1), 90-97. https://doi.org/10.1007/s12063-010-0030-6

Sodhi, M. S., & Tang, C. S. (2018). Corporate social sustainability in supply chains: a thematic analysis of the literature. *International Journal of Production Research*, *56*(1-2), 882-901. https://doi.org/10.1080/00207543.2017.1388934

Stindt, D. (2017). A generic planning approach for sustainable supply chain management—How to integrate concepts and methods to address the issues of sustainability? Journal of Cleaner Production, 153, 146–163. https://doi.org/10.1016/j.jclepro.2017.03.126

Tarhan, A., Turetken, O., & Reijers, H. A. (2016). Business process maturity models: A systematic literature review. *Information and Software Technology*, *75*, 122-134. https://doi.org/10.1016/j.infsof.2016.01.010

Tate W, Ellram, L. M., & Kirchoff, J. F. (2010). Corporate social responsibility reports: a thematic analysis related to supply chain management. *Journal of Supply Chain Management,* 46 (1), 19–44. https://doi.org/10.1111/j.1745-493X.2009.03184.x

Tonelli, F., Evans, S., & Taticchi, P. (2013). Industrial sustainability: challenges, perspectives, actions. *International Journal of Business Innovation Research*, 7(2), 143-163. https://doi.org/10.1504/IJBIR.2013.052576

Wang, J., & Dai, J. (2018). Sustainable supply chain management practices and performance. *Industrial Management & Data Systems*. https://doi.org/10.1108/IMDS-12-2016-0540

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and software technology*, *54*(12), 1317-1339.

Wolf, C., & Seuring, S. (2010). Environmental impacts as buying criteria for third party logistical services. *International Journal of Physical Distribution & Logistics Management*. https://doi.org/10.1108/09600031011020377

Xie, G. (2016). Cooperative strategies for sustainability in a decentralized supply chain with competing suppliers. *Journal of Cleaner Production*, *113*, 807-821. https://doi.org/10.1016/j.jclepro.2015.11.013

Zailani, S., Jeyaraman, K., Vengadasan, G., & Premkumar, R. (2012). Sustainable supply chain management (SSCM) in Malaysia: A survey. *International journal of production economics*, *140*(1), 330-340. https://doi.org/10.1016/j.ijpe.2012.02.008

Zhu, Q., Sarkis, J., & Lai, K-H (2007). Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *Journal of Environmental Management*, 85 (1), 179–189. https://doi.org/10.1016/j.jenvman.2006.09.003

Chapter 2

Supply Chain Sustainability: Concept clarification and framework proposal

This chapter consists of the following paper:

Supply Chain Sustainability: Concept clarification and framework proposal
Garrido, S.; Correia, E., and Carvalho, H. (2022)
CeBER Working paper, Faculdade de Economia, Universidade de Coimbra, Coimbra, Portugal

SUPPLY CHAIN SUSTAINABILITY: CONCEPT CLARIFICATION AND FRAMEWORK PROPOSAL

Susana Garrido Azevedo
University of Coimbra, CeBER - Centre for Business and Economics Research, Faculty of Economics

Elisabete Correia
Polytechnic of Coimbra, Coimbra Business School Research Centre| ISCAC, Coimbra Portugal

Helena Carvalho
Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal

CeBER Working Papers
No. 6 / 2022

CeBER is funded by the Foundation for Science and Technology, I.P.
FCT Fundação para a Ciência e a Tecnologia

SUPPLY CHAIN SUSTAINABILITY: CONCEPT CLARIFICATION AND FRAMEWORK PROPOSAL

Susana Garrido
Univ Coimbra, CeBER, Faculty of Economics, Av Dias da Silva 165, 3004-512 Coimbra, Portugal, garrido.susana@fe.uc.pt

Elisabete Correia
Coimbra Business School | ISCAC, Polytechnic of Coimbra, Coimbra Portugal, ecorreia@iscac.pt

Helena Carvalho
Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal, hmlc@fct.unl.pt

ABSTRACT

Considering the diversity of definitions and understandings of some concepts related to sustainability and its importance in the context of the Supply chain, the main objective of this paper is to clarify and propose a conceptual framework to help clarify the concept of Supply chain sustainability. Based on a comprehensive literature review, different perspectives and ideas are considered for understanding the meaning of Supply chain sustainability. Also, the main differences between some concepts that have been used interchangeably with the meaning of sustainability are pointed out. In the proposed framework, a focus on the triple bottom line approach and the supply chain stakeholders' expectations at intra and inter-organizational levels are considered.

Keywords: Sustainable development, Corporate sustainability, Supply chain sustainability, Framework.

1. INTRODUCTION

In recent decades the increasing demand for and consumption of products has put pressure on organizations and their supply chains (SCs) and resulted in negative impacts on the environment and society (Rajeev et al., 2017). Organizations' decisions, for example, regarding their choice of materials and suppliers, manufacturing processes, employment and labor practices, customer services, land use, or community activities, impact the natural environment, workforces, and society in general (Diesendorf, 2000). It is recognized that industrial production has been a major cause of growing socio-environmental problems (Khan et al., 2021), such as: vast solid and liquid waste creation, air and water pollution, global warming, depletion of the world's critical non-renewable resources and materials (Shekarian et al., 2022), and human health problems (Carvalho et al., 2013). Pressure from the media and Non-governmental organizations (NGOs), requests from the global community (e.g., 17 sustainable development goals set by the United Nations and the recent World Climate Change Conference held in Glasgow in 2021), and various sustainability expectations from customers and stakeholders are some of

the significant motivations driving organizations to integrate the concept of Sustainability into their supply chain (SC) operations (Shekarian et al., 2022). Extensive regulations and legislation (for example, the European Commission has developed a wide range of policies and legislation regarding these issues) are also a driving factor in changing the behaviour of organizations (Mota et al., 2015).

Since the definition in 1987 of Sustainable Development with the increased interest in the topic of sustainability, it has been a noticeable significant increase in studies, especially since 2011 on the subject (Olawumi & Chan, 2018). The diversity of research from different fields has caused, in the academic community, a lack of clarity around the use of the concepts of Sustainable development (SD), Sustainability (S), and Corporate sustainability (CS). This lack of clarity can also be identified in companies that have referred to sustainability only in the environmental field (Costa et al., 2022).

On the other hand, integrating sustainability into the SC context has become considered a key component of Sustainable development (Tonelli et al., 2013) and a way to achieve improvements in resource utilization (Carter & Easton, 2011). Fahimnia et al. (2019) point out that sustainability improvement can be more fully realized when concerns outside the firm's boundaries are considered. The growing importance of sustainability in the context of SC (Sajjad et al., 2020) has also translated into a prolific field of research with multidisciplinary perspectives (Martins & Pato, 2019; Negri et al., 2021; Khan et al., 2021). It has added terms such as Green supply chain management (SSCM), Sustainable supply chain management (SSCM) and Supply chain sustainability, to the field of terminology. Thus, there is also some confusion regarding the concepts related to sustainability in SC.

The main objective of this paper is to propose a conceptual framework to help clarify the concept of Supply chain sustainability. Based on a comprehensive literature review, different perspectives and ideas are considered for understanding the meaning of Supply chain sustainability.

The paper is organized as follows: in section 1, the concepts of sustainability, Sustainable development and their relationship with Corporate sustainability are analyzed. In section 2, the factors that make it essential to consider sustainability in the SC context and the concepts of SSCM are analyzed. Section 3 presents the conceptual framework. The paper ends by highlighting the main conclusions and limitations of the study.

2. LITERATURE REVIEW

2.1. Sustainability

The concept of Sustainable development (SD) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987, p. 43) was introduced in 1987 in the Brundtland Commission Report. Since then, the scope of sustainable development has been both enlarged and deepened. According to Steurer et al. (2005), the concept has expanded from the macroeconomic to the microeconomic and individual levels. Sustainable

development at the organizational level is treated as Corporate sustainability. Thus, Sustainable development is commonly perceived as a societal guiding model, which addresses a broad range of quality of life issues in the long term; Corporate sustainability is perceived as a corporate guiding model, addressing the short and long-term economic, social and environmental performance of corporations (Steurer et al., 2005).

Political and scientific oppositions have marked the debate over Sustainable development and sustainability concepts, and multiple definitions of them have emerged (Barkemeyer et al., 2011). According to Ahi and Searcy (2015), the complex and multifaceted nature of sustainability, covering a broad spectrum of issues, may explain the diversity of definitions. In the literature, the terms sustainability and Sustainable development are used in different ways and with different meanings (Waas et al., 2011). Sometimes, some authors use the terms interchangeably (Lozano, 2008; Golicic & Smith, 2013; Müller & Pfleger, 2014; Amini & Bienstock, 2014). Other authors make distinctions between the concepts for example, Diesendorf (2000), Lozano (2008), and Ahi and Searcy (2015). Ahi and Searcy (2015) argue that sustainability stands for the "goal", an ideal dynamic state, which needs to be continually reassessed. In contrast, Sustainable development refers to the "path" or "process" to achieve it" i.e., Sustainable development is concerned with processes, while sustainability is a state. The Council for Supply Chain Management Professionals (CSCMP, 2013) has another perspective. This organization provided the concept of sustainability as a business effort to comply with the Sustainable development elements, considering stakeholder requirements and corporate social responsibility. To Waas et al. (2011), the two concepts are distinct, with sustainable development being mainly about economic development/growth. The concept of sustainability has evolved and has come to be interpreted in terms of three dimensions "that must be in harmony: social, economic and environmental" (Kuhlman & Farrington, 2010, p. 3438). This perspective is shared by Zailani et al. (2012), who recognize sustainability as the balance between "economic development, caring for the environment, and social equity" (p. 331). Despite the different definitions in the literature, the most notable and consistent notion is the inclusion of all three dimensions and the assurance of future evolution (Seuring & Müller, 2008; Sánchez-Flores et al., 2020).

The growing interest in sustainability has attracted, especially since the 1990s, researchers and practitioners to study various aspects of sustainability (Rajeev et al., 2017). At the organizational level, this has translated into different approaches (e.g., concerning key elements necessary for integrating it into corporate practices) and definitions of Sustainability and Corporate sustainability (Pazienza et al., 2022). Table 1 shows some studies presenting various approaches in the analysis of Corporate sustainability and their main conclusions.

Table 1. Overview of approaches for analysing the concept of CS and main conclusions

Author(s) (year)	Objective/Approach	Conclusions
Montiel & Delgado-Ceballos (2014)	Literature Review article to bring a better understanding of the field of Corporate sustainability.	A standardized definition of CS does not exist. CS has been conceptualized using different approaches: 1. phenomena-driven analysis not framed within traditional approaches concluding within the observed phenomena;2. Framed within organizational theories: stakeholders, resource-based etc.; 3. New theoretical frameworks.
Lankoski, (2016)	Unpacks the contested concept of Corporate sustainability into three constituents: management relevant dimension, substitutability, and goal orientation.	It concludes that the concept of sustainability is interpreted in quite different ways, hindering the sustainability transition achievement. Introduces a novel typology for categorizing conceptions of sustainability into eight basic types to improve the clarity of the concept and build a typical frame of reference.
Bergman et al. (2017)	Empirical analysis of the relevant academic literature on Corporate sustainability using Content Configuration Analysis.	The findings reveal three conceptual types and nine subtypes of Corporate sustainability.
Hahn et al. (2017)	Illustrate the diversity of scholarly enquiry in the field of Corporate Sustainability and the various angles that authors adopt by analysing six articles which are relevant to the subject of Corporate sustainability.	Given Corporate sustainability's complex and diverse nature, further definitional and conceptual convergence seems unlikely to happen. Diversity of views to be celebrated as a fruitful way to foster novel insight in the field.
Swarnapali (2017)	Review of 50 articles from 2002 to 2016 summarizing the Corporate sustainability evolution, definitions, measures and applied theories.	The findings highlight that the Corporate sustainability field is still evolving, and different approaches have been used to define, measure, and theorize Corporate sustainability. Overall, the review evidence that a commonly agreed definition of sustainability is lacking.
Frecè & Harder (2018)	Explain how the current approaches to address the definitional gaps in Corporate sustainability is insufficient for enabling implementation in corporate practices by analyzing the sustainability practices of 50 companies in Switzerland.	Companies often base their sustainability effort on the Brundtland Commission's definition, which shows conceptual problems when removed from its original context of social policies and transposed to the corporate context. Companies are more willing to engage in new norms when they are presented in a specific form and with limited scope.
Shah & Rahim (2019)	Literature review to address the ambiguities of the conceptual understanding of Corporate sustainability.	Corporate sustainability is still considered to be a vague concept, and scholars on a single definition have developed no consensus.
Meuer et al. (2020)	Address the lack of conceptual clarity of the concept of Corporate sustainability by adopting the Aristotelian perspective on definitions, one that promotes reducing concepts to their essential attributes.	Argues that the criticism of Corporate sustainability practices failing to contribute to sustainable development effectively is due to the fundamental ambiguity around the nature of Corporate sustainability. Develops the Corporate sustainability Cube framework to compare Corporate sustainability definitions.
Urdan & Luoma (2020)	Clarify the elusive and complex definitions and uses of Sustainability and Corporate social	Sustainability and Corporate social responsibility are commonly and frequently used interchangeably in academic research and the classroom by textbook authors and business reports. Corporate terminology heavily

	responsibility by reviewing the nomenclature from academics, corporation, and business and society course textbooks.	influences student work, which supersedes textbook, nomenclature, and classroom instruction. Call for future research to delve into the issue of clarifying the definitional complexity and conflation.

Source: Adapted from Pazienza et al. (2022)

In research, some effort has been made to clarify the different Corporate sustainability interpretations and integrate the various viewpoints. This clarification is considered essential since the lack of clarity can constitute an obstacle hindering the progress of theoretical development and hinder decision-making and the existence of guidelines for organizations to adopt sustainability (e.g., Meuer et al., 2020; Frecè et al., 2018). Table 2 shows some definitions of Corporate sustainability. It highlights some of the main components present in the definitions (TBL Focus, Time dimension and reference to stakeholders).

Table 2. Definitions of Corporate sustainability

Author(s) Year	**Definition**	**Components**		
		TBL Focus	Time dimens.	Stakehol.
Dyllick and Hockert (2002)	Corporate sustainability can be defined as meeting the needs of a firm's direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities, etc.) without compromising its ability to meet the needs of future stakeholders as well.		✓	✓
Van Marrewijk (2003)	In general, Corporate sustainability […] refers to voluntary company activities that include social and environmental concerns in business operations and interactions with stakeholders.			✓
Bansal (2005)	Corporate sustainability means applying the principles of economic integrity, social equity, and environmental integrity simultaneously to products, policies, and practices.	✓		
Russell et al. (2007)	Working toward long-term economic performance, working toward positive outcomes for the natural environment, supporting people and social outcomes, and adopting a holistic approach.	✓	✓	
Lozano (2012)	Corporate activities that proactively seek to contribute to sustainability equilibria, including the economic, environmental, and social dimensions of today, as well as their interrelations within and throughout the time dimension while addressing the company's system (including Operations and production, Management and strategy, Organizational systems, Procurement and marketing, and Assessment and communication); and its stakeholders.	✓	✓	✓
Hahn et al. (2014)	A concept that "refers to a company's activities […] demonstrating the inclusion of social and environmental concerns in business operations and interactions with stakeholders.			✓
Sharma (2014)	The achievement of a firm's short-term financial, social, and environmental performance without compromising its long-term financial, social, and environmental performance.	✓	✓	

According to Pazienza et al. (2022), one of the most cited definitions of Corporate sustainability is that of Dyllick and Hockerts (2002). The authors defined Corporate sustainability as "... meeting the needs of a company's direct and indirect stakeholders (such as shareholders, employees, customers,

pressure groups, communities, etc.) without compromising its ability to meet the needs of future stakeholders as well" (Dyllick & Hockerts,2002, p. 131). This definition highlights a temporal perspective. Other definitions emphasize other elements. Some of the elements common to several definitions are: i) they focus on economic, social, and environmental aspects and present an integrated triple bottom line perspective; ii) they focus on addressing the needs of key stakeholders; iii) and sustainability contemplates a short and long-term perspective (Van Marrewijk, 2003; Bansal, 2005; Gao & Bansal, 2013; Hassini et al., 2012). In Table 1, only Lozano's (2012) definition considers these various elements simultaneously. Figure 1 seeks to represent Corporate sustainability considering this perspective.

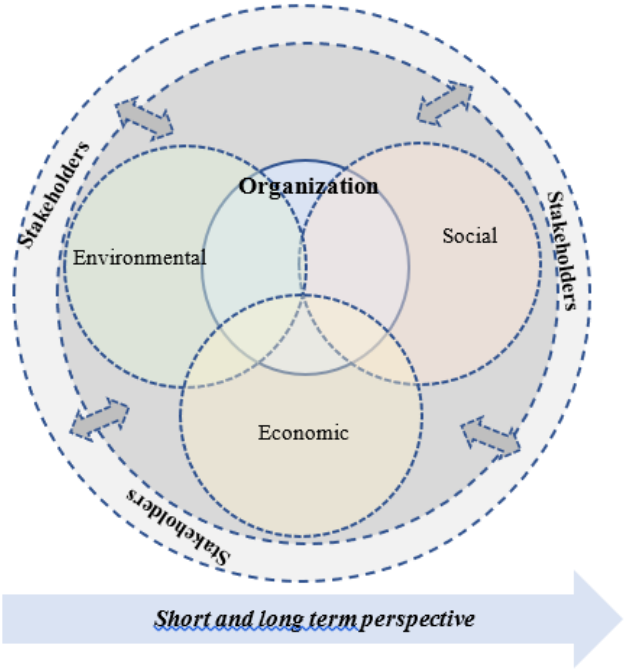


Figure 1. Corporate sustainability

Considering the different approaches and definitions of SC present in the literature and after ontological analysis of the various concepts and their main constitutive elements, Pazienza et al. (2022) conclude that this concept is more straightforward than most authors claim. According to the authors, Corporate sustainability can be well defined around its environmental, social, and economic constitutive pillars to provide equal opportunities to future generations.

Baumgartner and Ebner (2010) highlight the link of Corporate sustainability to the concept of Sustainable development, which also seems to be present in Pazienza et al.'s (2022) perspective. According to Baumgartner and Ebner (2010), Corporate sustainability is the "transfer of the concept of Sustainable development from society to the business context in a fundamental way that enables a company to achieve the twin goals of sustainable development and organizational objectives".

According to Elkington (1998), sustainable development "involves the simultaneous pursuit of economic prosperity, environmental integrity, and social equity" (Elkington, 1998). Economic prosperity promotes a good quality of life through the productive capacity of organizations and

individuals in society. It involves creating and distributing goods and services that will help raise the standard of living worldwide. Environmental integrity ensures that human activities do not erode the earth's land, air, and water resources. Finally, social equity ensures that all members of society have equal access to resources and opportunities (Bansal, 2005). The author believes that Corporate sustainability is only achieved through the intersection of the previous three principles: environmental integrity, through environmental management of enterprises; social equity, through corporate social responsibility; and economic prosperity, through value creation. These three principles are aligned with the TBL perspective that companies need to pursue to become more sustainable. The TBL model operationalises sustainability as the intersection and balance of economic, environmental, and social concerns (Elkington, 1998).

Analyzing the concepts of Sustainable development and Corporate sustainability, Steurer et al. (2005) argue that the concept of Corporate sustainability is rooted in the idea of Sustainable development since it captures the company's desire to achieve long-term sustainability, supporting the continuous improvement of social, environmental, and economic conditions. Each sustainable development principle can be put into action through some practices. For example, to minimize and mitigate environmental impacts, companies can undertake initiatives, such as: using green materials, renewable energy for lighting and transportation, recycling or reusing all waste, or applying leadership to influence the industry, i.e. buying green energy or green materials from suppliers to drive the industry (Hitchcock & Willard, 2006). To contribute to community development, companies can also play a proactive and cooperative role in creating a community that is an excellent place to live and conduct business. Therefore, Sustainable development principles or sustainability values must be embedded in all aspects of the company, in the different functional areas and activities, including those involving SC partners (Seuring & Gold, 2013) and other stakeholders such as ONGs.

2.2. Sustainability dimensions

Golicic and Smith (2013) highlight the term "sustainability" without a dimensional descriptor preceding it (i.e., environmental, economic, or social) refers to the broad definition of sustainability which encompasses all three dimensions. The social, environmental, and economic dimensions are complementary and connected.

However, each has its emphasis, and in practice, not all dimensions are always considered together (Sánchez-Flores et al., 2020). Thus, when a specific dimension of sustainability is meant (e.g., environmental), the dimensional descriptor is used (e.g., environmental sustainability), an approach we follow in this paper. Negri et al. (2021) point out that while many studies define sustainability, including the three pillars of the TBL, some consider only the environmental dimension, others only the social dimension, and there are even studies that combine two dimensions. The meaning of each of these dimensions is discussed below.

Environmental dimension

The environmental dimension of sustainability is related to the natural environment, which includes land, water, plants, and animals (Sánchez-Flores et al., 2020). More specifically, it involves preserving natural resources for society (Bansal, 2002; Waas et al., 2011; Hanss & Böhm, 2012) and using them responsibly (Appelbaum et al., 2016). It relates to the need to avoid the depreciation of natural capital (natural resources and ecosystem services) (Dyllick & Hockerts, 2002). At the corporate level, the environmental component of sustainability primarily addresses the organization's impact of processes, products, and services on living and non-living natural systems, including ecosystems, land, air, and water (Jamali et al., 2006). A company acting according to the TBL tries to preserve the natural environment, limit its impact, or at least not damage it (Żak, 2015).

Jamali et al. (2006) point out that "environmental responsibility involves more than compliance with all applicable government regulations or even initiatives such as recycling or energy efficiency". It involves a comprehensive approach to a company's operations, products and facilities that includes assessing business products, processes, and services; eliminating waste and emissions; maximising the efficiency and productivity of all assets and resources; and minimising practices that might adversely affect the enjoyment of the planet's resources by future generations. The responsibility to the environment (the planet) manifests itself in the company's undertaking environmental protection practices to prevent water, soil, and air pollution, using appropriate materials and substances, as well as installing filters and sewage treatment plants (Żak, 2015). In the same vein, Goel (2010) points out that this dimension refers to engaging in practices that do not compromise the environmental resources for future generations and contribute to the efficient use of energy resources, reducing greenhouse gas emissions, and minimizing the ecological footprint, etc.

Social dimension

The social dimension of sustainability is related to human capital (Morais et al., 2018). To Hanss and Böhm (2012), sustainability's social dimension means improving the living conditions of the world's poor and promoting equal opportunities for all. According to Waas et al. (2011), this dimension means social justice to achieve an equal distribution of welfare, equal access to natural resources and equal opportunities between people (gender, social groups, *etc*.). Mani et al. (2015) highlight that it primarily focuses on social interactions that include inequality, gender discrimination, poverty, diversity, wages and education. To McKenzie (2004), the social aspects support the creation and development of skills, and the capabilities of current and future generations, to promote health and support fairly and equitably to everyone.

At the corporate level, Winter and Knemeyer (2013) consider that the social dimension is bipolar: it refers to both individual and organizational levels. Improving this dimension involves developing and implementing fair and beneficial practices for workers, the community, and the region where the firm operates (Elkington, 1997; Żak, 2015; Morais et al., 2018). Examples of practices that show companies'

responsibility to workers may include fair wages, treating workers according to the principles of fairness and honesty in mutual relations, creating the best working conditions in terms of safety, ensuring satisfactory employment conditions, and providing health care coverage (Żak, 2015). Companies can also undertake and support actions to benefit the strengthening and development of the local community in matters such as healthcare and education (Żak, 2015). To Mani et al. (2015), the social aspects that need to be considered at the firm level may include, for example: public health issues, community issues, public controversies, skills and education, social justice, workplace safety, working conditions, human/labour rights, and equal opportunity. Social aspects such as: diversity, philanthropy, safety, and human rights have been established in US manufacturing firms (Carter & Jennings, 2002); equity, gender discrimination, gender diversity, education, wages, ethics, child and slave labour, health and safety, and hygiene, have emerged related to Indian manufacturing industries (Mani et al., 2015). To Klassen and Vereecke (2012), the social dimension at the SC level involves aspects related to the products or processes of operations that affect human safety and well-being, community development, and protection from harm.

Economic dimension

Sustainability's economic dimension is related to the economic viability and growth that secure human well-being (Hanss & Böhm, 2012). Para Waas et al. (2011) this dimension is associated with economic growth as an engine for long-term welfare creation to satisfy essential needs for jobs, income, food, energy, water, sanitation, social security, and consumption opportunities.

At the firm level, Vachon and Mao (2008) point out that the economic aspects have to do with whether they generate sufficient cash flow to produce persistent returns, which includes an idea of long-term success. According to Jamali et al. (2006, p. 398), this dimension "refers to financial viability and encompasses issues of competitiveness, job and market creation, and long-term profitability." Although it is focused on the efficient use of resources and cost reduction (Jamali et al., 2006), economic sustainability is increasingly understood as referring to the generation of added value in the broader sense, rather than conventional financial accounting" (Jamali et al., 2006, p. 398). Similarly, Sheth et al. (2011) point out that economic sustainability should encompass two distinct aspects: "one relating to the firm-centric aspect of financial performance, the other relating to the economic interests of external stakeholders, such as a broad-based improvement in economic well-being and standards of living." Jamali et al., (2006) emphasize the fact that the economic dimension includes the financial aspect and comprises aspects such as: reducing the cost of doing business through rigorous business integrity policies, increasing productivity through a motivated workforce, satisfying customers with goods and services of real value, obtaining a fair return on the funds entrusted to the firm by its investors. According to Torugsa et al. (2013), to support economic growth and prosperity, firms anticipate problems (e.g., customer satisfaction, product quality and safety) that may arise in their interactions with customers, suppliers, and other stakeholders. Economic prosperity can also be achieved through value creation

(Bansal, 2005). It can contribute to value creation, for example, by encouraging the development of new and different products that are desired by consumers, reducing resource costs, and improving production efficiency (Bansal, 2005, Torugsa et al., 2013).

3. INTEGRATING SUSTAINABILITY IN THE SUPPLY CHAIN CONTEXT

Any company interacts with other organizations and creates interdependencies at the strategic level and daily operations. Its decisions in many different areas (e.g., purchasing, production, design) have various implications for its SC (Seuring & Gold, 2013). The SC can be defined as a "set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer" (Mentzer et al., 2001). For the same authors, supply chain management is understood as "the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, to improve the long-term" (Mentzer et al., 2001, p.18). In a more recent definition of supply chain management, it is understood "as the organization and coordination of the set of distinctively performed functions within and across firms that constitute the SC to create value by delivering products and services to the market" (Martins & Pato, 2019, p. 996). Other definitions exist, emphasizing certain aspects.

For example, in a proposed definition of SCM, Lambert et al. (2006) highlight the goal of adding value for stakeholders. An effective and efficient SCM can represent advantages for the organization, translated for example, in terms of service, cost reduction and speed of response to market needs, and fewer errors, delays and losses along the SC (Soni & Kodali, 2008). Incorporating sustainability into SCM is a challenge for organizations. The debate on the application of sustainability in a SC context has grown (Ahi & Searcy, 2015) and has translated into an increasingly large research output (Martins & Pato, 2019).

3.1. Sustainable Supply Chain Management (SSCM)

The fact that the incorporation of sustainability into SC initially focused on the environmental dimension (Martins & Pato, 2019) perhaps accounts for the initial attention to Green supply chain management (GSCM), with the first studies appearing in the 2000s (Negri et al., 2021).

Green Supply Chain Management (GSCM) means "Integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life" (Srivastava, 2007, p.54). The product life cycle perspective is present in this definition. However, this and other definitions of GSCM fail to address social aspects, which is one of the

significant concerns of SD (Rajeev et al., 2017). Incorporating the social dimension of sustainability has led to Sustainable supply chain management (SSCM), the dominant research domain as of the 2010s (Rajeev et al., 2017). Although some authors consider GSCM a subset of SSCM (Ahi & Searcy, 2013; Ashby et al., 2012), with SSCM becoming an extension of GSCM, other authors continue to explore the environmental dimension in the SC and focus on GSCM. The first contributions to SSCM appear after 2003, increasing significantly after 2010 (Negri et al., 2021).

In contrast to traditional SCM, which typically focuses on the economic and financial performance of companies (Brandenburg et al., 2014), SSCM is characterized by the direct integration of environmental and social objectives that extend the economic dimension to TBL (Seuring & Müller, 2008). Figure 2 illustrates this perspective.

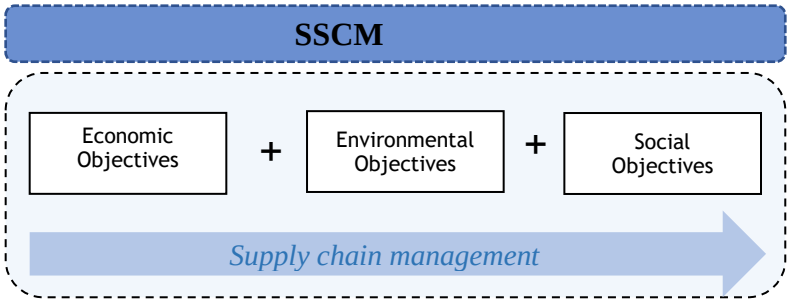


Figure 2. Integration of economic, environmental, and social objectives on SCM

Negri et al. (2021) analysed a comprehensive set of SSCM definitions and concluded that there is some lack of consistency in those definitions, a point already made by Stindt (2017) and also noted about the concept of Corporate sustainability. It should also be noted that the incorporation of sustainability into SCM is also known as Supply chain sustainability (Chowdhury & Quaddus, 2021).

The most recent definitions of SSCM tend to include the three pillars of sustainability (Negri et al., 2021). While not claiming to be exhaustive, Table 2 presents some definitions of SSCM and highlights its main components.

Table 3. Overview of some of the main definitions of sustainable supply chain management

Author(s), Year	Definition	Components		
		TBL Focus	Time dimens.	Stakehol.
Carter and Rogers, 2008	SSCM as the strategic, transparent integration and achievement of an organization's social, environmental and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual companies and its SC. *	✓	✓	
Seuring, 2008	The integration of sustainable development and supply chain management [in which] by merging these two concepts, environmental and social aspects along the supply chain have to	✓		

	be taken into account, thereby avoiding related problems, but also looking at more sustainable products and processes.			
Seuring and Müller, 2008	SSCM is the management of material, information, and capital flow as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account, which are derived from customer and stakeholder requirements. *	✓		✓
Pagell and Wu, 2009	The specific managerial actions taken to make the supply chain more sustainable with an end goal of creating a truly sustainable chain. *			
Wolf and Seuring, 2010	SSCM means producer collaborates with its SC members and collaboratively manages inter-and intra-firm processes for sustainable development.			
Hassini et al., 2012	Sustainable supply chain management as the management of supply chain operations, resources, information, and funds to maximize the supply chain profitability while at the same time minimizing the environmental impacts and maximizing the social well-being.*	✓		
Ahi and Searcy, 2013	The creation of coordinated supply chains through the voluntary integration of economic, environmental, and social considerations with key inter-organizational business systems designed to efficiently and effectively manage the material, information, and capital flows associated with the procurement, production, and distribution of products or services to meet stakeholder requirements and improve the profitability, competitiveness, and resilience of the organization over the short- and long-term. *	✓	✓	✓
Stindt, 2017	We interpret SSCM in a broad sense as planning, execution and control of corporate value creation processes by integrated consideration of economic, ecological and social aspects to improve the long-term performance of an individual company and the supply chain as a whole.	✓	✓	
Negri et al., 2021	The planning, execution, and control of corporate value creation processes along the whole supply chain by integrating economic, environmental, and social aspects into decision-making to improve long-term performance and mitigate risks.	✓	✓	

Note: (*) The most highly co-cited documents on SSCM (Nimsai et al., 2020).

One of the most cited definitions of SSCM in the literature (Negri et al., 2021) is that of Seuring and Müller (2008). The authors consider SSCM as "The management of material, information and capital flow as well as cooperation among companies along the SC while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account, which are derived from customer and stakeholder requirements" (Seuring & Müller, 2008, p. 1700). This definition focuses on the TBL and includes stakeholders. Stakeholders are an essential component of SSCM (Beske & Seuring, 2014). In addition to being able to justify the activities and behaviors of companies in sustainability issues, stakeholders can develop relational and technical capabilities that companies can use to respond to the expectations and needs of society in general (Gualandris et al., 2015). According to Hyatt and Johnson (2016), companies need the knowledge and participation of multiple stakeholders, such as environmental groups and other non-governmental organizations (NGOs) to transition Supply chain sustainability toward economic, social, and environmental ends. These stakeholders can play advisory, observer, coordinator or even partner roles in the design and implementation of sustainable

evaluation and verification processes (Gualandris et al., 2015). Although many companies develop sustainability-level programs involving various stakeholders such as NOGs, Merchant Organizations or Consultants (Alvarez et al., 2010), these stakeholders are viewed as outsiders by traditional SC companies and typically identified as "non-traditional" SC members (Rodriguez et al., 2016). However, the movement towards sustainability in SCs requires innovation in several areas, including rethinking who is in the SC (Pagell & Wu, 2009). Thus, companies can develop sustainability practices involving not only traditional SC partners but also other stakeholders such as NGOs or community members.

3.2 Why integrate sustainability into supply chains?

There are several reasons for considering sustainability in an SC context. On the one hand, the entire product journey from the extraction of raw materials to its delivery to the end user involves various processes (design, sourcing, production, and distribution) that are responsible for large consumption of resources and environmental impacts (Gupta & Palsule-Desai, 2011). Thus, efforts to minimize on the undesirable effects on the environment should be made not only in the stages of production and disposal of products (Tsoulfas & Pappis, 2004) but also in other stages and activities involving other SC participants. In the same way, we can extend that idea to the social dimension and conclude that each stage of the SC affects the sustainability of the final product (Vachon & Klassen, 2006). Thus, companies not only need to consider their own environmental and social performance but also that of the other SC partners since they can easily be held accountable for a negative environmental, as well as social, performance occurring at different points (by members) of their SC (Tate et al., 2010; Gimenez & Tachizawa, 2012). This can negatively affect their reputation, negatively impacting their economic performance (Caniëls et al., 2013). Other aspects related to labor practices in non-industrialized countries have been in the spotlight of NGOs, which are increasingly relevant issues for companies because they can impact their business (Leipziger, 2017). In this regard, Lippman (1999) highlights that customers do not distinguish the company's environmental performance from its suppliers' environmental performance. For example, Apple (Garside, 2013) has been associated with child labor, but the misconduct has occurred at their suppliers in the Asian continent. Walmart has also been linked to suppliers of shrimp manufactured in Thailand, where the workers in these facilities are deprived of basic living conditions such as minimum wage, health and safety facilities, and bonded labor questioned by NGOs and human rights activists (Mani et al., 2015).

Thus, companies must implement practices promoting sustainability in SCs that avoid any association with anything that could negatively affect their reputation and Sustainability performance. Given that the various SC partners are interconnected, high levels of Sustainability performance from one company may be difficult to achieve due to poor performance levels from other SC partners, such as suppliers. Implementing intra- and inter-organizational sustainability practices can improve the sustainability of the company and its SC.

Other roles are now required from companies about how they can contribute to Sustainability,

including product life cycle management or social and environmental practices involving their SC partners such as suppliers or customers. For example, Sancha et al. (2016) highlight the need for purchasing companies to implement practices that ensure their suppliers are sustainable. Suppose companies develop initiatives for their SC partners to improve Sustainability, in that case, we can argue, like Ashby et al. (2012), that focusing on SCs is a step toward wider adoption and development of Sustainability. In this view, Seuring and Gold (2013) also state that companies cannot, in an increasingly interconnected world, identify and address Sustainability challenges alone, which has contributed to the increased interest in Sustainability issues at the inter-organizational level.

In synthesis, the factors that can drive (or inhibit) progress towards Sustainability considering the context of SC are of diverse order. They relate, for example, to the need to manage risks, and the desire to improve environmental, social, or economic performance, such as reducing costs or increasing quality (Ahi & Searcy, 2015). Several literature reviews (e.g., Carter & Rogers, 2008; Seuring & Müller, 2008; Walker et al., 2008) have highlighted the benefits of SSCM. According to Wolf (2014), companies improve sustainability in SC to mitigate stakeholder pressures. The will of managers, pressure from investors, responding to pressures from customers, and competitors, regulatory demands, technological developments, and corporate history are some of the drivers and enablers that can initiate or motivate in the adoption of practices that operationalize the integration of sustainability at the SC level (Ahi & Searcy, 2015; Negri et al., 2021). In a recent systematic literature review, Khan et al. (2021) identifies a broad and diverse set of drivers and barriers. The implementation of sustainability in SC has been a concern of many studies, focusing on pressures or drivers, barriers, decision making and practices (Negri et al., 2021). Divergent and multiple practices identification and study are examples of SSCM being still an essentially contested concept (Negri et al., 2021).

4. CONCEPTUAL FRAMEWORK

The idea that in an SC it is necessary to guarantee that the sustainability objectives are simultaneously met considering the context of the SCs is present in the literature. For example, Pagell and Wu (2009, p. 38) argue, "To be truly sustainable, a supply chain would at worst do no net harm to natural or social systems while still producing a profit over an extended period." Thus, to achieve sustainable supply chains, it becomes necessary to manage the SC, integrating Sustainability into this management (Delai & Takahashi, 2016).

The literature review conducted in the previous sections allowed us to identify the main elements that support the Supply chain sustainability framework proposal. There are some common elements when considering sustainability at the organizational and SC level:

i) the TBL perspective, where the economic, environmental and social dimensions of sustainability are simultaneously considered;

ii) the time dimension since it is relevant for sustainability to admit the short term ("to meet the needs of the present"), and the long term ("without compromising the ability of future generations to meet their own needs";

iii) consideration of stakeholders, i.e., meet the needs and requirements of internal and external stakeholders. These elements are present in the framework presented in figure 3 and had already been considered in figure 1, representing Corporate sustainability. However, for the integration of sustainability at the SC level, it will be essential to consider the interconnections and interdependencies between the organization and its traditional partners (customers and suppliers) and also with other stakeholders such as NGOs or community groups reconfiguring the SC (ultimate SC approach) (Gualandris et al., 2015; Hyatt and Johnson, 2016). These stakeholders can play an important role in the sustainability path of companies and their SC.

Finally, and considering the context of SC it should be noted that the integration of sustainability must be contemplated beyond the company's boundaries and included in the various processes and activities within and between the various SC members. Figure 3 presents the proposal of a framework for Supply chain sustainability.

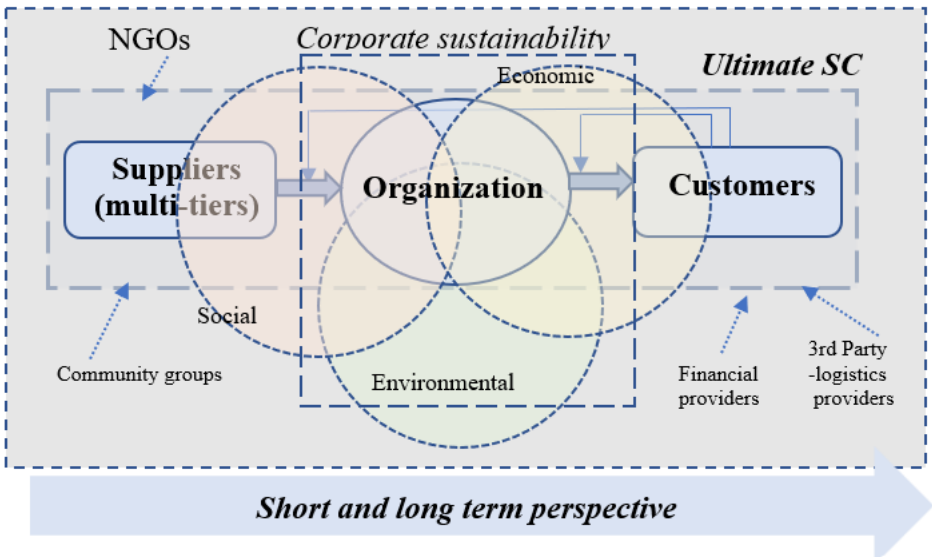


Figure 3. Supply chain sustainability framework

5. CONCLUSION

Considering that "sustainability requires thinking beyond the boundaries of a single entity or organization to consider entire value chains and production and consumption systems" (Lebel & Lorek, 2008), Supply chains and Supply chain management (SCM) are thus placed at the center of the policy and practice agenda for sustainability. Based on a comprehensive literature review, this study analyses the importance of integrating sustainability in the context of SC and some important concepts to better understand this theme: Sustainability, Sustainable development, Corporate sustainability, Sustainable supply chain management and Supply chain sustainability. The ambiguity and the vast number of definitions and constructs related to sustainability at various levels (societal, organizational, and SCs)

and the lack of clarity surrounding the use of the concepts makes it necessary to clarify them (Martins & Pato, 2019; Negri et al., 2021; Khan et al., 2021; Costa et al., 2022).

This study proposes a conceptual framework that integrates the main components to be considered for sustainability in supply chains. These components result from an analysis of different definitions and perspectives. To improve Sustainability in SCs, it is necessary to consider: a TBL perspective, where the various dimensions of sustainability (economic, environmental and social) are contemplated; to consider the short and long term; to consider the expectations and needs of the SC organizations and their stakeholders and integrate the objectives of sustainability at the intra-organizational and inter-organizational levels in the management of the various processes or flows of materials, information and capital among companies along the SC.

This study aims to contribute to literature broadening the understanding of the meaning of Supply chain sustainability and its related concepts. It is hoped that it will that it constitutes a useful contribution that can serve as a basis for other studies which intend to investigate these issues. However, some limitations should be noted. First, the literature review may have left out many studies important to the discussion and understanding of the topic. Future research could adopt a systematic review of the literature as its methodology. It would also be interesting to understand how these concepts are perceived and used in practice in organizations. On the other hand, the study focuses on the analysis and comparison of concepts and the aspects that must be considered for SC sustainability but does not explore how to operationalize the integration of sustainability. This topic may also be deepened in future research.

REFERENCES

Ahi, P., & Searcy, C. (2015). Assessing sustainability in the supply chain: A triple bottom line approach. *Applied Mathematical Modelling*, *39*(10-11), 2882-2896. https://doi.org/10.1016/j.apm.2014.10.055

Alvarez, G., Pilbeam, C., & Wilding, R. (2010). Nestle´ Nespresso AAA sustainable quality program: an investigation into the governance dynamics in a multi-stakeholder supply chain network. *Supply Chain Management: An International Journal*, 15(2), 165-182. https://doi.org/10.1108/13598541011028769

Amini, M. & Bienstock, C. (2014). Corporate sustainability: an integrative definition and framework to evaluate corporate practice and guide academic research. *Journal Of Cleaner Production*, 76, 12-19. https://doi.org/10.1016/j.jclepro.2014.02.016

Appelbaum, S. H., Calcagno, R., Magarelli, S. M., & Saliba, M. (2016). A relationship between corporate sustainability and organizational change (Part Three). *Industrial and Commercial Training*, 48(1), 16–23. https://doi.org/10.1108/ICT-07-2014-0047

Ashby, A., Leat, M., & Hudson-Smith, M. (2012). Making connections: a review of supply chain management and sustainability literature. *Supply Chain Management: An International Journal*, 17 (5), 497-516. https://doi.org/10.1108/13598541211258573

Bansal, P. (2005). Evolving sustainably: A longitudinal study of corporate sustainable development. *Strategic Management Journal*, 26(3), 197–218. https://doi.org/10.1002/smj.441

Barkemeyer, R., Holt, D., Preuss, L., & Tsang, S. (2011). What Happened to the "Development" in Sustainable Development? Business Guidelines Two Decades After Brundtland. *Sustainable Development*. https://doi.org/10.1002/sd

Baumgartner, R.J., & Ebner, D. (2010). Corporate sustainability strategies: sustainability profiles and maturity levels. *Sustainable Development*, 18, 76-89. https://doi.org/10.1002/sd.447

Bergman, M. M., Bergman, Z., & Berger, L. (2017). An empirical exploration, typology, and definition of corporate sustainability. *Sustainability*, *9*(5), 753. https://doi.org/10.3390/su9050753

Beske, P., & Seuring, S. (2014). Putting sustainability into supply chain management. *Supply Chain Management: An International Journa*l, 19 (3), 322-331. https://doi.org/10.1108/SCM-12-2013-0432

Brandenburg, M., Govindan, K., Sarkis, J., & Seuring, S. (2014). Quantitative models for sustainable supply chain management: developments and directions. *European Journal of Operational Research*, 233, 299–312. https://doi.org/10.1016/j.ejor.2013.09.032

Caniëls, M. C. J., Gehrsitz, M. H., & Semeijn, J. (2013). Participation of suppliers in greening supply chains: An empirical analysis of German automotive suppliers. *Journal of Purchasing & Supply Management*, 19, 134–143. https://doi.org/10.1016/j.pursup.2013.02.005

Carter, C. R. & Easton, P. L. (2011). Sustainable supply chain management: evolution and future directions. *International Journal of Physical Distribution & Logistics Management*. 41 (1), 46-62. https://doi.org/10.1108/09600031111101420

Carter, C., & Rogers, D.S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution & Logistics Management*, 38 (5), 360-387. https://doi.org/10.1108/09600030810882816

Carter, C.R.; & Jennings, M.M. (2002). Logistics social responsibility: an integrative framework. *Journal of Business Logistics*, 23 (1), 145-80. https://doi.org/10.1002/j.2158-1592.2002.tb00020.x

Carvalho, A., Matos, H. A., & Gani, R. (2013). SustainPro—A tool for systematic process analysis, generation and evaluation of sustainable design alternatives. *Computers & Chemical Engineering*, *50*, 8-27. https://doi.org/10.1016/j.compchemeng.2012.11.007

Costa, A. J., Curi, D., Bandeira, A. M., Ferreira, A., Tomé, B., Joaquim, C., ... & Marques, R. P. (2022). Literature Review and Theoretical Framework of the Evolution and Interconnectedness of Corporate Sustainability Constructs. *Sustainability*, *14*(8), 4413. https://doi.org/10.3390/su14084413

Council of Supply Chain Management Professionals. Available online: https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921

Chowdhury, M. M. H., & Quaddus, M. A. (2021). Supply chain sustainability practices and governance for mitigating sustainability risk and improving market performance: A dynamic capability perspective. *Journal of Cleaner Production*, *278*, 123521. https://doi.org/10.1016/j.jclepro.2020.123521

Diesendorf, M. (2000). Sustainability and sustainable development. *Sustainability: The corporate challenge of the 21st century*, *2*, 19-37.

Dyllick, T., & Hockerts, K. (2002). Beyond the business case for corporate sustainability. *Business Strategy and the Environment*, 11, 130–141. https://doi.org/10.1002/bse.323

Elkington, J. (1998). *Cannibals with folks: the triple bottom line of 21st century business*. Stony Creek, CT: New Society Publishers.

Fahimnia, B., Sarkis, J., & Talluri, S. (2019). Editorial design and Management of Sustainable and Resilient Supply Chains. *IEEE Transactions on Engineering Management*, 66(1), 2–7. https://doi.org/10.1109/TEM.2018.2870924

Frecè, J. T., & Harder, D. L. (2018). Organisations beyond Brundtland: a definition of corporate sustainability based on corporate values. *Journal of Sustainable Development, 11*(5), 184-193. https://doi.org/10.5539/jsd.v11n5p184

Gao, J., & Bansal, P. (2013) Instrumental and Integrative Logics in Business Sustainability. *Journal of Business Ethics*, 112, 241–255. https://doi.org/10.1007/s10551-012-1245-2

Garside, J. (2013). Child labour uncovered in Apple's supply chain. *The Guardian. http://www.theguardian.com/technology/2013/jan/25/apple-childlabour-*

Gimenez, C., & Tachizawa, E. M. (2012). Extending sustainability to suppliers: a systematic literature review. *Supply Chain Management: An International Journal*, 17(5), 531–543. https://doi.org/10.1108/13598541211258591

Goel, P. (2010). Triple bottom line reporting: An analytical approach for corporate sustainability. *Journal of Finance, Accounting, and Management, 1*(1), 27-42.

Golicic, S. L., & Smith, C. D. (2013). A meta-analysis of environmentally sustainable supply chain management practices and firm performance. *Journal of Supply Chain Management*, 49(2), 78-95. https://doi.org/10.1111/jscm.12006

Gualandris, J., Klassen, R.D., Vachon S., & Kalchschmidt, M. (2015). Sustainable evaluation and verification in supply chains: Aligning and leveraging accountability to stakeholders. *Journal of Operations Management,* 38, p. 1–13. https://doi.org/10.1016/j.jom.2015.06.002

Gupta, S., & Palsule-Desai, O. D. (2011). Sustainable supply chain management: Review and research opportunities. *IIMB Management Review*, 23, 234-245. https://doi.org/10.1016/j.iimb.2011.09.002

Hahn, T., Figge, F., Aragón-Correa, J. A., & Sharma, S. (2017). Advancing research on corporate sustainability: Off to pastures new or back to the roots?. *Business & Society*, *56*(2), 155-185. https://doi.org/10.1177/0007650315576152

Hahn, T., Preuss, L., Pinkse, J., & Figge, F. (2014). Cognitive frames in corporate sustainability: Managerial sensemaking with paradoxical and business case frames. *Academy of Management Review*, *39*, 463-487. https://www.jstor.org/stable/43699260

Hanss, D., & Böhm, G. (2012). Sustainability seen from the perspective of consumers. *International Journal of Consumer Studies*, 36, 678–687. https://doi.org/10.1111/j.1470-6431.2011.01045.x

Hassini, E., Surti, C., & Searcy, C. (2012). A literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics*, 140 (1), 69-82. https://doi.org/10.1016/j.ijpe.2012.01.042

Hitchcock, D. E., & Willard, M. L. (2006), *The Business Guide to Sustainability: Practical Strategies and Tools for Organizations*, Earthscan, London.

Hyatt, D. G., & Johnson, J.L. (2016). Expanding boundaries: Nongovernmental organizations as supply chain members. *Elementa: Science of the Anthropocene*, 4, 1-14. https://doi.org/10.12952/journal.elementa.000093

Jamali, D., Mezher, T., & Bitar, H. (2006). Corporate social responsibility and the challenge of triple bottom line integration: insights from the Lebanese context. *International Journal of Environment and Sustainable Development*, 5(4), 395-414. https://doi.org/10.1504/IJESD.2006.011557

Khan, S. A. R., Yu, Z., Golpira, H., Sharif, A., & Mardani, A. (2021). A state-of-the-art review and meta-analysis on sustainable supply chain management: Future research directions. *Journal of Cleaner Production*, *278*, 123357. https://doi.org/10.1016/j.jclepro.2020.123357

Klassen, R. D., & Vereecke, A. (2012). Social Issues in Supply Chains: Capabilities Link Responsibility, Risk (Opportunity), and Performance. *International Journal of Production Economics*, 140 (1), 103–115. https://doi.org/10.1016/j.ijpe.2012.01.021

Kuhlman, T. & Farrington, J. (2010). What is Sustainability?, *Sustainability*, 2, 3436-3448. https://doi.org/10.3390/su2113436

Lambert, D. M.; Garcia-Dastugue, S. J., & Croxton, K. L. (2006). Implementing supply chain management, in D. M. Lambert (Ed.). *Supply chain management; processes, partnerships, performance.* 2nd ed. Sarasota, FL: Supply Chain Management Institute, 217–235.

Lankoski, L. (2016). Alternative conceptions of sustainability in a business context. *Journal of cleaner production, 139*, 847-857. https://doi.org/10.1016/j.jclepro.2016.08.087

Lebel, L., & Lorek, S. (2008). Enabling sustainable production-consumption systems. *Annual Review of Environment and Resources*, *33*, 241-275. https://doi.org/10.1146/annurev.energy.33.022007.145734

Leipziger, D. (Ed.). (2017). *SA8000: The first decade: Implementation, influence, and impact*. Routledge.

Lippmann, S. (1999). Supply chain environmental management: elements for success. *Corporate Environmental Strategy*, *6*(2), 175-182. https://doi.org/10.1016/S1066-7938(00)80027-5

Lozano, R. (2008). Envisioning sustainability three-dimensionally. *Journal of Cleaner Production, 16*(17), 1838-1846. https://doi.org/10.1016/j.jclepro.2008.02.008

Lozano, R. (2012). Towards better embedding sustainability into companies' systems: An analysis of voluntary corporate initiatives. *Journal of Cleaner Production*, *25*, 14-26. https://doi.org/10.1016/j.jclepro.2011.11.060

Mani. V, Agrawal, R., & Sharma, V. (2015). Social sustainability practices in the supply chain of Indian manufacturing industries. *International Journal of Automation and Logistics*, 1(3), 211–233. https://doi.org/10.1504/IJAL.2015.071721

Martins, C. L., & Pato, M. V. (2019). Supply chain sustainability: A tertiary literature review. *Journal of Cleaner Production*, *225*, 995-1016. https://doi.org/10.1016/j.jclepro.2019.03.250

McKenzie, S. (2004). *Social Sustainability: Towards Some Definitions.* Hawke Research Institute, University of South Australia, Magill.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics*, *22*(2), 1-25. https://doi.org/10.1002/j.2158-1592.2001.tb00001.x

Meuer, J., Koelbel, J., & Hoffmann, V. H. (2020). On the nature of corporate sustainability. *Organization & Environment*, *33*(3), 319-341. https://doi.org/10.1177/1086026619850180

Montiel, I. & Delgado-Ceballos, J. (2014). Defining and Measuring Corporate Sustainability: Are We There Yet?. *Organization & Environment*, 27 (2), 113-139. https://doi.org/10.1177/1086026614526413

Morais, D. O., & Silvestre, B. S. (2018). Advancing social sustainability in supply chain management: Lessons from multiple case studies in an emerging economy. *Journal of Cleaner Production*, *199*, 222-235. https://doi.org/10.1016/j.jclepro.2018.07.097

Mota, B., Gomes, M. I., Carvalho, A., & Barbosa-Povoa, A. P. (2015). Towards supply chain sustainability: economic, environmental and social design and planning. *Journal of cleaner production*, *105*, 14-27. https://doi.org/10.1016/j.jclepro.2014.07.052

Müller, A. & Pfleger, R. (2014). Business transformation towards sustainability. *Business Research*, 7, 313–350. https://doi.org/10.1007/s40685-014-0011-y

Negri, M., Cagno, E., Colicchia, C., & Sarkis, J. (2021). Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda. *Business Strategy and the environment*, *30*(7), 2858-2886. https://doi.org/10.1002/bse.2776

Nimsai, S., Yoopetch, C., & Lai, P. (2020). Mapping the knowledge base of sustainable supply chain management: A bibliometric literature review. *Sustainability*, *12*(18), 7348. https://doi.org/10.3390/su12187348

Olawumi, T. O., & Chan, D. W. (2018). A scientometric review of global research on sustainability and sustainable development. *Journal of cleaner production*, *183*, 231-250. https://doi.org/10.1016/j.jclepro.2018.02.162

Pagell, M., & Wu, Z. (2009). Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *Journal of Supply Chain Management*, 45 (2), 30-56. https://doi.org/10.1111/j.1745-493X.2009.03162.x

Pazienza, M., Jong, M. D., & Schoenmaker, D. (2022). Clarifying the Concept of Corporate Sustainability and Providing Convergence for Its Definition. *Sustainability*, *14*(13), 7838. https://doi.org/10.3390/su14137838

Rajeev, A., Pati, R. K., Padhi, S. S., & Govindan, K. (2017). Evolution of sustainability in supply chain management: A literature review. *Journal of Cleaner Production*, *162*, 299-314. https://doi.org/10.1016/j.jclepro.2017.05.026

Rodriguez, J.A., Thomsen, C. G., & Arenas, D. (2016). NGOS' initiatives to enhance social sustainability in the supply chain: poverty alleviation through supplier development programs. *Journal of Supply Chain Management*, 52(3), 83-108. https://doi.org/10.1111/jscm.12104

Russell, S. V., Haigh, N., & Griffiths, A. (2007). Understanding corporate sustainability: Recognizing the impact of different governance systems. In S. Benn & D. Dunphy (Eds.), *Corporate governance and sustainability: Challenges for theory and practice* (pp. 36-56). New York, NY: Routledge.

Sajjad, A., Eweje, G., & Tappin, D. (2020). Managerial perspectives on drivers for and barriers to sustainable supply chain management implementation: Evidence from New Zealand. Business Strategy and the Environment, 29(2), 592–604. https://doi.org/10.1002/bse.2389

Sánchez-Flores, R. B., Cruz-Sotelo, S. E., Ojeda-Benitez, S., & Ramírez-Barreto, M. E. (2020). Sustainable supply chain management—a literature review on emerging economies. *Sustainability*, *12*(17), 6972. https://doi.org/10.3390/su12176972

Seuring M. & Müller S. (2008). Core issues in sustainable supply chain management – a delphi study. *Business Strategy and the Environment*, 17 (8), 455-466. https://doi.org/10.1002/bse.607

Seuring, S. A. (2008). Assessing the rigor of case study research in supply chain management. *Supply Chain Management: an international journal*, 23(2), 128-137. https://doi.org/10.1108/13598540810860967

Seuring, S., & Gold, S. (2013). Sustainability management beyond corporate boundaries: from stakeholders to performance. *Journal of Cleaner Production*, 56, 1-6. https://doi.org/10.1016/j.jclepro.2012.11.033

Shah, S. I. U., & Rahim, N. A. (2019). Addressing the recent developments and potential gaps in the literature of corporate sustainability. *Journal of Studies in Social Sciences and Humanities*, *5*(1), 27-40.

Sharma, S. (2014). *Competing for a sustainable world: Building capacity for sustainable innovation*. New York, NY: Routledge.

Shekarian, E., Ijadi, B., Zare, A., & Majava, J. (2022). Sustainable Supply Chain Management: A Comprehensive Systematic Review of Industrial Practices. *Sustainability*, *14*(13), 7892. https://doi.org/10.3390/su14137892

Shekarian, E., Ijadi, B., Zare, A., & Majava, J. (2022). Sustainable Supply Chain Management: A Comprehensive Systematic Review of Industrial Practices. *Sustainability*, *14*(13), 7892. https://doi.org/10.3390/su14137892

Sheth, J. N., Sethia, N. K., & Srinivas, S. (2011). Mindful consumption: a customer-centric approach to sustainability. *Journal of the Academy of Marketing Science*, 39, 21–39. https://doi.org/10.1007/s11747-010-0216-3

Soni, G., & Kodali, R. (2008). Evolution of Supply Chain Management: developments in Academia and Industry. *ICFAI Journal of Supply Chain Management*, 5 (4), 7.

Srivastava, S.K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews*, 9(1), 53–80. https://doi.org/10.1111/j.1468-2370.2007.00202.x

Steurer, R., Langer, M.E., Konrad, A. and Martinuzzi, A. (2005). Corporations, stakeholders and sustainable development I: a theoretical exploration of business-society relations. *Journal of Business Ethics*, 61 (3), 263-281. https://doi.org/10.1007/s10551-005-7054-0

Stindt, D. (2017). A generic planning approach for sustainable supply chain management—How to integrate concepts and methods to address the issues of sustainability? Journal of Cleaner Production, 153, 146–163. https://doi.org/10.1016/j.jclepro.2017.03.126

Swarnapali, R. (2017). Corporate Sustainability: A Literature Review. Available online: https://www.researchgate.net/publication/317428267_Corporate_sustainability_A_Literature_review (accessed on 16 May 2022)

Tate W; Ellram, L. M., & Kirchoff, J. F. (2010). Corporate social responsibility reports: a thematic analysis related to supply chain management. *Journal of Supply Chain Management*, 46 (1), 19–44. https://doi.org/10.1111/j.1745-493X.2009.03184.x

Tonelli, F., Evans, S., & Taticchi, P. (2013). Industrial sustainability: challenges, perspectives, actions. *International Journal of Business Innovation Research*, 7(2), 143-163. https://doi.org/10.1504/IJBIR.2013.052576

Torugsa, N. A., O'Donohue, W. , &Hecker, R. (2013). Proactive CSR: An Empirical Analysis of the Role of its Economic, Social and Environmental Dimensions on the Association between Capabilities and Performance. *Journal of Business Ethics*, 115, 383–402. https://doi.org/10.1007/s10551-012-1405-4

Tsoulfas G.T, & Pappis C.P (2006). Environmental principles applicable to supply chains design and operation. *Journal of Cleaner Production*, 14 (18), 1593–1602. https://doi.org/10.1016/j.jclepro.2005.05.021

United Nations. (1987). *Our Common Future (Brundtland Report): World Commission on Environment and Development*. Oxford, England: Oxford University Press.

Urdan, M. S., & Luoma, P. (2020). Designing effective sustainability assignments: How and why definitions of sustainability impact assignments and learning outcomes. *Journal of Management Education*, *44*(6), 794-821. https://doi.org/10.1177/1052562920946798

Vachon, S., & Klassen, R. D. (2006). Extending green practices across the supply chain: The impact of upstream and downstream integration. *International Journal of Operations & Production Management*, 26 (7), 795-821. https://doi.org/10.1108/01443570610672248

Van Marrewijk, M. (2003). Concepts and Definitions of CSR and Corporate Sustainability: Between Agency and Communion. *Journal of Business Ethics*, 44 (2/3), 95-105. https://doi.org/10.1023/A:1023331212247

Waas, T. Hugé, J., Verbruggen, A., & Wright, T. (2011). Sustainable Development: A Bird's Eye View. *Sustainability*, *3*, 1637-1661. https://doi.org/10.3390/su3101637

Walker, H., Di Sisto, L., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of purchasing and supply management*, *14*(1), 69-85. https://doi.org/10.1016/j.pursup.2008.01.007

Winter, M., & Knemeyer, A. M. (2013). Exploring the integration of sustainability and supply chain management. *International Journal of Physical Distribution & Logistics Management*, 43 (1), 18-38. https://doi.org/10.1108/09600031311293237

Wolf, C., & Seuring, S. (2010). Environmental impacts as buying criteria for third party logistical services. *International Journal of Physical Distribution & Logistics Management*. https://doi.org/10.1108/09600031011020377

Wolf, J. (2014). The Relationship Between Sustainable Supply Chain Management, Stakeholder Pressure and Corporate Sustainability Performance. *Journal of Business Ethics*, 119, 317-328. https://doi.org/10.1007/s10551-012-1603-0

Zailani, S., Jeyaraman, K., Vengadasan, G., & Premkumar, R. (2012). Sustainable supply chain management (SSCM) in Malaysia: A survey. *International journal of production economics*, *140*(1), 330-340. https://doi.org/10.1016/j.ijpe.2012.02.008

Żak, A. (2015). Triple bottom line concept in theory and practice. Research papers of Cracow university of economics- Social Responsibility of Organizations. Changes and their Directions, Cracow University of Economics, 387, 251-264.

Chapter 3

Maturity Models in Supply Chain Sustainability:A Systematic Literature Review

This chapter consists of the following paper:

Maturity models in supply chain sustainability: A systematic literature review
Correia, E., Carvalho, H., Azevedo, S. G., & Govindan, K. (2017).
Sustainability (2017), *9*(1), 64.
https://doi.org/doi:10.3390/su9010064

Best Paper Awards in the journal Sustainability in 2019

sustainability

MDPI

Review

Maturity Models in Supply Chain Sustainability: A Systematic Literature Review

Elisabete Correia [1], Helena Carvalho [2], Susana G. Azevedo [3] and Kannan Govindan [4,*,†]

[1] ISCAC—Instituto Politécnico de Coimbra, Coimbra 3040-316, Portugal; ecorreia@iscac.pt

[2] UNIDEMI, Faculty of Science and Technology, FCT, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal; hmlc@fct.unl.pt

[3] CEFAGE-UBI, UNIDEMI, Department of Business and Economics, University of Beira Interior, 6201-001 Covilhã, Portugal; sazevedo@ubi.pt

[4] Center for Engineering Operations Management, Department of Technology and Innovation, University of Southern Denmark, Odense M-5230, Denmark

* Correspondence: kgov@iti.sdu.dk; Tel.: +45-65503188

† Authorship listing follows a reverse seniority order.

Academic Editor: Marc A. Rosen

Received: 21 June 2016; Accepted: 23 December 2016; Published: 6 January 2017

Abstract: A systematic literature review of supply chain maturity models with sustainability concerns is presented. The objective is to give insights into methodological issues related to maturity models, namely the research objectives; the research methods used to develop, validate and test them; the scope; and the main characteristics associated with their design. The literature review was performed based on journal articles and conference papers from 2000 to 2015 using the SCOPUS, Emerald Insight, EBSCO and Web of Science databases. Most of the analysed papers have as main objective the development of maturity models and their validation. The case study is the methodology that is most widely used by researchers to develop and validate maturity models. From the sustainability perspective, the scope of the analysed maturity models is the Triple Bottom Line (TBL) and environmental dimension, focusing on a specific process (eco-design and new product development) and without a broad SC perspective. The dominant characteristics associated with the design of the maturity models are the maturity grids and a continuous representation. In addition, results do not allow identifying a trend for a specific number of maturity levels. The comprehensive review, analysis, and synthesis of the maturity model literature represent an important contribution to the organization of this research area, making possible to clarify some confusion that exists about concepts, approaches and components of maturity models in sustainability. Various aspects associated with the maturity models (i.e., research objectives, research methods, scope and characteristics of the design of models) are explored to contribute to the evolution and significance of this multidimensional area.

Keywords: maturity models; sustainability; supply chain; systematic literature review

1. Introduction

After the development of the Capability Maturity Model (CMM) in 1993, the maturity model (MM) concept became widely accepted among researchers and practitioners [1]. The CMM is used to assess an organization on a scale of five process maturity levels. Each level ranks the organization according to its standardization of processes in areas as diverse as software engineering, systems engineering, project management, risk management, system acquisition, information technology (IT) services and personnel management. Despite the popularity of the MM concept, as pointed out by Wendler [2], there is not a clear definition of the term "maturity model". Kohlegger et al. [3] state that an MM "represents phases of increasing quantitative or qualitative capability changes of a maturing

element to assess its advances with respect to defined focus areas" [3] (p. 59). These focus areas or domains can be processed maturity, digital resources, and skills of people, and the maturing element can be an individual, an object or a social system [3]. Cuenca et al. [4] stress that "MMs describe the development of an entity over time" [4] (p. 898). This entity can be anything of interest: a human being, an organizational function, and so on. Bititci et al. [5] consider an MM to be a "matrix of practices that define, for each organisational area, the level of formality, sophistication, and embeddedness of practices from ad hoc to optimising" [5] (p. 3065).

The literature has focused mainly on proposing and deploying MMs in the domain of software engineering and system information. Kohlegger et al. [3] identify more than 70 MMs in these areas. Despite this trend, Wendler [2] recognizes the use of MMs in more than 20 domains, such as risk management, project management, new product development, human resources management, process management, and supply chain management (SCM), among others. MMs are also deployed in topics related to sustainability, such as eco-design [1] and corporate sustainability [6]. The application of the MMs to this diversity of research areas has contributed to making the topic of MMs increasingly confused. In this context, it is important to analyse the literature on MMs in a more structured way.
The attention to and increasing concerns about the sustainability of businesses have created pressure from societal stakeholders on companies to address environmental and social concerns, and not to focus only on economic aspects so that they address the triple bottom line (TBL) [7]. The TBL was coined by John Elkington with the aim of achieving universal sustainability reporting standard and refers to the three bottom lines of "economic prosperity, environmental quality, and social justice" i.e., people, planet, and profit dimension [8].

Sustainability has been widely recognized as a critical issue for business survival [9]. Measuring the performance of sustainability is central to the evaluation of how companies respond to pressures and demands from stakeholders [10]. Companies can deal in different ways with the issue of sustainability [11]. Management practices can be implemented in a more or less extensive and sophisticated way, focusing on resources and capabilities of companies to promote their sustainability, but also to address issues of the associated supply chain (SC) [12]. These practices can be related to one or more dimension of sustainability: environmental, social and economic [13]. The SC concept provides a comprehensive perspective of the sustainability since it is defined as the alignment of firms that bring products or services to market [14]. The integration of sustainability in an SC context is a fundamental component of sustainable development [15] and one way of achieving improvements in the use of resources [16]. Beske and Seuring [17] argue that to achieve sustainability SCs should be managed with this objective in mind, especially when considering the deployment of management practices. The SCM is considered "the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole" [18] (p. 18).

The integration of sustainability concerns into SCM brings new challenges regarding the management of resources and flows of SCs. The implementation of sustainability practices requires better coordination among activities and information sharing, which increases the level of complexity and requires decision-making processes at various SC levels [19]. Also, it is necessary to attend the requirements of all SC stakeholders in a continuous way and over time, making adequate frameworks to attend these issues essential [19].

Since MMs describe the evolution of a specific system over time [4], they are a useful tool for analysis and evaluation of SC sustainability. Monitoring and evaluating are fundamental to incorporate sustainability concerns into the SC, not only to communicate the performance to internal stakeholders and the market but also to achieve improvements [20,21]. The focus on internal stakeholders is vital since they are those parties, individual or group that participates in the management of the company. Therefore, they can influence and can be affected by the success or failure of the entity

because they have vested interest in the organization (i.e., employees, owners, directors, managers, and investors) [22].

MMs have been suggested to assess the initial state and progress of companies regarding sustainability [23], and they are considered strategic tools for diagnosis and improvement of SC operations [24]. The development of MMs in the context of SC sustainability is an important contribution since these models are generally presented as: (i) a descriptive tool for the evaluation of strengths and weaknesses [25]; (ii) a prescriptive instrument to help develop a guide (roadmap) for performance improvement [24]; or (iii) a comparative tool to evaluate the processes/organization and compare it with standards and best practices from other organizations [26], thus enabling internal and external benchmarking [27]. Klimko [26] argues that the MMs simplicity is their main advantage. A sustainability MM applied to a set of entities that constitute an SC can be of significant benefit. It can enable decision makers to evaluate their organizational efforts regarding sustainability, highlighting their position on the various dimensions of sustainability and guiding improved sustainability. Applying the MM to the whole SC makes it possible to assess the level of maturity of the SC.

The development of MMs on SC sustainability will represent a contribution to research in the field of Sustainable Supply Chain Management (SSCM). However, the development of MM is not a trivial task [28,29]. The main objective of this paper is to give insights into methodological issues related to the development of MMs in the domain of sustainability and SC sustainability. As suggested by Wendler [2] and Becker et al. [30], before the development of new MMs it is crucial to evaluate other available solutions; previous research and models should be reviewed and analysed. Therefore, this paper intends to review existing MM on sustainability and SC sustainability to identify their research objectives, the research methods used to develop, validate and test them, their scope and also the key characteristics associated with their design.

The main contribution of this paper is to offer a systematic review of the existing literature on MMs related to SC sustainability to provide guidance on the topic, and showing gaps in the literature, as well as finding new paths for research.

2. Methodology

Traditional narrative literature reviews aim to develop a comprehensive understanding and critical assessment of knowledge relevant to a specific topic [31]. Systematic literature reviews (SLRs) seek to provide answers to specific questions or test particular hypotheses [32]. An SLR was chosen to overcome the perceived weaknesses of narrative reviews [33] and as a mean of evaluating and interpreting all available research relevant to the research topic [34], in this case, the MMs used in SC sustainability. Also, it makes possible to identify gaps in current research and to suggest areas for further investigation [35]. SLRs can also identify diversity in SC sustainability MMs. Practitioners can save considerable time if they access pre-filtered evidence, such as that provided by an SLR [36]. Essentially, SLR aims to synthesize the results of multiple original studies by using strategies that reduce bias.

According to Rousseau et al. [37] an SLR should have the following characteristics: comprehensive in the sense that it should include all relevant studies; use transparent analyses, and apply specific criteria to generate value from a body of previous literature. To monitor decisions, procedures, and conclusions of the researcher, and minimize bias Tranfield et al. [33] suggest the use of a replicable, scientific and transparent process. This approach is a way of raising the confidence of users regarding the status of present knowledge on a given question [37].

The SLR process includes planning, conducting and reporting, and dissemination stages. Each of these stages may include several steps in the review process that "is designed about and specifically to address the question the review is setting out to answer" ([38], p. 338). In the literature, the number and designation of the proposed phases for a systematic review differ. For example, Tranfield et al. [33] propose ten phases while Briner and Denyer [38] propose five key phases. Based on the contributions of Tranfield et al. [33], Denyer and Tranfield [39] and Rousseau et al. [37] in this study we define five phases: (1) problem formulation and question identification; (2) literature search; (3) evaluation of

research; (4) research analysis and interpretation; and (5) presentation of results. This set of phases represents a process that is replicable, transparent, objective, unbiased, and rigorous [40]. Therefore, it strengthens the research on MMs used in SC sustainability, serving as a unified, verifiable, and trustworthy source for further research [41]. The literature review approach followed in this study is illustrated in Figure 1.

In the following sections, the first four research phases will be presented in detail. The final phase "presentation of results" will be discussed in Section 3. This last phase will make it possible to extract the main findings from the analysis of the literature review.

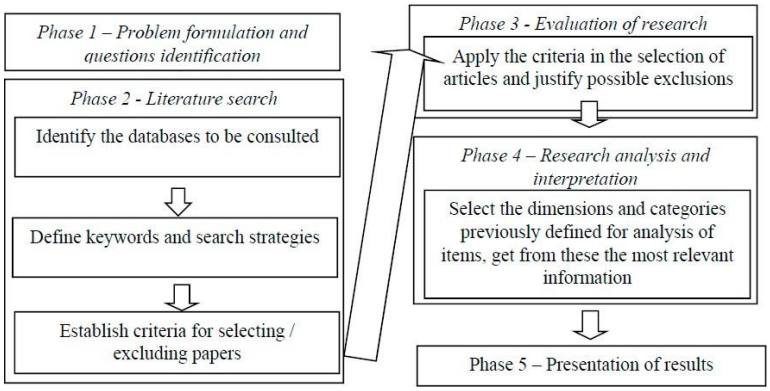


Figure 1. Literature review approach.

2.1. Phase 1—Problem Formulation and Question Identification

The MM takes on a path of development or evolution [42]. The development line is drawn through a series of levels or stages from an initial state to a maturity stage, and each level is used to characterise the state of the system or organisation [30]. According to Müller and Pfleger [43], the concept of stages or levels of development can be used objectively to evaluate an organization state with regards to sustainability. Moreover, Baumgartner and Ebner [11] point out that MMs provide a scheme that supports the development, establishment, and persecution of the sustainability strategy of an organization.

Considering that an SC "includes all the organizations involved in all the upstream and downstream flows of products, services, finances, and information from the initial supplier to the ultimate customer" ([18], p. 4), the maturity analysis of sustainability of individual organizations could be an important element to support the study of sustainability in SC. Benmoussa et al. [44] consider that the maturity approach is more appropriate to understand how SC sustainability can be improved than an approach based on performance outcomes. Although there are some frameworks that seek to assess sustainability in the SC (e.g., [21]), Reefke et al. [19] and Kurnia et al. [45] highlight that MMs allow managers and other stakeholders to understand the sustainability level that the company and its SC have attained and what actions should be taken to maintain and promote progress.

Considering the relevance of the implementation of MMs for assessing and improving sustainability, particularly in the context of an SC, a review that provides further analysis of the research that has been published in the domains of sustainability and SC is highly desirable. Many literature reviews were conducted in the field of MMs, but they do not target these two domains. For example, Wendler [2] identified 231 articles and provides an overview of the MMs domains, research design, development, and validation. Carvalho et al. [46] identified 14 MMs for information systems and technologies (IST) management in healthcare. Tarhan et al. [47] (2016) sought an overall understanding of the existence, characteristics, and use of MMs in business process management; in a sample of 61 studies, they identify 20 business process MMs.

As regards the research methods used to develop MMs is important to detect potential systematic patterns in the literature research [48]. According to Wendler [2], empirical studies predominate in MMs literature. In business process management, the same conclusion was reached by Tarhan et al. [47].

However, there is no evidence that this pattern is repeated in research on sustainability MMs, which led to the emergence of the following research questions:

RQ1: Which are the main research objectives in the literature on MMs in the domain on "Sustainability" and "SC sustainability"?
RQ2: What research methods are mainly used in papers on MMs in the domain on "Sustainability" and "SC sustainability"?

The MM scope is another critical issue. According to De Bruin et al. [49], "maturity models have been designed to assess the maturity (i.e., competency, capability, the level of sophistication) of a selected domain based on a more or less comprehensive set of criteria". The scope will determine the degree of the model application within its domain. The MM scope can be generic (i.e., apply to all organizational processes) or more specific (i.e., apply to a specific process). Carvalho et al. [46] use the MMs scope analysis. In the context of healthcare information systems to identify: (i) generic or comprehensive models (i.e., models representing the hospital information system); and (ii) highly specialized models targeting specific process (i.e., electronic medical record process). In the SC sustainability context, the MM scope is defined by two interrelated characteristics: (i) sustainability dimensions: the MM could integrate simultaneously the environmental, social and economic dimensions (TBL approach), or a combination of two sustainable dimensions, or just one dimension; and (ii) SC level: the MM could target different hierarchic levels—such as process, company, and network—within the SC.

The balance between economic, environmental and social dimensions is crucial to operationalize sustainability [50]. However, the environmental dimension of sustainability has dominated works on sustainability [51], and it has been the main focus of companies' initiatives in this field [52]. Even at the level of the SC, the majority of published studies have dealt with only one or two dimensions [53–57]. The identification of the scope will support a more detailed analysis of MMs and test whether the sustainability issues (that have attracted the attention of the scientific community in the MMs) follow the trend reported in the literature. This gave rise to the third research question:

RQ3: What is the main scope of MMs in the domain on "Sustainability" and "SC sustainability"?

Despite the widespread use and deployment of MMs [5], neither their meaning nor their components are yet established [2]. MMs diverge in some design elements, such as their typology, architecture, and components [2]. For example, MMs can comprise different levels and also use different criteria to define the maturity levels [42]. Attending to this, the fourth research question arises in the following way:

RQ4: Which typologies, architectures, and components are used in the design of MMs in the domain on "Sustainability" and "SC sustainability"?

The purpose of the SLR is to summarize and synthesize the empirical evidence on MMs in SC sustainability. To this end, Table 1 lists the four research questions defined, along with their main motivations.

Table 1. Description and main motivations associated with the research questions.

ID	Research Questions	Motivation
RQ1	Which are the main research objectives in the literature on MMs in the domain on "Sustainability" and "SC sustainability"?	To identify research objectives in the literature on MMs in sustainability.
RQ2	What research methods are mainly used in papers on MMs in the domain on "Sustainability" and "SC sustainability"?	To discuss the methodologies used in works about MMs in sustainability and to identify which predominate.
RQ3	What is the main scope of MMs in the domain on "Sustainability" and "SC sustainability"?	To identify the contexts of application of MMs in SC sustainability.
RQ4	Which typologies, architectures, and components are used in the design of MMs in the domain on "Sustainability" and "SC sustainability"?	To discuss issues associated with the design of MMs.

2.2. Phase 2—Literature Search

In the second phase of the literature review the bibliographic databases, descriptors or keywords, and the search strategy are identified. Tranfield et al. [33] recommend the use of various sources of information from unpublished studies, conference proceedings, and the Internet. Denyer and Tranfield [39] suggest the utilization of peer-reviewed publications as a way of controlling the quality of the papers in the sample. Another method to control the quality or relevance of information sources is to restrict the search to publications using journal rankings [58]. However, this last option is too restrictive considering the lack of works on MMs in the context of SCs and sustainability. Thus, given the main objective of this paper, the SCOPUS, Emerald Insight, EBSCO and Web of Science databases were considered.

To obtain the broadest sample of papers for analysis, synonyms for the term "maturity models" were identified. To this end, a small sample of papers on the subject was used. From this procedure, the following terms emerged: "model capability", "maturity grid", "process improvement model" and "excellence model". In a first test using the SCOPUS database, the two last expressions return publications, mainly related to the areas of quality management, and human resources and not to the topic of MMs. Moreover, it was found that the first two terms mostly resulted in papers that also mentioned the expression "maturity models". Thus, it was decided to consider this expression or just the word "maturity" to obtain all papers on MMs.

Given the purpose of this study, it was also considered appropriate to include in the search terms related to SC and sustainability. For this purpose, three classes of keywords were selected: (i) keywords related to maturity: "maturity" and "maturity models"; (ii) keywords related to sustainability: "sustainab *", "environment *" and "social"; and (iii) keywords related to SCM: "supply chain" and "supply chain management". The search strategy was to select papers that contain in the title, abstract or keywords various combinations of those keywords, from January 2000 to March 2015, in the databases SCOPUS, Emerald Insight, EBSCO and Web of Science.

2.3. Phase 3—Evaluation of Research

To ensure that only relevant papers are analysed, several inclusion/exclusion criteria were established. As decisions relating to inclusion and exclusion are relatively subjective Tranfield et al. [33] recommend that this phase should be carried out by more than one researcher. Therefore, three researchers with expertise in SCM and sustainability were involved in this phase. The inclusion/exclusion criteria were used in a stepwise process as reported in Table 2.

Table 2. Results after Step 1 and Step 2 by the bibliographic database.

Database / Keywords	Scopus		EBSCO		Emerald Insight		Web of Science	
	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2
"maturity AND sustainability"	481	17	224	11	83	4	353	9
"maturity model AND sustainability",	169	17	26	6	33	3	120	7
"maturity AND supply chain AND sustainability"	31	11	11	2	11	1	13	5
"maturity AND supply chain AND environment *"	83	12	26	6	34	2	62	9
"maturity AND supply chain AND social"	25	3	9	3	12	1	15	5
Total	789	60	296	28	173	11	563	35

Note: The asterisk "*" is used to obtain related/derived words from "environment".

Initially, a set of results (Step 1) was obtained using the different keywords in each database. From the results achieved in each database only papers in English were analysed.
In Step 2, papers that did not make reference to MMs and simultaneously to any subject within sustainability were eliminated. Multiple references to the same paper were also eliminated. This procedure reduced the number of potentially relevant papers in each database. Subsequently the results across the different databases were compared and duplicated papers eliminated. The papers comprising this second set were read in full to evaluate their focus on MMs and relevance to the

research questions. From this process, a final sample of 11 papers was reached. Of these, 82% are dispersed across a wide range of journals. The remainder were conference proceedings. At this stage, the proposal of Wolf [58] to use journal rankings was considered. The list of journal rankings of the 2015 Academic Journal Guide (AJG) produced by the Association of Business Schools was used. Only 36% of the papers are published in AJG journals. To avoid losing potential contributions for the research topic, it was decided to keep all 11 papers, whether or not they appeared on the AJG list.

The small sample dimension deserves some consideration. By definition, the SLR ends when the inclusion and exclusion criteria established before the start of the review (keywords, years of review, search field, etc.) are satisfied, not when a number of items are reached. Moreover, the PRISMA guide ("Transparent reporting of systematic reviews and meta-analyses") does not establish a minimum number of papers to validate an SLR. Although it is true that the number of studies in an SLR is usually higher, there are examples of SLR in sustainability and MM topics with a reduced number of articles; for example, Wiese et al. [59] with 13 studies in corporate social responsibility or Carvalho et al. [46] with 14 articles identifying MMs for the management of IST in healthcare.

Kitchenham et al. [41] use the following criteria to evaluate the quality of SLR: (i) appropriated inclusion and exclusion criteria; (ii) literature search includes all relevant studies; (iii) the quality/validity of the included studies was assessed; and (iv) description of basic data about each study. As detailed above, the present SLR complies with the first three quality criteria. The results of individual primary studies will be specified in Section 3.

2.4. Phase 4—Research Analysis and Interpretation

Step 4 is to summarize and document the information extracted from the sample papers. The analysis of information requires the creation of analytical categories that facilitate the ranking and the synthesis of each study [60]. In the present study, a set of eight categories was used to analyse the papers (Table 3). The first category corresponds to the paper identification (i.e., authors, publication date, and publication type). Then a set of categories and subcategories were created considering several contributions from MM literature (as indicated in Table 3). If a paper does not contain sufficient information about a category, the label "not applicable" was used.

Table 3. Categories used in the literature review analysis.

Category	Subcategories	Description
Paper identification	Authors	List of authors
	Publication date	Year of publication
	Publication type	Journal, conference proceeding, etc.
Domain	Research field	"Sustainability" or "SC sustainability"
Research objectives	Development	Develop, adapt or create a new MM
	Application	Deploy MMs in different contexts or domains and evaluate the maturity of organizations, SCs, processes, etc.
	Validation	Validate proposed or existing models, from the conceptual or empirical point of view
Research methods [1]	Analytical	Conceptual (e.g., futures research scenarios or conceptual modelling), mathematical (e.g., mathematical simulation) or statistical methodologies
	Empirical	Experimental design (e.g., experimental empirical design), statistical sampling (e.g., surveys or expert panels), case studies, content analysis, mixed methods
	Others	Other methodologies not included in previous subcategories
Scope [2]	Sustainability dimension	The sustainability dimension target by the MM: environmental sustainability (Env. sust.), social sustainability (Soc. sust.), economic sustainability (Econ. sust.) or TBL perspective
	SC hierarchic level	The SC level of analysis it can range from process, company to network level
Typology [3]	Structured models	A formal and complex structure, similar to the CMM
	Maturity grids	A number of maturity levels attending to the several aspects of the research area
	Likert-like questionnaires	A set of questions where the respondent classify the company or SC performance on a scale from 1 to *n*
	Hybrid models	A combination of characteristics of maturity grids and Likert-like model structure

Table 3. *Cont.*

Category	Subcategories	Description
Architecture [4]	Staged	A cumulative set of areas defining each level. All the areas included in a level need to be successfully achieved before moving to the next level
	Continuous	A set of areas that can be approached separately. Rather than having to address all the areas for a given level, the focus of improvement can be a specific area
	Others	Other representations not included in previous subcategories
Components [4]	Number of maturity levels	Count of the number of maturity levels
	Descriptors	The descriptive name for each maturity level
	Level description	It takes the value "Yes" if contains the description or summary of the characteristics of each level, "No" otherwise.
	Elements	Different perspectives for the analysis or evaluation of maturity considering one or several common characteristics. Alternatively, it can be a set of practices /activities/capabilities that contribute to achieving a set of goals considered to reach higher levels of maturity.

Legend: [1] [48,61]; [2] [42,62]; [3] [42,63]; [4] [42,62,63].

3. Results

In this section, the fifth phase of the research methodology is presented. The main objective is to analyse in detail the sample contents and provide answers to the research questions.

3.1. Sample Description

The papers in the sample were classified according to their publication period and domain (Table 4). In the area of SC sustainability, the number of papers is still very low, with only four published studies identified in the 2013–2014: Okongwu et al. [64], Srai et al. [65], Kurnia et al. [45], and Reefke et al. [19].

Table 4. Domain of the papers included in the review.

	Year				
Domain	2000	2001–2005	2006–2010	2011–2015	*Total*
Sustainability	0	0	2	5	7
SC sustainability	0	0	0	4	4
Total	0	0	2	9	11

3.2. Research Objectives and Methods

Table 5 makes it possible to answer research question one (RQ1) and research question two (RQ2). The analysis of the papers in sample identifies 11 papers with the objective of developing an MM; from these sub-set seven papers intend to perform the MM validation. There are two conceptual papers, Standing and Jackson [66] and Reefke et al. [19], in which the developed models are not validated or applied. The column "Application" is empty, meaning that there is no work deploying existing MMs previously developed in others contexts or domains.

Table 5. Research objectives and research methods.

Research Methods \ Research Objectives		Development	Application	Validation
Analytical	Conceptual	• Standing and Jackson [66] • Reefke et al. [19] • Edgeman and Eskildsen [67]		
Surveys		• Hynds et al. [68]		• Hynds et al. [68]
Action research		• Pigosso et al. [1]		• Pigosso et al. [1]
Empirical	Case studies	• Golinska and Kuebler [69] • Kurnia et al. [45] • Srai et al. [65] • Robinson et al. [70]		• Kurnia et al. [45] • Srai et al. [65] • Robinson et al. [70]
Content analysis		• Okongwu et al. [64]		• Okongwu et al. [64]
Mixed methods		• Babin and Nicholson [71]		• Babin and Nicholson [71]

The literature review also indicates the MMs validation was performed adopting different empirical research strategies. The validity of MMS models is important because it makes possible to assess the degree to which a result from an MM is likely to be true and free from bias [72]. For example, Kurnia et al. [45] validate their model using an in-depth case study approach. Srai et al. [65] have developed and validated an MM using a case study analysis of 12 companies. A different empirical research method was employed by Okongwu et al. [64]. They performed a content analysis of the corporate sustainability reports of 50 companies belong to 10 different industries sectors. Babin and Nicholson [71] used a mixed research method conducting qualitative interviews in a first phase followed by quantitative content analysis. In the papers under study, only Okongwu et al. [64] presents a solution using a statistical methodology (principal component analysis) reducing the MM degree of subjectivity. The validation process is not highlighted in the research works. The exception is Pigosso et al. [1] that provide detailed information on the validation process of their model.

3.3. Maturity Model Characteristics

The SLR provides evidence that there is any accepted MM definition. Considering the 14 researched papers, only two provide a definition for an MM:

- Pigosso et al. [1] using the definition of Klimko [26] consider that an MM is: "a conceptual framework made up of parts that describe the development of a particular area of interest over time" and
- Okongwu et al. [64] present the definition of Pullen [73]: "a structured collection of elements that describe the characteristics of effective processes at different stages of development."

This finding is in line with Wendler [2], who argues that a clear definition of the term "maturity model" is not present in most works. Considering this lack of consensus about what an MM is and what should be its characteristics, the MMs described in the sample were analysed using the categories in Table 3. The 11 papers under study are briefly described below in chronological order.

- Robinson et al. [70] consider that a knowledge management strategy is central to operationalising the concept of corporate sustainability. They argue that a knowledge management strategy enables an organisation to leverage the different types of knowledge or intangible assets (such as intellectual capital, technology competence, patents, and goodwill) necessary to develop the ability to put sustainability principles into practice. Benefits from better corporate governance include improved access to capital, improved human development and labour practices. They propose the "STEPS maturity roadmap" with five steps reflecting different levels of knowledge management maturity. The higher the maturity levels are, the more capable the companies are to put in practice the sustainability principles. They develop the MM in the construction industry context.

- Standing and Jackson [66] suggest the integration of sustainability issues with the Information Systems (IS) area proposing the "IS Sustainability Maturity Model". The model intends to help companies identify their performance level regarding sustainability processes, enable them to compare across an industry sector, set targets for improvement and define paths to get there. Although the authors state, "IS must look beyond an economic rationale to embrace a wider purpose that incorporates social and environmental issues", there is a lack of information in the study related to the features associated with the social and environmental dimensions of sustainability.
- Babin and Nicholson [71] suggested a model focusing on the sustainability of Global Information Technologies Outsourcing (GITO) providers. The model represents a robust way to identify, classify and assess sustainability capability in GITO providers. They considered three sustainable capabilities: to understand and adopt global sustainability standards, to anticipate and respond to requests from stakeholders and to embed and develop organizational sustainability. This is in line with the Morash et al. [74] definition for capabilities: "attributes, abilities, organizational processes, knowledge, and skills that allow a company to achieve superior performance and sustained competitive advantage over competitors". It makes possible a practical assessment of a GITO provider's stage and enables planning for the next stage of maturity. In addition, it represents a tool for buyers perform a benchmarking analysis and assesses the maturity level of sustainability of their providers. The benchmarking refers to the use of tools (analysis and comparison) containing knowledge that is codified and can be easily understood. The objective is helping the companies to "understand" its practices as well as those presented by the tool highlight the need to activate improvements but also to suggest how the improvements can be carried out.
- Okongwu et al. [64] developed a model to be used in sustainability reporting area considering the TBL perspective. A transparent sustainability reporting allows companies to attract a broader range of investors and customers, enhance operational efficiency, improve brand positioning and develop leadership in the marketplace. The model aims to improve knowledge about the maturity levels attained by organisations in reporting their SC (as well as a non-supply chain) sustainability initiatives and construct a tool to help them improve their reporting of sustainability initiatives continuously. This model is based on the approach used by the European Foundation for Quality Management (EFQM) for auditing the quality competences and maturity levels of organisations [75].
- Pigosso et al. [1] present the "eco-design maturity model" which is specifically orientated to the eco-design process. The model aggregates some important practices that integrate environmental issues into the product development and related processes. The goal is to minimize environmental impacts throughout the product's lifecycle without compromising criteria such as performance, functionality, quality and cost. Based on a diagnosis of the current maturity profile of a company, the model suggests the better aproach to implement a suitable set of eco-design practices (management practices and operational practices).
- Srai et al. [65] extend the MMs design outside the companies' boundaries and propose the "Sustainable supply network maturity model (SSN-MM)". This model adopts a network and a TBL perspective that enables a systematic analysis and assessment of practices that support sustainable operations. The MM considers five groups of capabilities that are considered strategic to sustainability and also five maturity levels. Each group, depending on their characteristics, can be associated with a specific level of maturity (from 1 to 5).
- Edgeman and Eskildsen [67] propose a sustainable enterprise excellence system (named "Springboard to SEE") that emphasises the financial stability of the enterprise while considering the societal and environmental challenges. Maturity levels and scales are proposed to describe graduated performance levels that range from very low to very high maturity. The model considers six elements, called "compass dimensions", covering different issues related to the enterprise excellence (from strategy and governance to human capital results). However, the authors do not clarify how these areas should be approached to achieve a higher performance level.

- Golinska and Kuebler [69] develop an MM with a focus on sustainability in re-manufacturing companies using the TBL approach. The purpose of the MM is to identify the potential for optimization of resource utilization in the re-manufacturing companies. It assumes that as the company advances toward higher levels of maturity its performance increases. Each sustainability dimension is unfolded into five categories of practices. For example, the social dimension is assessed in the following areas: Workplace Design, Ergonomics and Safety, Training and Development of Employees, Innovation Management, and Corporate Image.
- Hynds et al. [68] propose the "IRI Sustainability Model" which is focused on sustainability in new product development (NPD) considering only features related to the environmental dimension of sustainability. The NPD process consists of the activities carried out by firms when developing and launching new products; it involves a sequence of stages, beginning with an initial product concept or idea that is evaluated, developed, tested and launched on the market [76]. This model can be used to benchmark progress on the journey to integrate sustainability into NPD for competitive advantage. It represents a framework that can help companies to understand their core strengths and key needs and how they compare with others in their industry.
- Kurnia et al. [45] propose an MM with a focus on the assessment of capabilities to implement SSCM practices. The proposed model identifies four categories of organizations (i.e., Unaware, Unprepared, Committed, and Advanced) which differ in the status of their respective maturity levels of SSCM capabilities. To this end, it considers six capability types (each one with four increasing levels of maturity). According to the model, companies that are in the first three categories have an internal focus on the implementation of SSCM practices. Those that are in the category "Advanced" focus on internal and external features of sustainability and demonstrate high interaction with their SC partners.
- Reefke et al. [19] propose the "SSCM maturity model" with six maturity levels providing an orientation towards the development of higher levels of SC sustainability. For each of the levels is provided a description, goals, and requirements. This model is supported by a cyclical multi-step approach for maturity progression. It considers five stages of discovery and learning, strategizing, design, transformation, and monitoring and controlling. After the last phase, a new cycle can be performed to further support maturity development efforts. This model does not identify the dimensions or key areas to be evaluated, but the description of the maturity levels suggests some SC sustainability features, including continuous improvement of processes, performance measurement systems, sets of goals and standards, strategic and functional alignment with SC partners, and SC cooperation.

The detailed analysis of the papers in the sample is presented in Table 6, which summarizes the main characteristics of the MMs namely scope, typology, architecture and components.

Table 6. Main characteristics of maturity models.

	Authors, Year	Scope-SC Level	Typology	Architecture	No. of Maturity Levels	Model Components		
						Descriptors	Level Description	Elements
Scope—Environmental sustainability	Babin and Nicholson, 2011 [71]	Company— IT outsourcing providers	Maturity grids	Not Applicable	3	Mature leaders, Aspirant, Early stage	Yes, detailed description	3 capabilities (Understand and adopt global sustainability standards. Anticipate and respond to stakeholder sustainability requests, Embed and develop sustainability capabilities within the organization)
	Pigosso et al., 2013 [1]	Process— Eco-design	Not Applicable	Others	5	Level 1, Level 2, Level 3, Level 4, Level 5	Yes, detailed description	8 elements resulting from 5 capabilities (deployment of eco-design practices: incomplete, ad hoc, formalized, controlled, improved) and 3 dimensions for eco-design implementation (implementation paths, company widening for implementation, knowledge level on eco-design)
	Hynds et al., 2014 [68]	Process— new product development (NPD)	Likert—like questionnaires	Continuous	4	Beginning, Improving, Succeeding, Leading	Yes, generic description	2 dimensions (Strategy and Design Tools) subdivided in 14 areas (Corporate Sustainability Policy, Overall Sustainability Strategy, Government Policy and Regulation, Impact of Trends, Supply Chain, Green labelling, Sustainability Design for Environment (DfE), Specifications/Customer Insights, Life Cycle Assessment Process, DfE-Material and Part Selection, DfE-Supply Chain, DfE-Manufacturing Impact, DfE-Use Phase Impact, DfE-End of Life Impact)
Scope—TBL approach	Robinson et al., 2006 [70]	Process— knowledge management	Maturity grids	Not Applicable	5	Start-up, Take-off, Expansion, Progressive, Sustainability	Yes, generic description	Not Applicable
	Standing and Jackson, 2007 [66]	Process— information system management	Not Applicable	Not Applicable	6	No. n-existent, Initial/ad hoc, Repeatable but intuitive, Defined process, Managed and measurable, Optimised	Yes, generic description	Not Applicable
	Okongwu et al., 2013 [64]	Network— sustainability disclosure	Maturity grids	Continuous	4	Primeval, Initial, Intermediate, Advanced, Word Class	Yes, detailed description	8 areas (Use of standards, Performance management—associated to governance; Life cycle management, Pollution management—associated to environment dimension of sustainability; Relationship management of suppliers, customers and society, Employee management—associated to social dimension of sustainability; Profitability management, and Economic value distribution management—associated to economic dimension of sustainability.

Table 6. *Cont.*

	Authors, Year	Scope-SC Level	Typology	Architecture	No. of Maturity Levels	Model Components		
						Descriptors	Level Description	Elements
Scope—TBL approach	Srai et al., 2013 [65]	Network	Maturity grids	Continuous	5	Not applicable	Yes, detailed description	5 clusters of capabilities (Sustainable Supply Network strategic design, Network connectivity, Network efficiency, Network process development and reporting, Network product and service enhancement) subdivided into 24 elements
	Reefke et al., 2013 [19]	Network	Maturity grids	Staged	6	Un-aware and Non-compliant, Ad-hoc and Compliance Basic, Defined and Compliance, Linked and Exceeds Compliance, Integrated and Proactive, Extended and Sustainability Leadership	Yes, generic description	Not Applicable
	Kurnia et al., 2014 [45]	Network	Maturity grids	Continuous	4	Unaware, Unprepared, Committed, Advanced	Yes, generic description	6 capabilities (Sustainable data collection, Sustainability reporting, Sustainability benchmarking, Sustainability training, Sustainability risk analysis, Sustainability governance)
	Golinska and Kuebler, 2014 [69]	Company—remanufacturing companies	Likert-like questionnaires	Continuous	5	Level 0, Level 1, Level 2, Level 3, Level 4	Yes, generic description	3 dimensions (Economic, Ecological and Social performance) subdivided in 15 key areas (Energy Efficiency, Material Efficiency, Disposal and Recycling, Compressed Air, Emissions, Inventory, Scrap and Rework, Production Organisation, Production Disruptions, Quality Management, Workplace Design, Ergonomics and Safety, Training and Development of Employees, Innovation Management, and Corporate Image)
	Edgeman and Eskildsen, 2014 [67]	Company—excellence model	Likert-like questionnaires	Continuous	5	Very low maturity, Low maturity, Moderate maturity, High maturity, Very high maturity	Yes, detailed description	6 areas (Strategy and governance, Process implementation and execution, Financial results and refinement, Sustainability results and refinement, Innovation results, Human capital results and refinement) each one is subdivided in 4 key areas

3.3.1. Scope, Typology, and Architecture of the Maturity Model

From the sustainability perspective, the SLR supports the identification of MMs with two different scopes: they address the maturity considering the TBL perspective or just the environmental dimension of sustainability. The SLR does not identify any MMs exclusively related to the social or economic sustainability. The proposed MMs diverge on the deployment of the TBL approach. For example, sustainability is treated as a stand-alone element (e.g., [19]) without an assessment of maturity on the various dimensions of sustainability. If the various dimensions of sustainability are addressed (e.g., [65]), the papers do not provide enough detailed information to assess them.

From the SC perspective, the MMs scope ranges from "process", "company" and "network" level. In the analysed sample, the MMs with scope "process" cover different SSC initiatives such as (i) "eco-design" [1] and "new product development" [68]—these initiatives assist companies in apply their efforts systematically to achieve higher environmental performance on products and processes; (ii) "knowledge management" [70]—if knowledge assets are properly managed and reported they can lead to better corporate governance, facilitate continuous improvement and enhance stakeholder value and improving TBL performance; and (iii) "information systems management" [66]—they support the organization processes, as a whole, to operate in a more sustainable way.

The SLR identified three MMs with a scope on company level. Two models applied the maturity concept in different inter-companies contexts: IT providers [71] and remanufacturing companies [69]. A third MM is proposed by Edgeman and Eskildsen [67] focusing the company innovation, organizational design and business intelligence (it represents the ability of an organization to take all input data and convert them into knowledge, ultimately, providing the right information to the right people at the right time via the right channel).

The last category of MMs identified in the SLR is related to the network perspective. This category contains four MMs related to reporting of SSC [64] and to sustainability practices or initiatives [19,45,65]. The MMs under study contain a set of SSC practices capabilities [45] and enablers [19] that are deployed at the strategic and operational level.

3.3.2. Design of the Maturity Model

Although different types of typologies can be used in the development of MMs, in the research sample 6 MMs follow a maturity grid representation (e.g., [64]). There are also some MMs that adopt typologies based on Likert-like questionnaires.

In what is concerned with the MM architecture as can be seen in Table 6, the predominant form of representation is the continuous representation. The stage representation is present only in [19]. Pigosso et al. [1] propose another approach: the model suggests the continuous or the staged implementation of practices after the diagnosis of the current maturity profile.

The MMs presume a path of development or evolution composed by some maturity levels. In most MMs under study a description of the level designation, meaning and intention are provided. The levels are described in more or less detail, providing indications on the main requirements and how they have accomplished. Table 6 provides evidence that six MMs only present a vague characterization of each maturity level (e.g., [45]). The five remaining works provide a detailed description of each level for the respective MM (e.g., [64]).

Another characteristic shared by MMs is the definition of the various elements used to analyse/measure maturity. The SLR reveals that these elements take on different designations and there is no common terminology. For example, they are sometimes called "dimensions" [69], "focus areas" [68], or "process areas" [64]. As most MMs analysed are quite specific, it was expected this diversity in the definition of the type of elements.

Despite the path of development and how to reach higher maturity levels being a critical aspect of the MM application, not all the authors clarify this. In the MM under study different approaches are proposed, from continuous improvement frameworks (with five or more steps) to simple statements indicating that higher levels could be achieved using a continuous improvement approach or implementing more sustainable elements (in these cases, only one step for the improvement

approach or implementing more sustainable elements (in these cases, only one step for the improvement process was considered).

The SLR provides evidence of the existence of MMs with different components in the domain of sustainability and SC sustainability. The main components associated with each MM are described by authors, by increasing complexity, in the following way:

- Standing and Jackson [66] define an MM based on Information Technology Governance framework, COBIT [77] with six levels (from "non-existent" to "optimized"). However, there is no information related to the model elements or how to achieve higher levels of maturity.
- Robinson et al. [70] propose a maturity roadmap with five steps to sustainability reflecting different levels of knowledge management maturity, but without information on the elements that must be evaluated. The roadmap is intended to be used as a tool to develop actions plan to reform, provide resources and evaluate results. However, it is not clear how the organizations will deploy the action plan.
- Golinska and Kuebler [69] define three sustainability dimensions, and in each of them, five different categories of practices are identified. For example, the social dimension can be assessed by whether companies conduct various practices in the areas of workplace design, ergonomics, and safety, training and development of employees, innovation management, and corporate image. However, the practices associated with each area are not identified. A total of 15 practices categories is identified. For each category, the score is computed by the sum of the positive responses to the questions. There is no information on how to reach higher levels of maturity.
- Kurnia et al. [45] propose four levels of maturity (non-existent, low, moderate, high) based on the extent of coverage within the SC and the scope of the TBL addressed by six types of capabilities: sustainable data collection represents the ability of an organization to gather a data related to sustainability practices and the impacts within the organization and across the supply chain; sustainability reporting refers to the ability of an organization to generate reports related to various aspects of sustainability practices as required by the internal and external stakeholders as well as government; sustainability benchmarking refers to the ability of an organization to compare the sustainability performance across various units and supply chain members; sustainability training translates the ability to create awareness among senior managers, various levels of employees, and other stakeholders; sustainability risk analysis represents the ability to identify and evaluate potential negative consequences associated with implementing an SSCM practice; and sustainability governance refers to the ability to manage and align the sustainability goals across organizational units and supply chain members). There is no information on how to reach higher levels of maturity.
- Babin and Nicholson [71] define three levels of maturity determined by a process involving two elements: (i) a sustainability score, which is computed assigning one point if the companies comply with sustainability standards (e.g., Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP), or ISO 26000 [78]; and (ii) assessment of three sustainable capabilities using interviews. With these two elements, it is possible to construct a three-stage model and rank companies into different maturity levels. The authors propose that the transition from an early stage to the aspirant, to mature sustainability is achieved by implementing more sustainability standards (like ISO 26000 [78]).
- Okongwu et al. [64] analyse four levels of maturity attained by organisations in reporting their sustainability initiatives in eight areas (use of standards, performance management, life cycle management, pollution management, relationship management of suppliers, customers and society, employee management, profitability management, and economic value distribution management). The maturity gain is based on a continuous improvement approach; however, the authors do not clarify how it could be applied.

- Hynds et al. [68] propose an MM for companies creating innovative sustainable products, suggesting four maturity levels. For each level of maturity, a set of behaviours, processes, tools, and outcomes that a company at a particular level of competency should demonstrate is identified. The model contains two focus areas ("strategy" and "design tools") which are subdivided into 14 dimensions (e.g., corporate sustainability policy, government policy and regulation, green labelling, and sustainability design for the environment). The model contains an assessment tool to identify various activities and outcomes for each level of maturity using 171 yes/no questions. This type of questions aims to register whether or not a specific activity is developed by the company. For each dimension, the score is evaluated by the sum of the positive responses to the questions on the dimension. Each level of maturity is associated with a range of values (designated by the dimension score). This makes it possible to assign different focus areas at a certain level of maturity, allowing a deeper understanding of the progress of integration of sustainability in different areas, identifying the necessary actions to improve it.
- Pigosso et al. [1] suggest a seven stage MM for the eco-design process. In a first step, is identified the company "evolution level in eco-design" (using three dimensions for eco-design implementation). In a second step is assessed the company "capability levels in eco-design" (using a set of five capabilities). In the third step, the company profile in eco-design is outlined using the concept of "eco-design maturity level" (which is defined by a matrix with the combination of the evolution and capability level); five maturity levels are proposed. The next four steps are related to the selection, planning and implementation of projects in a continuous improvement perspective. To advance to a higher level of maturity, it is necessary that the practices associated with a particular level of development reach a certain level of capability.
- Edgeman and Eskildsen [67] propose the model of "Sustainable Enterprise Excellence" as a tool to drive a strategy of equity, ecology and economy to improve the TBL performance. The model includes a maturity evaluation approach with five levels to evaluate six elements called "compass dimensions": strategy and governance, process implementation and execution, financial, sustainability, innovation, and human capital. Each element is assessed considering four key areas resulting in 24 elements. There is no information on how to reach higher levels of maturity as clarified by the following quote: "Springboard does in fact explicitly identify performance areas that should be emphasized, and maturity scales describe graduated performance levels that range from very low to very high maturity. How these areas should be approached is, however, left entirely to the enterprise and should be guided by its competitive landscape and vision for the future".
- Reefke et al. [19] propose is no explicit description of dimensions or areas to be evaluated. However, the description of the six maturity levels suggests the following issues that should be addressed: continuous improvement of processes towards sustainability, sustainability performance measurement systems, set of goals and standards for sustainability, strategic and functional alignment with SC partners for sustainability, and SC cooperation for sustainability. This framework is supported by a cyclical multi-step approach for maturity improvement with five stages (discovery and learning, strategizing, design, transformation, and monitoring and controlling). After the last phase, a new cycle can be performed to support maturity development efforts. However, this framework does not provide sufficient information about how to apply the model, in particular about how to determine maturity levels or achieve higher levels of maturity.
- Srai et al. [65] consider five capabilities: sustainable supply network strategic design, network connectivity, network efficiency, network process development and reporting, network product and service enhancement. All capabilities are described using five maturity levels and a respective descriptor. For example, for the group "Network process development and reporting", the descriptors for each level of maturity are Baseline, Functional Integration, Internal integration, External integration and Cross-enterprise collaboration. A total of 24 elements is considered and described in detail for each capability. Besides that, no information is provided on how those characteristics are evaluated or how to reach upper maturity levels.

To provide an overview of the SLR findings related to the MM components, Figure 2 present a plot where the bubble size is the number of steps in the maturity improvement process; the y-axis contains the number of levels and the x-axis the number of elements of the studied MM. In Figure 2 the MMs are clusteredin five categories according to their scope: (i) TBL-process: deployment of TBL perspective within a process; (ii) TBL-company: deployment of TBL perspective within a company; (iii) TBL-network: deployment of TBL perspective within a network of companies; (iv) env.-process: deployment of environmental strategies within a process; and (v) env.-company: deployment of environmental strategies within a company.

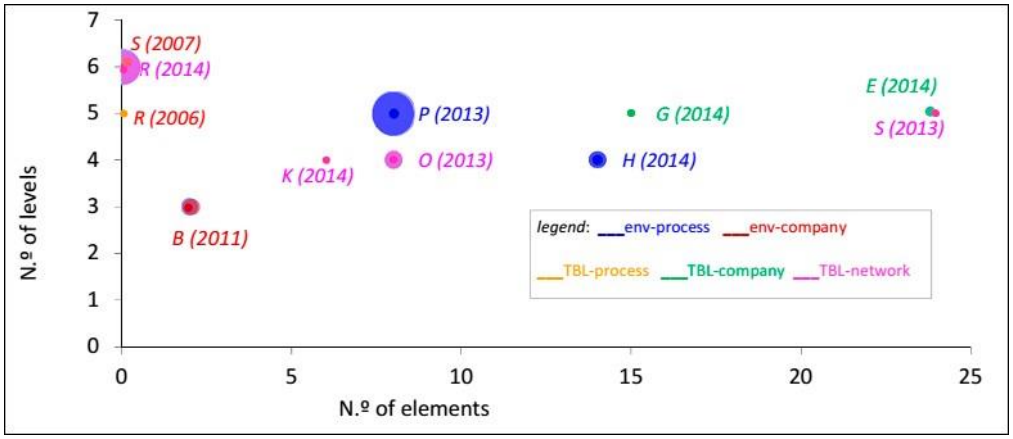


Figure 2. Maturity models overview. Legend: *B* (2011)—Babin and Nicholson [71]; *E* (2014)—Edgeman and Eskildsen [67]; *G* (2014)—Golinska and Kuebler [69]; *H* (2014)—Hynds et al. [68]; *K* (2014)—Kurnia et al. [45]; *O* (2013)—Okongwu et al. [64]; *P* (2013)—Pigosso et al. [1]; *R* (2014)—Reefke et al. [19]; *R* (2006)—Robinson et al. [70]; *S* (2013)—Srai et al. [65]; *S* (2007)—Standing and Jackson [65].

As can be seen in Table 6 and Figure 2, the number of maturity levels in the analysed MMs ranges between three and six, with five the most common. The SLR does not allow identifying a trend for a specific number of maturity levels in the different scopes. For example, the models that connect SC network perspective and the TBL consider four levels [45], five levels [64,65] and six levels of maturity [19].

Another characteristic shared by MMs is the definition of the various elements used to analyse/measure maturity. The last column of Table 6 reveals that these elements take on different designations from model to model and there is no common terminology. For example, they are sometimes called "dimensions" [69], "focus areas" [68], or "process areas" [64]. Figure 2 highlight that the MMs with a scope on the deployment of TBL within companies present a higher number of elements, as well as the MMs with a scope on environmental performance within the process. The MMs with a scope on TBL in a network perspective present a higher dispersion in the number of elements; there is one MM without elements identified [19] and an MM with 24 elements [65].

4. Discussion

The SLR provides evidence that MM development is the research objective of the majority of papers under analysis. Most authors make use of empirical methodologies, such as case studies or action research, to develop their models. After the development, the model validation is not always carried out by the authors. When made, the validation was performed adopting different empirical research strategies.

The focus on qualitative methods in the area of MMs had already been highlighted by Wendler [2]. As stated by Winter and Knemeyer [79] the lack of quantitative studies in a given field of research is usually considered as one indicator of its immaturity. Qualitative studies (such as case studies), typically used in exploratory works, produce a first-hand understanding of complex phenomena [65].

MMs can be quite generic and applicable to all type of organizations, or more narrow, only employed in a certain industry or area [80]. According to Maier et al. [81] (p. 149) for a model to be considered specific it is necessary "to gather information about the context, the idiosyncrasies and terminology of the specific domain for it to be understood by and of relevance to the audience". Narrowing the scope influences the MM extensibility to its entire domain or particular features. The choice of the MM scope should take into consideration the definition of knowledge source and audience, i.e., it should be aligned with the stakeholder (e.g., practitioners, academia, non-profit organizations) needs [28]. In the SLR, there is no evidence of the rational used by the authors to select the MM scope or reference to the stakeholder needs and available information sources.

The SLR reveals that the MMs in the domain on "Sustainability" and "SC sustainability" do not necessarlly follow a TBL approach either a network perspective. There are MMs addressing just the environmental dimension of sustainability disregarding the social and economic sustainability. This evidence confirms the results of Toubolic and Walker [82], who observed that the majority of articles in the literature on SC sustainability explore links with the environment/green dimension, rather than social dimension. In this way, the MMs under study fail to capture the core of SSCM: combining the SCM goals with the TBL perspective [21]. The focus on environmental issues obstructs the identification of critical elements that contribute to higher levels of sustainability. Moreover, narrowing the MM scope regarding sustainability dimensions hinder the opportunity to satisfy multiple and contradictory objectives as maximizing profits while reducing operating costs, minimizing the environmental impacts and maximizing the social well-being [21].

The SLR exposes the existence of MMs covering a set of processes within the SC, namely eco-design, new product development, knowledge management and information systems management. This is not unexpected, since environmental conservation (including the design for ecology), corporate strategy and commitment, and enabling information technologies (EIT—represents an equipment and/or methodology that, alone or in combination with associated technologies, provides the means to generate improvements in performance and capabilities of the user) are key-drivers for SSCM [83]. Moreover, Beske et al. [84] consider that joint development of products, common IT systems and knowledge sharing are dynamic capabilities for SSCM that can result in a better sustainability performance for the overall network. Considering the company level, the SLR pointed out two MM focusing IT providers and remanufacturing companies. Babin and Nicholson [71] stress that since the IT providers are members of SC, it is expected that they should have the same TBL performance than the organizations contracting their services. The remanufacturing companies are essential for assuring the reverse logistic (RL) flow along the network; therefore, they are key contributors for supporting an SSC [85]. Moreover, Govindan et al. [86] argue that RL providers be expected to have sophisticated information system capabilities to offer complete reverse SC solutions. The existence of MMs to be deployed at company level indicates the need to build collaboration competences among SC entities to improve the overall TBL performance. In this line, Beske et al. [84] consider that partner development program and partner-bases synergies are dynamic capabilities for SSCM.

In what is respect to the MM design, the SLR reveals that five MMs use a maturity grid representation. The Likert-type and maturity grids are considered less complex than models with a structure like CMM or hybrids [63]. This statement can also be found in Paes [42] who highlights a trend to the adoption of more simple structures like the Likert-style questionnaires and maturity grids. From the 11 MMs under study, nine present a continuous representation. Their practices are organized to support growth and improving areas of processes, and it is possible to select and improve them without allocating an area to a specific level of maturity. In this representation, there is thus autonomy to choose the order of improvement attending to the considered areas and processes. Paes [42] stress that this type of representation can be extended to others MMs and not just to the ones centred on SC processes.

As stress by De Bruin et al. [49] the number of maturity levels varies from model to model. Fraser et al. [63] also highlight that the number of levels is to some extent arbitrary, and depends on

the ability to identify suitable labels or descriptive text which clearly differentiates the levels. The SLR identified MMs with a different number of levels.

The same dispersion was found in the number of MM elements. The number of elements used should be a reflection of what needs to be measured and how it could be measure [29]. There is no ideal number of elements. The MM design should resolve the trade-off between the perceived complexity of the model and the independence of elements: a model oversimplified may not reflect the specificities of the domain and may not provide usable information, in opposite a complex model could result in misleading outcomes [49]. In the SLR the MMs with a scope on the deployment of TBL within companies, as well as the MMs with a scope on environmental performance within the process, are the ones composed by a higher number of elements. This could be justified since the proposed models intent to target particular audiences: IT provider providers and remanufacturing companies, and eco-design and new product development processes. Therefore, the MM should offer more detailed information. The models with a scope on the SC network perspective and TBL disclosure a lower number of elements (except [65]). This could be justified since these MMs are more generic and applied to a vast set of industrial contexts and do not reflect specificities of industries, process or product.

Another divergence found in the MMs under analysis is the disparity in the elements (dimension/areas) wording and meaning. Although this reflects the different scopes under analysis, the elements used in the MM under study capture the critical success factors in the implementation of an SSC. Table 7 suggests a typology for classifying them.

The critical success factors for SSCM that emerged from the SLR are in line with the literature. Dubey et al. [83] propose a framework with a set of SSCM drivers and respective relationships which are explained by the implementation of several actions. The proposed critical success factors for SSCM are aligned with that framework; some examples of actions explaining the relationships among drivers are: (i) better packaging and energy efficient storage (an environmental initiative); (ii) safe working condition and high employee morale (related to human resources management); (iii) defining the organizational policy (related to the sustainability governance); or (iv) make better collaboration with the help of better brand equity (related to supplier management). Beske et al. [84] propose a set of SSCM practices that are also related to the factors proposed in Table 7; some examples are: orientation and SC continuity (related to sustainability governance); collaboration (it includes logistical integration which is related to supplier management); or risk management (it includes standards and certification which is one of the proposed critical success factors)

The MMs under study provide little orientation on the specific steps and practices that should be performed to improve the maturity levels. This criticism applies to most MMs [27]. This lack of orientation and information is highlighted by Poeppelbuss et al. [87] (p. 519): "academic articles often present new MMs as a rough sketch that would not suffice for practical application. Thus far, academics often fall short in providing detailed guidelines and helpful (software-based or online) toolkits to support the practical adoption of models developed in academia".

Table 7. Critical success factors in the implementation of an SSC.

SSC Critical Success	Maturity Model Elements	References
Sustainability governance	Embed and develop sustainability capabilities	[71]
	Sustainability reporting Sustainability benchmarking Sustainability risk analysis	[45,65]
	Corporate image	[69]
	Performance management	[64]
	Corporate sustainability policy Overall sustainability strategy	[67,68]
Sustainability standards and regulations	Understand and adopt global standards	[71]
	Government policy and regulation	[68]

Table 7. *Cont.*

SSC Critical Success	Maturity Model Elements	References
Stakeholder focus	Anticipate and respond to stakeholder sustainability requests	[71]
	Relationship management of society	[64]
Human resources management	Employee management	[64]
	Workplace design Ergonomics and safety	[69]
	Sustainability training	[45,69]
	Human capital results and refinement	[67]
Customer management	Specifications/customer insights	[68]
	Network product and service enhancement	[65]
Environmental initiatives	Implementation level of eco-design practices	[1]
	Sustainability design for environment Green labelling	[68]
	Life cycle assessment	[64,68]
	Pollution management	[64]
	Energy and material efficiency Disposal and recycling	[69]
Supplier management	Relationship management of suppliers	[64]
Financial results	Profitability management Economic value distribution management	[64]
	Financial results and refinement	[67]
Innovation	Innovation management	[69]
	Innovation results	[67]

5. Conclusions

Using an SLR, the state of the art of MMs in sustainability and SC sustainability was examined. Based on methodologies proposed by Tranfield et al. [33], Denyer and Tranfield [39] and Rousseau et al. [37], 11 articles (published from 2000 to 2015) were selected from the SCOPUS, Emerald Insight, EBSCO and Web of Science databases. The objective was to provide a useful synthesis so that future researchers could reorganise all the concepts and issues associated to MMs in SC sustainability. The findings of this study indicate that the growing interest in issues related to sustainability, either at company level or in the context of SCs, began only lately (since 2006), compared with the interest in MMs. The number of works that simultaneously study MMs and sustainability is very small, which highlights the need to explore this research area.

Most of the papers in the sample have as their main objective the development of MMs followed by their validation. This result makes it possible to answer the first research question (RQ1). These results seem to follow the pattern recorded in studies of MMs that consider multiple domains/areas [2]. Another issue that receives little attention in the papers under study is model validation. Testing the proposed MMs is necessary "to ensure they measure what it was intended they measure and reliability to ensure results obtained are accurate and repeatable" [49] (p. 9). Without an adequate validation of the structure and applicability of the models, their relevance and usefulness are questionable [2]. The papers under study present an empirical research, where case studies predominate, with a focus on the development and validation of MMs (RQ2).

In regards to the MM scope (RQ3), this study indicates some MMs focus only on the environmental dimension, covering specific process (eco-design and new product development) and without a wide SC perspective. On the other hand, and following the recent trend in the literature to address sustainability with a TBL approach [80], several MMs focus the sustainability in a TBL approach considering the process, company, and network perspectives.

Sustainability brings new challenges and more complexity for the companies and their SCs. According to Wu and Pagell [56] (p. 577), "the need for environmental protection and increasing demands for natural resources are forcing firms to reconsider their business models and restructure their SC operations". To develop MMs in this complex domain, the adequate design of models is of extreme importance. It is a challenge to find a balance between the domain complexity and the simplicity of the MM. As regards the main characteristics associated with the design of MMs (RQ4), in the papers under study there is a tendency to use maturity grids and a continuous representation. The SLR results do not allow identifying a trend for a specific number of maturity levels. The same result arises in the analysis of the number of elements used to analyse/measure maturity. The analysis of the elements disclosed in the MM support the identification of the following critical success factors for the SSCM: sustainability governance, sustainability standards and regulations, stakeholder focus, human resources management, customer management, environmental initiatives, supplier management, financial results and innovation.

5.1. Research Implications for Research and Practice

This research contributes to a comprehensive review, analysis, and synthesis of the MM literature. Various issues associated with MMs (i.e., research objectives, research methods, focus/scope and characteristics of the design of models) are explored to reveal the dynamics and the significance of this multidimensional area. The primary emphasis on empirical research, mostly using case studies, illustrates the emerging nature of this area and the need to develop it.

Moreover, this research has implications for researchers, practitioners, universities and research institutions. It is likely to form the basis and motivation for other studies on MMs applied to SC sustainability, making it possible to perform a benchmarking analysis between companies belonging to the same SC and also between SCs. This work systematises the studies of MMs in SC sustainability and provides a guide for practitioners who want to use MMs to assess the level of maturity of their company and corresponding SC regarding sustainability.

5.2. Limitations and Future Research

The present study has some limitations and readers, future academics, as well as researchers, should interpret the material presented in this paper in that light. While the authors conducted a thorough literature search through the SCOPUS, Emerald Insight, EBSCO and Web of Science databases to identify all possible relevant papers, it is still likely that some research papers were missed. A more comprehensive research is required using other keywords (such as process maturity framework and SC, maturity matrix and sustainability, process maturity framework and sustainability). Another important issue is the fact that the MMs developed by practitioners and consultants are often difficult to access using scientific databases. The inclusion of other sources of information, such as magazines and organizations' internal documents, should be considered in future. Although every effort was made to acquire all the relevant information regarding the research questions, if the relevant information was not available they were excluded from the literature analysis.

The SLR described in this paper reveals state of the art on MMs for SSCM providing the following guidance about future research directions in this topic.

- Research objectives and methods: The model application and validation should be a major concern in future works, and not just on the development. The utilization of multiple research methodologies will support data triangulation and increase the model reliability and validity. In addition, the utilization of statistical methods could bring more robustness to the MM. Oliveira et al. [88] already use exploratory factorial analysis to define constructs supporting the maturity levels assessment. A design process that includes close collaboration with practitioners working MM in area/domain (e.g., management and staff, executives, CEO) could be a good support for the development and validation of the models.

- Scope: Multi-dimensions of sustainability in a network context should be integrated. Moreover, from the SC perspective, the unit of analysis should be carefully selected according to the MM objective. Besides the process, company and network, others approaches could be used, such as individual as the unit of analysis. The assessment of employee attitudes and commitment in different organizations along SC or clarify how the individual managers can influence the efficacy of SSCM initiatives [16] would highlight the importance of an organization to become more sustainable and encourage their SC partners to implement SSC practices.
- Theoretical background: One or more theoretical lenses to properly identify the components of an MM and propose progression paths should be utilized. Some theories that can be useful in SSCM research are stakeholder theory, resource-based view, dynamic capabilities, and brand equity [16]. Different theoretical approaches may have implications for the conceptualisation of MMs in SSCM.

Moreover, the detailed analysis of the existing MMs on SSC reveals the following research gaps in the literature.

- To identify sustainability trade-offs in SCM and maturity define progressions paths. In the development of MMs for sustainability is necessary to consider the multiple dimensions of sustainability. There are trade-offs among the economic, social and environmental goals, therefore is necessary to identify these divergences and clarify if how the maturity progress can achieve in the multiple dimensions.
- To develop tools and guidelines on how to effectively implement improvement actions. An important feature associated with MMs is the determination of the maturity level and how to reach higher maturity levels. Only Robinson et al. [70] and Pigosso et al. [1] provide that kind of information with sufficient detail to makes it possible the implementation of the proposed models. As argued by Mettler [28] the lack of description of improvement actions to achieve higher state is one of the main weaknesses of MMs. Fulfil this gap allows managers to have a clear and strategic vision of how new initiatives and projects will improve the sustainability of organisations and respective SCs.
- To identify the critical success factors in SSCM. In the development of MMs in SSC domain, the questions of what need to be measured and how it will be measured still do not have clear answers. The objective is to identify SSC elements that capture the SSC domain complexities and specificities. The utilisation of several evidence sources improves and expands the MM findings. In this process, the MMs users profile, since different users will have different needs, should be considered. In addition, different SC stakeholders will have different (and conflicting) interests in the development of SCs.

Building on the rich foundation of the research findings described and overall understanding acquired in the course of this literature review, this paper contributes to further research in the development of MMs in the context of SC sustainability.

Acknowledgments: The authors are pleased to acknowledge financial support from Fundacão para a Ciência e Tecnologia (grant UID/EMS/00667/2013) and FEDER/COMPETE (grant UID/ECO/ 04007/2013).

Author Contributions: Susana Azevedo conceived the study. Elisabete Correia, Helena Carvalho and Susana Azevedo performed the systematic literature review. Helena Carvalho reviews the data. Kannan Govindan provides guidance in the application of the methodological steps and contributes with ideas and concepts incorporated in work. All the authors wrote the paper. All the authors read carefully and approved the final version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Pigosso, D.C.A.; Rozenfeld, H.; McAloone, T.C. Eco-design. *J. Clean. Prod.* **2013**, *59*, 160–173. [CrossRef]
2. Wendler, R. The maturity of maturity model research: A systematic mapping study. *Inf. Softw. Technol.* **2012**, *54*, 1317–1339. [CrossRef]

3. Kohlegger, M.; Maier, R.; Thalmann, S. Understanding maturity models: Results of a structured content analysis. In Proceedings of the I-KNOW '09 and ISEMANTICS '09, Graz, Austria, 2–4 September 2009; pp. 51–60.
4. Cuenca, L.; Boza, A.; Alemany, M.M.E.; Trienekens, J.J.M. Structural elements of coordination mechanisms in collaborative planning processes and their assessment through maturity models: Application to a ceramic tile company. *Comput. Ind.* **2013**, *64*, 898–911. [CrossRef]
5. Bititci, U.S.; Garengo, P.; Ates, A.; Nudurupati, S.S. Value of maturity models in performance measurement. *Int. J. Prod. Res.* **2015**, *53*, 3062–3085. [CrossRef]
6. Amini, M.; Bienstock, C. Corporate sustainability: An integrative definition and framework to evaluate corporate practice and guide academic research. *J. Clean. Prod.* **2014**, *76*, 12–19. [CrossRef]
7. Meixell, M.J.; Luoma, P. Stakeholder pressure in sustainable supply chain management. *Int. J. Phys. Distrib. Logist. Manag.* **2015**, *45*, 69–89. [CrossRef]
8. Elkington, J. *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*; Capstone: Oxford, UK, 1997.
9. Ahi, P.; Searcy, C. An analysis of metrics used to measure performance in green and sustainable supply chains. *J. Clean. Prod.* **2015**, *86*, 360–377. [CrossRef]
10. Bourlakis, M.; Maglaras, G.; Gallear, D. Examining sustainability performance in the supply chain: The case of the Greek dairy setor. *Ind. Market. Manag.* **2014**, *43*, 56–66. [CrossRef]
11. Baumgartner, R.J.; Ebner, D. Corporate sustainability strategies: Sustainability profiles and maturity levels. *Sustain. Dev.* **2010**, *18*, 76–89. [CrossRef]
12. Chardine-Baumann, E.; Botta-Genoulaz, V. A framework for sustainable performance assessment of supply chain management practices. *Comput. Ind. Eng.* **2014**, *76*, 138–147. [CrossRef]
13. Marshall, D.; McCarthy, L.; Heavey, C.; McGrath, P. Environmental and social supply chain management sustainability practices: Construct development and measurement. *Prod. Plan. Control* **2014**, *26*, 673–690. [CrossRef]
14. Lambert, D.M.; Stock, J.R.; Ellram, L.M. *Fundamentals of Logistics Management*; Irwin/McGraw-Hill: Boston, MA, USA, 1998.
15. Tonelli, F.; Evans, S.; Taticchi, P. Industrial Sustainability: Challenges, perspectives, actions. *Int. J. Bus. Innov. Res.* **2013**, *7*, 143–163. [CrossRef]
16. Carter, C.R.; Easton, P.L. Sustainable supply chain management: Evolution and future directions. *Int. J. Phys. Distrib. Logist. Manag.* **2011**, *41*, 46–67. [CrossRef]
17. Beske, P.; Seuring, S. Putting sustainability into supply chain management. *Suppl. Chain Manag. Int. J.* **2014**, *19*, 322–331. [CrossRef]
18. Mentzer, J.T.; DeWitt, W.; Keebler, J.S.; Min, S.; Nix, N.W.; Smith, C.D.; Zacharia, Z.G. Defining Supply Chain Management. *J. Bus. Logist.* **2001**, *22*, 1–25.
19. Reefke, H.; Ahmed, M.D.; David Sundaram, D. Sustainable Supply Chain Management—Decision Making and Support: The SSCM Maturity Model and System. *Glob. Bus. Rev.* **2014**, *15*, 1–12. [CrossRef]
20. Taticchi, P.; Tonelli, F.; Pasqualino, R. Performance measurement of sustainable supply chains. *Int. J. Product. Perform. Manag.* **2013**, *62*, 782–804. [CrossRef]
21. Azevedo, S.G.; Carvalho, H.; Ferreira, L.M.; Matias, J.C.O. A proposed framework to assess upstream supply chain sustainability. In *Environment, Development and Sustainability*; Springer: Berlin, Germany, 2016; pp. 1–22.
22. Evan, W.; Freeman, E. A Stakeholder Theory of the Modern Corporation: Kantian Capitalism. In *Ethical Theory and Business*; Beauchamp, T., Bowie, N., Eds.; Prentice-Hall: Englewood Cliffs, NJ, USA, 1988.
23. Mani, M.; Lyons, K.; Sriam, R. Towards the development of a sustainability manufacturing maturity model. In Proceedings of the IMS2010 Summer School on Sustainable Manufacturing, Zurich, Switzerland, 26–28 May 2010; pp. 311–319.
24. McCormack, K.; Ladeira, M.B.; Oliveira, M.P.V. Supply chain maturity and performance in Brazil. *Suppl. Chain Manag. Int. J.* **2008**, *13*, 272–282. [CrossRef]
25. Neuhauser, C. A maturity model: Does it provide a path for online course design? *J. Interact. Online Learn.* **2004**, *3*, 1–17.

26. Klimko, G. Knowledge management and maturity models: Building common understanding. In Proceedings of the Second European Conference on Knowledge Management, Bled, Slovenia, 8–9 November 2001; pp. 269–278.
27. Röglinger, M.; Pöppelbuß, J.; Becker, J. Maturity models in business process management. *Bus. Process Manag. J.* **2012**, *18*, 328–346. [CrossRef]
28. Mettler, T. Thinking in Terms of Design Decisions When Developing Maturity Models. *Int. J. Strateg. Decis. Sci.* **2010**, *1*, 76–87. [CrossRef]
29. De Bruin, T.; Freeze, R.; Kaulkarni, U.; Rosemann, M. Understanding the Main Phases of Developing a Maturity Assessment Model. In Proceedings of the Australasian Conference on Information Systems (ACIS), Sydney, Australia, 30 November–2 December 2005; Campbell, B., Underwood, J., Bunker, D., Eds.; pp. 8–19.
30. Becker, J.; Knackstedt, R.; Pöppelbuß, J. Developing maturity models for IT management—A procedure model and its application. *Bus. Inf. Syst. Eng.* **2009**, *1*, 213–222. [CrossRef]
31. Green, B.N.; Johnson, C.D.; Adams, A. Writing Narrative Literature Reviews for Peer-Reviewed Journals: Secrets of the trade. *J. Chiropr. Med.* **2006**, *5*, 101–117. [CrossRef]
32. Greenhalgh, T.; Peacock, R. Effectiveness and Efficiency of Search Methods in Systematic Reviews of Complex Evidence: Audit of primary sources. *Br. Med. J.* **2005**, *331*, 1064–1065. [CrossRef] [PubMed]
33. Tranfield, D.; Denyer, D.; Smart, P. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *Br. J. Manag.* **2003**, *14*, 207–222. [CrossRef]
34. Webster, J.; Watson, R.T. Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Q.* **2002**, *26*, 13–23.
35. Von Wangenheim, C.G.; Carlo, J.; Hauck, R.; Salviano, C.F. Systematic literature review of software process capability/maturity models. In Proceedings of the 12th International Conference on Product Focused Software Development and Process Improvement, PROFES'11, Helsinki, Finland, 10–12 December 2010; pp. 2–5.
36. Brereton, P.; Kitchenham, B.; Budgen, D.; Turner, M.; Khalil, M. Lessons from applying the systematic literature review process within the software engineering domain. *J. Syst. Softw.* **2007**, *80*, 571–583. [CrossRef]
37. Rousseau, D.M.; Manning, J.; Denyer, D. Evidence in management and organizational science: Assembling the field's full weight of scientific knowledge through syntheses. *Acad. Manag. Ann.* **2008**, *2*, 475–515. [CrossRef]
38. Briner, R.B.; Denyer, D. Systematic review and evidence synthesis as a practice and scholarship tool. In *Handbook of Evidence-Based Management: Companies, Classrooms and Research*; Rousseau, D.M., Ed.; Oxford University Press: New York, NY, USA, 2012; pp. 112–129.
39. Denyer, D.; Tranfield, D. Producing a systematic review. In *The Sage Handbook of Organizational Research Methods*; Buchanan, D., Bryman, A., Eds.; Sage Publications Ltd.: London, UK, 2009; pp. 671–689.
40. Boell, S.; Cecez-Kecmanovic, D. On Being 'systematic' in Literature Reviews in IS. *J. Inf. Technol.* **2015**, *30*, 161–173. [CrossRef]
41. Kitchenham, B.; Brereton, O.P.; Budgen, D.; Turner, M.; Bailey, J.; Linkman, S. Systematic literature reviews in software engineering—A systematic literature review. *Inf. Softw. Technol.* **2009**, *51*, 7–15. [CrossRef]
42. Paes, R.L. Construção de um Modelo Para Avaliação e Melhoria do Gerenciamento da Cadeia de Suprimentos em Condomínios Industriais Automotivos Suportado por níveis de Maturidade. Ph.D. Thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, 2011. (In Portuguese)
43. Müller, A.L.; Pfleger, R. Business Transformation towards Sustainability. *Bus. Res.* **2014**, *7*, 313–350. [CrossRef]
44. Benmoussa, R.; Abdelkabir, C.; Abd, A.; Hassou, M. Capability/maturity based model for logistics processes assessment. *Int. J. Product. Perform. Manag.* **2015**, *64*, 28–51. [CrossRef]
45. Kurnia, S.; Rahim, M.M.; Samson, D.; Singh, P. Sustainable supply chain management capability maturity: Framework development and initial evaluation. In Proceedings of the 22nd European Conference on Information Systems, ECIS, Tel Aviv, Israel, 9–11 June 2014; pp. 1–10.
46. Carvalho, J.V.; Rocha, A.; Abreu, A. Maturity Models of Healthcare Information Systems and Technologies: A Literature Review. *J. Med. Syst.* **2016**, *40*, 1–10. [CrossRef] [PubMed]
47. Tarhan, A.; Turetken, O.; Reijers, H.A. Business process maturity models: A systematic literature review. *Inf. Softw. Technol.* **2016**, *75*, 122–134. [CrossRef]
48. Burgess, K.; Singh, P.J.; Koroglu, R. Supply chain management: A structured literature review and implications for future research. *Int. J. Oper. Prod. Manag.* **2006**, *26*, 703–729. [CrossRef]

49. De Bruin, T.; Rosemann, M.; Freeze, R.; Kulkarni, U. Towards a business process management maturity model. In Proceedings of the Thirteenth European Conference on Information Systems, Regensburg, Germany, 26–28 May 2005; Bartmann, D., Rajola, F., Kallinikos, J., Avison, D., Winter, R., Ein-Dor, P., Eds.; pp. 26–28.
50. Barkemeyer, R.; Holt, D.; Preuss, L.; Tsang, S. What Happened to the 'Development' in Sustainable Development? Business Guidelines Two Decades after Brundtland. *Sustain. Dev.* **2011**, *22*, 15–32. [CrossRef]
51. Gimenez, C.; Sierra, V. Sustainable Supply Chains: Governance Mechanisms to Greening Suppliers. *J. Bus. Ethics* **2013**, *116*, 189–203. [CrossRef]
52. Ahi, P.; Searcy, C. A comparative literature analysis of definitions for green and sustainable supply chain management. *J. Clean. Prod.* **2013**, *52*, 329–341. [CrossRef]
53. Labuschagne, C.; Brent, A.C.; van Erck, R.P.G. Assessing the sustainability performances of industries. *J. Clean. Prod.* **2005**, *13*, 373–385. [CrossRef]
54. Seuring, S.; Müller, M. From a literature review to a conceptual framework for sustainable supply chain management. *J. Clean. Prod.* **2008**, *16*, 1699–1710. [CrossRef]
55. Pagell, M.; Wu, Z. Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *J. Suppl. Chain Manag.* **2009**, *45*, 37–56. [CrossRef]
56. Wu, Z.; Pagell, M. Balancing priorities: Decision-making in sustainable supply chain management. *J. Oper. Manag.* **2011**, *29*, 577–590. [CrossRef]
57. Ashby, A.; Leat, M.; Hudson-Smith, M. Making connections: A review of supply chain management and sustainability literature. *Suppl. Chain Manag. Int. J.* **2012**, *17*, 497–516. [CrossRef]
58. Wolf, J. *The Nature of Supply Chain Management Research: Insights from a Content Analysis of International Supply Chain Management Literature from 1990 to 2006*; Gabler: Frankfurt, Germany, 2008.
59. Wiese, A.; Kellner, J.; Lietke, B.; Toporowski, W.; Zielke, S. Sustainability in retailing—A summative content analysis. *Int. J. Retail Distrib. Manag.* **2012**, *40*, 318–335. [CrossRef]
60. Broome, M.E. Integrative literature reviews for the development of concepts. In *Concept Development in Nursing*, 2nd ed.; Rodgers, B.L., Knafl, K.A., Eds.; W.B. Saunders Co.: Philadelphia, PA, USA, 1993; pp. 231–250.
61. Wacker, J. A definition of theory: Research guidelines for different theory-building research methods in operations management. *J. Oper. Manag.* **1998**, *16*, 361–385. [CrossRef]
62. Santana Tapia, R.G.; Daneva, M.; van Eck, P.; Wieringa, R. Towards a Business-IT Alignment Maturity Model for Collaborative Networked Organizations. In Proceedings of the 12th Enterprise Distributed Object Computing Conference Workshops, Munich, Germany, 15–18 September 2008; pp. 276–287.
63. Fraser, P.; Gregory, M. The use of maturity models/grids as a tool in assessing product development capability. In Proceedings of the Engineering Management Conference, Cambridge, UK, 18–20 August 2002; pp. 244–249.
64. Okongwu, U.; Morimoto, R.; Lauras, M. The maturity of supply chain sustainability disclosure from a continuous improvement perspective. *Int. J. Product. Perform. Manag.* **2013**, *62*, 827–855. [CrossRef]
65. Srai, J.S.; Alinaghian, L.S.; Kirkwood, D.A. Understanding sustainable supply network capabilities of multinationals: A capability maturity model approach. *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.* **2013**, *227*, 595–615. [CrossRef]
66. Standing, C.; Jackson, P. An approach to sustainability for information systems. *J. Syst. Inf. Technol.* **2007**, *9*, 167–176. [CrossRef]
67. Edgeman, R.; Eskildsen, J. Modeling and Assessing Sustainable Enterprise Excellence. *Bus. Strategy Environ.* **2014**, *23*, 173–187. [CrossRef]
68. Hynds, E.J.; Brandt, V.; Burek, S.; Jager, W.; Knox, P.; Parker, J.P.; Zietlow, M. A Maturity Model for Sustainability in New Product Development. *Res. Technol. Manag.* **2014**, *57*, 50–57. [CrossRef]
69. Golinska, P.; Kuebler, F. The method for assessment of the sustainability maturity in remanufacturing companies. In Proceedings of the 21st CIRP Conference on Life Cycle Engineering (CIR LCE), Trondheim, Norway, 18–20 June 2014; Volume 15, pp. 201–206.
70. Robinson, H.S.; Anumba, C.J.; Carrillo, P.M.; Al-Ghassani, A.M. STEPS: A knowledge management maturity roadmap for corporate sustainability. *Bus. Process Manag. J.* **2006**, *12*, 793–808. [CrossRef]
71. Babin, R.; Nicholson, B. How green is my outsourcer? Measuring sustainability in global IT outsourcing. *Strateg. Outsourcing Int. J.* **2011**, *4*, 47–66. [CrossRef]

72. Hair, J.F.; Black, W.C.; Babin, B.J.; Anderson, R.E. *Multivariate Data Analysis*, 7th ed.; Prentice Hall: Upper Saddle River, NJ, USA, 2010.
73. Pullen, W. A public sector HPT maturity model. *Perform. Improv.* **2007**, *46*, 9–15. [CrossRef]
74. Morash, E.A.; Droge, C.L.; Vickery, S.K. Strategic logistics capabilities for competitive advantage and firm success. *J. Bus. Logist.* **1996**, *17*, 1–22.
75. EFQM. The EFQM Excellence Model. 2013. Available online: http://www.efqm.org/the-efqm-excellence-model (accessed on 2 February 2016).
76. Booz-Allen, S.; Hamilton, S. *New Product Management for the 1980's*; Booz-Allen & Hamilton, Inc.: New York, NY, USA, 1982.
77. ISACA. COBIT 5. 2016. Available online: http://www.isaca.org/cobit/pages/default.aspx (accessed on 5 February 2016).
78. International Standards Organization. *ISO 26000—Guidance on Social Responsibility*; International Standards Organization: Brussels, Belgium, 2010.
79. Winter, M.; Knemeyer, A.M. Exploring the integration of sustainability and supply chain management. *Int. J. Phys. Distrib. Logist. Manag.* **2013**, *43*, 18–38. [CrossRef]
80. Jia, G.; Chen, Y.; Xue, X.; Chen, J.; Cao, J.; Tang, K. Program management organization maturity integrated model for mega construction programs in China. *Int. J. Proj. Manag.* **2011**, *29*, 834–845. [CrossRef]
81. Maier, A.M.; Moultrie, J.; Clarkson, P.J. Assessing Organizational Capabilities: Reviewing and Guiding the Development of Maturity Grids. *IEEE Trans. Eng. Manag.* **2012**, *59*, 138–159. [CrossRef]
82. Touboulic, A.; Walker, H. Theories in Sustainable Supply Chain Management: A Structured Literature Review. *Int. J. Phys. Distrib. Logist. Manag.* **2015**, *45*, 16–42. [CrossRef]
83. Dubey, R.; Gunasekaran, A.; Papadopoulos, T.; Childe, S.J.; Shibin, K.T.; Wamba, S.F. Sustainable supply chain management: Framework and further research directions. *J. Clean. Prod.* **2016**, *142*, 1119–1130. [CrossRef]
84. Beske, P.; Land, A.; Seuring, S. Sustainable supply chain management practices and dynamic capabilities in the food industry: A critical analysis of the literature. *Int. J. Prod. Econ.* **2014**, *152*, 131–143. [CrossRef]
85. Agrawal, S.; Singh, R.K.; Murtaza, Q. A literature review and perspectives in reverse logistics. *Resour. Conserv. Recycl.* **2015**, *97*, 76–92. [CrossRef]
86. Govindan, K.; Palaniappan, M.; Zhu, Q.; Kannan, D. Analysis of third party reverse logistics provider using interpretive structural modelling. *Int. J. Prod. Econ.* **2012**, *140*, 204–211. [CrossRef]
87. Poeppelbuss, J.; Niehaves, B.; Simons, A.; Becker, J. Maturity Models in Information Systems Research: Literature Search and Analysis. *Commun. Assoc. Inf. Syst.* **2011**, *29*, 505–532.
88. Oliveira, M.P.V.; Ladeira, M.B.; McCormack, K.P. The Supply Chain Process Management Maturity Model—SCPM3. Supply Chain Management—Pathways for Research and Practice. Onkal, D., Ed.; 2011, pp. 201–218. Available online: http://www.intechopen.com/books/supply-chain-management-pathways- for-research-and-practice/the-supplychain-process-management-maturity-model-scpm3 (accessed on 20 March 2015).).

© 2017 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (http://creativecommons.org/licenses/by/4.0/

Chapter 4

Sustainability Supply Chain Practices: Proposal for a Framework

This chapter consists of the following article:

Correia, E., Garrido, S., & Carvalho, H.
International Journal of Logistics Management (2022)
Undergoing peer review

International Journal of Logistics Manag

Sustainability Supply Chain Practices: Proposal for a Framework

Journal:	*International Journal of Logistics Management*
Manuscript ID	IJLM-05-2022-0231
Manuscript Type:	Original Article
Keywords:	Sustainability, Supplier management, Supply chain processes
Research Method:	Case study
Geography:	Europe

SCHOLARONE™
Manuscripts

Sustainability Supply Chain Practices: Proposal for a Framework

Elisabete Correia[1], Susana Garrido[2]* and Helena Carvalho[3]

[1]Polytechnic of Coimbra, Coimbra Business School Research Centre ISCAC, Coimbra [2]Faculty of Economics, Faculdade de Ciências e Tecnologia, Universidade de Coimbra, Av Dias da Silva 165, 3004512, Coimbra,Portugal

[3]Universidade Nova de Lisboa, Caparica,Portugal

Abstract

This paper proposes a framework for the implementation of sustainability practices by individual companies and corresponding supply chains (SCs), considering the various SC tiers, the three dimensions of sustainability, and the following critical areas: Governance, Product and Process, Customers and Suppliers Management, and Stakeholder focus. Using several case studies of small and medium size companies, a qualitative methodology is used to develop the proposed framework. The analysis of these case studies makes it possible to identify the sustainability practices that are the most important for practitioners, thereby reducing the number of sustainability practices specified in the literature and giving some insights regarding which should be used in addressing critical areas. A set of guidelines and actions is also suggested for managers to continue the path of sustainability.

Keywords: Corporate sustainability, Governance, Product and Process, Customers and Suppliers management; Stakeholders; Case study, framework proposal.

1. Introduction

The integration of sustainability in both organizational and Supply Chain (SC) contexts calls for developing efforts and implementing practices. The literature highlights a number of practices that include sustainability objectives internally and beyond the organization's boundaries and that are critical for the organization's sustainability (Preuss, 2005) and a more sustainable SC (Pagell & Wu, 2008). The type of practices and the extent to which they are implemented internally and, in their SC, reflect how companies combine sustainability principles and objectives. Within supply chain relationships organizations face significant pressure from their customers to adopt sustainability practices (Seuring et al., 2019; Somsuk & Laosirihongthong, 2017; Walker et al, 2008). Small companies are especially pressured from their customers in this regard (Walker et al., 2008).

These practices can be implemented in a broader and more sophisticated way to promote sustainability, considering the expectations and pressures, especially from their SC and other stakeholders. In recent decades especially there has been a growing trend in regulation and legislation in the European Union in the environmental and social areas (Alzawawi, 2014), which

*Corresponding author. E-mail: garrido.susana@fe.uc.pt

may constitute coercive pressures (Zhu & Zang, 2015). In the light of institutional theory, companies face coercive isomorphism since actions and transformations occur by imposition and force of authority (DiMaggio & Powell, 1983; Meyer & Rowan, 1977). Glover et al. (2014) state that coercion can also arise from the influence of those in positions of greater power in the SC. On the other hand, customer pressures typify normative forces, justifying the implementation of practices because companies want "to be perceived as legitimate and professional in handling their responsibilities" (Hoejmose et al., 2014, p. 217). Companies could also adopt practices to follow competitors' success paths and obtain legitimacy (mimetic isomorphism).

The companies' resources and capabilities are also considered important drivers for the implementation of sustainability practices (Chardine-Baumann & Botta-Genoulaz, 2014). According to the Resource-Based View (RBV) theory, an organization's ability to respond to internal and external changes and challenges varies with its internal resource base and capabilities (Hervani et al., 2005). For example, environmental challenges may lead to the development of intangible resources. These resources can be sources of improvements in environmental performance, which may lead to a competitive advantage (Hart, 1995). With the implementation of sustainability practices, companies expect that this can result in improved brand image and firm reputation (Zhu et al., 2007; Paulraj et al., 2017), enhanced employee morale (Paulraj et al., 2017), cost reductions (Bowen et al., 2001; Zhu & Sarkis, 2006, Luzzini et al., 2015), financial performance (Weber et al., 2008), and other benefits such as operational efficiency and increased sales (Govindan et al., 2014). It can also lead to improved environmental and social performance (Baliga et al., 2020).

The Institutional and the RBV theories are used as theoretical backgrounds supporting this study. The complementary use of different theoretical lenses provides greater explanatory power in analyzing issues associated with sustainability (Zhu et al., 2008; Carter & Rogers, 2008).

Research on sustainability has focused on large companies despite the importance of small and medium-sized enterprises (SMEs) in the global economy. SMEs account for more than 90% of all companies in the European economy, including in Portugal, and have great importance for sustainability given their collective impact at the economic, environmental, and social level (López-Pérez et al., 2018; Tsvetkova et al., 2020; Ali et al., 2021; Jelačić et al., 2021). Kot (2018) and Tsvetkova et al. (2020) point out that research on sustainability in SMEs regarding both the sustainability practices and the management of SC is underdeveloped. This study therefore seeks to better understand these issues associated with this type of company.

Hong et al. (2018) argue that sustainability practices have been inconsistently defined throughout the literature. Moreover, with the proliferation of studies on sustainability practices to be adopted in organizations and their SCs, very diverse proposals for categorization have emerged, not always with a holistic perspective of sustainability, i.e., considering neither the different dimensions of sustainability nor the various partners of the SC (e.g., Marshall et al., 2014; Masoumik et al., 2014; Das, 2017; Karaosman et al., 2017). For example, in Supply Chain Management (SCM) a gap has already been identified in the literature regarding the availability of a proper scale for practices that include all three dimensions of sustainability (Das, 2017). A bibliometric and content analysis on sustainability in SMEs covering the last two decades (2000 to 2019) reveals that this holistic sustainability perspective is almost absent in the literature (Prashar & Sunder M., 2020). In addition,

sustainability practices are a topic addressed by a minimal number of studies (in only 8 of the 117 articles analyzed) (Prashar & Sunder M., 2020). Considering the gap identified in the literature review, the suggested research question for this study is defined: which sustainability practices should be implemented by SME organizations and their corresponding SCs considering the environmental, social, and economic dimensions, the critical areas, and engagement with SC partners? We propose a framework to help individual companies and corresponding SCs to implement sustainability practices considering the various dimensions of sustainability, critical areas, and SC's various partners.

This paper is divided into sections as follows. Following this introduction, the second section is a literature review about sustainability practices. Section three describes the methodology in detail. The case study data were collected from five companies in the Portuguese mouldmaking sector to obtain a comprehensive survey of the most critical environmental, economic, and social practices. Section four presents the results. This section is split into three subsections: the first presents the individual case study analysis and the second the cross-case analysis, followed by the proposal of a framework for implementing sustainability practices in critical areas, and a discussion is provided in section 5. Section six has the main conclusions and some contributions, along with implications for management and theory.

2. Literature Review

2.1. Sustainability practices in the SC

2.1.1. Sustainability practices in the literature

Given the great diversity of sustainability practices mentioned in the literature, several studies have sought to organize and systematize these practices. Some studies consider sustainability practices as a single construct, i.e., assuming a TBL approach but not explicitly distinguishing between the practices associated with the different dimensions of sustainability (e.g., Gopal & Thakkar, 2016; Hallikas et al., 2020); others distinguish between environmental, social, and economic practices. Table 1 summarizes some studies focusing on these practices, considering the different dimensions and SC tiers.

It is noteworthy that the works that focus simultaneously on all dimensions of sustainability and the various SC partners are scarce. The different works present different practices for each of the dimensions. A literature review was carried out to identify the leading practices associated with each sustainability dimension.

Table 1. Works focusing on practices by the dimension of sustainability and SC tier

Authors	Sustainability Dimension			Supplier	Focal comp.	Customer	Other Stakeholders
Carter & Jennings (2002)	●	❖		✓	✓		
Vachon & Klassen (2006)	●			✓	✓	✓	
Zhu et al. (2008)	●			✓	✓	✓	
Holt & Ghobadian (2009)	●			✓	✓		
Awaysheh & Klassen (2010)		❖		✓			
Gavronski et al. (2011)	●			✓			
Azevedo et al. (2011)	●			✓	✓	✓	
Shi et al. (2012)	●			✓	✓	✓	
Albino et al. (2012	●			✓	✓	✓	✓
Zhu et al. (2013)	●			✓	✓	✓	
Laosirihongthong et al. (2013)	●			✓	✓	✓	
Gimenez & Sierra (2013)	●			✓			
Diabat et al. (2013)	●			✓	✓	✓	
Masoumik et al. (2014)	●			✓	✓	✓	✓
Marshall et al. (2015)	●	❖		✓	✓	✓	✓
Tachizawa et al. (2015)	●			✓			
Paulraj et al. (2017)	●			✓	✓	✓	
Mani et al. (2015)		❖		✓	✓	✓	✓
Jia et al. (2015)	●			✓	✓	✓	
Sancha et al. (2016)		❖		✓			
Kirchoff et al. (2016)	●			✓	✓	✓	
Das (2017)	●	❖	□	✓	✓	✓	✓
Hussain et al. (2019)	●	❖	□	✓	✓	✓	
Green et al. (2019)	●		□	✓	✓	✓	

Note: ●Environmental; ❖ Social; □ Economic

As a literature selection methodology, we searched peer-reviewed scholarly journals from SCOPUS, Emerald Insight, EBSCO, and Web of Science databases for works published between January 2002 and July 2020. All studies were included regardless of the methodology used, including conceptual and review articles, to understand the topic's treatment (Karaosman et al., 2017). Only articles written in English and Portuguese were considered. Articles whose scope was the company and SC were also included to include the practices that can be regarded at the various levels of SC. Conference papers/proceedings, working papers, technical reports, editorials, and book chapters were excluded from the search to guarantee the quality of content. The keywords used to select articles belonged to the following categories: sustainability, companies and supply chain, and practices. Each class includes a variety of related keywords. The asterisk was used at the end of some keywords to obtain variations (e.g., Sustainab* covers both sustainable and sustainability). The keywords for each category were: (i) for sustainability: Sustainab*; green; social*; environment*; Corporate Social Responsibility; CSR; (ii) for companies and supply chain: company; enterprise; Supply chain; Supply chain management; SCM; SSCM; and, (iii) for practices: practices; practice; initiatives; actions. After gathering the results of several searches conducted by title, abstract, and subject terms, and excluding duplicates, 267 articles were obtained. After a content analysis process, first of the abstracts and then the text, all articles that mentioned/addressed practices in only a very general way and did not present how they could be operationalized were excluded. In the end, 64 articles were retained for analysis. Tables 2, 3, and 4 present the main groups of practices based on the literature review for each of the environmental, social, and economic dimensions.

The methodology adopted to organize/group the sustainability practices follows previous works such as Marshall et al. (2015) and Das (2017), in which various specific practices, designated in this study as sub-practices, are aggregated as a way of making possible their operationalization.

Table 2. Environmental practices

Code	Environmental practices	Definition	Sub-practices
PE1	Corporate Environmental governance	Includes practices related to organizational policies and structures, procedures, and audit standards, and which reflect the commitment and engagement of the organization's management with reducing environmental impacts (Zhu & Sarkis 2004; Zhu et al., 2008; Green Jr et al., 2012; Diabat et al., 2013).	• Existence of pollution prevention programs (Zhu et al., 2012; Zhu et al., 2013) • Obtaining ISO 14001 certification (Zhu et al., 2007; Zhu et al., 2008; Holt & Ghobadian, 2009; Azevedo et al., 2011; Zhu et al., 2012; Zhu et al., 2013; Liu et al., 2012; Masoumik et al., 2014; Kirchoff et al., 2016; Das, 2017) • Implementing environmental management systems (Zhu et al.; 2008; Azevedo et al., 2011; Zhu et al., 2012) • Cross-functional cooperation for environmental improvements (Zhu et al, 2007; Zhu et al., 2008; Zhu et al., 2012; Masoumik et al., 2014) • Special training for workers on environmental issues (Zhu et al., 2012; Zhu et al., 2013; Jia et al., 2015) • Regular use of environmental performance metrics by corporate management (Kirchoff et al., 2016) • The internal performance evaluation system incorporates environmental factors (Zhu et al., 2012; Zhu et al., 2013) • Generate environmental reports for internal evaluation (Zhu et al., 2012; Zhu et al., 2013) • Link compensation to performance on environmental factors for managers and workers (Zhu et al., 2012) • Environmental compliance and auditing programs in all departments (Zhu et al., 2007; Zhu et al., 2008; Zhu et al., 2013; Kirchoff et al., 2016; Jia et al., 2015) • Commitment to GSCM from senior and mid-level managers (Zhu et al, 2007; Zhu et al., 2008; Zhu et al., 2013; Zhu et al., 2012; Masoumik et al., 2014; Jia et al., 2015)
PE2	Ecodesign	Requires that manufacturers design products that minimize the consumption of materials and energy, that facilitate the reuse, recycling, and recovery of component materials and parts, and that avoid or reduce the use of hazardous products in the manufacturing process (Zhu et al., 2008; Green Jr et al., 2012; Diabat et al., 2013; Pinto et al., 2014).	• Design of products for reduced consumption of material and energy (Zhu et al., 2007; Zhu et al., 2008; Zhu et al., 2012; Zhu et al., 2013; Jia et al., 2015; Kirchoff et al., 2016; Das, 2017). • Designing products/processes to avoid or reduce the use of hazardous materials/substances (Zhu et al., 2007; Zhu et al., 2008; Marshall et al., 2014; Jia et al., 2015; Vanalle & Santos, 2015). • Design or redesign products to reduce the overall environmental impact of the product and increase product life (Kirchoff et al., 2016). • Designing products for reuse, recycling, and recovery of materials, components, and parts (Zhu et al. 2007; Zhu et al., 2008; Zhu et al., 2012; Zhu et al., 2013; Masoumik et al., 2014; Kirchoff et al., 2016). • Designing products to use environmentally friendly materials (Paulraj et al, 2017; Laosirihongthong et al., 2013; Azevedo et al., 2011; Shi et al., 2012). • Designing products for reduced raw materials (use of recycled materials) (Azevedo et al., 2011; Jia et al. 2015; Laosirihongthong et al., 2013). • Designing products for disassembly (Azevedo et al., 2011; Paulraj et al., 2017). • Designing products to optimize the process to reduce solid/liquid waste/emission (Zhu et al., 2012; Jia et al., 2015). • Use ecological materials for primary packaging (Masoumik et al., 2014). • Minimize the use of materials in packaging (Laosirihongthong et al., 2013). • Formal guidelines for environmental product design (Paulraj et al., 2017).

PE3	Green purchasing	Practices related to the supply of raw materials and components that seek to ensure that purchased products or materials meet environmental objectives (Carter & Carter, 1998; Min & Galle, 2001; Zsidisin & Siferd, 2001; Zhu et al., 2008; Diabat et al., 2013; Pinto, 2014, 2020).	• Purchase energy or water-efficient materials/products/services (Hsu et al., 2014). • Purchase easily recycled materials/products (Hsu et al., 2014). • Purchases of recycled packaging (Zailani et al., 2012). • Purchase nontoxic materials/products/services/ environmentally friendly raw materials (Rao & Holt, 2005; Masoumik et al., 2014; Hsu et al., 2014). • Purchase used products from recyclers or remanufactures as a valuable source of components and materials (Hsu et al., 2014; Masoumik et al., 2014). • Have green purchasing or logistics guidelines that recommend the environment is considered (Holt & Ghobadian, 2009; Azevedo et al., 2011). • Have a formal policy on green procurement/purchasing (Holt & Ghobadian, 2009). • Suppliers are selected using environmental criteria (e.g., environmental competence, performance, ISO 14001) (Holt & Ghobadian, 2009; Thun & Müller, 2010; Paulraj, 2011; Gavronski et al., 2011; Zhu et al., 2013; Hoejmose et al., 2014 Masoumik et al., 2014; Rao & Holt, 2005; Miemczyk & Luzinni, 2018; Baliga et al, 2020) • Compliance with environmental legislation such as external purchasing directives (e.g., the EC procurement directive or franchise agreements) (Holt & Ghobadian, 2009; Vanalle & Santos, 2015). • Environmental education for internal purchasing staff (Liu et al., 2012). • Provide design specifications to suppliers that include environmental requirements for purchased items (Zhu et al., 2007; Zhu et al., 2008; Azevedo et al., 2011; Zhu et al., 2013; Paulraj, 2011; Liu et al., 2012; Grekova et al., 2016; Das, 2017; Miemczyk & Luzinni, 2018). • Purchase products with eco-labels (Baliga et al., 2020).
PE4	Green production	It encompasses practices that seek to minimize the impact of the manufacturing process on the environment at every stage (Dube1 & Gawande, 2016).	• Optimization of the process to reduce solid/liquid waste and the generation of hazardous wastes and optimize material exploitation (Rao & Holt, 2005; Shi et al., 2012; Hassan, 2013; Zhu et al., 2013; Masoumik et al., 2014). • Optimization of the process to reduce air emissions (Rao & Holt, 2005; Masoumik et al., 2014). • Optimization of the process to reduce noise pollution (Rao & Holt, 2005; Masoumik et al., 2014). • Internal recycling of materials in the production phase (Azevedo et al., 2011; Shi et al., 2012). • Active management of the disposal of all solid wastes in the organization (Holt & Ghobadian, 2009). • Processes designed to avoid or reduce the use of hazardous material (Marshall et al., 2014; Paulraj et al., 2017; Jia et al., 2015). • Using filters and controls for emissions and discharges (Azevedo et al., 2011). • Minimized use of packaging in internal processes (Marshall et al., 2014). • Reutilization of by-products and other wastes (Liu et al., 2012). • Maximize the use of renewable or recycled source materials for product manufacturing (Azevedo et al., 2011; Zailani et al., 2012; Marshall et al., 2014; Jia et al., 2015). • Reducing resource consumption during production (Jia et al., 2015; Vanalle & Santos, 2015). • Reducing energy consumption (Azevedo et al., 2011; Masoumik et al., 2014). • Use of environmentally friendly raw materials (Azevedo et al., 2011; Shi et al., 2012). • Minimized use of fossil fuels in favor of alternative energy sources (Marshall et al., 2014; Masoumik et al., 2014). • Using standardized components to facilitate their reuse (Azevedo et al., 2011). • Use cleaner technology processes to achieve savings (Rao & Holt, 2005; Masoumik et al., 2014; Dubey et al., 2016). • Constantly reengineer processes to reduce their environmental impact (Paulraj et al., 2017).
PE5	Environmental supplier management practices	Practices that reflect the company's effort and direct involvement with its suppliers in planning and executing joint environmental solutions to reduce pollution or other negative environmental impacts from production processes or products (Vachon & Klassen, 2006; Vachon & Klassen, 2008; Diabat et al., 2013; MacCarthy & Jayarathne, 2012; Sancha et al., 2016, Gimenez & Sierra, 2013; Gravonski et al., 2011).	• Require suppliers to use environmental packaging (degradable and non-hazardous) (Zhu et al., 2012; Zhu et al., 2013; Shi et al., 2012) • Ask suppliers to commit to waste reduction goals (Gavronski et al., 2011; Zailani et al., 2012; Jia et al., 2015). • Request existing primary suppliers to provide evidence of all environmental licenses and permits (Gavronski et al., 2011). • Environmental monitoring/evaluation of suppliers (Azevedo et al., 2011; Liu et al., 2012; Marshall et al., 2014; Liu et al., 2012; Laosirihongthong et al., 2013). • Conduct regular environmental audits into suppliers' internal operations (Paulraj, 2011; Tate at al., 2012; Gavronski et al., 2011; Gimenez & Sierra, 2013; Zhu et al., 2013; Marshall et al., 2014; Hoejmose et al., 2014; Tachizawa et al., 2015; Jia et al., 2015; Miemczyk & Luzinni, 2018).

	• A set of environmental criteria/standards should be met by suppliers (Holt & Ghobadian, 2009; Miemczyk & Luzinni, 2018). • Assess suppliers' performance through formal evaluation, using established guidelines and procedures (e.g., standard procedures, pre-determined frequency) (Gimenez & Sierra, 2013; Tachizawa et al., 2015; Holt & Ghobadian, 2009). • Use questionnaires to monitor environmental compliance (Gold et al., 2010; Gavronski et al., 2011; Marshall et al., 2014) • Require Suppliers' ISO 14000 certification (Zhu et al., 2007; Zhu et al., 2008; Zhu et al., 2012; Shi et al., 2012; Zhu et al., 2013; Jia et al., 2015; Kirchoff et al., 2016). • Bring together suppliers in the same industry to share their know-how and problems (Shi et al., 2012; Hoejmose et al., 2014) • Joint development and usage of eco-friendly technology (Thun & Müller, 2010; Tate et al., 2012; Zhu et al., 2008; Gavronski et al., 2011; Shi et al., 2012; Zhu et al., 2012; Zhu et al., 2013; Jia et al., 2015, Kirchoff et al., 2016, Baliga et al, 2020). • Achieve environmental goals collectively with suppliers (Vachon & Klassen, 2008). • Make joint efforts with suppliers to reduce waste (Liu et al., 2012; Gimenez & Sierra, 2013; Tachizawa et al., 2015). • Work with suppliers for cleaner production (Paulraj, 2011). • Arrange for funds to help suppliers purchase equipment for pollution prevention, wastewater, recycling etc. (Hoejmose et al., 2014). • Provide training/education to suppliers' personnel (Gimenez & Sierra, 2013, Tate et al., 2012; Liu et al., 2012; Tachizawa et al., 2015; Jia et al., 2015; Miemczyk & Luzinni, 2018). • Visit suppliers to help them improve their performance (Gimenez & Sierra, 2013, Paulraj, 2011; Tate et al., 2012). • Guide suppliers in setting up their environmental programs (Shi et al., 2012; Hoejmose et al., 2014; Rao & Holt, 2005; Das, 2017). • Cooperate with suppliers to reduce/eliminate packaging (Thun & Müller, 2010; Zhu et al., 2012; Gold et al., 2010; Zhu et al., 2013; Vanalle & Santos, 2015). • Work with suppliers to reduce the overall environmental impact of logistics operations (Kirchoff et al., 2016). • Joint product design with suppliers (e.g., design for reduced consumption of material/energy, design for recycling, design to avoid the use of hazardous products, etc.) (Zhu et al., 2007; Holt & Ghobadian, 2009; Vanalle & Santos, 2015; Tachizawa et al., 2015). • Develop a mutual understanding (with suppliers) of responsibilities regarding environmental performance (Vachon & Klassen, 2008; Thun & Müller, 2010; Paulraj, 2011; Gavronski et al., 2011). • Work together (with suppliers) to reduce the environmental impact of activities (Vachon & Klassen, 2008; Gavronski et al., 2011; Azevedo et al., 2011; Vanalle & Santos, 2015; Grekova et al., 2016). • Conduct joint planning (with suppliers) to anticipate and resolve environmentally related problems (Vachon & Klassen, 2008; Paulraj, 2011; Gavronski et al., 2011; Kirchoff et al., 2016). • Develop product/processes with suppliers to use recycled or reclaimed resources (Marshall et al., 2014). • Major suppliers are involved in environmental research and development (Miemczyk & Luzinni, 2018).

PE6	Environmental customer-management practices	This category encompasses practices that seek to promote a green image, encourage customers to purchase green or recovered products and components and provide the customers with insights into green consumption. It also includes collaborative practices (Soda et al., 2005; Diabat et al., 2013; Pinto, 2020; Masoumik et al., 2014; Wong et al., 2015; Gopal, 2016; Dube & Gawande, 2016).	• Eco-labelling of products (Rao & Holt, 2005; Masoumik et al., 2014). • Providing instructions for environmentally friendly use of products (Rao & Holt, 2005; Shi et al., 2012; Masoumik et al., 2014) • Achieving environmental goals collectively with customers (Vachon & Klassen, 2008). • Developing a mutual understanding (with customers) of responsibilities regarding environmental performance (Vachon & Klassen, 2008; Paulraj et al, 2017; Baliga et al, 2020). • Working together (with customers) to reduce the environmental impact of activities (Vachon & Klassen, 2008; Albino et al., 2012; Kirchoff et al., 2016; Baliga et al, 2020). • Cooperation with customers for green packaging (Zhu et al., 2007; Zhu et al., 2008; Azevedo et al., 2011; Zhu et al., 2012; Masoumik et al., 2014; Jia et al., 2015). • Cooperation with customers for eco-design (Zhu et al., 2008; Azevedo et al., 2011; Albino et al., 2012; Zhu et al., 2012; Shi et al., 2012; Zhu et al., 2013; Masoumik et al., 2014; Jia et al., 2015; Das, 2017). • Cooperation with customers to use less energy during product transportation (Zhu et al., 2007; Zhu et al., 2008; Zhu et al., 2012; Zhu et al., 2013; Grekova et al., 2016). • Cooperation with customers for product take back (Zhu et al., 2012; Zhu et al., 2013). • Providing consumers with information on environmentally friendly products and production methods (Shi et al., 2012; Masoumik et al., 2014; Baliga et al, 2020). • Cooperation with customers for cleaner production (Zhu et al., 2008; Azevedo et al., 2011; Zhu et al., 2012; Zhu et al., 2013; Masoumik et al., 2014; Jia et al., 2015; Das, 2017; Baliga et al, 2020). • Addressing environmental concerns of customers in terms of eco-friendly design/distribution of products (Das, 2017).
PE7	Green distribution and logistics	This includes all practices related to transport and packaging that aim to minimize the environmental impact of product distribution. It consists of the whole distribution process from the warehouse, packaging, improving vehicle loadings, and delivery to the customer or purchaser (Pinto, 2014; Masoumik et al., 2014).	• Consider environmental matters generally in transport decisions (Holt & Ghobadian, 2009; Baliga et al, 2020). • Planning the routes of vehicles to reduce environmental impacts (Zhu et al., 2008; Paulraj, 2011; Holt & Ghobadian, 2009; Azevedo et al., 2011; Tirkolaee et al., 2019). • Investing in vehicles designed to have reduced environmental impacts (Holt & Ghobadian, 2009). • Use of environmentally friendly transportation (Rao & Holt, 2005; Holt & Ghobadian, 2009; Azevedo et al., 2011; Shi et al., 2012; Masoumik et al., 2014; Baliga et al., 2020). • Use recyclable or reusable packaging/containers in logistics (Shi et al., 2012; Masoumik et al., 2014). • Environmental improvement of packaging, such as using ecological materials for primary packaging (Zhu et al., 2008; Shi et al., 2012; Zhu et al., 2013; Masoumik et al., 2014; Kirchoff et al., 2016). • Having energy-efficient systems in operation in warehouses (Holt & Ghobadian, 2009). • Have a formal policy on green logistics/transport (Holt & Ghobadian, 2009; Azevedo et al., 2011).
PE8	Reverse logistics	This involves planning, implementing, and controlling a proficient, cost-effective flow of resources, work in progress, finished products, and associated information from the end consumers to the manufacturer to recapturer value and have proper disposal (Diabat et al., 2013; Pinto, 2020; Dube & Gawande, 2016).	• Collect used or unwanted products from customers for recycling, remanufacturing, reclamation of materials, or reuse (Hsu et al., 2016; Masoumik et al., 2014). • Collect used packaging from customers for reuse or recycling (Laosirihongthong et al., 2013; Hsu et al., 2016). • Recovery of the company's end-of-life products (Zhu et al., 2012; Zhu et al., 2013; Shi et al., 2012; Diabat et al., 2013; Masoumik et al., 2014). • Labelling packaging material for retrieval purposes (Masoumik et al., 2014). • Return packaging to suppliers for reuse or recycling (Laosirihongthong et al., 2013). • Require suppliers to collect their packaging materials (Laosirihongthong et al., 2013). • Return products to suppliers for recycling (Laosirihongthong et al., 2013). • Return products to customers after refill or repair (Hsu et al., 2016),
PE9	Stakeholder focus (in environmental issues)	Practices reflecting the company's involvement with stakeholders other than its traditional SC partners (e.g., NGOs) to pursue diverse environmental aims (Albino et al., 2012; Marshal et al., 2014).	• Collaboration with the government in initiatives/projects to reduce environmental impacts (Albino et al., 2012). • Collaboration with universities and research institutions on research to develop new technologies for more environmentally friendly products (Albino et al., 2012). • Working with industry peers to standardize requirements for suppliers and purchasing items (Azevedo et al., 2011).

			• Collaboration with NGOs on education/training (of managers, customers) in environmental issues (Dahan et al., 2010; Whitehead, 2014). • Collaboration with NGOs to pursue diverse environmental aims: to foster environmental innovations, preserve biodiversity, and protect the natural environment (Albino et al, 2012).

Table 3. Social practices

Code	Social practices	Definition	Sub-Practices
PS1	Corporate social governance	Contemplates the general social management practices of SCs that reflect the commitment and engagement of the company's management in reducing the social impacts of its operations (Pinto, 2014)	• SA 8000 certification and other social responsibility systems (adapted from Pinto, 2020) • Established a set of transparent, comprehensive, and stringent ethical codes of conduct (Mani et al., 2016) • Inter-functional cooperation for social improvements (adapted from Pinto, 2020. • Detailed hazard identification and risk assessment exercise is carried out (Mani et al., 2015) • Collecting data on social aspects (adapted from Okongwu et al., 2013) • Reporting is performed on a regular basis and considers internal and external social issues (adapted from Okongwu et al., 2013) • Commitment to social SCM from senior and mid-level managers (adapted from Zhu et al, 2007, Zhu et al., 2008; Zhu et al., 2013; Zhu et al., 2012; Masoumik et al., 2014; Jia et al., 2015),
PS2	Social purchasing	Practices that consider the social issues in purchasing decisions to minimize/reduce social impacts (Pullman et al., 2010)	• Formally consider ethical and human rights/welfare issues in purchasing decisions (Holt & Ghobadian, 2009). • Purchases from minority/women-owned business enterprise (MWBE) suppliers (Carter & Jennings, 2002). • Has a formal MWBE supplier purchase program (Carter & Jennings, 2002). • Ensures the safe, incoming movement of products to our facilities (Carter & Jennings, 2002; Mani et al., 2020) • Purchase from local suppliers (Pullman et al., 2010). • Has ethical sourcing training programs for the purchasing department (Awaysheh & Klassen, 2010). • Selection of suppliers using ethical and social criteria (adapted from Vachon & Klassen, 2006; Rao & Holt, 2005; Thun & Müller, 2010; Miemczyk & Luzinni, 2018).
PS3	Labor practices	These include practices that focus on the social responsibility of the company toward its workforce and have issues related to employment (e.g., fair compensation, contracts, diversity, equity in employment) (Pinto, 2014; Maloni & Brown, 2006; Andersen & Skjoett-Larsen, 2009; Wong et al., 2010, Husgafvel et al., 2015)	• Assign fair compensation (living wage) to all employees (Pullman et al., 2010; Baliga et al, 2020). • Ensure worker quality of life (Pullman et al., 2010). • Sign labor contracts with all employees (Zhu & Zhang, 2015). • Promote equality (e.g., all employees wear the same uniform and dine in the same canteen and are entitled to similar medical benefits) (Mani et al., 2015; Das, 2017; Baliga et al, 2020). • Ensure that there is no discrimination against any employee on the grounds of race, color, religion, caste, gender, age, marital status, disability, or nationality (Mani et al., 2015; Baliga et al, 2020; Mani et al., 2020) • Regulated overtime wage policies (e.g., employees are paid a higher wage for overtime work) (Marshall et al., 2014). • Promote diversity in the workplace, ensuring the inclusion of women and minorities (Marshall et al., 2014; Mani et al., 2015). • Firm prohibits bonded labor and child labor (Mani et al., 2015; Das, 2017; Baliga et al, 2020).
PS4	Employee health and safety	Practices that focus on the health and safety of the workforce and that aim to maintain or promote the physical, social, and mental well-being of workers and prevent occupational accidents due to working conditions (Labuschagne et al., 2005; Lozano & Huisingh, 2011; Pinto, 2014; Husgafvel et al., 2014; Marshall et al., 2015).	• Use advanced prevention and safety systems at work (Shi et al., 2012). • Increase safety measures for employees, visitors, and contractors (Mani et al., 2015). • The firm conducts periodic health checkups to improve the employees' health (Mani et al., 2015). • A structured occupational health and safety management system is in place (Zhu & Zhang, 2015; Mani et al., 2015; Baliga et al., 2020). • The company provides health care facilities for the employees (Mani et al., 2015; Baliga et al, 2020). • Detailed hazard identification and risk assessment exercise is carried out (Mani et al., 2015). • Ensure the safe, incoming movement of products to facilities (Carter & Jennings, 2002). • Safe working conditions for employees (Pullman et al., 2010). • Provide necessary safety protection equipment (Zhu & Zhang, 2015). • Focus on safety and health measures at the manufacturing stage (Mani et al., 2015).

PS5	Employee development, training, and education	Encompasses the practices related to the development, training, and education of workers and that seek to recognize, value, and strengthen the capacities and skills and the satisfaction of workers (Pinto et al., 2014; Husgafvel et al., 2014; Lozano & Huisingh, 2011; Mani et al., 2015).	• The company provides opportunities for the employees to enhance their skills and knowledge for career advancement (Mani et al., 2015) • Employees are engaged with various activities (e.g., divisional communication meetings, human resource initiatives, etc.) (Mani et al., 2015) • Systems to assess worker job satisfaction (Pullman et al., 2010; Marshall et al., 2014; Marshall et al., 2015) • Has ethical sourcing training programs for the purchasing department (Awaysheh & Klassen, 2010) • Educating and training people for skill development (Baliga et al., 2020) • Providing employees with a pension or retirement plan (Baliga et al., 2020) • Scholarships for meritorious wards of employees (Baliga et al., 2020)
PS6	Social supplier management	Encompasses practices related to controlling and evaluating suppliers' practices and performance concerning social issues (e.g., working conditions, use of child labor, compliance with human rights) (Gavronski et al., 2011; Klassen & Vereecke, 2012; Gimenez & Sierra, 2013; Marshall et al., 2014; Pinto, 2014; Sancha et al., 2016).	• Send health and safety questionnaires to suppliers to monitor their compliance (Marshall et al., 2014; Marshall et al., 2015; Croom et al., 2018; Thong & Wong, 2018) • Assess suppliers' performance through formal evaluation, using established guidelines and procedures with a social focus (Sancha et al., 2016) • Ensure that suppliers provide their employees with protective equipment in hazardous areas (Awaysheh & Klassen, 2010) • Perform audits/has audit procedures for suppliers' internal management system related to social issues (e.g., related to health and safety, appropriate labor/work conditions) (Awaysheh & Klassen, 2010; Marshall et al., 2014; Marshall et al., 2015; Sancha et al., 2016; Mani et al., 2018; Tong and Wong, 2018; Miemczyk & Luzinni, 2018; Baliga et al., 2020) • Require suppliers to report the safety of all chemicals present in a component (Klassen & Vereecke, 2012) • Ensure that suppliers do not discriminate against their workers (Awaysheh & Klassen, 2010) • Ensure that suppliers did not use child, forced or sweatshop labor (Marshall et al., 2014; Awaysheh & Klassen, 2010) • Audit suppliers and ensure non-employment of child labor and bonded labor, gender discrimination, and sexual harassment (Mani et al., 2015; Mani et al., 2016; Mani et al., 2018; Mani et al., 2020) • Ensure that suppliers comply with labor laws (Carter & Jennings, 2002) • Ensure suppliers obtain OHSAS 18001 certification or other health and safety management system certification such as SA 8000 (Klassen & Vereecke, 2012; Marshall et al., 2014; Marshall et al., 2015; Mani et al, 2015; Croom et al., 2018; Thong & Wong, 2018) • Firm requires its suppliers to ensure that second-tier suppliers are complying with regulations (Klassen & Vereecke, 2012) • Supporting and encouraging suppliers to adopt advanced technologies with regular training programs and field monitoring (Mani et al., 2015) • Design systems for work/family balance across the supply chain with critical suppliers (Marshall et al., 2014; Marshall et al., 2015; Croom et al., 2018) • Introduce employee health and safety compliance and auditing systems with critical suppliers (Marshall et al., 2014; Marshall et al., 2015) • Core suppliers are required to attend conferences (related to social issues) at which managers provide regulatory and policy updates, among other competitive matters (Klassen & Vereecke, 2012) • Develop an ethical code of conduct system with suppliers (Marshall et al., 2014; Marshall et al., 2015; Croom et al., 2018; Tong & Wong, 2018) • Have a supplier code of conduct (Kaynak & Montiel, 2009; Awaysheh & Klassen, 2010; Baliga et al., 2020) • Encourage stricter design and product safety specifications from suppliers (e.g., restricted use of hazardous materials) (Klassen & Vereecke, 2012; Mani et al., 2018) • Develop new products/processes with suppliers that provide a healthy and safe working environment for employees (Marshall et al., 2014; Marshall et al., 2015; Croom et al., 2018) • Develop new products/processes with suppliers that reduce health risks for consumers (Marshall et al., 2014; Marshall et al., 2015; Mani et al., 2015; Croom et al., 2018) • Visit suppliers' facilities to help them improve their social performance (Awaysheh & Klassen, 2010; Sancha et al., 2016) • Collaboration with suppliers to develop training, sharing technical expertise with tier 1 and tier 2 suppliers (Mani et al., 2015)

			• Help suppliers develop local suppliers and improve community conditions (Mani et al., 2018) • Monitor suppliers to ensure adherence to social expectations (Baliga et al., 2020) • Major suppliers are required to adhere to specific ethical and social standards (Miemczyk & Luzinni, 2018) • Major suppliers are involved in stakeholder dialogue and engagement in ethical or social issues (Miemczyk & Luzinni, 2018) • Encourage suppliers to participate in philanthropic activities (Mani et al., 2016)
PS7	Social customer management	Includes practices that seek to guarantee the safety and health of customers and the identification of problems that may arise with the product (e.g., safety) (Klassen and Vereecke, 2012; Pinto, 2014; Sancha et al., 2016).	• Ensure the basic safety of products for consumers, reducing health risks for them (e.g., avoid or reduce the use of hazardous materials/contaminants/nutrients) (Marshall et al., 2014; Das, 2017; Thong & Wong, 2018) • Information about the product to users (such as labelling, info about ingredients, origin, and potential dangers) to educate the user on how to properly use, consume, and dispose of the product (Baliga et al., 2020) • Assess product misuse (with potential health hazards), encouraging consumer self-reporting (Klassen & Vereecke,2012) • Engage customers in brand tracking, customer meets, and customer satisfaction feedback. (Mani et al., 2015) • Measures to improve the health and well-being of the customer (Mani et al., 2015) • Maintain a quality hotline or other medium to allow customers and end-users to contact the company if there are product issues (Baliga et al., 2020) • Enable the end-user to track the product to ensure that it is genuine (authentic) (Baliga et al., 2020)
PS8	Stakeholder focus (social issues)	Practices reflecting the company's involvement with stakeholders other than its traditional SC partners (e.g., NGOs, community) related to social issues (e.g., human rights, child labor, and bonded labor (Yang, 2013; Pinto, 2014; Marshall et al., 2015)	• Innovative partnerships (e.g., NGOs and community groups) related to projects focused on social development and local education (e.g., training local workers, providing products and services adapted to these communities) (Dahan et al., 2010, Klassen &d Vereecke, 2012; Das, 2017) • Collaboration with NGOs and community groups to train local workers (Dahan et al., 2010) • Collaboration with NGOs to support local communities by providing new products and services tailored to these communities (Dahan et al., 2010) • Collaboration with NGOs to support local communities by identifying funding sources or connecting to markets (Dahan et al., 2010) • Programs for the benefit of the larger society, such as skill training and other community development activities (Mani et al., 2015; Baliga et al., 2020; Mani et al., 2020) • Provide health care facilities to the local community (Das, 2017; Baliga et al., 2020) • Provide education facilities to the surrounding people (Das, 2017; Baliga et al., 2020) • The company makes its social sustainability data (ethical code of conduct/impact on communities) throughout the supply chain available to the public (Marshall et al., 2014; Marshall et al., 2015) • Donate to philanthropic organizations (Carter & Jennings, 2002; Baliga et al., 2020; Mani et al., 2016; Mani et al., 2020) • Volunteer at local charities (Carter & Jennings, 2002; Baliga et al., 2020; Mani et al., 2016; Mani et al., 2020)

Table 4. Economic practices

Code	Economic practices	Definition	Practices
PE1	Quality management practices (internal)	Includes the practices for directing and controlling an organization to carry out organizational improvements that can generate improved products and services, reduced costs, more satisfied customers, and better bottom-line financial performance, such as TQM/Six sigma implementation (Su et al., 2008; Sousa & Voss, 2002; Das, 2017)	• Implementing a continuous quality improvement program (Yang, 2013) • Using and maintaining available quality data and reporting (defects, complaints, satisfaction, etc. at different management levels (Wu et al., 2015) • Using statistical process control techniques to reduce process variance (Yang, 2013; Wu et al., 2015; Patyal & Koilakuntla, 2017; Green et al., 2019; Baliga et al., 2020) • Conducting preventive equipment maintenance (Yang, 2013; Filho et al., 2016; Patyal & Koilakuntla, 2017; Hussain et al., 2019; Baliga et al., 2020; Green et al., 2019) • Implementing continuous improvement programs through systematic initiatives (e.g., Kaizen, improvement teams, etc.) (Hong et al., 2014; Hussain et al., 2019) • Ensuring that shop floors are well organized and clean (Patyal & Koilakuntla, 2017) • Implementing quality management system/ISO 9000 certification (Yang, 2013; Shokri et al., 2014; Torugsa et al., 2013; Jabbour

			et al., 2014; Hussain et al., 2019; Green et al., 2019)
PE2	Lean manufacturing practices (internal)	Practices that aim to reduce waste in every form, i.e., to reduce non-value-added activities within the organization, such as the implementation of JIT (Hajmohammad et al., 2013; Das, 2017).	• Attempting to achieve economies of scale in inbound and/or outbound transportation (Das, 2017) • Following Just-in-time/Scientific inventory control technique consistently to keep inventory under control in the production environment (Hussain et al., 2019; Das, 2017) • Using a "Pull" production system. (Yang, 2013; Baliga et al., 2020) • Implementing lean production and following it consistently to minimize waste (Hussain et al., 2019; Das, 2017) • Working to lower equipment setup times in the plant (Yang, 2013; Filho et al., 2016; Baliga et al., 2020; Green et al., 2019) • Use of Kanban, containers, etc., for production control (Baliga et al., 2020)
PE3	Supplier management (Economic issues)	Practices performed by the buying firm related to controlling and evaluating suppliers' practices and performance concerning economic issues. (Adapted from Gavronski et al., 2011; Klassen & Vereecke, 2012; Gimenez & Sierra, 2013; Marshall et al. 2014; Sancha et al. 2016; Marshall et al. 2014; Pinto, 2014; Das, 2017)	• Engaging suppliers in activities such as a quality month, supplier club, quality circle competition, vendor conference, and energy and safety audits (Mani et al., 2015) • Creating collaboration centers with suppliers to develop training and share technical expertise with tier 1 and tier 2 suppliers (Mani et al., 2015) • Suppliers deliver to the plant on a Just-in-time (JIT) basis (i.e., adopt a JIT logistics system) (Hussain et al., 2019; Mani et al., 2015; Baliga et al., 2020) • Offer training for suppliers' personnel to improve quality performance (Yang, 2013) • Assess the quality standard of suppliers (e.g., through ISO 9001 certification) (Yang, 2013; Jabbour et al., 2014) • Carry out quality auditing on suppliers (Kuei et al., 2001) • Use of joint quality planning (Theodorakioglou et al., 2006) • Sharing delivery schedule for products with major suppliers (Yang, 2013) • Bringing together suppliers in the same industry to share their know-how and problems (Shi et al., 2012; Hoejmose et al., 2014) • Facilitating suppliers' implementation of quality programs/TQM/Six Sigma/TPM/TQC to build quality into the product (Das, 2017)
PE4	Customer management (Economic issues)	Includes practices performed by the buying firm related to understanding and meeting customers' needs and requirements, improving the overall satisfaction of customers, and economic performance (Pinto, 2014; Husgafvel et al., 2014; Lozano & Huisingh, 2011; Mani et al., 2015; Das, 2017).	• Maintaining frequent close contact with customers (Kaynak & Montiel, 2009; Filho et al., 2016; Hussain et al., 2016; Baliga et al., 2020; Green et al., 2019) • Conducting regular customer satisfaction surveys (Filho et al., 2016; Hussain et al., 2016) • Requesting customer feedback at the end of sales by handing out a questionnaire (Subramanian et al., 2017; Green et al., 2019) • Customers frequently visit the company's plants (Filho et al., 2016; Green et al., 2019) • Our customers give us feedback on our quality and delivery performance (Baliga et al., 2020) • Directly involve our customers in current and future product offerings (Filho et al., 2016; Baliga et al., 2020) • Collecting customer data at various touch points (Hussain et al., 2019) • Estimate customers' future needs (Das, 2017). • Quickly communicate customers' future needs to the suppliers (Das, 2017)

3. Methodology

A set of steps were followed to reach the main objective of this study, which is to propose a framework for the sustainability of SCs considering the various dimensions of sustainability by critical areas and SC's multiple partners and explore that framework using case studies of companies from the mouldmaking industry (Figure 1).

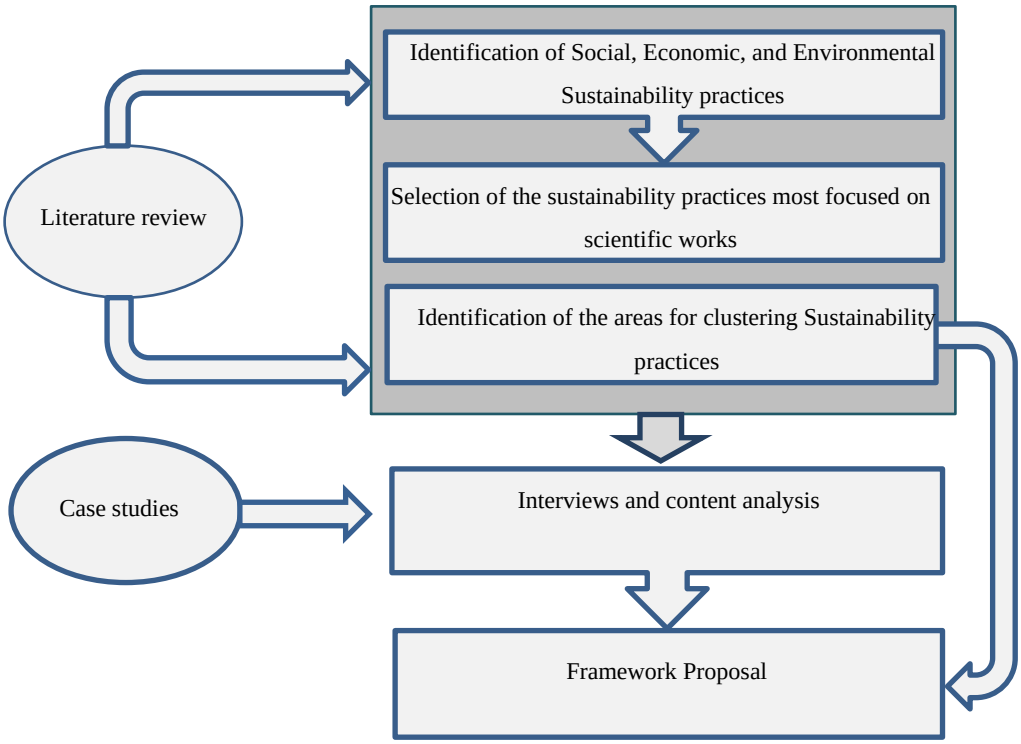


Figure 1 – Research design

As shown in Figure 1, through an extensive literature review we identified the practices most focused on in the literature associated with each sustainability dimension. Considering many practices identified, the most important ones were selected.

After identifying the sustainability practices and grouped areas, a qualitative methodology based on the case study was used (Yin, 2003). According to Ellram (1996), case studies are the best way to understand a given phenomenon, as they provide depth and rich information, allowing the researcher to understand it more thoroughly. Also, according to Yin (2003), choosing multiple cases allows the researcher to analyze the data within each situation and across different situations. This aligns with the purpose of this study, which is to collect data about the sustainability practices considered most important by companies from the mould industry to propose a framework (Gustafsson, 2017).

Additionally, compared with a single case study, the use of multiple cases is a research strategy that is more robust and reliable (Baxter & Jack, 2008; Mohajan, 2018). Studying the same problem with a multiplicity of methods and from various perspectives can be helpful not only for the study itself

but also for the validity of the analysis. According to Denzin (1978), the case study approach enhances triangulation and the internal validity of the results. Voss et al. (2002) points out that using multiple cases increases the external validity. Noor (2008, p. 1604) also points out that, "examining several organizations enhances the results' accuracy, validity, and reliability by capturing the holistic essence of the subject studied." By exploring multiple data sources such as interviews, documents, and surveys (data triangulation), this approach facilitates obtaining empirical evidence. It enables sales to better understand the phenomenon to be analyzed (Schoch, 2016).

Thus, to ensure the validity, quality, and reliability of the case study methodology, and according to the suggestion of Voss et al. (2002), the following measures were observed: i) Validity – multiple sources of evidence were used – the information was collected from primary (interviews) and secondary (documents and websites' companies analysis) sources; ii) Internal validity – the case study findings were validated by all participants in the research, ensuring their internal validity and, iii) Reliability – a case study protocol was developed based on contributions from the literature. The entire process of undertaking the case studies research is shown in Figure 2.

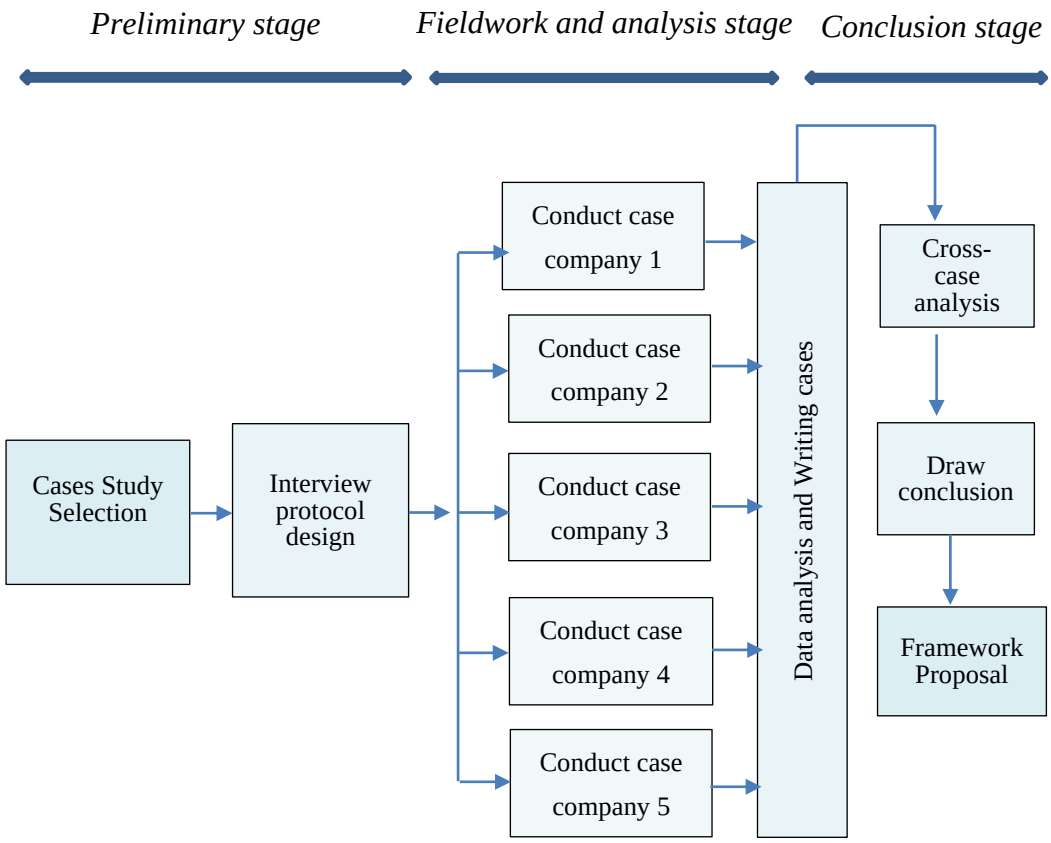


Figure 2. The process used for a framework proposal
Source: (Adapted from Schoch, 2016)

Preliminary stage

As shown in Figure 2, the first research stage was carried out after the cases were selected. In

this phase, it is necessary to define the number of cases to be analyzed. In case-study research, there is no single ideal number of cases (Voss et al., 2002). In traditional sampling methods, after identifying the population a random or stratified sample is used from that population. In case-study research different logics/criteria can be used to select cases (Voss et al., 2002). Multiple case studies often use replication logic, but a polar-type sampling approach can also select typical cases within a particular domain (Eisenhardt & Graebner, 2007; Voss et al. 2002; Eisenhardt, 1991). Considering the aim of the study, in the first phase of case selection all SMEs belonging to the TOP 100 Portuguese companies in the mould-making sector were contacted by email to participate in this research, informing them about the goal of the study and the terms pertaining to their participation. After repeated reminders to respond to the invitation and some requests for additional information from some companies, the selection process ended with five companies accepting to collaborate on the project.

In this study, the replication logic justifies using five case studies. Other studies investigating sustainability in the SC context also used this number of cases (e.g., Govindan et al., 2014; Azevedo et al., 2011). According to Leon-Bravo et al. (2017), several authors' suggestions include cases that complement each other in similar contexts (e.g., cases in the same industry and the same supply chain stage), as is the case in this study.

Companies from the mouldmaking industry have characteristics that make them suitable for proposing a framework for sustainability. Moulds are complex tools that must have high reliability and precision and are the basis of products and components in various materials such as plastic, rubber, light alloys, and glass. Thus, besides being an industry that cuts across many others, mouldmaking is a structuring industry because it is at the base of the development of a great many products (Lee et al., 2020).

The sector comprises mainly small companies: in 2016, 93.6% of the companies employed fewer than 50 people (DGAE, 2018). These companies are dedicated to designing, developing, and manufacturing moulds and specialized tools, mostly for plastic injections (CEFAMOL, 2014). Portugal is one of the world's leading manufacturers in the mould industry: in terms of exports, in 2020 it ranked in third place in Europe and eighth in the world, holding this position for several years (AICEP, 2018, CEFAMOL, 2021). It is an industry with a high installed production capacity, supported by state-of-the-art technology and skilled labor, and that ships a large part of its production to foreign markets (AICEP, 2018). In 2017 more than 80% of sales were exported to 93 countries, with the automotive industry accounting for more than 75% of the customers of these companies (DGAE, 2018). Sustainability is one of the main challenges facing this industry today (CEFAMOL, 2022). Correia et al. (2021) highlight the relevance of this sector and seek to characterize the website sustainability disclosure of the Portuguese mouldmaking industry. The authors emphasize that case studies may help to better understand how these companies approach sustainability. Table 7 summarizes the profile of the five case studies.

These companies supply large multinationals from several sectors, with companies in the automotive industry as one of their main clients (CEFAMOL, 2014; CEFAMOL, 2021). Thus, mouldmaking companies are subject to the pressures and requirements of sustainability by the various stakeholders, namely these companies, and it is expected that they endeavor to respond to their pressures and demands. However, little is known about how mouldmaking companies handle sustainability internally or in their SC, for example, which practices (considering the environmental, social, and economic dimensions of sustainability) they consider to be more important for

sustainability, and which practices they implement.

According to Pagell and Wu (2009), sustainability studies within the scope of SCM should focus on exemplary cases of focal companies that seek to be more sustainable than their competitors and that can perhaps be seen as examples of the best sustainability practices. Focal companies' initiatives are emphasized in this research because these companies have a leadership role relative to the other actors in the supply chain, as they specify supply chain policies for other members and exercise control over various decisions and activities (Cooper & Ellram, 1993; Seuring & Müller, 2008; Silvestre, 2015). In addition, focal companies establish direct contact with consumers and receive the most pressure to adopt sustainable practices and increase sustainability performance (Seuring, 2008). The focal companies are usually held accountable by consumers, NGOs, and the media for disruptions, accidents, or poor sustainability performance (Beske et al., 2015). Often companies with a leadership role relative to the other actors in the SC are also analyzed (Morais & Silvestre, 2018). However, we consider it essential to know how other companies that do not have these characteristics approach the issue of sustainability. Table 5 summarizes the profile of the five case studies.

Table 5. Profile of cases studied and respondents

Company	Activity - Products and services	Position in the SC	Size		Exports/Main clients' sectors	Respondents
			Turnover 2017 (euros)	Employees		
Company 1	Plastics injection Compression moulds Plastic injection moulds	2nd tier supplier 1st tier supplier	29,837,733	248	90% export/ Automotive Electronics/ Telecommunications Housewares	Quality and environmental manager
Company 2	Plastic injection moulds	2nd tier supplier	8,497,868	126	99% export/Automotive; Appliances; Houseware	Managing partner
Company 3	Die Casting Moulds	2nd tier supplier	7,697,479	69	100% export/Automotive; Appliances. Packaging	Responsible for Quality and maintenance
Company 4	Design and Engineering; Plastics Injection; Compression Moulds; Moulds for rubber; Die Casting Moulds; Plastic Injection Moulds; Vacuum and Blow Moulds; Rapid Tooling; Machining and Rectification	2nd tier supplier	4,315,837	73	96% export/Aeronautics; Agricultural/Irrigation; Automotive; Toys; Cosmetics; Medical devices; Electrical; Appliances; Electronics/ Telecommunications; Packaging; Office Equipment; Fittings; Houseware	Managing partner
Company 5	Plastics injection Compression moulds Plastic injection moulds	2nd tier supplier	5,565,062	68	90% export/ Automotive; Appliances; Packaging	Quality Manager

Note: The names of the companies have been omitted for confidentiality.

Before fieldwork and case analysis, the research instruments (interviewee protocol) were defined. According to Noor (2008) and Voss et al. (2002), the interview was the primary data gathering instrument for the research; however other sources of data could be used, such as personal observation, informal conversations, attendance at meetings and events, surveys administered within the organization, etc. As data-gathering instruments, a semi-structured interview was chosen in this study, whereby questions were designed to provide adequate coverage for the research. In addition, and as

suggested by Voss et al. (2002), a research protocol was developed and sent in advance to the companies containing the subjects to be covered during the interview, stating the questions to be asked and indicating the specific data required.

Data collection method

After analyzing the protocol and agreeing to participate in the study, the companies were contacted to arrange an interview with the person in charge of the sustainability area. Since none of the companies has a department or person dedicated to this area, the company chose the interviewee(s) considering their skills and functions to provide the requested data and answer the questions mentioned in the protocol. In the present study, triangulation was used regarding data sources, such as semi-structured interviews, formal documents made available by companies (e.g., Code of ethics and conduct, Guide to good safety and environmental practices, Organizational system manual), and corporate websites. To avoid bias by the interviewer, the same structured interview protocol was used at each interview session. Each interview was recorded and transcribed, and thereafter sent to the company for feedback and validation (Voss et al., 2002).

This study used a qualitative methodology based on interviews and content analysis. Data are presented in words and themes, easing the interpretation of the results (Bengtsson, 2016).

4. Analysis of Results

4.1 - Individual case study analysis

This section describes the importance level of a set of sustainability practices from the case study companies' point of view. Some excerpts from the interviews were used, and also information was gathered from the other sources of data mentioned above.

Case of Company 1

Company 1 includes in its strategic guidelines some features related to the environmental dimension (e.g., environmental pollution) and social dimension (e.g., safe and healthy working environment, support for social solidarity institutions). However, the predominant focus remains on the economic dimension, namely customer satisfaction through the guarantee of a consistent supply of products and services and product profitability.

A significant milestone in the company was implementing a management system and the company's certification by ISO 9001 standards in 1995. According to the interviewee:

> *it gives added value even for the organization, for the company's functioning.* (Interviewee E1). [Ex_1]

This was followed in 2004 by implementing and certification of the ISO 14001 environmental management system, which was a company choice and a client requirement. Implementing these management systems brought advantages through greater formalization, consistency of procedures, more excellent quality, predictability and efficiency, and an improvement in the company's image. Regarding ISO 14001, the company also highlights gains in terms of the rationalization of natural resources. In the interview, it was mentioned:

> *It is unthinkable to be in the automotive market and not have an ISO 9001 certification. We started a few years ago (...). After ISO 9001, it was ISO 14001 for internal motivation. (...) But in our clients' contractual requirements, there started to be more and more pressure to move towards ISO 14001 and even certification in hygiene and safety at work. ISO 14001 was thinking about the environmental issue and that this would be a differentiating factor. It brought benefits in terms of image and relation to competitors.* (Interviewee E1) [Ex_2].

Despite considering the growing importance of issues associated with occupational safety and health and management systems in this area, there seem to be other priorities regarding implementing occupational safety and health management systems.

The implementation of these systems implies the involvement of everyone in the organization. It requires workers' skills at a technical level and in the field of legislation, which is not always present even when there is already some experience in implementing and certification of other systems. As the interviewee states:

> *The environmental part requires technical knowledge, which we didn't have (...) nowadays there is more demand [for legislation] both in terms of the environment and health and safety at work. Regarding occupational safety and health, the legislation is already huge, and it is necessary to have great control of this area. We are looking to do this, but a system is something more complex and not urgent now.* (Interviewee E1) [Ex_3].

The company acknowledges that the experience of implementing other systems has not diminished the resistance on the part of the workers to introduce some changes. For example, about the implementation of ISO 14001, the interviewee states:

> *It was difficult at the beginning to show [workers] that sustainability issues were important. The awareness itself has improved, but we have to continue to insist, to make workers aware of these issues.* (Interviewee E1) [Ex_4].

Raising the awareness of these workers about sustainability issues implies continuous work at the level of the company's formal structure for quality, environment and occupational health, and safety management. Middle management also developed this awareness-raising role with suppliers at the environmental and social level. Those responsible areas have a vital role in the company in ensuring that environmental and social management procedures are documented, established, and monitored. They are responsible for managing and ensuring compliance with regulatory requirements in the various processes (management, implementation, support, monitoring, and measurement) involving different departments. The interviewee highlights the role of these areas of responsibility:

> (…) *also the work and persistence of the people are evolving, and one notices more improvements at an environmental and social level in many activities of the company.* (Interviewee E1) [Ex_5]

The company considers the existence of clear guidelines and principles in the environmental and social areas that guide the professional activity of all employees and their internal and external relations with all stakeholders to be very important. To this end, it defines a code of conduct.

> *we have a code of conduct where our social concerns are present.* (Interviewee E1) [Ex_6]

The company's commitment to fair business practices is expressed in this code. The document adapts the principles of the United Nations global compact covering several areas: human resources, labor, environment, anti-corruption, fair business practices, use of funds, services and assets, relationship with customers and suppliers, conflicts of interest, and confidentiality. Assuming the ISO 9001 standards as a process approach, implementing this system is considered extremely important to improve economic performance. According to the interviewee, quality is very closely linked to sustainability:

> *Sustainability is also about keeping the business going, and that means keeping a compliant product, from the perspective of the lowest possible cost, with the possible profitability, with the best possible quality.* (Interviewee E1) [Ex_7]

In addition to the extreme importance attached to ISO 9001, new technologies or techniques/initiatives such as Kaisen, to decrease the setup times, stood out, having been introduced a few years earlier. Assembly times are crucial for mouldmakers because they reduce manufacturing times and respect deadlines. Interviewee E1 highlights:

> *One of the most important deadlines in terms of the moulds is the date of the 1st test (…) customers give us tighter deadlines with ever-increasing demands. We must work, reduce downtimes and others, to be able to meet [them]*. (Interviewee E1) [Ex_8]

Also, fundamental aspects for the company to guarantee product quality and process optimization are statistical process control techniques to reduce process variance, and preventive equipment maintenance. In the case of preventive maintenance, this is ensured by a dedicated area to support production and ensure all equipment maintenance. The optimization of processes in the production area to reduce solid/liquid waste and generation of hazardous wastes and to optimize material exploitation is also extremely important and is implemented regularly. In production, the company also considers it very important to maximize the use of renewable or recycled source materials for product manufacturing. The company's main concern is to comply with the applicable legislation on waste and classify it.

> *In production, steel filings are the main metallic waste. They are recovered: we work with a licensed operator for their collection. Oils/emulsions resulting from manufacturing operations are also recovered at the end of their life cycle. In this case, we try to extend this cycle by reusing them*. (Interviewee E1) [Ex_9]

The implementation of ISO 14001 makes it possible to control and document all aspects of managing the various types of waste. But the concern with waste production and other environmental impacts starts right from the product design and purchasing stage. As far as design is concerned, it is worth noting the great importance attributed to the reduction of material and energy consumption:

> *In designing the new mould, several requirements related to natural resources and the commercial and economic side are analyzed. For example, we will not buy more because we will be paying more with a greater cost. On an environmental level, if we buy a larger block, we will have a greater impact on the consumption of natural resources and energy, as we will have to cut more wood and produce more waste. These factors are then considered when purchasing the product*. (Interviewee E1) [Ex_{10}]

The company recognizes even greater importance regarding the systematically and controlled implementation of the inclusion of environmental requirements in the supply process. In purchasing, it requires its suppliers to design specifications that include environmental requirements for purchased items. The inclusion of environmental aspects is also important in selecting suppliers. In its selection process, the company proceeds as follows:

> *The supplier is selected based on certain requirements. One is ISO 14001 certification. For those that are not certified, an analysis is made of the suppliers' environmental performance (...) we question in legal terms whether they comply with the legislation that applies to them about waste, gas emissions, etc.* (Interviewee E1) [Ex_{11}]

The company's concern with compliance is well known in environmental legislation in purchasing. Still, it is also essential to include the social dimension in this process, either by considering ethical and human rights/welfare issues formally in purchasing decisions or by including social concerns in the supplier selection process. The requirement for certifications associated with the social dimension, such as safety and health of workers or forms of collaboration to ensure safety in the use of products, is not considered very relevant:

> *Considering the type of materials supplied, there is routine care with their handling only for hazardous materials. But we still do not make major demands on suppliers in these areas [environmental or social certifications], nor do we develop partnerships in this area*. (Interviewee E1) [Ex_{12}].

Employee-related practices such as education and training and employee evaluation are considered extremely important for the company's sustainability:

> *We provide initial training when we join the company. We have several awareness-raising actions according to our needs (...) when new legislation arises, or we want to implement something new, or when we want to improve our activities. We also have training given by external entities. Almost every year we have on-the-job training (...) on management issues, among others, and for middle management, for example, in terms of health and safety, environment, first aid, etc.* (Interviewee E1) [Ex_{12}]

This training aims to keep up with technological developments for the company to remain at the cutting edge and comply with legislative requirements. Employee satisfaction is considered a fundamental factor in retaining workers who in this industry are very specialized. The company maintains a system to assess this satisfaction, adopting some workplace practices that it considers essential: fair compensation (living wage) to all employees and prohibiting bonded labor and child labor. This last practice is present in its code of conduct. The health and safety of its workers have always been a concern, and it supplies health care facilities for the employees.

In the management of its SC, the company considers it extremely important and promotes the implementation of practices involving its clients and related to the economic dimension; however, the inclusion of environmental aspects is also of high importance.

Considering the production strategy used, the permanent contact and communication with the customer (PCE1), especially in the mould design and manufacturing phases, is advantageous and has positive economic impacts. Over time the company has built up a close, trusting relationship with many of its clients, enabling it to work collaboratively on moulding projects to maintain these customers' loyalty. The company's primary concern is to offer a product that meets the customer's needs:

The most important thing, and that is why companies exist, is to satisfy a need of the market, of the customers, which is the product. (Interviewee E1) [Ex_{14}]

For the company, close contact and communication between the company and its customers exists and is extremely important to allow them to assess the company's conditions and offer that product under the desired conditions, also making it easier to obtain feedback about the company's performance in terms of quality, delivery of the product/services, and product safety. This feedback comes in various forms, through traditional media and also through audits and company visits:

In terms of audits, when clients come to audit the company in terms of quality or capacity, they pay more and more attention to safety, cleanliness of the premises and organization (…) (Interviewee E1) [Ex_{15}]

These contacts and working together make it possible to build a relationship of trust with customers and suppliers while demanding economic and environmental terms. Among the most important requirements are: assessing the quality standard of suppliers (e.g., through ISO 9001 certification) and environmental audits of suppliers, as was highlighted by the interviewee:

In the evaluation of suppliers, ISO 9001 is a desirable requirement. In the environmental part, whenever the verification of the legislation is done monthly, the supplier is sent this information, when applicable, and what we expect the supplier to comply with... and sometimes audits are made in this area. (Interviewee E1) [Ex_{16}]

The company's policies also include issues of social responsibility by contributing to the development and improvement of the conditions of the local community in which it operates:

There is support, sponsorship in sports issues, local clubs, purchase of ambulances, support for the voluntary fire brigade (...). There are also partnerships with schools and universities. The company provides machinery and equipment availability and welcomes trainees. (Interviewee E1) [Ex_{17}]

Case of Company 2

The company has sought to keep up with changes at the level of society, being responsive to the various challenges such as the current demands in terms of sustainability. Although the management recognizes the importance of the environmental and social dimensions, the most significant concern is with the economic part:

The economic part always weighs more, although without harming any of the other. (Interviewee E2) [Ex_{18}]

As the interviewee points out, the fundamental concern about the environmental and social dimensions is to comply with legislation.

We are concerned with what the law requires of us. We must bear in mind that a company and anyone who thinks like that cannot survive in the market, is meant to make a profit. (Interviewee E2) [Ex_{19}]

The company does not attribute the decision to be more proactive in terms of environmental or social sustainability to simply a lack of financial or human resources, but asserts that it is more a top management choice:

Sometimes it is a question of allocating financial resources to other investments that will bring more benefits, but it is more by the administration's decision. For now, we are not a large company that runs the risk of something getting out of control (...). We are not going to go any further because it is not worth investing in that direction. (Interviewee E2) [Ex_{20}]

Existing management structures and tools are considered capable of meeting the objectives of top management and sufficient for the company's size.

Issues [related to environmental and social sustainability] are addressed, but there are no formal, specific structures. (Interviewee E2) [Ex_{21}]

The involvement of middle managers becomes even more important in the company's activities and projects in the environmental and social areas. Top management deals with environmental issues and the human resources department in the case of employee-related problems. A department for quality management is justified by the need to manage the quality management system. Implementing the quality management system ISO 9001 and its certification in 2004, which resulted from market and competitor pressure, was essential for the company. However, there was some resistance to the introduction of changes that the certification process required:

There was the idea that anyone who was not certified could not enter certain market niches. Some customers demanded certification. The automobile industry is very demanding (...). If we did not get certified, we would never be suppliers of any car parts for the major brands. (...) At the time, certification was to satisfy the laws of competition. (Interviewee E2) [Ex_{22}]

In addition to the extreme importance attributed to ISO 9001, the company also considers the "pull" approach to its production system critical. It allows for savings in materials and, therefore, lower costs and shorter times. However, the company believes that it is not yet able to make this system work.

We have software in design, in machining and top equipment, but we don't have tools at management level, software, for example, to make this system [pull] work as it should. (Interviewee E2) [Ex_{23}]

In terms of products and processes, it is essential to avoid and reduce using hazardous materials/substances through product and process design and process optimization to reduce solid/liquid waste, and hazardous wastes, and optimize material exploitation of hazardous materials/substances. However, the company does not appear to have a high level of implementation of this type of practice:

When designing the moulds, we consider the raw materials and components used, but the technical issues of the project are the fundamental ones. Although we know that there are important aspects [environmental issues] to consider at this stage, such as the reduction of materials and the way they can then be recovered, what matters most is the hardness of the steel, the dimensions of the mould, the quality of the accessories. (Interviewee E2) [Ex_{24}]

Swarf is the main waste [from the production process], followed by oils, because of electroerosions, emissions at atmospheric level, but they are easy to solve. We also require certificates to guarantee the quality of these materials, and we pass the responsibility to the supplier. (Interviewee E2) [Ex_{25}]

The company also highlights as very important in terms of environmental impacts, the type of packaging used and how it is disposed of. However, in the company these packages are not in very significant quantities, and the company mainly seeks to comply only with what is regulated at the legislative level for the types of materials used:

> *We have a company that collects the production waste and the same for the packaging, and they do the recycling themselves. But there aren't so many packages, and there is some care whenever possible to use environmentally friendly packaging. For paper packaging, we have a company that collects it.* (Interviewee E2) [Ex$_{26}$]

About the social dimension of sustainability, the aspects related to workers' health and safety are very important, namely the existence of a structured occupational health and safety management system and ensuring safe working conditions. In this sense, the company provides these conditions but does not go beyond what is required by law:

> *At the moment, it's to comply with labor legislation... I know some companies offer certain conditions such as gyms, etc. I'm probably more in favor than against, but these issues need to be considered very carefully*. (Interviewee E2) [Ex$_{27}$]

To position itself as a privileged supplier of significant customers, namely in the automobile and household appliances industries, the focus has been on the qualification of its human resources and continuous monitoring of technological innovation. The focus of the social dimension on the workers is visible in the importance it gives to their education and training and the existence of ways of assessing their satisfaction. However, the company recognizes that in recent years it has not always been able to ensure compliance with these practices as it would have wished, mainly due to lack of time:

> *Our staff is very experienced, very specialized. We do training, when necessary, but it's not very regular... our workers are almost always motivated but when there are problems, we try to solve them in the best way possible*. (Interviewee E2) [Ex$_{28}$]

One of the aspects causing the most dissatisfaction is the difficulty in reconciling schedules with family life and wages. However, the company complies with labor legislation. It ensures Fair compensation (living wage) to all employees and the prohibition of bonded labor and child labor, considering the legislation to be of high importance and systematically implementing it in the company. Another of the strengths deemed fundamental to the company's success is its responsibility toward its customers. The company seeks to foster a culture in which everyone in the company understands the impact of their work on customer satisfaction:

> *Above all, the company is interested in working so that the client gets the product he wants and in the time he wants, but if a client walks through the company's door and the space is minimally clean and tidy, the company's door...that already sells. Everyone is important*. (Interviewee E2) [Ex $_{29}$]

Focusing on the customer, the company meets its requirements, including on an environmental and social level, for example, about the health risk of the materials that are used:

> *We are in a company where our focus is on meeting customer specifications (...). There is some flexibility in some products, but in other products, the customers even specify the materials, the components, their*

origin, and hazardousness; it has to be what the customer asks for. (…) we ensure that we provide them with enough data that they want to know that we meet their legal and environmental requirements. But this has only started to show up very recently. (Interviewee E2) [Ex_{30}]

For customers to achieve high satisfaction, co-engineering collaborations are developed between the company and the customers during the mould development. The exchange of information and close communication between company and customer is fundamental.

(…) *communication is fundamental...after the quotation, when the order comes in, a technical mould sheet is issued with the essential requirements and is complemented by the client's specifications. We start working on a preliminary draft that we must put to the client for him to validate. He also has his technicians who evaluate, give ideas, and promote changes if necessary. When it is approved, we develop a project, and if all is well, we are given the authorization to start machining*. (Interviewee E2) [Ex_{31}]

Monitoring the entire mould development process and even after its manufacture by the customer, with continuous feedback, allows for improved quality and delivery performance. The focus on the customer is considered the most important for the company, not thinking it relevant to collaborate with other stakeholders. However, sometimes some sponsorships are made. As the interviewer highlights:

(…) *what we do is sporadic. There will be few companies that do that in this industry and even in others... only if they are the big companies... it gives visibility. But in our case, our marketing, it's the clients, it's the product*. (Interviewee E2) [Ex_{32}]

Case of Company 3

Company 3 acknowledges that its sustainability concerns are minimal, and it is not an area has received much attention from management in recent years. The focus has been on quality, increased capacity, and technological innovation:

Our priority has been to invest in a certain type of moulds, to specialize and increase our production capacity, to increase the space and have more advanced machines. (Interviewee E3) [Ex_{33}]

Although it is a family business, with the integration of a new generation of managers more prepared and more conscientious about addressing these new challenges, some receptiveness to issues related to sustainability can already be noted more recently:

If there's no support from the management, and they do not understand that this [environmental and social sustainability] is important, it all falls apart. But this second generation is open. We need to evolve in this sense within the company and with our partners, with the support of those in charge and the management as a whole. (Interviewee E3) [Ex_{34}]

This receptiveness does not translate into specific sustainable policies as there is only one person in charge of the quality department who is simultaneously responsible for quality management, ensuring legal compliance with environmental issues, and for the health and safety of workers. The human resources department manages some of the problems associated with the social dimension:

In the demands are many, they involve a lot of bureaucracy and apply to administration, production, warehouses...and if there is no control by all, and only one person is responsible for everything, it is

impossible. (Interviewee E3) [Ex$_{34}$]

More than the scarcity of financial investments allocated to equipment, technologies, and other resources that the implementation of specific environmental or social practices require, it is the lack of human resources and specific skills that prevents the company from advancing further in terms of environmental and social sustainability:

> *These areas [environment and workers' safety and hygiene] are distinct areas, and with a single person in charge (...) it makes it difficult to go further (...)because we don't have more people dedicated to this or with skills in these areas, training, and knowledge*. (Interviewee E3) [Ex$_{35}$]

Other measures are identified for greater involvement of all and to show management support:

> *Just as there is a quality policy, there could be other ways to show that management is betting on these areas, such as certifications and dissemination of clear rules, which would give guidance. It would then be easier to also demand from the workers*. (Interviewee E3) [Ex$_{36}$]

In this sense, the company assumes that it would be essential to have a code of conduct aligned with some certification systems. Considering the benefits brought by certification by the ISO 9001 standard at an organizational level, the company assumes that the certification of other management systems, namely the management system by the ISO 14001 would also be very beneficial and vital and a way to provide the necessary structure for management:

> *Other certifications such as in the environment or social responsibility is an added value that the company will want to develop by itself and by the vision of the junior managers. It would help to formalize things and manage tasks better. Certification brings these advantages*. (Interviewee E3) [EX$_{38}$]

In the case of ISO 9001 certification, the company obtained this certification in 1997 to meet the requirement of the automobile industry, which represents its main customers.

> *Quality certification came about mainly because of customers (...) it helps to measure and formalize and improve processes. It is advantageous for the workers, the company, and the customers*. (Interviewee E3) [Ex$_{39}$]

The importance given to quality is also associated with implementing preventive maintenance of equipment and statistical process control techniques to reduce process variability.

> *Quality management has worked to improve the area of maintenance [with planning in this area] and the introduction of techniques to control processes*. [Ex$_{40}$]

The company has recorded improvements in preventive maintenance of equipment, but not systematically. Curative maintenance is still significant because outdated equipment causes breakdowns and problems (e.g., leaks, oil spills) with some frequency. In recent years there have been significant investments in equipment, and new technologies/techniques have been introduced, eliminating some problems in the production area:

> *The changes introduced in the production area also made it possible to eliminate machine-related problems such as breakdowns (e.g., the result of not changing filters with more frequency, use of*

unsuitable products), which resulted in costs. (Interviewee E3) [Ex41]

The investments made also allowed solving legal issues that were registered since it was not possible to eliminate some environmental problems verified in the production and provided the company with new important technologies/techniques for its competitiveness, as they have a positive impact on quality, speed, and better use of resources. For example, implementing a Just-in-time/Scientific inventory control technique and a "Pull" system is very important. This last practice is not yet implemented for the reasons mentioned:

Conditions are not met in the company for this [pull system]. Lack of tools and reorganization of activities. (Interviewee E3) [Ex42]

In terms of reducing production resources, the company has taken some measures to reduce energy costs and replace some sources with more sustainable energy sources:

We are doing a study to solve the problems due to the energy peaks we have and are considering placing solar panels in the building. (Interviewee E3) [Ex43]

The concern with legal obligations at the environmental level is also reflected in the high importance of complying with these obligations in procurement.

In the practices implemented at the level of products and processes, the company attributes more significant importance to economic and social issues instead of environmental issues. Regarding the social dimension, issues related to workers' health and safety are critical: a health and safety management system, adequate medical offices on company premises, and ensuring safe conditions in all the company's spaces. Although several efforts have been made in recent years, there is still room for improvement in this field. For example, the company provides health care facilities for the employees. Nevertheless, they should be improved.

Once a month a doctor comes to the company, which is not always enough (...) we decided to establish partnerships with a medical center in the square for medical and health and safety issues. (Interviewee E3) [Ex44]

But the company is concerned about this issue and has offered health insurance for workers and families. The company seeks to implement what is defined in the legislation about workers' safety. For example, the company provides personal protective equipment, but the workers do not always use it:

The company supplies everything: gloves, headphones, goggles. But sometimes this fails. People are warned... in case there is a more serious situation the company will call the person to account. (Interviewee E3) [Ex45]

According to the interviewee, a more structured system for health and safety management, with more people responsible for the management, is mandatory to reduce the gaps and the difficulty in implementing further measures in this area.

It is also considered very important for retaining workers to ensure fair wages and a system to evaluate their satisfaction. This system has identified some discontent among workers, mainly due to the lack of career progression perspectives:

In recent years there has been discontent among the workers, and some have left due to saturation and

did not see any prospects in terms of evolution. This is common to all areas: programming, production area. (Interviewee E3) [Ex$_{46}$]

An area that is considered very important but which the company believes needs to more investment and improved capabilities in the future is its workers' training and development. The company relies on the transmission of knowledge from more experienced people, and occasionally some training actions are carried out during the year, when possible. The interviewee refers to:

The more experienced pass on the knowledge (...) we promote specific training, but more in the areas of software. And then we have training in areas such as fire extinguishers and first aid. (Interviewee E3) [Ex$_{47}$]

The company also complies with Portuguese and European anti-discrimination legislation that prohibits discrimination against workers based on race, gender, religion, etc., and legislation prohibiting bonded labor and child labor:

We seek to comply with labor legislation, right from recruitment. Some issues don't even arise, such as child labor or racism, although we could go further in some areas, such as recruiting people with disabilities. (Interviewee E3) [Ex$_{48}$]

At the level of its SCM, the company favors customers as critical partners in improving environmental sustainability. Practices of cooperation with customers for eco-design, energy saving in the transport of products, and cleaner production are essential and implemented by the company. These practices involve not only long-standing customers who are loyal to the company but also customers with whom the company has more recent relationships:

Maybe 60% of the work comes from two or three clients. Some clients come and go. But we have managed to gain new customers (...). More and more customers are asking us for certifications of the steel, of its origin, certificates for transport and the materials used in the delivery boxes, which must be made of treated wood, and environmental requirements to be met during the production and design phase. The following are requirements for the delivery of the work to the client. (Interviewee E3) [Ex$_{49}$]

This collaboration is done by the company not only to improve its environmental performance but as a differentiation factor compared to its competitors:

They [the clients] come here to watch the tests and moulds follow-up...we must be available. They see if we meet the requirements. (Interviewee E3) [Ex$_{50}$]

This is considered an asset to the company as it allows the company to stand out from competitors:

If we want to go further and want to stand out [from competitors], we have to collaborate. (Interviewee E3) [Ex$_{51}$]

The company does not make many demands about their suppliers to improve their environmental or social performance. Although they understand the importance of the auditing procedures to the internal management system of suppliers related to social issues (such as adequate working conditions), this practice is not implemented in the company:

> *We do not ask for information or make demands about working conditions (...). We don't have the dimension for that... in this industry, most companies work with the same suppliers*. (Interviewee E3) [Ex_{52}]

Purchasing demands focus on meeting delivery deadlines and on the quality of raw materials and accessories, and no support is provided to the supplier to improve its performance. Only a few certifications are requested:

> *Actually, we only ask the suppliers for ISO 9001 certification and product certification. Technical or other support could be interesting to improve the delivery of materials, implement a JIT system, or the quality of services. (...) But it is easier to ask for certifications straight away.* (Interviewee E3) [Ex_{53}]

The importance of the company's participation in the community in which it operates and its contribution to its development is paramount. However, the company's initiatives are limited to collaboration with schools to receive trainees and others such as support to sports and recreational associations or local environmental groups/projects.

> *There is not much receptiveness to collaborating with vocational schools or other institutions. Some collaborations could be advantageous for all (...), in the future there may be more openness and conditions for this to happen*. (Interviewee E3) [Ex_{54}]

Case of Company 4

The company's strategy is to focus not only on the automotive industry but also on the medical/pharmaceutical and other industries. This is to mitigate the risks of excessive dependence and take advantage of new opportunities from new technologies and specific knowledge of those industries. To this end, the company has invested heavily in new technology and has set up a research and development center.

> *It is important to capture some technological challenges that may be brought by different customers and that are specific to certain industries (...) when there is an oscillation in the automotive industry, it is immediately noticeable, and the company does not want that (...). We are making investments to enable us to supply these industries*. (Interviewee E4) [Ex_{55}]

Top and middle management are also aware of sustainability's environmental and social dimensions, considering it extremely important that these aspects are considered within the company and in the relationship with their partners in the supply chain. To this end, it is essential to have structured and up-to-date information on environmental and social aspects, but the information is limited and dispersed. For example, regarding the information on social factors, the interviewer points out:

> *This collection and processing of information is done by the human resources department and is limited to what is legally required*. (Interviewee E4) [Ex_{56}].

There are no specific structures to deal with environmental issues in the company – not in collecting information, processing it, or managing the implemented measures. This is done by several people in different areas (e.g., production department, quality department, administrative department). The main concern is collecting and processing information for reporting to official entities.

If this information were centralized and measures managed in one place, it would be easier. This is something to be reconsidered as the demands and volume of initiatives and measures increase. (Interviewee E4) [Ex_{57}]

There are already some measures implemented in various departmental areas of the company regarding environmental issues. Still, the management priority for the next 5-6 years is not on environmental or social aspects. Although these are important, the focus is on empowering the company technologically and making it flexible. The interviewee considers that this is a way to ensure the sustainability of the company:

There is a great need for the company to equip itself with the necessary tools to become flexible, invest in technology, and be attentive to the mutations of the markets. This is part of sustainability. (Interviewee E4) [Ex_{58}]

The company's competitiveness is based on innovation using new information technologies and others. It is based on this factor that it intends to differentiate itself:

There are clients who are very demanding in terms of technology and know-how to reach certain demand levels, such as zero errors. Because of these demands, we must innovate to be a reference company. (Interviewee E4) [Ex_{59}]

The option for certification based on standard NP 4457 (Management System in Research, Development and Innovation) indicates the importance considered of this factor, which is not yet the case in the environmental area. The company understands that the certification process is fundamental to providing the structure of rules, documentation, and responsibility for good management, as was verified about quality. According to the interviewee:

The certification focuses on the rules, on the methodology, on the systematization of processes ... and it helps to sell because it demonstrates to our customers that we have our production under control, it shows that we know what we are doing and that if there is something that goes wrong we have it written down, ... we have history and, therefore, this is where the ISO 9001 certification comes in... the customers did not impose it. (Interviewee E4) [Ex_{60}]

The company also obtained the IATF 16949 certification, which includes special requirements for the automotive sector and complements the requirements of standard quality management systems. However, and recognizing the advantages brought by these certifications, the certification by ISO 14001 standards, while necessary, requires specialized human resources that the company does not yet possess:

It takes resources with other specializations, but if we must go, there is no problem. Today companies are fully aware of this [not ignoring environmental impacts]; it cannot be like 15 years ago (...). We have not yet gone to that standard because we have been a year and a half, two years with the process for certification by innovation (for injection). After all, it is essential. It is now our priority. (Interviewee E4) [Ex_{61}]

The same applies to the implementation and certification of other systems such as occupational health and safety:

It is important [health and safety management system certification], but it is not an option of the

company for the near future. (Interviewee E4) [Ex$_{62}$].

At the product and process level, the company considers integrating environmental aspects in design, production, and logistics and integrating the social dimension in purchasing to be very important. For the company, human enhancement is one of its fundamental values:

> *We all know that people are the most important assets of companies. The technology, the company acquires and pays for itself, people don't (...) that capital must be sought, must be built, and developed.* (Interviewee E4) [Ex$_{63}$]

Top and middle management also consider it very important to develop practices that show greater concern for workers and ensure that fundamental human rights are preserved, namely to ensure dignified work in which there is no exploitation or discrimination, with a good working environment with satisfied and motivated people and teams. A condition in the company is to comply with labor legislation (working hours, wages, non-discrimination, labor exploitation, and child labor):

> *Management does everything it can to make people feel motivated, give them tools (...) pays salaries above the industry average, and as required by law, complies with all issues related to overtime pay, schedules (...), we do not want differences in treatment here because of gender, or others...what matters are not these differences, but whether they are competent or not (...).* (Interviewee E4) [Ex$_{64}$]

The company bets on improving employees' skills through education/training by investing in this area. For example, the training on updating computer skills is very important for a company that started a digitalization process in 2018. This transition implies implementing new working methods with new tools. Preparing employees for the changes is essential. The company also supports increasing the education of its employees:

> *The company supports workers who want to study. Several workers have the status of student-worker and are given the necessary time to study. But, if this allows organizations to have more capable people, on the other hand, this allows them to leave for other organizations*. (Interviewee E4) [Ex$_{65}$].

A fundamental aspect of retaining workers and having motivated teams is their evaluation. Faced with a flawed evaluation system, the company established a protocol with a university to design a more suitable system. As the interviewee states:

> *How do you evaluate a person without knowing them, without knowing their work? The first step is to know and then evaluate. (...) a group of psychologists will have time with each employee to see if they can smooth out any rough edges that each one may have: some lack of commitment, and capacity (...). After this check-up, everything is analyzed and evaluated. We try to determine if that person should be doing another job and what can be improved. This systematized work is vital.* (Interviewee E4) [Ex$_{66}$]

Another critical aspect of workers is protecting their health and safety and contributing to their well-being. The company has adequate spaces where medical assistance is provided and complies with legal issues regarding workers' safety and health, such as the provision of individual protection equipment and safety signs on the factory floor and administrative spaces. But it does develop some initiatives to promote a sense of belonging and the well-being of its workers:

> *At the internal level, the legal issues of safety and health of workers are attended to, but sometimes there are gaps, and one can go further. We make lunches to foster team spirit and periodically a fishing, an*

outing (...). (Interviewee E4) [Ex67]

Lean management is considered very important in the production area alongside quality management. The implementation of quality management systems facilitated the introduction of some lean techniques and tools. The company highlights the importance of using lean manufacturing methods to optimize processes and eliminate time-related waste but considers there is still room for improvement. It expects to continue to improve in this area and to invest in tools (e.g., Kanban, JIT, Value Stream Mapping) that will make it possible to optimize processes further:

> *We already have tools like Kaisen, and we will continue to work in this area [lean management] because they allow people to be focused and help discipline, which is important to gain efficiency.* (Interviewee E4) [Ex68]

Optimizing processes is also very important for the company to reduce solid and liquid waste. The replacement of equipment with more recent equipment and investments in the facilities also allowed the company to minimize waste. The increasingly demanding legislation was also a factor that drove the company to introduce changes and improvements, not only in the production area but also in other areas of the company:

> *All the waste (from production and others) we make is separated, conditioned, taken to the correct places. Everything is treated: we report all the waste we produce, where it goes to the regulations, and the companies that pick it up are certified. In this aspect, it has improved a lot, but more can still be done* (...). (Interviewee E4) [Ex69].

Despite the investments made, they were insufficient to reduce the energy bill, nor did they focus on alternative, more renewable energy sources. This concern with energy expenditure is present at the design level:

> *The moulds are designed with the least possible amount of steel, and in such a way as to use as little energy as possible (...) there are fewer costs, but it is also good for the environment (...), but the most important factor in design and purchase is the quality of steel. We buy the steel for its quality; we don't know the material content of that steel that is recycled*. (Interviewee E4) [Ex70]

But the company has an increasing concern regarding the materials used in the manufacturing of moulds. Its clients are more demanding and want to know the origin of the steel and other materials. The quality of the steel is essential because the moulds are subject to faster production cycles. Some industries, such as the medical and food industries, use several polymers for their parts, requiring higher quality steel. One of the ways to guarantee the quality of materials to customers is to use those that are certified. Therefore, the company also makes some demands in its purchases regarding environmental and social aspects, sometimes requesting certificates in this area.

> *Now they demand many certificates: for example, for wood, heat treatments, surface treatments... everything is certified. Hazard certificates, too. Even for steel. There are cases in other countries where steel has been found to contain radioactivity from submarines... and customers are demanding.* (Interviewee E4) [Ex71].

These requests are mainly made when their clients have specific requirements, but it is generally enough to comply with the legislation. It is also essential to meet customers' demands. The company is increasingly important to manufacture moulds, steel, accessories, and other renewable

materials or recycled components. Although suppliers are evaluated annually, the most used criteria are price, delivery deadlines, and others impacting productivity. Environmental certifications are not yet required in selecting suppliers, nor are any demands made in this area.

In terms of supply chain management, the focus on customers stands out. Customers are at the center of the company's decisions, and it has sought to distinguish itself through its leadership in product quality, innovation capacity, and technical skills. The moulds are manufactured with the characteristics defined by the client, which requires proximity and involvement of the customer in the design and manufacturing phases. As it is a unique product, regular and close contact is essential for the development to meet the customer's requirements. These potential customers always make prior visits to the company to assess its capacity. Some make demands about environmental and social issues:

> *Clients ask for more information and come to see how we have things, and the company has to demonstrate that it has the conditions. They do not deliver a project without visiting the company, without knowing its capacity (…). Many of our customers are very concerned about the environment, and suppliers must be aligned with their policies… We have to demonstrate that we have the conditions in terms of organization, safety, waste, in the warehouses ... we must collaborate if we want to keep those customers. This collaboration must be in all areas: from the project, production, delivery* (...). (Interviewee E4) [Ex_{72}]

From the moment of the first contact until the delivery of the mould, there is a constant connection with the company, which allows feedback to be obtained:

> *Although not formally, we realize by the connection to the customers, if the customers are satisfied when we are doing a good job. It is good to be challenged by the customers. Knowing what we have done, we have the guarantee of a good result.* (Interviewee E4) [Ex_{73}]

After the delivery of the mould, the link to the customer is still maintained, namely when there is a need, for example, to replace or repair defective components:

> *Repairs may need to be made... in the end, the steel from the mould goes on to the steelworks, and the other components of the fittings are also recycled*. (Interviewee E4) [Ex_{74}]

The company also collaborates with local community entities such as higher education institutions, secondary and vocational schools, and sports clubs. It is part of its values to support social and corporate organizations, both regional and national. This support is done, for example, in the form of offering scholarships to higher education students and sponsoring sporting events.

Case of Company 5

Although there are some concerns about sustainability issues, namely on the part of middle and operational managers, this is still very low. The focus of top management has been mainly on ensuring economic sustainability, as the interviewee points out:

> *The main concern of the management is productivity and costs, [as this] is what makes it possible to sustain this whole structure there is not much receptivity to suggestions that some people in charge sometimes make... the strategy at the environmental level is to comply with the minimum, with what is*

regulated, and even then, it does not comply (…) 100%. (Interviewee E5) [Ex$_{75}$]

The low commitment of top management is reflected in the lack of policies or guidelines on sustainability or the provision of resources. There is also no organizational unit in the company structure dedicated to sustainability:

> *We don't have any specific structure [for sustainability]. Environmental issues are focused on the area dedicated to quality. It is the quality [department] that supports the day-to-day environmental responses*. (Interviewee E5) [Ex$_{76}$]

The human resources department deals with social issues such as training, safety, and hygiene at work, workloads, etc., which also reports the information required by official/governmental entities. The implementation of a quality management system in the company and its certification by the ISO 9001 standards in 2007 allowed the various activities in this area to be structured. The company obtained this certification to improve processes and customer satisfaction.

> *This system ... requires a lot of documentation, records, rules...if this existed in other areas like safety and hygiene, it would improve that field… If there is no system set up ... it does not force them, the people in charge, nor does it give them the strength to impose measures.* (Interviewee E5) [Ex$_{77}$]

Thus, and despite the recognized advantages that the implementation and certification of management systems such as ISO 14001 offer, it does not seem to be an objective for the near future:

> *The logic was to move forward that way [ISO 14001], but the administration has other things in mind*. (Interviewee E5) [Ex$_{78}$]

Although some practices have already been implemented in the production area allowing the company to comply with its legal obligations, improve its environmental performance, and have a positive economic impact, much more remains to be done on the environmental dimension. For example, the company has made efforts in recent years to reduce waste production and make better use of materials:

> *The majority of our moulds are subject to processes that have been reviewed to comply with the values that we are required to comply with regarding emissions, effluents (...). But these processes always result in some wastes. From the grinding of steel, for example, result in the filings that are the most important residue...before the process the steel is chosen so that there is not much waste which is also a cost for the company.* (Interviewee E5) [Ex$_{79}$]

After being collected by an authorized operator, swarf is sent to the steelworks, and other waste, such as oil from production, is also given the appropriate treatment and recovery:

> *A few years ago, the collection of oils was not even done in the production part. ... This is now done. For example, the liquids used in the erosion process and highly polluting oils are removed to an appropriate container.* (Interviewee E5) [Ex$_{80}$]

Nevertheless, there are some improvements to be made:

> *When we are in the course of the process, vapors are poured into the atmosphere. They are not highly polluting components, but those components stay in the atmosphere of the company*. (Interviewee E5) [Ex$_{81}$]

The company also seeks to use in its production, whenever possible, recycled accessories or

accessories made with recycled materials. However, this is not always possible as the clients can define the specifications of the fittings and even the brands and suppliers of the same. Also, the integration of environmental concerns in the design phase is considered an important element, either reducing material consumption or avoiding using hazardous materials/substances.

However, this integration also depends on the customer. From the moment of contact with the customer to the manufacture of the mould, the customer can define some requirements that the company will have to meet.

> *In the preliminary project, the steels and the feasibility of the part are validated...although a type of steel has already been quoted, if it turns out that this is not the most suitable, this will have to be reviewed with the customer. The same happens (…) in the design phase about accessories and other components such as screws, bushes, guides (...) some clients only work with a certain type of supplier.* (Interviewee E5) [Ex_{82}]

Valuing people is fundamental for the company, improving their satisfaction and impact on productivity. This valuing involves enhancing working conditions. Although this aspect is essential in terms of safety conditions, there are some difficulties implementing certain practices on the shop floor. For example, the interviewee points out:

> *We have safety equipment, but many are not used. The boots, yes, and the gloves, but there is other equipment like masks, goggles... the company provides it, but they don't use it...we have to be persistent.* (Interviewee E5) [Ex_{83}]

To change this situation and to make workers aware of the need to comply with specific rules, the company has carried out several training sessions on safety and the environment, but the problems persist:

> *We have another problem, ... which is that people smoke inside, in the production area. This is very difficult to combat because the bosses themselves smoke inside.* (Interviewee E5) [Ex_{84}]

Training has been used as an essential tool to change some behaviors and improve workers' skills, but in technical areas linked to production:

> *This activity is not mass production; it requires that the labor force has a lot of knowledge. The focus is on production*. (Interviewee E5) [Ex_{85}]

This training has not been done regularly, as the company recognizes it as necessary. Valuing workers also involves compliance with labor legislation, for example, paying wages and overtime and ensuring that human rights are guaranteed. About equality issues and the prohibition of child labor or exploitation of workers; the company ensures that it complies with what is defined by legislation, and about other matters related to wages and progression and participation of workers. However, this is not always the case:

> *The company has to keep in mind the compliance with the legal requirements. The quality management system obliges so. But all [workers] wanted to have higher pay and other benefits, to progress more easily, to go beyond the legislation in these aspects.* (Interviewee E5) [Ex_{86}]

According to the interviewee, the company complies with the minimum legal requirements because of the cultural and historical nature of the organization, whose concern in recent years has been on its financial recovery. Although the company does not have a system that allows an individual

evaluation of the satisfaction of each of the workers, the interviewee recognizes that a good environment at the workplace contributes to the satisfaction of its workers, for example, allowing them to reconcile work with personal and family life:

> *The company thinks that the workers must be happy to produce well. Workers must perform their duties well, but they are also given the facility to take time off or change schedules if they need to go to the doctor or be with their family*. (Interviewee E5) [Ex$_{87}$].

Considering the specificities and complexity of the mould production process, the communication between different departments such as engineering, commercial, and production is essential to find technical solutions and develop together with the customers' innovative ideas for the mould construction. Contact with customers before starting mould manufacturing is therefore necessary and continues throughout the process

> *Before the contract [the client] comes to know the company. That client, who manages several moulds, will report to his client ... where the mould is. And then, for final verification, they visit the company again*. (Interviewee E5) [Ex$_{88}$]

The relationship with the customer does not end when the mould leaves the premises:

> *There is a permanent after-sales service that accompanies our customers throughout the process and responds to their needs*. (Interviewee E5) [Ex$_{89}$]

The demand for high-quality materials, especially steel, from customers and a problem in the past with the quality of steel led the company to require in its supplier selection process a quality guarantee:

> *When we initially make the supply agreement for the critical suppliers, such as steel, we ask for quality certification; for others, we do not. Other environmental certifications [ISO 14001] are not requested for potential suppliers, even the most important ones, to be part of our suppliers. Some demands related to environmental issues are made but only to the most important ones*. (Interviewee E5) [Ex$_{90}$]

During periods of a heavy workload, the company makes subcontracts:

> *There are specialized services, for example in heat treatments, or textures, it does not compensate us for having in the company people and equipment for that treatment... if we resort to subcontracting, we must have reference to a company that is certified [by ISO 9001], and that is indicated to the client*. (Interviewee E5) [Ex$_{91}$]

The collaborative relationship with these suppliers ensures that the company develops and provides a timely response to its customers' projects. Whenever requested, the company participates in the quality improvement initiatives of these suppliers. Regarding subcontracting services, the company and not the subcontractor purchases the materials, if necessary, respecting the client's specifications to guarantee the quality of the products and control the purchasing process. In the supplier selection process, the company is very demanding, but only about some of them:

> *The only suppliers who are careful in their selection are steel suppliers and subcontractors (...); in the others, the supplier is chosen based on the friendship created with the supplier... and this is not always the ideal supplier*. (Interviewee E5) [Ex$_{92}$]

The selection criteria consider the quality of service, delivery times, and in some cases compliance with environmental legislation. Regarding the most critical suppliers, they are asked to

make a more significant contribution toward improving product quality and pay more attention to environmental problems and develop initiatives in this area:

> *For the company, it could only gain by deepening the relationship with suppliers, especially those of injection and machining services. Time was saved, and problems of deadlines and costs were solved, and on the environmental side, they facilitated our control in this area.* (Interviewee E5) [Ex_{93}]

However, the company stresses that there is little collaboration between the company and suppliers in the environmental field:

> We exchange information, and there is some environmental awareness of suppliers, for example with the delivery of leaflets, which address issues such as the transportation of materials, the packaging used, but we do not go much further. (Interviewee E5) [Ex_{94}]

Visits made by the company to suppliers are typical but do not involve environmental collaboration. About outsourced service providers, the company audits them regularly:

> *We had to go to the [contractors'] company almost every day to check that the work was being done as it should be. We don't go with the main purpose of controlling whether or not they use dangerous products in our work, or to see the safety conditions, or to check issues of that type. But customers are already starting to ask what we do about suppliers (...). In the future, this is likely to happen; it starts to be important*. (Interviewee E5) [Ex_{95}]

The company shows some concern about environmental impacts in the logistics area. For transporting the moulds, the company uses road transportation for short distances and maritime transport for more distant places. The interviewee considered it essential for the reduction of atmospheric emissions:

> *The issue of emissions is critical today. We try to group our loads, and it is necessary to consider fleets with vehicles that have fewer years of life for the transport of moulds and define routes. But it is not always possible. The costs and the clients' requirements for delivery are what dictate*. (Interviewee E5) [Ex_{96}]

Regarding packaging for accessories and other warehouse materials and transportation, recycled (e.g., paper, plastic) or recyclable packaging materials are preferred whenever possible. Although with some flaws, procedures for packaging separation have existed for some years. These packages are collected and forwarded by competent entities to a good destination. It is also common practice in the company to collaborate with social and educational entities, but only in the local community where it operates.

4.2. Cross-case analysis

This section compares how companies approach sustainability practices. With this cross-analysis it is possible to identify the specific sustainability practices (sub-practices) that are most important to the SMEs investigated (Table 6).

Table 6. Sustainability practices identified as the most important in the case studies.

Sustainability practices				
PE1- Implementing quality management system/ISO 9000 certification [Ex2] [Ex22] [Ex40]	PEN1- Obtaining ISO 14001 certification [Ex2] [Ex78]	PS1- - Established a set of transparent, comprehensive, and stringent ethical codes of conduct [Ex6]	PEN4- Maximizing the use of renewable or recycled source materials for product manufacturing [Ex9]	PEN4 - Reducing resource consumption during production [Ex10]
PEN3 - Providing design specifications to suppliers that include environmental requirements for purchased items [Ex11]	PEN3- Suppliers are selected using environmental criteria (e.g., environmental competence, performance, ISO 14001 [Ex11]	PEN3 - Compliance with environmental legislation such as external purchasing directives [Ex71]	PS6 - Ensuring suppliers obtain OHSAS 18001 certification or other health and safety management system certification such as SA 8000 [Ex12]	PS6 - Develop new product/process with suppliers that reduce health risks for consumers [Ex12]
PEN5 - Conduct regular environmental audits into suppliers' internal operations [Ex16]	PS8 - Innovative partnerships (e.g., NGOs and community groups) related to projects focused on social development and local education [Ex17]	PS8 - Donates to philanthropic organizations [Ex17]	PEN3 - Designing products/processes to avoid or reduce the use of hazardous materials/substances [Ex24]	PN7 - Environmental improvement of packaging such as using ecological materials for primary packaging [Ex26] [Ex96]
PEN2 - Designing products for reuse, recycling, and recovery of materials, components, and parts [Ex24] [Ex82]	PE4 - Our customers give us feedback on our quality and delivery performance [Ex31] [Ex49] [Ex73]	PE4 - Our customers are directly involved in current and future product offerings [Ex31] [Ex50]	PS7 - Ensuring the basic safety of our products for consumers, reducing health risks for them (e.g., avoiding or reducing the use of hazardous materials/contaminants/ nutrients [Ex30]	PS7 - Information about the product to users (such as labelling, info about ingredients, origin, and potential dangers) to educate the user on how to properly use, consume and dispose of the product [Ex30]
PS7 - Assess product misuse (with potential health hazards) encouraging consumer self-reporting [Ex30]	PE4 –We frequently are in close contact with our customers [Ex31]	PS1 - Commitment to social SCM from senior and mid-level managers [Ex34]	PEN1- Commitment to GSCM from senior and mid-level managers [Ex34]	PS2 - Suppliers are selected using criteria that include ethical and/or social dimensions [Ex12] [Ex71]
PE1 - Use statistical process control techniques to reduce process variance [Ex40] [Ex41]	PE1 - Conducts preventive equipment maintenance [Ex40]	PE2 - Use a "pull" production system [Ex42]	PE2 - Working to lower setup times in our plant [Ex8] [61]	PS4 - The company provides health care facilities for the employees [Ex44]
PS4 - Safe working conditions for employees [Ex45] [Ex83]	PS5 - Educating and training people for skill development Ex13] [Ex47] [Ex65] [Ex67]	PS3 - Firm prohibits bonded labor and child labor [Ex48] [Ex64]	PS3 - The firm ensures that there is no discrimination against any employee on the grounds of race, color, religion, caste, gender, age, marital status, disability, or nationality [Ex48 [Ex64]	PEN6 - Cooperation with customers for eco-design [Ex48] [Ex72]
PEN6 - Cooperation with customers for cleaner production [Ex49] [Ex72]	PS2 - Formally consider ethical and human rights/welfare issues in our purchasing decisions [Ex53] [Ex71]	PS6 - Perform audits/has audit procedures for suppliers' internal management system related to social issues, e.g., related to health and safety, appropriate labor/working conditions) [Ex53] [Ex95]	PE3 - We facilitate our suppliers' implementation of quality programs/TQM/Six Sigma/TPM/TQC to build quality into the product [Ex53]	PE3 - Assess the quality standard of suppliers (e.g., through ISO 9001 certification) [Ex16] [Ex53] [Ex90]
PS1 - Data on social aspects are collected [Ex56]	PS4 - A structured occupational health and safety management system is in place [Ex62]	PS5 - Systems to assess worker job satisfaction [Ex66]	PE2 - Follow the Just-in-time/Scientific inventory control technique consistently to keep inventory under control in the	PEN4- Optimization of the process to reduce solid/liquid waste and generation of hazardous wastes and optimize material exploitation [Ex69] [Ex79] [Ex80]

			production environment [Ex$_{68}$]	
PEN2 - Design of products for reduced consumption of material and energy [Ex$_{70}$]	PEN6 -Cooperation with customers for using less energy during product transportation [Ex$_{72}$]	PEN8 - Recovery of the company's end-of-life products or unwanted products and materials (for recycling, reuse, remanufacturing, repair) [E$_{74}$]	PEN5 - Cooperate with suppliers to reduce/eliminate packaging [Ex$_{94}$]	PEN5 - Joint product design with suppliers (e.g., design for reduced consumption of material/energy, design for recycling, design to avoid the use of hazardous products, etc.) [Ex$_{95}$]
PEN7 - Use of environmentally friendly transportation [Ex$_{96}$]	PEN7 - We plan the routes of our vehicles in order to reduce environmental impacts [Ex$_{96}$]	PEN1 - Environmental compliance and auditing programs in all departments [Ex$_{5}$]	PS3 - Fair compensation (living wage) for all employees [Ex$_{64}$]	

Notes:

Pi – Sustainability sub-practice *i* identified in companies associated with each of the sustainability dimensions: environmental dimension (PEN1 to PEN9), social dimension (PS1 to PS8), and an economic dimension (PE1 to PE4) (*see table 3, table 4 and table 5*)

Ex$_i$ - Example of sustainability practice identified in the interviewee extract *i*.

All companies are concerned about sustainability and consider all practices present in the table as important, although they attribute greater importance to some practices than others. Through the analysis of individual cases, we can verify that each company individually has a different perspective on the most important practices to achieve sustainability. However, some practices assume added importance for all companies. For example, the high importance of economic management aspects related to quality, lean, and customers (issues), as can be corroborated by most interviewees' statements and the other sources analyzed, seem to be shared by all the companies. These practices associated with the economic dimension deserve particular attention from all companies.

All companies also express a specific concern with the social dimension, especially in aspects related to their workforce, such as their workers' development, training, education, and other work practices (e.g., fair compensation for all employees). On the other hand, the environmental dimension seems to assume minor importance for all companies compared with the different dimensions. However, this has gained importance over time, mainly due to the growing requirements at the regulatory and legislative levels.

Specific environmental practices within the scope of eco-design (PEE2), green production (PP1), and green purchasing (PPE1) seem to be considered the most important/relevant for all companies. However, it should be noted that the importance that some companies recognize in certain practices does not always translate into their implementation. For example, the analysis of the cases shows that there are specific practices that, while being considered essential for companies, are not implemented by them. This is the case of the practice of development and training of workers (PED2), which, being important for all companies, is not implemented by company 2 (PED2); or the implementation of an occupational health and safety management system (PEH1) that is not in place at the companies or the obtaining and certification of an ISO 14000 environmental management system that only Company 1 has implemented.

Company 1 is the one that seems to be more focused on sustainability issues and has sought to implement more practices, whether at an economic, social, or environmental level and an intra- and inter-organizational level. Among the remaining companies, Company 3 has a lower number of practices implemented and/or are not yet implemented systematically and controlled in the company.

In all companies, the focus has been more on implementing practices in their products and processes (intra-organizational practices) and on practices involving their customers, especially those related to environmental and economic issues. Environmental and social practices involving interaction/collaboration with suppliers are not priorities for these companies. The implementation of practices involving other stakeholders is also done promptly by most companies, with Company 1 being the one that systematically adopts this type of practice. Differences in implementation between companies may be associated with different drivers that lead companies to set other priorities and the difficulties/barriers they encounter.

4.3. Framework for the implementation of sustainability practices in critical areas

According to Mani et al. (2015) sustainability can be considered at three levels: the internal level within the firm's operations; the inter-organizational level, where vital economic ties are found involving suppliers and customers and consumers; and the third level, which involves other external stakeholders such as community, NGO, and regulators. Based on this idea and having analyzed the sustainability practices considered in the literature review and the various instruments commonly used to support the integration of sustainability (e.g., Global Reporting Initiative (GRI) guidelines; ISO 14000 – Environmental Management System standard; ISO 26000 – Social responsibility Guidance standard) to have a complete perspective on them and as suggested by Labuschagne et al. (2005), we propose a way of grouping the sustainability practices identified (Table 8) into critical areas taking into account common features/characteristics between them.

The suggested critical areas are as follows:

- Governance – brings together the sustainability practices that reflect how the company undertakes the overall management (at the level of planning, organizing, communicating, and controlling) of sustainability-related issues (Jia et al., 2015) and that highlight the company's commitment to sustainability (Paggel & Wu, 2008; Jia et al., 2015; Silva et al., 2015);
- Product and process level – brings together intra-organizational sustainability practices at the product and process level (Marshall et al., 2015; Karaosman et al., 2017);
- Customer and Supplier management – brings together inter-organizational sustainability practices at the SC level associated with suppliers and customers (Karaosman et al., 2017);
- Stakeholder focus – brings together inter-organizational sustainability practices related to stakeholders other than customers and suppliers (NGOs, local communities, etc.) (Mathivathanan et al., 2018).

These areas are also considered essential components to assess the evolution in terms of sustainability, addressing an intracompany perspective and the SC perspective (Correia et al., 2018). Based on a systematic literature review of supply chain maturity models with sustainability concerns, Correia et al. (2017) identified several critical success factors for implementing a sustainable SC that coincide with some of these areas. It is intended that the areas proposed herein ensure that all previously identified practices are represented and distinguishable (Das, 2017).

Table 7 presents a proposed framework for implementing sustainability practices, organized by critical areas to allow both the individual companies and corresponding SCs to implement them in an easy and focused way.

Table 7. Proposed framework for the implementation of sustainability practices in critical areas.

Governance	Product and process level	Customer and Supplier management	Stakeholder focus
• **PEN1 - Corporate environmental governance:** PEG1 - Obtaining ISO 14001 certification; PEG2 - Environmental compliance and auditing programs in all departments; PEG 3- Commitment to GSCM from senior and mid-level managers ❖ **PS1 – Corporate social governance**: PGS1 - Establishing a set of transparent, comprehensive, and stringent ethical codes of conduct; PGS2 - Data on social aspects are collected; PGS3 - Commitment to social SCM from senior and mid-level managers	• **PEN2 – Ecodesign**: PEE1 - Designing products for reduced consumption of material and energy; PEE2 - Designing products/processes to avoid or minimize the use of hazardous materials/substances; PEE3 - Designing products for reuse, recycling, recovery of materials, components and parts • **PEN3 - Green purchasing**: PPE1- Suppliers are selected using environmental criteria (e.g., environmental competence, performance, ISO 14001); PPE2 - Compliance with environmental legislation such as external purchasing directives; PPE3 - Providing design specifications to suppliers that include environmental requirements for purchased items • **PEN4 - Green production**: PP1- Optimization of the process to reduce solid/liquid waste and hazardous wastes and optimize material exploitation; PPE2 - Maximizing the use of renewable or recycled source materials for product manufacturing; PPE3 - Reducing resource consumption during production • **PA7 - Green distribution and logistics:** PD1 - Plan the routes of vehicles to reduce environmental impacts; PD2 - Use environmentally friendly transportation; PD3 - Environmental improvement of packaging such as using ecological materials for primary packaging ❖ **PS2 – Social purchasing**: PSP1 - Formally consider ethical and human rights/welfare issues in purchasing decisions; PSP2 – Select suppliers using criteria that include ethical and/or social dimensions ❖ **PS3 - Labor practices**: PEL1. Fair compensation (living wage) for all employees; PEL2 - Ensure that there is no discrimination against any employee on the grounds of race, color, religion, caste, gender, age, marital status, disability, or nationality; PEL3 - Prohibit bonded labor and child labor ❖ **PS4 - Employee health and safety**: PEH1 - A structured occupational health and safety management system is in place; PEH2 - The company provides health care facilities for the employees; PEH3 - Safe working conditions for employees ❖ **PS5 - Employee development, training, and education**: PED1 - Systems to assess worker job satisfaction; PED2 - Educating and training people for skill development ☐ **PE1- Quality management practices**: PQ1 - Use statistical process control techniques to reduce process variance; PQ2 - Conduct preventive equipment maintenance; PQ3 - Implement quality management system/ISO 9000 certification ☐ **PE2 - Lean management practices**: PLM1 - Follow Just-in-time/Scientific inventory control technique consistently to keep inventory under control in the production environment; PLM2 - Use a "pull" production system; PLM3 - Work to lower setup times in our plant	• **PEN5 - Environmental supplier management practices**: PES1 - Conduct regular environmental audits into suppliers' internal operations; PES2 - Cooperate with suppliers to reduce/eliminate packaging; PES3 - Joint product design with suppliers (e.g., design for reduced consumption of material/energy, design for recycling, design to avoid the use of hazardous products, etc.) • **PEN6 – Environmental customer management practices**: PEC1 - Cooperation with customers for eco-design; PEC2 -Cooperation with customers for using less energy during product transportation; PEC3 - Cooperation with customers for cleaner production • **PEN8 - Reverse logistics**: PRL1 - Recovery of the company's end-of-life products or unwanted products and materials (for recycling, reuse, remanufacturing, repair) ❖ **PS6 – Social supplier management practices**: PSS1 - Perform audits/have audit procedures for suppliers' internal management system related to social issues, e.g., related to health and safety, appropriate labor/working conditions); PSS2 – Ensure that suppliers obtain OHSAS 18001 certification or other health and safety management system certification such as SA 8000; PSS3 – Develop new product/process with suppliers that reduce health risks for consumers ❖ **PS7 – Social customer management practices**: PSC1 - Ensure the basic safety of products for consumers, reducing health risks for them (e.g., avoiding or reducing the use of hazardous materials/contaminants/nutrients); PSC2 - Information about the product to users (such as labelling, info about ingredients, origin, potential dangers) to educate the user on how to use, consume, and dispose of the product correctly; PSC3 - Assess product misuse (with potential health hazards) encouraging consumer self-reporting ☐ **PE3 – Supplier management (economic issues)**: PEI1 - Suppliers deliver to plant on a Just-in-time (JIT) basis; PEI2 - Assess the quality standard of suppliers (e.g., through ISO 9001 certification); PEI3 – Facilitate suppliers' implementation of quality programs/TQM/Six Sigma/TPM/TQC to build quality into the product ☐ **PE4 - Customer management (economic issues)**: PCE1 – Frequent close contact with customers; PEC2 - Customers give feedback on quality and delivery performance; PEC3 – Customers are directly involved in current and future product offerings	❖ **PS8- Stakeholder focus (social issues):** PK1 – Innovative partnerships (e.g., NGOs and community groups) related to projects focused on social development and local education; PK2 – Donate to philanthropic organizations
Legend:	❖ Social practices;	• Environmental practices	☐ Economic practices

5. Discussion of Results

The results show that companies' sustainability practices associated with production and design (Ecodesign) are essential. Laosirihongthong et al. (2020) point out that design and production are core competencies in manufacturing organizations. These are both "internal" activities, which the organizations have complete or substantial control over, which may explain sustainability concerns in these areas in terms of importance. For mouldmakers, issues such as low manufacturing lead times and compliance with deadlines are fundamental to be competitive in this industry (Lee et al., 2020). Since the moulds are intended for moulding parts with tiny tolerance margins of manufacturing imperfections and are specified and standardized, the mouldmaking companies seek systematic quality improvement to meet these products' accuracy and precision requirements. This may justify the priority that companies seem to give to implementing practices related to quality and lean management and corroborate the results of a study on disseminating information on sustainability carried out in companies in the mould industry (Correia et al., 2021). The authors conclude that companies in this sector tend to favor disseminating information related to quality, human resources, and customers. The importance and implementation of social practices described to workers observed in all companies, mainly related to employee development, training, and education, and labor practices are noteworthy. There is some scope for evolution in health and safety in some companies.

The results show that companies consider essential practices in the area of suppliers and customers considering all dimensions (economic, social, and environmental) but in terms of implementation, the enhanced practices involving SC partners are the environmental and economic areas and also some related to customers (environmental customer management and customer management – economic issues).

Small companies are especially under pressure from their customers (Walker et al., 2008). The results show the importance given to many of the intra-organizational and inter-organizational practices involving customers, which are also implemented to meet the expectations and demands of these customers to ensure their satisfaction. Similar results regarding the importance of customer satisfaction were found in a previous study on mouldmaking companies (Correia et al., 2021). These may be explained by the way and the conditions under which the companies perform their activity. The entire production process is triggered by the interaction between the customer and the company: the process starts with the customers, who define the product specifications, and only after analysis by the company and budgeting, may there be a decision to order. The steps leading up to shipping (preliminary design, approval, manufacturing, testing, homologation) involve interaction between the company and customers.

Despite being considered necessary, the adoption of environmental and social practices involving interaction/collaboration with suppliers are poorly implemented (only Company 1 and Company 5 implement some sub-practices), such as the implementation of practices related to interface areas of the company (green purchasing, social purchasing, and green distribution and

logistics) with the other partners. Here too, few companies implement specific practices in these areas, or when they do, they do so sporadically. Regarding the low priority in implementation given to practices related to the purchasing and distribution areas, Laosirihongthong et al. (2020) find similar results and point out that this may be related to the fact that these areas are not core competencies of some companies. Other authors (e.g., Azevedo et al., 2011; Zhu et al., 2007) also report a low priority regarding green purchasing. According to Zhu et al. (2007) this happens because it typically requires the engagement of dominant organizations. Regarding practices involving suppliers, Azevedo et al. (2011) also observed a weak implementation of environmental collaboration with suppliers in companies of different sizes and positions belonging to the Portuguese automotive SC. According to Walker and Jones (2012) this may indicate that these companies are not well developed in implementing sustainability practices in SCM by not valuing working with suppliers.

In the area of customers and suppliers, the practice of reverse logistics also stands out as having importance but seems less so when compared to other practices and is implemented in a timely way by only two companies. In other studies (e.g., Laosirihongthong et al., 2019; Azevedo et al., 2011) this practice is pointed out as essential and with a high level of implementation. However, it is not considered relevant for mould companies, given the product and production strategy used. These aspects seem to influence the importance and type of practices adopted by companies.

The companies still consider the sustainability practices associated with governance important, but in terms of implementation, these practices are also not implemented by all companies. The company that seems to have more resources (given its size compared to the others) stands out as the one in which the practices associated with this area are more implemented. The stakeholders' focus area also reveals little implementation by the companies analyzed. SMEs are known to be quite sensitive to the demands of the local community, given their social proximity (Lähdesmäki et al., 2019). Workers and the managers/owners themselves reside and are closely attached to the local community, so it would be expected that sustainability practices related to stakeholders would be important and implemented (Lähdesmäki et al., 2019).

Understanding the reasons that lead to prioritizing or not implementing certain practices and the reasons for the different levels of implementation evidenced for each practice and different companies can help managers establish and promote more reasonable sustainability practices (Azevedo et al., 2011).

The literature suggests that motivators leading to sustainability practices originate from external and internal pressures. This study shows that the primary external pressures exerted on mouldmaking companies come mainly from regulatory agencies, government, and customers, and the internal pressures come from managers. Literature reports that the significant driver/barrier of SMEs' sustainability actions is government-associated (Prashar & Sunder M., 2020). As already pointed out, the companies analyzed recognize the power that their customers have in the SC and their influence

on the decision to implement sustainability practices. On the other hand, there are mouldmaking companies that look at how competitors behave regarding sustainability issues, configure the existence of mimetic isomorphism, adopt practices to follow their success path, and obtain legitimacy.

Mouldmaking companies' main motivations to implement sustainability practices, whether economic, environmental, or social, seem to be to reduce costs and achieve operational efficiency. These motivations can be understood based on the Resource-Based View (RBV) (Amit & Schoemaker, 1993; Barney, 1991; Grant, 1991). Mouldmaking companies acknowledge that the capabilities developed when implementing sustainability practices (in particular, economic and social practices) make them more competitive in a highly competitive international market such as the moulds market. The literature highlights that providing adequate organizational resources facilitates and encourages the adoption of sustainability practices (Oelze, 2017; Saeed & Kersten, 2019), and some studies point out that the absence of these resources and capabilities may be considered as an important barrier to sustainability in companies and their SC (Walker et al., 2008; Walker & Jones, 2012). Lack of resources seems to be the primary barrier to integrating sustainability in SMEs (Kiesnere & Baumgartner, 2019).

According to the results reached, mouldmaking companies consider that the difficulties in implementing practices are related to the nonexistence or scarcity of specific resources and capabilities, namely: i) insufficient human resources with skills and capabilities to carry out activities that involve all the dimensions of sustainability, particularly in the environmental and social areas; ii) lack of organizational structures dedicated to sustainability issues.

The involvement and motivation of workers are of great importance in the implementation of sustainability practices (Oelze, 2017; Kumar et al., 2019; Tsvetkova et al.,2020). Professional expertise and capabilities in sustainability management are realized when companies implement these practices, which encourages them to implement even more sustainability-related actions (Walker et al., 2008; Saeed& Kersten, 2019). Thus, to continue on the path of sustainability, managers should seek to develop actions to improve the capabilities and involvement of their workers. Training and education can encourage employees to update their skills, improve job performance, and reduce errors and waste (Saeed & Kersten, 2019. Previous studies suggest that training in sustainability topics is essential for environmental and social implementations in the SC (Govindan et al., 2016; Oelze et al., 2016; Alzawawi, 2014; Mohanty & Prakash, 2014).

The existence of dedicated sustainability structures can indicate the priority given to sustainability and determine the success of sustainability-related initiatives (Klettner et al., 2014). For example, Klettner et al. (2014) recommend that companies set up a board or senior management committee responsible for guiding and monitoring the development of sustainability strategy and its implementation. Other structures can be sustainability workgroups/teams or departments usually responsible for reporting on and/or preparing sustainability policies and guidelines (Okongwu et al., 2013; Klettner et al., 2014; Kurnia et al., 2014). In alignment with Walker et al. (2008), we found that

the companies examined lack structure for implementing practices that consider the various dimensions of sustainability. The size of the companies analyzed may justify the absence of and difficulty in creating this type of structure, but this may be due to the lack of top management commitment. This lack of commitment can be a significant barrier (Alzawawi, 2014). The results show that the practices implemented in the companies analyzed are highly dependent on the top management's choices and commitment to sustainability, giving overall greater importance to economic practices, followed by environmental and social ones, as verified in Laosirihongthong et al. (2019). Kot (2018) also points out that the priorities of the owner-manager have a substantial impact on how small companies face sustainability in their actions.

Epstein and Roy (2001) consider that implementing management systems provides appropriate structures/bases to guide sustainability–implementation. Oelze (2017) argues that certification is an invaluable source of organizational learning, which can guide the firm in developing and instilling the right capabilities for responsible supply chain management. The case companies investigated here acknowledge the importance of these systems. Still, the focus is on implementing and certification ISO 9001 quality management systems, and only these are requested from their suppliers. This practice contributes mainly to improved economic performance. Several studies state that ISO 14001 certified companies are more likely to adopt green practices in supply chain activities (Alzawawi, 2014), which is considered an internal enabler to SC sustainability (Walker & Jones, 2012). On the other hand, the experience derived from a certification scheme helps identify unnecessary processes (Oelze et al., 2017) and allows the development of capabilities that can be useful for implementing other management systems. This study encourages managers to think about the certification of management systems in areas related to the environmental (e.g., ISO 14001) or social dimension (e.g., ISO 45001, OHSAS 18001).

6. Conclusion

This paper proposes a framework for implementing sustainability practices that contributes to the literature. It considers a holistic perspective whereby the various dimensions of sustainability and the intra-organizational and inter-organizational practices involving the different SC partners are addressed and go through different critical areas. In the first phase, and drawing on existing studies, sustainability practices were identified. To propose a framework that can help SMEs implement sustainability practices, we chose a qualitative methodology based on multiple case studies using SME mouldmaking companies. The analysis of these cases allowed us to identify the sustainability practices considered most important. Found in the literature review and taking into account common aspects, these practices were associated with different areas: Governance, Product and Process, Customers and Suppliers management, and Stakeholder focus.

This study contributes to a deeper knowledge of sustainability in SME companies, which is an

underdeveloped area of research (Kot, 2018; Tsvetkova et al., 2020). Literature on sustainability practices in SMEs has focused on intra-organizational practices (Prashar & Sunder M., 2020). This study offers a more comprehensive approach and makes an important contribution to the future by simultaneously presenting an internal, a Supply Chain, and holistic perspectives in proposing a sustainability framework. Moreover, it constitutes support for managers seeking to respond to sustainability concerns by assisting in integrating sustainability internally and in their SCs.

Kot (2018) stresses that using SMEs as a research unit can bring new opportunities to formulate questions and new research areas on sustainability in companies and their SC. One of the main findings of this study is that organizations may not implement certain sustainability practices even though they consider them to be important and understand their benefits. This study contributes to the reflection and better understanding of the factors that influence the implementation, or not, of sustainability practices, that is, the motivators/enablers/drivers and the barriers to their implementation in small and medium-sized enterprises. According to Ashby (2014) the study of sustainability in the supply chain should consider several characteristics of SMEs, such as owner principles and resource availability. Several studies have explored the influence of SMEs and their owner/managers' characteristics on the sustainability performance (Prashar & Sunder M., 2020). The results of this study show that the practices implemented are highly dependent on the resources that the company can mobilize and, on the choices, and commitment to sustainability on the part of top management. Future research might analyze how the personal principles and values of owner/managers can influence the implementation of sustainability practices, as already suggested by Mariadoss et al. (2016).

The literature has used different theoretical frameworks to justify companies' responses to sustainability concerns. Considering the results of this study, it seems that some contributions from institutional theory and the Resource-Based View may be valuable in helping to understand the integration of sustainability in companies and their SCs, since in isolation these approaches seem unable to fully explain how companies operating in the same context differ in terms of implementation of sustainability practices. Thus, this study also contributes to reinforcing the idea that multi-faceted theoretical perspectives can help understand a phenomenon/concept as dynamic and complex as sustainability in SC (Kot, 2018).

This study has some limitations. The proposed framework for the sustainability of SCs in different areas was derived from the analysis of five case studies of the Portuguese mouldmaking industry, and the results therefore may not be universally applicable to the whole population of SMEs and/or firms in different sectors. Different sectors may have other factors (e.g., product and process characteristics or legislative requirements) influencing their sustainability behavior. The second limitation is that research was conducted on Portuguese SMEs, and research in other countries could bring new perspectives. Thus, further studies in other cultural and national realities and industrial

contexts are desirable to assess the proposed framework's suitability and the results obtained. Finally, this research was conducted using a qualitative approach, and it is believed that quantitative analysis would also contribute to testing/improving the proposed framework.

Acknowledgement
This work was funded by national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., Project UIDB/05037/2020

References

Agência para o Investimento e Comércio Externo de Portugal (AICEP) Portugal Global (2018, September). Flashmoldes, Revista Portugal Global, 1-2. Available at: rom:http://www.portugalglobal.pt/PT/Biblioteca/Paginas/Detalhe.aspx?documentId=973a35ca-aead-4ebd-a8e0-71516fb52c0f (accessed 22 April 2019)

Albino, V., Dangelico, R.M., & Pontrandolfo, P. (2012). Do inter-organizational collaborations enhance a firm's environmental performance? A study of the largest U.S. companies. *Journal of Cleaner Production, 3*, 304-315. https://doi.org/10.1016/j.jclepro.2012.07.033

Ali, H., Chen, T., & Hao, Y. (2021). Sustainable Manufacturing Practices, Competitive Capabilities, and Sustainable Performance: Moderating Role of Environmental Regulations. *Sustainability*, *13*(18), 10051. http://dx.doi.org/10.3390/su131810051

Alzawawi, M. (2014). Drivers and Obstacles for Creating Sustainable Supply Chain Management and Operations. In 2014 Zone I Student Papers Proceedings Archive; American Society for Engineering Education (ASEE): Washington, DC, USA, 1–8

Amit, R. & Schoemaker, P.J.H. (1993). Strategic assets and organizational rent. *Strategic Management Journal*, *14*(1), 33–46. Retrieved June 9, 2021, from http://www.jstor.org/stable/2486548

Ashby, A. (2014). From Principles to Practice: Sustainable Supply Chain Management in SMEs. Doctoral dissertation. Plymouth Business School, Plymouth University, UK

Awaysheh, A. & Klassen, R.D. (2010). The impact of supply chain structure on the use of supplier socially responsible practices. *International Journal of Operations & Production Management*, *30*(12), 1246 – 1268. https://doi.org/10.1108/01443571011094253

Azevedo, S.G., Carvalho, H., & Machado, V.C. (2011). The influence of green practices on supply chain performance: A case study approach. *Transportation Research Part E*, *47*, 850–871. https://doi.org/10.1016/j.tre.2011.05.017

Baliga, R., Raut, R., & Kamble, S. (2020), The effect of motivators, supply, and lean management on sustainable supply chain management practices and performance: Systematic literature review and modeling, *Benchmarking: An International Journal*, *27*(1), 347-381. https://doi.org/10.1108/BIJ-01-2019-0004

Barney, J.B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, *17*, 99-120. https://doi.org/10.1177/014920639101700108

Baxter, P. & Jack., S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, *13*(4), 544-559. https://doi.org/10.46743/2160-3715/2008.1573

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis, *Nursing Plus Open*, 2, 8–14. http://dx.doi.org/10.1016/j.npls.2016.01.001

Beske-Janssen, P., Johnson, M.P., & Schaltegger, S. (2015). 20 years of performance measurement in sustainable supply chain management–what has been achieved? *Supply chain management: An International Journal*. 20(6), 664 – 680. http://dx.doi.org/10.1108/SCM-06-2015-0216

Carter, C.R. & Jennings, M.M. (2002). Logistics social responsibility: an integrative framework. *Journal of Business Logistics*, *23*(1), 145-80. https://doi.org/10.1002/j.2158-1592.2002.tb00020.x

Carter, C.R. & Rogers, D.S. (2007). A framework of sustainable supply chain management: towards new theory. *International Journal of Physical Distribution & Logistics Management*, 38(5), 360-387. https://doi.org/10.1108/09600030810882816

CEFAMOL (2014). *Posicionamento competitivo da indústria de moldes*, Associação nacional da indústria de moldes.

CEFAMOL (2021). Portuguese moulds industry report '21. Available at: www.cefamol.pt/downloads/file278_pt.pdf (accessed 05 May 2022)

CEFAMOL (2022). Molde, 123, January 2022. Available at: https://www.cefamol.pt/index.php?id=85&idn=510 (accessed 05 May 2022)

Chardine-Baumann, E. & Botta-Genoulaz, V. (2014). A framework for sustainable performance assessment of supply chain management practices. *Computers & Industrial Engineering*, 76, 138–147. https://doi.org/10.1016/j.cie.2014.07.029

Correia, E, Azevedo, S.G., & Carvalho, H. (2018). Proposal of a framework to construct a supply chain sustainability maturity model. 5th Euroma 4-6 Kassel (2018), Germany

Correia, E., Carvalho, H., Azevedo, S.G., & Govindan, K. (2017). Maturity models in supply chain sustainability: A systematic literature review. *Sustainability*, *9*(1), 64. https://doi:10.3390/su9010064

Correia, E., Garrido, S. & Carvalho, H. (2021). Online sustainability information disclosure of mould companies, *Corporate Communications: An International Journal*, 26(3), 557-588. https://doi.org/10.1108/CCIJ-05-2020-0085

Croom, S., Vidal, N., Spetic, W., Marshall, D., & McCarthy, L. (2018). Impact of social sustainability orientation and supply chain practices on operational performance. *International Journal of Operations & Production Management*, 38(12), 2344-2366. https://doi.org/10.1108/IJOPM-03-2017-0180

Dahan, N.M.; Doh, J.P., Oetzel, J., & Yaziji, M. (2010). Corporate-NGO Collaboration: Co-creating New Business Models for Developing Markets. *Long Range Planning*, *43*(2-3), 326-342. https://doi.org/10.1016/j.lrp.2009.11.003

Das, D. (2017). Development and validation of a scale for measuring Sustainable Supply Chain Management practices and performance. *Journal of Cleaner Production*, *164*(15), 1344-1362. https://doi.org/10.1016/j.jclepro.2017.07.006

Denzin, N.K. (1978). *The Research Act: A Theoretical Introduction to Sociological Methods*, McGraw-Hill, New York, NY.

Diabat A., Khodaverdi, R., & Olfat, L. (2013) An exploration of green supply chain practices and performances in an automotive industry. *The International Journal of Advanced Manufacturing Technology*, 68, 949–961. https://doi.org/10.1007/s00170-013-4955-4

DiMaggio, P.J. & Powell, W.W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48(2): 147-160. https://doi.org/10.2307/2095101

Direção Geral das Actividades Económicas (DGAE) (2018). Indústria de moldes- sinopse 2018.

https://dgae.gov. pt › sinopse-industria-moldes_Vf_2018

Dubey, R, Gunasekaran, A, Papadopoulos, T, Childe, S.J., Shibin, K.T., & Wamba, S.F. (2017). Sustainable Supply Chain Management: Framework and Further Research Directions. *Journal of Cleaner Production*, 142(2), 20, 1119-1130, ttps://doi.org/10.1016/j.jclepro.2016.03.117.

Eisenhardt, K.M. (1991). Better Stories and Better Constructs: The Case for Rigor and Comparative Logic. *The Academy of Management Review*, *16*(3), 620-627. https://doi.org/10.2307/258921

Eisenhardt, K.M. & *Graebner*, M.E. (*2007*). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/AMJ.2007.24160888

Ellram, L.M. (1996). The use of the case study method in logistics research. *Journal of Business Logistics*, *17*(2), 93-138.

Epstein, M.J. & Roy, M.J. (2001). Sustainability in Action: Identifying and measuring the key performance drivers. *Long Range Planning*, 34, 585-604. https://doi.org/10.1016/S0024-6301(01)00084-X

Etikan, I., Musa, S.A., & Alkassim, R.S. (2016). Comparison of Convenience Sampling and Purposive Sampling, *American Journal of Theoretical and Applied Statistics. 5*(1), 1-4. Https://doi: 10.11648/j.ajtas.20160501.11

Filho, M.G., Ganga, G.M.D., & Gunasekaran, A. (2016). Lean manufacturing in Brazilian small and medium enterprises: implementation and effect on performance. *International Journal of Production Research*, 54(24), 7523-7545. https://doi.org/10.1080/00207543.2016.1201606

Gavronski, I., Klassen, R.D., Vachon, S., & Machado do Nascimiento, L.F. (2011). A resource-based view of green supply management. *Transportation Research Part E: Logistics and Transportation Review*, *47*(6), 872–885. https://doi.org/10.1016/j.tre.2011.05.018

Gimenez, C. & Sierra, V. (2013). Sustainable Supply Chains: Governance Mechanisms to Greening Suppliers. *Journal of Business Ethics,* 116, 189-203. https://doi.org/10.1007/s10551-012-1458-4

Glover, J.L., Champion, D., Daniels, K.J., & Dainty, A.J.D. (2014). An Institutional Theory perspective on sustainable practices across the dairy supply chain. *International Journal of Production Economics*, 152, 102–111. https://doi.org/10.1016/j.ijpe.2013.12.027

Gold, S., Seuring, S., & Beske, P. (2010). Sustainable supply chain management and inter-organizational resources: a literature review. *Corporate Social Responsibility and Environmental Management*, 17(4), 230–245. https://doi.org/10.1002/csr.207

Gopal, P.R.C. & Thakkar, J. (2016) Sustainable supply chain practices: an empirical investigation on Indian automobile industry. *Production Planning & Control*, 27(1), 49-64, https://doi.org /10.1080/09537287.2015.1060368.

Govindan, K., Azevedo, S. G., Carvalho, H., & Cruz-Machado, V. (2014). Impact of supply chain management practices on sustainability. *Journal of Cleaner Production*, 85, 212-225. https://doi.org/10.1016/j.jclepro.2014.05.068

Govindan, K., Muduli, K., Devika, K., & Barve, A. (2016). Investigation of the influential strength of factors on adoption of green supply chain management practices: An Indian mining scenario. *Resources, Conservation and Recycling*, 107, 185–194. http://dx.doi.org/10.1016/j.resconrec.2015.05.022

Grant, R.M. (1991). The Resource-based Theory of Competitive Advantage: Implications for Strategy Formulation. *California Management Review,* 33 (3): 114–135. https://doi.org/10.2307/41166664

Green, K.W., Inman, R.A., Sower, V.E., & Zelbst, P.J. (2019), Impact of JIT, TQM and green supply chain practices on environmental sustainability, *Journal of Manufacturing Technology Management*, 30(1), 26-47. https://doi.org/10.1108/JMTM-01-2018-0015

Green Jr., K. W., Zelbst, P. J., Bhadauria, V. S., & Meacham, J. (2012). Do environmental collaboration and monitoring enhance organizational performance?. *Industrial Management & Data Systems*, 112(2). 186 – 205. https://doi.org/10.1108/02635571211204254

Grekova, K., Calantone, R.J., Bremmers, H.J., Trienekens, J.H., & Omta, S.W.F. (2016). How environmental collaboration with suppliers and customers influences firm performance: evidence from Dutch food and beverage processors. *Journal of Cleaner Production*, 112 (3), 1861-1871. https://doi.org/10.1016/j.jclepro.2015.03.022

GRI (2013). G4 Sustainability Reporting Guidelines. Global Reporting Initiative, Amsterdam.

Gustafsson, J. (2017). Single Case Studies vs. Multiple Case Studies: A Comparative Study. In https://www.diva-portal.org/smash/get/diva2:1064378/FULLTEXT01.pdf

Hajmohammad, S., Vachon, S., Klassen, R.D., & Gavronski, I. (2013). Lean management and supply management: their role in green practices and performance. *Journal of Cleaner Production*, 39, 312-320. https://doi.org/10.1016/j.jclepro.2012.07.028

Hallikas, J., Lintukangas, K., & Kähkönen, A. (2020). The effects of sustainability practices on the performance of risk management and purchasing. *Journal of Cleaner Production*, 263, 121579. https://doi.org/10.1016/j.jclepro.2020.121579

Hart, S.L. (1995). A natural resource-based view of the firm. *Academy of Management Review*, *20*(4), 986-1014. https://doi.org/10.2307/258963

Hervani, A.A., Helms, M.M., & Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An International Journal*, *12*(4), 330-353. https://doi.org/10.1108/14635770510609015

Hoejmose, S.U., Grosvold, J., & Millington, A. (2014). The effect of institutional pressure on cooperative and coercive 'green' supply chain practices. *Journal of Purchasing & Supply Management*, *20*(4), 215–224. https://doi.org/10.1016/j.pursup.2014.07.002

Holt, D. & Ghobadian, A. (2009). An empirical study of green supply chain management practices amongst UK manufacturers. *Journal of Manufacturing Technology Management*, 20(7), 933 - 956. https://doi.org/10.1108/17410380910984212

Hong, J., Zhang, Y., & Ding, M. (2018). Sustainable Supply Chain Management Practices, Supply Chain Dynamic Capabilities, and Enterprise Performance. *Journal of Cleaner Production*, 172, 3508–3519. https://doi:10.1016/j.jclepro.2017.06.093.

Hong, P., Yang, M.G. (Mark), & Dobrzykowski, D.D. (2014). Strategic customer service orientation, lean manufacturing practices and performance outcomes. *Journal of Service Management*, 25(5), 699 – 723. https://doi.org/10.1108/JOSM-12-2013-0355

Hsu, C.-C., Tan, K.-C., & Zailani, S.H.M. (2016). Strategic orientations, sustainable supply chain initiatives, and reverse logistics. *International Journal of Operations & Production Management*, 36(1), 86 – 110. https://doi.org/10.1108/IJOPM-06-2014-0252

Hsu, P. F., Hu, P. J. H., Wei, C. P., & Huang, J. W. (2014). Green purchasing by MNC subsidiaries: The role of local tailoring in the presence of institutional duality. *Decision Sciences*, *45*(4), 647-682. https://doi.org/10.1111/deci.12088

Hussain, M., Al-Aomar, R., & Melhem, H. (2019). Assessment of lean-green practices on the sustainable performance of hotel supply chains. *International Journal of Contemporary Hospitality Management*, *31*(6), 2448-2467. https://doi.org/10.1108/IJCHM-05-2018-0380

Jabbour, A.B.L.S., Jabbour, C., J. C., Latan, H., Teixeira, A.A., & Oliveira, J.H.C. (2014). Quality management, environmental management maturity, green supply chain practices and green performance of Brazilian companies with ISO 14001 certification: Direct and indirect effects,

Transportation Research Part E: Logistics and Transportation Review, 67, 39–51. https://doi.org/10.1016/j.tre.2014.03.005

Jelačić, D., Pirc Barčić, A., Oblak, L., Motik, D., Grošelj, P., & Jošt, M. (2021). Sustainable production management model for small and medium enterprises in some south-central EU countries. *Sustainability*, *13*(11), 6220. https://doi.org/10.3390/su13116220

Jia, P., Diabat, A., & Mathiyazhagan, K. (2015). Analyzing the SSCM practices in the mining and mineral industry by ISM approach. *Resources Policy*, 46, 76–85. https://doi.org/10.1016/j.resourpol.2014.04.004

Kaynak, H. & Montiel, I. (2009, August). The relationship between sustainable supply chain management and sustainable performance: an integrated framework In *Academy of Management Proceedings* (Vol. 2009, No. 1, pp. 1-6). Briarcliff Manor, NY 10510: Academy of Management.

Karaosman, H., Morales-Alonso, G., & Brun, A. (2017). From a Systematic Literature Review to a Classification Framework: Sustainability Integration in Fashion Operations. *Sustainability*, 9(1), 30. https://doi.org/10.3390/su9010030

Kiesnere, A.L. & Baumgartner, R.J. (2019). Sustainability management in practice: Organizational change for sustainability in smaller large-sized companies in Austria. *Sustainability*, *11*(3), 572. http//doi:10.3390/su11030572

Kirchoff, J.F., Tate, W.L., & Mollenkopf, D.A. (2016). The impact of strategic organizational orientations on green supply chain management and firm performance. *International Journal of Physical Distribution & Logistics Management*, 46(3), 269-292. https://doi.org/10.1108/IJPDLM-03-2015-0055

Klassen, R.D. & Vereecke, A. (2012). Social Issues in Supply Chains: Capabilities Link Responsibility, Risk (Opportunity), and Performance. *International Journal of Production Economics*, *140*(1), 103–115. https://doi.org/10.1016/j.ijpe.2012.01.021

Klettner, A.; Clarke, T., & Boersma, M. (2014). The Governance of Corporate Sustainability: Empirical Insights into the Development, Leadership and Implementation of Responsible Business Strategy. *Journal of Business Ethics*, 122, 145–165, https://doi.org/10.1007/s10551-013-1750-y

Kot, S. (2018). Sustainable Supply Chain Management in Small and Medium Enterprises, *Sustainability*, 10, 1143. https://doi.org/10.3390/su10041143

Kuei, C., Madu, C.N., & Lin, C. (2001). The relationship between supply chain quality management practices and organizational performance. *International Journal of Quality & Reliability Management*, 18(8), 864 – 872. https://doi.org/10.1108/EUM0000000006031

Kumar, A., Mangla, S.K., Luthra, S., & Ishizaka, A. (2019). Evaluating the human resource related soft dimensions in green supply chain management implementation. *Production, Planning and Control*, *30*(9), 699–715. https://doi.org/10.1080/09537287.2018.1555342

Kurnia, S., Rahim, M.M., Samson, D., & Singh, P. (2014). Sustainable supply chain management capability maturity: Framework development and initial evaluation. *in Proceedings of the 22nd European Conference on Information Systems in Tel Aviv*, ECIS 2014.1-10. http://aisel.aisnet.org/ecis2014/

Labuschagne, C., Brent, A.C., & van Erck. R.P.G. (2005). Assessing the Sustainability Performances of Industries. *Journal of Cleaner Production*, *13*(4), 373–385. https://doi.org/10.1016/j.jclepro.2003.10.007.

Lähdesmäki, M., Siltaoja, M., & Spence, L.J. (2019). Stakeholder salience for small businesses: a social proximity perspective. *Journal of business etics*. 158, 373–385. https://doi.org/10.1007/s10551-017-3707-z

Laosirihongthong, T., Adebanjo, D., & Tan, K.C. (2013). Green supply chain management practices and performance. *Industrial Management & Data Systems*, 113(8), 1088 – 1109. https://doi.org/10.1108/IMDS-04-2013-0164

Laosirihongthong, T., Samaranayake, P., Nagalingam, S.V., & Adebanjo, D. (2020). Prioritization of sustainable supply chain practices with triple bottom line and organizational theories: industry and academic perspectives, Production Planning & Control, 31:14, 1207-1221, https://doi.org/10.1080/09537287.2019.1701233

Lee, S., Cho, Y., & Lee, Y.H. (2020). Injection Mold Production Sustainable Scheduling Using Deep Reinforcement Learning. *Sustainability*, 12, 8718, https://doi.org/10.3390/su12208718

Leon-Bravo, V., Caniato, F., & Moretto, A. (2018). Sustainability performance in the food supply chain: the case of the ´Balsamic Vinegar of Modena´, 5th Euroma 4-6 Kassel (2018), Germany

Liu, X., Yang, J., Qu, S., Wang, L., Shishime, T., & Bao, C. (2012). Sustainable Production: Practices and Determinant Factors of Green Supply Chain Management of Chinese Companies. *Business Strategy and the Environment*, 21, 1–16. https://doi.org/10.1002/bse.705

López-Pérez, M.E., Melero-Polo, I., Vázquez-Carrasco, R., & Cambra-Fierro, J. (2018). Sustainability and business outcomes in the context of SMEs: Comparing family firms vs. nonfamily firms. *Sustainability*, 10, 4080. https://doi.org/10.3390/su10114080

Lozano, R. & Huisingh, D. (2011). Inter-linking issues and dimensions in sustainability reporting. *Journal of Cleaner Production*, 19(2–3), 99–107. https://doi.org/10.1016/j.jclepro.2010.01.004

Luzzini, D., Brandon-Jones, E., Brandon-Jones, A., & Spina, G. (2015). From sustainability commitment to performance: The role of intra- and inter-firm collaborative capabilities in the upstream supply chain. *International Journal of Production Economics*, 165, 51–63. https://doi.org/10.1016/j.ijpe.2015.03.004

Mani, V., Agarwal, R., Gunasekaran, A., Papadopoulos, T., Dubey, R., & Childe, S.J. (2016). Social sustainability in the supply chain: construct development and measurement validation. *Ecological Indicators*. 71, 270–279. https://doi.org/10.1016/j.ecolind.2016.07.007

Mani, V., Agrawal, R., & Sharma, V. (2015). Social sustainability practices in the supply chain of Indian manufacturing industries. *International Journal of Automation and Logistics*, 1(3), 211–233. https://doi.org/10.1504/IJAL.2015.071721

Mani, V., Jabbour, C.J.C., & Mani, K.T.N. (2020). Supply chain social sustainability in small and medium manufacturing enterprises and firms' performance: Empirical evidence from an emerging Asian economy. *International Journal of Production Economics*, 227, 107656, https://doi.org/10.1016/j.ijpe.2020.107656

Mani, V., Gunasekaran, A., & Delgado, C. (2018). Supply chain social sustainability: Standard adoption practices in Portuguese manufacturing firms. *International Journal of Production Economics*, 198, 149–164. https://doi.org/10.1016/j.ijpe.2018.01.032

Mariadoss, B.J., Chi, T., Tansuhaj, P., & Pomirleanu, N. (2016). Influences of firm orientations on sustainable supply chain management. *Journal of Business Research*, *69*(9), 3406-3414. http://dx.doi.org/10.1016/j.jbusres.2016.02.003

Marshall, D., McCarthy, L., Heavey, C., & McGrath, P. (2014). Environmental and social supply chain management sustainability practices: construct development and measurement. *Production Planning & Control: The Management of Operations*, 6(8), 673-690. https://doi.org/10.1080/09537287.2014.963726

Marshall, D., McCarthy, L., McGrath, P., & Claudy, M. (2015). Going above and beyond: how sustainability culture and entrepreneurial orientation drive social sustainability supply chain practice adoption, *Supply Chain Management*, *20*(4), 434-454. https://doi.org/10.1108/SCM-08-2014-0267

Masoumik, S.M., Abdul-Rashid, S.H., Olugu, E.U., & Ghazilla, R.A.R. (2014). Sustainable Supply Chain Design: A Configurational Approach, *The Scientific World Journal*, 2014. https://doi.org/10.1155/2014/897121

Mathivathanan, D., Mathiyazhagan, K., Haq, A.N., & Kaippillil, V. (2018). Comparative study on adoption of sustainable supply chain management practices in Indian manufacturing industries, *Journal of Modelling in Management*, 14(4), 1006-1022, https://doi.org/10.1108/JM2-09-2018-0137

Meyer, J.W. & Rowan, B. (1977). Institutionalized organizations: formal structure as myth and ceremony. *American Journal of Sociology*, 83, 340-363. Retrieved June 9, 2021, from http://www.jstor.org/stable/2778293

Miemczyk, J. & Luzzini, D. (2018). Achieving triple bottom line sustainability in supply chains: The role of environmental, social and risk assessment practices. *International Journal of Operations & Production Management*, 39(2), 238-259. https://doi.org/10.1108/IJOPM-06-2017-0334

Mohajan, H.K. (2018). Qualitative Research Methodology in Social Sciences and Related Subjects. *Journal of Economic Development, Environment and People*, 7 (1), 23-48.

Mohanty, R.P. & Prakash, A. (2014). Green supply chain management practices in India: an empirical study. *Production Planning and Control*, 25(16), 1322-1337, https://doi.org/10.1080/09537287.2013.832822

Morais, D.O.C. & Silvestre, B.S. (2018). Advancing social sustainability in supply chain management: Lessons from multiple case studies in an emerging economy. *Journal of Cleaner Production*, 199(20), 222-235, https://doi.org/10.1016/j.jclepro.2018.07.097

Noor, K.B.M. (2008). Case Study: A Strategic Research Methodology. *American Journal of Applied Sciences*, *5*(11), 1602-1604

Oelze, N. (2017). Sustainable supply chain management implementation- Enablers and barriers in the textile industry. *Sustainability*, *9*(8), 1435; https://doi.org/10.3390/su9081435

Oelze, N., Hoejmose, S.U., Habisch, A., & Millington, A. (2016). Sustainable Development in Supply Chain Management: The Role of Organizational Learning for Policy Implementation. *Business Strategy and the Environment*, 25(4), 241-260, https://doi.org/10.1002/bse.1869

Okongwu, U., Morimoto, R., & Lauras, M. (2013). The maturity of supply chain sustainability disclosure from a continuous improvement perspective. *International Journal of Productivity & Performance Management*, 62(8), 827-855. https://doi.org/10.1108/IJPPM-02-2013-0032

Pagell, M. & Wu, Z. (2009). Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *Journal of Supply Chain Management*, 45(2), 37-56. https://doi.org/10.1111/j.1745-493X.2009.03162.x

Patyal, V. S. & Koilakuntla, M. (2017). The impact of quality management practices on performance: an empirical study, *Benchmarking: An International Journal*, 24(2), 511-535. https://doi.org/10.1108/BIJ-11-2015-0109

Paulraj, A. (2011). Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability. *Journal of Supply Chain Management*, 47(1), 19–37. https://doi.org/10.1111/j.1745-493X.2010.03212.x

Paulraj, A., Chen, I., & Blome, C. (2017). Motives and Performance Outcomes of Sustainable Supply Chain Management Practices: A Multi-theoretical Perspective. *Journal of Business Ethics*, 145, 239–258, https://doi.org/10.1007/s10551-015-2857-0

Pinto, LA. M.J. (2014). O Impacto das práticas sustentáveis da Cadeia de Abastecimento no desempenho da empresa [Doctoral dissertation, Universidade de Aveiro]. Repositório institucional da Universidade de Aveiro. https://ria.ua.pt/handle/10773/13283

Pinto, L. (2020). Green supply chain practices and company performance in Portuguese manufacturing sector. *Business Strategy and the Environment*, 29, 1832-1848. https://doi.org/

10.1002/bse.2471

Prashar, A. & Sunder M. (2020). A bibliometric and content analysis of sustainable development in small and medium-sized enterprises. *Journal of cleaner production*, *245*, 118665. https://doi.org/10.1016/j.jclepro.2019.118665

Preuss, L. (2005). Rhetoric and reality of corporate greening: a view from the supply chain management function. *Business Strategy and the Environment*, 14(2), 123–39. https://doi.org/10.1002/bse.435

Pullman, M.E., Maloni, M.J., & Dillard, J. (2010). Sustainability Practices in Food Supply Chains: How is Wine Different? *Journal of Wine Research*, 21(1), 35-56, https://doi.org/10.1080/09571264.2010.495853

Rao, P. & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations & Production Management*, 25(9), 898 – 916. https://doi.org/10.1108/01443570510613956

Saeed, M.A. & Kersten, W. (2019). Drivers of Sustainable Supply Chain Management: Identification and Classification. *Sustainability*, 11, 1137; https://doi.org/10.3390/su11041137

Sancha, C., Gimenez, C., & Sierra, V. (2016). Achieving a socially responsible supply chain through assessment and collaboration. *Journal of Cleaner Production*, 112, 1934-1947. https://doi.org/10.1016/j.jclepro.2015.04.137

Schoch, K.W. (2016). Case study research. In Burkholder, Gary J., Cox, K. A., Crawford, L. M. (Eds.), *The Scholar-Practitioner's Guide to Research Design, 1st Edition* (pp. 227 – 241).

Seuring M. & Müller S. (2008). Core issues in sustainable supply chain management – a Delphi study. *Business Strategy and the Environment*, 17 (8), 455-466. https://doi.org/10.1002/bse.607

Seuring, S., Brix-Asala, C., & Raja K. (2019). Analyzing Base-of-the-Pyramid Projects through Sustainable Supply Chain Management. *Journal of Cleaner Production*, 212, 1086–1097. https://doi.org/10.1016/j.jclepro.2018.12.102.

Shi, V.G., Koh, S.C.L., Baldwin, J., & Cucchiella, F. (2012). Natural resource based green supply chain management. *Supply Chain Management: An International Journal*, 17 (1), 54 – 67. https://doi.org/10.1108/13598541211212203

Shokri, A., Oglethorpe, D., & Nabhani, F. (2014). Evaluating sustainability in the UK fast food supply chain. *Journal of Manufacturing Technology Management*, 25(8), 1224 – 1244. https://doi.org/10.1108/JMTM-04-2013-0031

Silva, M.E., Fritz, M.M.C., & Nunes, B. (2015). Sustainability and Supply Chain Management: Publications in Brazil, International Association for Management of Technology (IAMOT) 2015 Conference Proceedings, 1125-1140.

Silvestre, B.S. (2015). A hard nut to crack! Implementing supply chain sustainability in an emerging economy. *Journal of Cleaner Production*, *96*, 171–181. https://doi.org/10.1016/j.jclepro.2014.01.009.

Somsuk, N. & Laosirihongthong. T. (2017). Prioritization of Applicable Drivers for Green Supply Chain Management Implementation toward Sustainability in Thailand. *International Journal of Sustainable Development & World Ecology*, 24 (2), 175–191. https://doi.org/10.1080/13504509.2016.1187210.

Tachizawa, E.M., Gimenez, C., & Sierra, V. (2015). Green supply chain management approaches: drivers and performance implications. *International Journal of Operations & Production Management*, 35(11), 1546 – 1566. https://doi.org/10.1108/IJOPM-01-2015-0023

Tate, W.L., Ellram, L.M., & Dooley, K.J. (2012). Environmental purchasing and supplier management (EPSM): Theory and practice. *Journal of Purchasing & Supply Management*, 18 (3), 173–188. https://doi.org/10.1016/j.pursup.2012.07.001

Theodorakioglou, Y., Gotzamani, K., & Tsiolvas, G. (2006). Supplier management and its relationship to buyers' quality management. *Supply Chain Management: An International Journal*, 11(2), 148 – 159. https://doi.org/10.1108/13598540610652546

Thong, K. & Wong, W. (2018). Pathways for Sustainable Supply Chain Performance—Evidence from a Developing Country, Malaysia. *Sustainability*, 10, 2781, https://doi.org/10.3390/su10082781

Thun, J. & Müller, A. (2010). An Empirical Analysis of Green Supply Chain Management in the German Automotive Industry, *Business Strategy and the Environment*, 19, 119–132. https://doi.org/10.1002/bse.642

Tirkolaee, E. B., Goli, A., Pahlevan, M., & Malekalipour Kordestanizadeh, R. (2019). A robust bi-objective multi-trip periodic capacitated arc routing problem for urban waste collection using a multi-objective invasive weed optimization. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *37*(11), 1089–1101. https://doi.org/10.1177/0734242X19865340

Torugsa, N.A., O'Donohue, W., & Hecker, R. (2013). Proactive CSR: An Empirical Analysis of the Role of its Economic, Social and Environmental Dimensions on the Association between Capabilities and Performance. *Journal of Business Ethics*, 115, 383–402. https://doi.org/10.1007/s10551-012-1405-4

Tsvetkova, D., Bengtsson, E., & Durst, S. (2020). Maintaining Sustainable Practices in SMEs: Insights from Sweden, *Sustainability*, *12*(24), 10242; https://doi.org/10.3390/su122410242

Vachon, S. & Klassen, R.D. (2006). Extending green practices across the supply chain: The impact of upstream and downstream integration. *International Journal of Operations & Production Management*, 26 (7), 795-821. https://doi.org/10.1108/01443570610672248

Vachon, S. & Klassen, R.D. (2008). Environmental management and manufacturing performance: The role of collaboration in the supply chain. *International Journal of Production Economics*, 111(2): 299-315. https://doi.org/10.1016/j.ijpe.2006.11.030

Vanalle, R.M. & Santos, L.B. (2014). Green supply chain management in Brazilian automotive sector. *Management of Environmental Quality: An International Journal*, 25(5), 523 – 541. https://doi.org/10.1108/MEQ-06-2013-0066

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operational Production Management*, 22 (2), 195-219. https://doi.org/10.1108/01443570210414329

Walker, H. & Jones, N. (2012). Sustainable supply chain management across the UK private sector. *Supply Chain Management: An International Journal*, 17(1), 15 – 28. https://doi.org/10.1108/13598541211212177

Walker, H., Sisto, L.D., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors, *Journal of Purchasing & Supply Management*, 14(1), 69–85. https://doi.org/10.1016/j.pursup.2008.01.007

Weber, O., Koellner, T., Habegger, D., Steffensen, H, and Ohnemus, P. (2008). The relation between the GRI indicators and the financial performance of firms. *Progress in Industrial Ecology – An International Journal*, 5(3), 236-254.

Whitehead, D. (2014). Chinese NGO–Firm Partnerships and CSR from an Institutional Perspective, *Journal of Current Chinese Affairs*, 43, 4, 41–74. https://doi.org/10.1177/186810261404300403

Wu, L., Subramanian, N., Abdulrahman, M.D, Liu, C, Lai, K., & Pawa, K.S. (2015). The Impact of Integrated Practices of Lean, Green, and Social Management Systems on Firm Sustainability Performance—Evidence from Chinese Fashion Auto-Parts Suppliers, *Sustainability*, *7*(5), 3838-3858. https://doi.org/10.3390/su7043838

Yang, M.G. (2013). Developing a Focal Firm Sustainable Supply Chain Framework: Drivers, Orientation, Practices and Performance Outcomes [Doctoral dissertation, University of Toledo],

Yin, R.K. (2003). *Case Study Research: Design and Methods*, Sage, London.

Zailani, S., Jeyaraman, K., Vengadasan, G., & Premkumar, R. (2012). Sustainable supply chain management (SSCM) in Malaysia: A survey. *International Journal of Production Economics*, 140(1), 330–340. https://doi.org/10.1016/j.ijpe.2012.02.008

Zhu Q. & Sarkis J. (2006). An inter-sectoral comparison of green supply chain management in China: drivers and practices. *Journal of Cleaner Production*. 14(5), 472–486. https://doi.org/10.1016/j.jclepro.2005.01.003

Zhu, Q. & Zhang, Q. (2015). Evaluating practices and drivers of corporate social responsibility: the Chinese context. *Journal of Cleaner Production*, 100, 315-324. https://doi.org/10.1016/j.jclepro.2015.03.053

Zhu, Q., Sarkis, J., & Lai, K.H. (2012). Green supply chain management innovation diffusion and its relationship to organizational improvement: An ecological modernization perspective. *Journal of Engineering and Technology Management*, 29, 168–185. https://doi.org/10.1016/j.jengtecman.2011.09.012

Zhu, Q., Sarkis, J., & Lai, K. (2007). Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production*, 15, 1041-1052. https://doi.org/10.1016/j.jclepro.2006.05.021

Zhu, Q., Sarkis, J., & Lai, K. (2013). Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices. *Journal of Purchasing & Supply Management*, *19*(2), 106–117. https://doi.org/10.1016/j.pursup.2012.12.001

Zhu, Q., Sarkis, J., & Lai, K. (2007). Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *Journal of Environmental Management*, *85*(1), 179–189. https://doi.org/10.1016/j.jenvman.2006.09.003

Zhu, Q., Sarkis, J., Lai, K., & Geng, Y. (2008). The Role of Organizational Size in the Adoption of Green Supply Chain Management Practices. *Corporate Social Responsibility, and Environmental Management*, 15(6), 322–337. https://doi.org/10.1002/csr.173

Chapter 5

Proposal of a Sustainability Maturity Model for Supply Chain

This chapter consists of the following paper:

Proposal of a Sustainability Maturity Model for Supply Chain
Correia, E., Garrido, S., Carvalho, H., & Lima, T.
International Journal of Production Economics
Undergoing peer review

Proposal of a Sustainability Maturity Model for Supply Chain

Elisabete Correia
Coimbra Business School, ISCAC, Polytechnic of Coimbra,

Susana Garrido*
Faculty of Economics, CeBER, Univ Coimbra,
Coimbra, Portugal. Email: garrido.susana@fe.uc.pt

Helena Carvalho
Departamento de Engenharia Mecânica e Industrial,
Faculdade de Ciências e Tecnologia, UNIDEMI, Universidade NOVA de Lisboa,
Lisbon, Portugal. Email: hmlc@fct.unl.pt

Tânia Lima
Faculdade de Engenharia, Universidade da Beira Interior, Covilhã, Portugal,
tmlima@ubi.pt

*Corresponding author
Declarations of interest: none.

Abstract

Motivated by several factors, sustainability has become an element of great relevance for organizations. The objective of this article is to propose a maturity model that helps individual companies and corresponding SCs to identify their level of engagement with the sustainability practices by giving information on how and which are already implemented and what is the correct path they must follow to reach a high level of commitment with the sustainability. The model considers three integrative perspectives: Intra and inter-organizational sustainability practices involving various supply chain partners; economic, social, and environmental sustainability dimensions; and critical areas for sustainability: Sustainability governance, Product and Process level, Customer and supplier management and Stakeholder focus.

The construction of the maturity model was based on a literature review and had the participation of five Portuguese mouldmaking companies for its improvement, application and validation. The model comprises five maturity levels and focuses on the four critical areas mentioned above to assess the evolution in terms of sustainability. The model can be used as a self-assessment tool to provide a diagnosis and broader understanding of how and which organizational sustainability practices are implemented in individual companies and their supply chain. The model also represents an instrument to help develop a roadmap for sustainability behaviour improvement. It is a benchmarking tool to evaluate and compare standards and best practices among organizations and supply chains.

Keywords: Maturity Model, Sustainability, Supply Chain, Intra and inter-organizational perspective, TBL dimensions, Sustainability governance, Product and Process level, Customer and supplier management, Stakeholders.

Paper type: Research paper

1. Introduction

Sustainability has become a global concern; therefore, many forward-looking organizations are revisiting their internal and supply chain operations (Carter & Easton, 2011). Several studies emphasize that integrating environmental, social, and economic objectives into corporate decisions is a crucial success factor for transformation. However, companies approach the integration of sustainability into their operations differently (Formentini & Taticchi, 2016). For example, they may integrate sustainability internally into specific functional areas or different processes (e.g., purchasing and production processes), focus only on the environmental dimension or economic dimension or else take a TBL (Tiple Bottom Line) approach; they may or may not have a supply chain management orientation integrating sustainability into their supply chain (SC) management practices. Organizations are rethinking their supply chain operations considering their supply chains' environmental and social impacts (Capaldi, 2005; Carter & Easton, 2011; Chaabane et al., 2012). This has given rise to the concept of Sustainable Supply Chain Management (SSCM), which refers to the management of material, information, and capital flow as well as cooperation among companies along the supply chain, taking into account the economic, environmental and social dimensions, based on customer and stakeholder requirements (Seuring & Müller, 2008). Formentini and Taticchi (2016) consider that to have more significant impacts on sustainability, companies must increasingly make efforts that involve more complex activities that cover various areas at the internal and SC level and the different dimensions of sustainability. However, this also means a more significant challenge for management. In addition to establishing adequate resources, defining its initiatives/actions, and determining the partners involved in its initiatives, the company must carefully plan its evolution towards sustainability.

Considering that "achieving true sustainability means integrating triple-bottom-line concerns into all aspects of the business" (Hynds et al., 2014, p. 50) and that "sustainability is not achieved by single actions, but rather is an on-going process" (Müller & Pfleger, 2014, p. 313), decision-makers must have means to analyze the current state of an organization. It appears that most of the frameworks used to support the integration of sustainability into corporate decisions do not adequately account for environmental and social issues (Schalteger & Burritt, 2014). Besides, achieving true sustainability requires a cultural change within the entire organization towards sustainability which requires the involvement of its internal and external stakeholders (Zhang et al., 2013). Only a small number of tools and frameworks within the company or the supply chain (SC) consider the triple-bottom-line (TBL), i.e., the social, economic, and environmental perspectives simultaneously. Hepper et al. (2017) highlight the importance of frameworks and models to enable organizations to identify their current state of sustainability integration into their business, determine more advanced integration levels, and follow up on these initiatives over time. Since a maturity model (MM) is a conceptual framework made up of parts that describe the development of a particular area of interest over time (Klimko, 2001) or, as Cuenca et al. (2013) state, a framework that describes a specific system over time, it is a valuable tool for analysis and evaluation when applied to SC sustainability (Correia et al., 2017). Monitoring and evaluating are fundamental to incorporating sustainability concerns into the SC, not only to common communicate the performance to internal stakeholders and the market and to achieve improvements (Taticchi et al., 2013). To Müller and Pfleger (2014), sustainability

maturity models are prominent examples of sustainability measurement systems. According to the authors, "the basic idea of (sustainability) maturity models, i.e., the concept of stages or levels of development, can be used to evaluate a company's state with regards to sustainability objectively a sensible tool to manage with sustainability capability" (Müller & Pfleger, 2014, p. 315).

Thus, including the development of maturity models in the scope of supply chain sustainability is relevant for the following reasons: it is a descriptive tool for the evaluation of strengths and weaknesses; it is an instrument to help develop a guide (roadmap) for performance improvement; and it is a comparative tool to evaluate processes/organizations and compare it with the standards and best practices of other organizations, allowing them to implement external benchmarking (Klimko, 2001; Neuhauser, 2014; Röglinger et al., 2012; Moultrie et al., 2016). Although several authors highlight the interest in MM, literature on sustainability MM, considering the individual company or even the SC, is scarce, and the MM proposed presents several limitations (Correia et al., 2017; Sari et al., 2021; Santos et al., 2020). To achieve sustainability, a holistic view is needed spanning not just the product and the manufacturing processes but also the entire SC (Jayal et al., 2010). However, in literature, most MMs address sustainability issues for specific processes or focuses on the company and do neither contain details on the sustainability aspects nor explain in depth how a company can reach and surpass the maturity levels (Correia et al., 2017). Considering these research gaps, the objective of this paper is to propose a Maturity Model with a holistic approach to sustainability to assess the level of sustainability at individual company and SC levels by considering three integrative perspectives: (1) Intra and inter-organizational sustainability practices involving various supply chain partners, (2) TBL perspective, i.e., economic, social and environmental sustainability dimensions, (3) critical areas for sustainability: Sustainability governance, Product and Process level, Customer and supplier management and Stakeholder focus.

This paper is organized as follows: Section 2 performs a literature review on sustainability MM; Section 3 describes the research methodology followed in this study; Section 4 describes the different phases followed for the development of the sustainability MM including its proposal and test; finally, some conclusions are drawn in Section 5.

2. Literature review

With the growing interest in sustainability issues (Chardine-Baumann & Botta-Genoulaz, 2014), several instruments have emerged, and others have been adapted to assist their integration into companies and SC. The institutionalisation of sustainability issues has led to the emergence of standardised management systems (e.g., ISO 14000, SA 8000), guidelines and official recommendations for environmental and social reporting (e.g., GRI guidelines), tools for the measurement of corporate sustainability (Life Cycle Assessment, sustainability balanced scorecard) (Hassini et al., 2012; Chardine-Baumann & Botta-Genoulaz, 2014; Müller & Pfleger, 2014; Siew, 2016; Meza-Ruiz et al., 2017). While some of these instruments are more focused on issues related to one of the dimensions of sustainability (e.g., SA 8000 for the social dimension and ISO 14000 for the environmental dimension), there are internationally recognised frameworks that take a holistic approach by considering the social, environmental and economic aspects of sustainability (e.g., GRI). Labuschagne et al. (2005) point out that many sustainability

assessment frameworks vary as to their purpose (reporting, monitoring, rating, management or performance assessment), are indicator-based, and, for the most part, their focus is not on the entire organization. Searcy and Elkhawas (2012) also highlight other sustainability assessment instruments companies may resort to, such as Kinder, Lydenberg, and Domini (KLD) Index, Dow Jones Sustainability Index, Ethibel Sustainability Index, Calvert Social Index. In addition to using this type of instrument created by other organizations, companies can develop their tools to measure sustainability performance (e.g., using interviews and surveys) (Searcy & Elkhawas, 2012). Many companies resort to indicators that serve as a basis for measurement systems (Searcy, 2012; Montiel & Delgado-Ceballos, 2014), with a large diversity of the indicators that can be used (Montiel & Delgado-Ceballos, 2014). Sari et al. (2019) identify through a literature review a trend of two approaches in designing sustainability assessment: criteria-based approach (assessment indicators were derived directly or indirectly from the literature review) or model-based approach (the development of a particular model was done before to the formulation of the assessment indicators).

This last approach to sustainability assessment at the company level translates into the adaptation of models based on already tested methodologies, as is the case of the Balanced Scorecard (BSC), which can extend the four perspectives that are part of the model to sustainability (Dias-Sardinha & Reijnders, 2005; Hubbard, 2009; Searcy, 2012). Some of the tools mentioned may be useful to identify, clarify and confirm the main elements to be considered in integrating sustainability at the company level and the level of its SC. For instance, Hervani et al. (2005) highlight that the use of instruments such as the BSC or the Life cycle analysis (LCA), among others, can, with adjustments and extensions, be applied in the integration of sustainability at the SC level. Naini et al. (2011) suggest a system to assess the environmental performance of the SC based on SC-based. The BSC is one of several models/frameworks designed to help and improve SC management and evaluate its performance, such as the *SCOR model, Odette EVALOG, Efficient Customer response, Oliver Class A Checklist* (Estampe et al., 2013). Some of these instruments associated with SCM, particularly the SCOR (Supply Chain Operation Reference Model), present the potential to assist in the integration of sustainability in SC (Estampe et al., 2013; Chardine-Baumann & Botta-Genoulaz, 2014). From the analysis of the previous instruments, there seems to be no instrument that simultaneously gathers the following characteristics: i) presents a comprehensive approach to sustainability that considers the three dimensions of sustainability (environmental, social, economic); ii) management-oriented, structuring the field of action, i.e., contemplates the different functional/acting areas and concrete actions to be carried out to improve sustainability; iii) considers not only the practices/initiatives/actions to be developed internally but also those involving its SC and other stakeholders.

According to Sari et al. (2021, p. 1164), "the model-based approach is more suitable than the criteria-based approach because the model not only acts as a distinguishing identifier between other models but also describes the dimensions, attributes and relationships between them". Also, Benmoussa et al. (2015) assume that a maturity-driven approach is more relevant than a performance-driven approach (in which the performance measurement is done via performance indicators). Within the model-based approach and in addition to the instruments above, MM as an assessment tool could also be an interesting approach for analysis, management and assessment of sustainability in SC (Estampe et al., 2013; Benmoussa et al., 2015).

Despite the popularity of the MM concept, as pointed out by Wendler (2012), there is not a clear definition of the term "maturity model" (Correia et al., 2017). A Maturity model can be understood as "a conceptual framework made up of parts that describe the development of a particular area of interest over time" (Pigosso et al., 2013). We have adopted this definition, also proposed by Klimko (2001), as it assumes a comprehensive perspective of MM and does not limit it to a specific area (e.g., project management, processes). Maturity models have also been widely developed in many fields of knowledge to improve organizational performance (Wendler, 2012; Oliveira & Lopes, 2019): in the area of information technology, risk management, project management, new product development, human resources management, process management, and supply chain management (SCM), among others (Wendler, 2012; Correia et al., 2017; Oliveira & Lopes, 2019). Some MMs are oriented toward the integration of sustainability in specific areas such as Design (Pigosso et al., 2013), and in the company (corporate sustainability) (Amini & Bienstock, 2014; Sari et al., 2021) and the SC (Santos et al., 2020). Since sustainability incorporates a temporal dimension as it implies a dynamic process of change (transformation) over time (Lozano, 2008), the company will benefit if it can have tools to track its progress towards sustainability efforts. MM, in particular, assume an evolutionary perspective. According to Liebetruth (2017), it constitutes a potent and flexible tool not only for SC performance measurement and management but also a tool that can easily integrate aspects of sustainability.

3. Research methodology

Different approaches to developing a MM are presented (e.g., De Bruin et al., 2005; Mettler, 2009); Becker et al., 2009). The approach of De Bruin et al. (2005) constitutes one of the most recognised approaches for developing MMs. For example, Sari et al. (2021) adopt a strategy based on this approach to propose a corporate sustainability maturity model. De Bruin et al. (2005) proposed a six-step methodology to develop MMs (Figure 1). These steps are iterative because the results of a given phase may require that a previous phase be revisited for improvement.

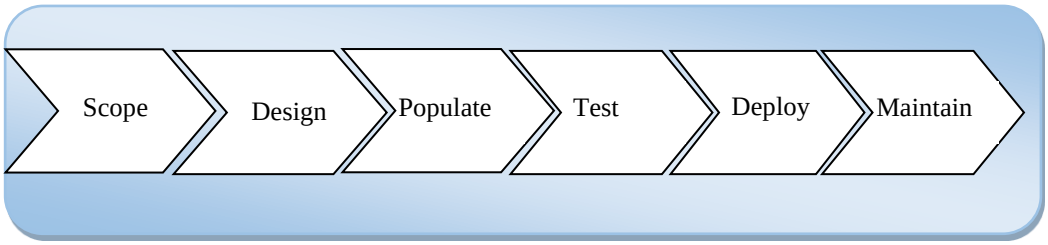


Figure 1. Model Development Phases
Source: De Bruin et al. (2005)

This study follows the methodology suggested by De Bruin et al. (2005). The objective of our study is the proposal of a MM comprising the following phases: scope definition, design, populated and test. The last two phases, i.e., deploy and maintain, are excluded from this study. Figure 2 shows the research design followed in this study.

One of the main criticisms of MM is the lack of validation in selecting the MM dimensions or variables (Lasrado et al., 2015). De Bruin et al. (2005) suggest that MMs should be validated considering the model's constructs (i.e., relevance and coverage of the domain components and subcomponents) and the model instruments' performance

(i.e., scale and assessments procedure). Pöppelbuß & Röglinger (2011) also sugest to analyse the MM usability. In this study, the improvement and validation process took place in two stages:

1) 1st stage of the validation process - the objective is to obtain contributions for the improvement and clarity of several aspects of the design and populate phases, namely: i) in the validation of the areas, practices and sub-practices; ii) in the allocation of sub-practices to the evolution levels and maturity levels defined based on the literature review; and, iii) in the assessment process for determining the maturity level of the areas and the company. This stage is described in detail in subsection 4.4;
2) 2nd stage of the validation process - the objective is to test the MM resulting from the previous phases (final MM) and validate it based not only on its content (i.e., areas, practices and respective sub-practices) but as well as maturity levels. Also, the MM usability (i.e., understandability, ease of use and practicality) is analysed, as suggested by Salah et al. (2014) and Pöppelbuß & Röglinger (2011). This stage is described in detail in subsection 4.6.

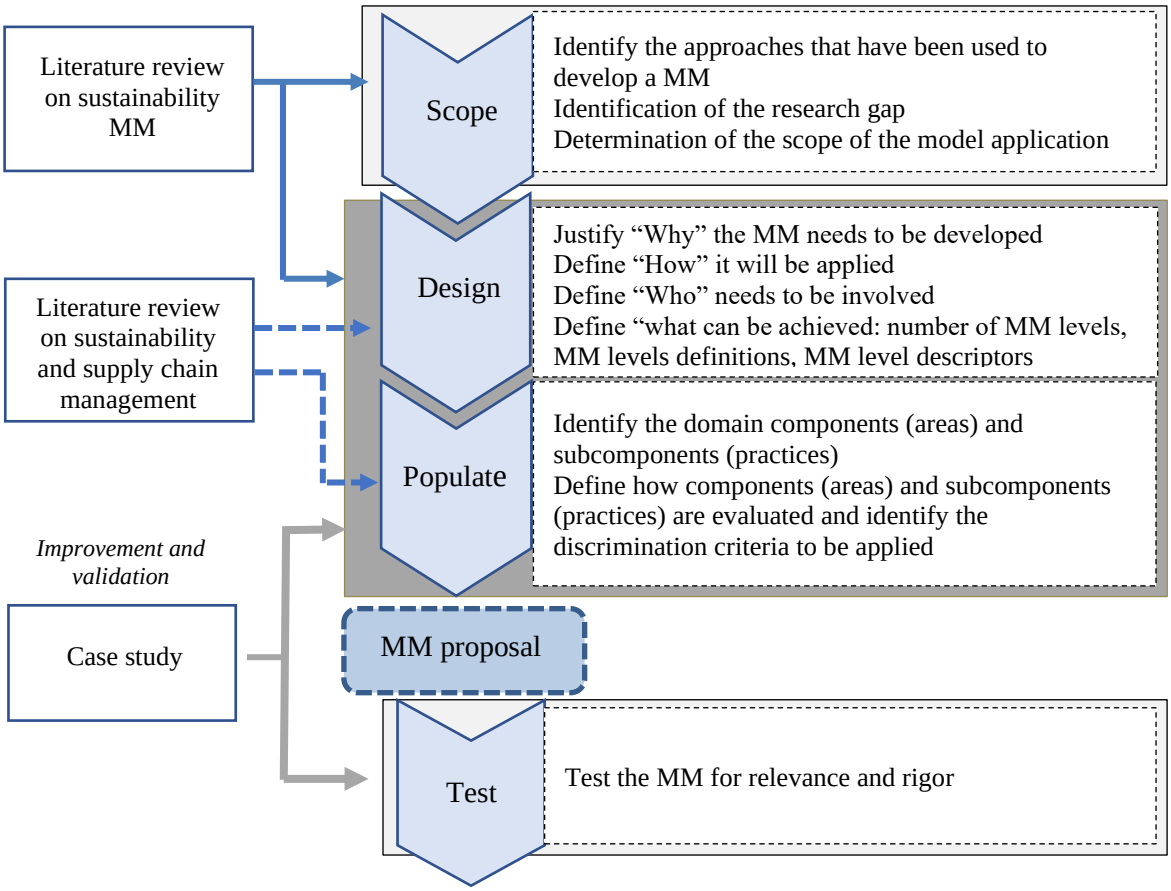


Figure 2. Research design

One of the decisions to be made in the development of MMs is the choice of the research methods to be used, which influences the scientific and practical quality of the resulting MM (Mettler, 2009). In this study, we used a combination of theory-driven and practitioner-based approaches. A literature review of existing sustainability MM and its characteristics provided the background knowledge to develop the MM being used mainly for the first three phases of MM development (Scope, Design, Populate).

The use of exploratory research methods such as the Delphi technique, Nominal Group technique, focus groups and case studies are recommended in the literature on the development of MMs (De Bruin et al., 2005; Lasrado et al., 2015). De Bruin et al. (2005) highlights the importance of these methods, particularly for the Populate phase, as the literature review is unlikely to provide sufficient information for MM development at this stage.

The case study method was also used to improve and validate the proposed MM. The case study methodology can be used to study under-researched phenomena, which requires an in-depth study of a few cases (Yin, 2003). For the development of the MM, the use of multiple case studies seemed appropriate. Compared to the single case study, this type of research strategy is more robust and reliable (Baxter & Jack, 2008). Also, it allows an exhaustive and in-depth analysis of different situations (Yin, 2003), providing richer information for the development of the MM.

For the case selection, we focus on the mould industry. Portugal is one of the world's leading manufacturers in this industry supplying large multinationals from different sectors (Correia et al., 2021). To this industry, sustainability is considered as one of its main challenges (CEFAMOL, 2022), so companies will have to make decisions regarding their implementation which makes a sustainability MM relevant.

To find out companies interested in participating in the study, the research team contacted the TOP 100 Portuguese companies in the mouldmaking industry (PBA, 2019). Only five companies confirmed their participation in the research. These companies are characterised by: i) small and medium-sized enterprises (SMEs) (number of employees <250; turnover<50 million euros); ii) use a make-to-order production strategy and export more than 90% of their production; iii) are suppliers to various industries, but their main customers are from the automotive industry. Table 1 presents a brief characterisation of the companies participating in this study.

Table 1. General characterization of case studies

Companies	*General Characterization*
Company 1	It started its activity in 1991 and is dedicated to the production of technical moulds of great accuracy and high size, with a capacity of up to 120 tons. Its main activity is centred on manufacturing compression moulds, Plastic injection moulds, and Plastics injection. About 90% of its production is aimed at the automotive industry, but it tries to preserve the markets of other sectors, namely Electronics/Telecommunications and Housewares. It employed 248 workers and had a turnover of 29,837,733 euros.
Company 2	Founded in 1997 is dedicated to manufacturing plastic injection moulds for the sectors Automotive; Appliances; Houseware exporting almost all its production. Its focus is moulds of medium and big dimensions (up to 60 Tons). It employed 126 workers and had a turnover of 8,497,868 euros.
Company 3	It started its activity in 1984 and is dedicated to the production of moulds with a capacity of up to 20 tons. It produces Die Casting Moulds for the Automotive, Appliances and Packaging sector, although the automotive sector represents the destination of almost all the production that is exported to the European and American markets. This company employed 69 (2017) workers and had a turnover of 7,697,479 euros.
Company 4	It is a family company founded in 1987 and dedicated to the production of high-precision moulds for parts, for various industries such as automotive, aeronautics, medical/pharmaceutical, electrical and electronics. The company has moulds of multiple types: thermoplastic injection, die casting, rotary injection, two-component injection, compression, transfer sandwich, with its main markets in countries in Europe, and North and South America. The company also injects plastic parts. It employed 73 workers and had a turnover of 4,315,837 euros.

Company 5	Company 5 was founded in the year 2005 and has been dedicated to plastic injection and manufacturing compression moulds and Plastic injection moulds for the Automotive; Appliances, and Packaging industries. It employed 68 workers and had a turnover of 5,565,062 Euros.

All five companies were informed of the study's objectives, procedures to be followed and the type of information sought. The companies indicated the experts as the most appropriate people, considering their skills and functions: Managing partner (Company 2 and Company 4); Quality and environmental manager (Company 1); Responsible for Quality and maintenance (Company 3), and Quality Manager (Company 5). These experts were the contact point between the company and the research team responsible. They were responsible for obtaining the information required to fill out the questionnaires. If necessary, they could discuss with colleagues from other teams/ functional areas to get an appropriate answer.

Multiple data collection instruments were used, considered valid for case studies (Yin, 2003), such as interviews, document collection and analysis, and questionnaires, which also allow for a greater understanding of the phenomenon to be studied (Schoch, 2016). The interviews were conducted after sending a protocol indicating the aspects to be covered in them, as Voss et al. (2002) suggested.

The interviews were an essential element of information collection and the starting point for accessing other sources of information. The aim was to get to know the company's approach to sustainability, present the MM in development and its main elements, and obtain contributions that would improve the MM. In addition to the interviews, three questionnaires were administered:

- The first questionnaire sought to obtain information on: areas, practices and sub-practices to be considered in the MM and allocation of sub-practices by evolution level; adequacy of the MM as to maturity levels; and adequacy as to discrimination criteria to be considered in the MM;
- The second questionnaire intended to know the level of application of sub-practices in the company:
- The third questionnaire was designed to know how the company evaluated the MM in managerial terms, i.e., its adequacy and practicality.

Whenever necessary, the research team provided support and requested clarifications and additional information, both in person and by email. This process was accompanied by secondary data collection, which allowed for a deeper and better understanding of the aspects under analysis and clarified some doubts.

4. Development of Maturity Model

4.1 Scope

The scope will determine the degree of the model application within its domain (Correia et al., 2017). De Bruin et al. (2005) suggested an extensive literature review to understand domain issues deeply. To define the scope of the MM, we ground our search in Correia et al. (2017) and Santos et al. (2020). Appendix A presents the MM and includes other sustainability MM that emerged in the literature.

To analyse the MM scope, two characteristics were defined: i) sustainability dimensions targeted by the MM, i.e., the TBL dimensions, and ii) SC hierarchic level that can range from the process, company to network-level. Table 2 presents a synthesis of the sustainability MM available in the literature, highlighting their unit of analysis and sustainability focus.

Table 2. Scope of sustainability MM

Authors, Year	*Unit of Analysis*			*Sustainability Focus*	
	Process	Company	Network	TBL approach	Envir. Sustain.
Robinson et al., 2006	✓			✓	
Standing & Jackson, 2007	✓			✓	
Babin & Nicholson, *2011*		✓			✓
Pigosso et al., 2013	✓				✓
Okongwu et al., 2013			✓	✓	
Srai et al., 2013			✓	✓	
Edgeman & Eskildsen, 2014		✓		✓	
Golinska & Kuebler, 2014		✓		✓	
Hynds et al., 2014	✓				✓
Kurnia et al., 2014			✓	✓	
Reefke et al., 2014			✓	✓	
Gouvinhas et al., 2016		✓		✓	
Rudnicka, 2016			✓	✓	
Verrier et al., 2016	✓				✓
Machado et al., 2017	✓			✓	
Subramanian et al., 2017	✓			✓	
Xavier et al., 2020	✓				✓
Santos et al., 2020			✓	✓	
Sari et al., 2021		✓		✓	

Analysis of the table suggests the following conclusions:

- The MMs scope ranges from “process” (e.g., Standing & Jackson, 2007; Pigosso et al., 2013; Hynds et al.., 2014), “company” (e.g., Edgeman & Eskildsen, 2014; Golinska & Kuebler, 2014; Gouvinhas et al., 2016), and “network” level (e.g., Rudnicka, 2016; Machado et al., 2017; Subramania et al., 2017).
- Some MM addresses the maturity considering just on the environmental dimension (e.g., Babin & Nicholson, 2011, Pigosso et al., 2013; Hynds et al., 2014; Verrier et al., 2016). Focusing on a single dimension makes it difficult "to identify critical elements that contribute to higher levels of sustainability" (Correia et al., 2017).
- Many MMs present a TBL approach. A more detailed analysis of the MMs shows that sustainability is treated as a stand-alone element of the TBL (e.g., Reefke et al., 2014); other MMs clearly distinguish the different dimensions of sustainability (economic, environmental, social) (e.g., Srai et al., 2013; Golinska & Kuebler,

2014; Santos et al., 2020).

- All the MMs with a network scope follow a TBL approach. However, these MMs have some shortcomings. For example, although several sustainability initiatives that address TBL call for interactions and collaboration between organisations, these elements do not receive sufficient attention in MMs (Munajat & Kurnia, 2015).

Most of MM present several limitations, such as:

- Lack of details on precise sustainability aspects to measure (e.g., Robinson et al., 2006; Standing & Jackson, 2007; Reefke et al., 2014; Vernier, 2016).
- Poor definition of each stage; it does not even explain in depth how a company can reach and surpass the maturity levels (e.g., Golinska & Kubler, 2014; Kurnia et al., 2014, Hynds et al., 2014; Gouvinhas et al., 2016; Verrier et al., 2016; Rudnicka, 2016; Machado et al., 2017).

According to Seuring and Müller (2008), integrating sustainable operations requires companies to engage in SCM practices. Thus, a MM should consider the integration of intra and inter-organizational sustainability practices (across different areas and organizational levels). Measuring a company's capacity to apply certain practices fulfils an essential purpose of MMs, which is to diagnose the company's current situation.

4.2 Design

In the design stage, it is necessary to respond to *why* the model needs to be developed, *how* it will be applied, *who* needs to be involved and *what* can be achieved (De Bruin et al., 2005).

4.2.1 Why the model needs to be developed

A MM can be used for three purposes (De Bruin *et al.*, 2005): i) descriptive tool - assessment of strengths and weaknesses ("as-is" assessments); ii) prescriptive tool - development of a roadmap for improvement ("to-be" maturity); iii) comparative tool – evaluation of the company, compared to standards and best practices.

The main value of assessing the maturity level is capturing the current situation's perception to support change. Correia et al. (2017) identify a scarcity in prescriptive models. Some of the few prescriptive studies are: i) Pigosso et al. (2013) with an application method that encompasses a diagnosis of the profile in eco-design in addition to the improvement implementation process; ii) Xavier et al. (2020) proposed the Eco-Mi to support the improvement of the integration of eco-innovation and the evolution of organizational performance; iii) Reefke et al. (2013) suggested a sustainable SC management system - the SSCM system - to support the realization of their MM.

Therefore, it is considered that the effective integration of sustainability in SCs requires the evaluation of their maturity and identifying their strengths and weaknesses; that is, the MM should be a descriptive tool. In addition, it should support the identification of improvement actions and changes that lead to higher sustainability levels, being a prescriptive tool. Moreover, it works as a comparative tool for benchmarking analysis.

4.2.2 How it will be applied

The MM implement mechanism selection implies considering the aim of the assessment

in addition to the resources and support infrastructure available for conducting the assessment (Maier et al., 2012). Most of the sustainability MMs proposed in the literature do not address the implementation of MM or do not describe in detail that application. For example, Paz et al. (2015) and Xavier (2017) argue the use of a computer software program to facilitate the application of their model, but they do not provide details about it. Pigosso et al. (2013) state that their MM is applied with documents, interviews, questionnaires, and computer resources to collect information about companies' processes, to understand how it is organized, structured and documented, and to evaluate which eco-design management practices the company applies. Interviews are also the preferred method to Xavier (2017) and Xavier et al. (2020).

Based on the literature review, we suggest the application of structured questionnaires using a computer software program (e.g., developed in Microsoft Office Excel) and cloud computing collect data from respondents regarding intra and inter-organization sustainability practices.

4.2.3 Who needs to be involved

The MM deployment could be made by self-assessment or by an external auditor (De Bruin et al. 2005). Fraser et al. (2002) emphasize that self-assessments' benefits are more significant if approached as a team exercise (e.g., involving people from different functional groups). This eliminates single-respondent bias and provides an opportunity for consensus and team building.

In this work, we suggest a self-assessment option. Considering that the suggested MM intends to describe different sustainability dimensions and involves intra and inter-organization processes to gather different perspectives. The approaches of Pigosso et al. (2013) and Xavier (2017) are followed. It is proposed the engagement of all involved in the structure of the organization to a better knowledge and evaluation of the various areas related to SC sustainability, namely: Logistics/Supply Chain Manager, Human Resources Manager, Production Manager, Development Manager, and Product Managers among others.

4.2.4 What can be achieved

At this stage, it is essential to specify the number of maturity levels of the model and their definitions. To this end, it is first necessary to clarify what maturity represents. The concept of maturity is usually associated with terms such as competency, capability or even level of sophistication (De Bruin et al., 2005). Correia et al. (2017) argue that there is neither a common understanding of the concept of maturity nor a defined path guiding on how to gain maturity within the SC sustainability domain.

Yimam (2011) argues that two alternatives can achieve the development of a company's maturity: i) developing the capacity to employ more advanced and effective practices, techniques, methods and tools; ii) systematizing and refining the processes/practices, that are, explicitly defining and documenting, managing, standardizing, measuring and controlling and continuously improving the organization's processes/practices (or area of knowledge). Thus, maturity can be understood as an organisation's ability to use more advanced and effective practices, tools, methods, techniques, and procedures improving by this way the possibility of achieving process or knowledge goals.

Maturity is a concept that indicates evolution and development. Moving from an initial

to a more mature state means that the organisation is better equipped to fulfil its purpose, i.e., has a higher level of sophistication, capability or availability of certain specific characteristics (Mettler et al., 2009). In terms of sustainability, Göcer et al. (2018, p. 8) consider that maturity "refers to the level that an organization is able to scan, seize, comprehend, disseminate, and control sustainability-related issues within itself, across the supply chain and even in the broad organizational environment". Rudnicka (2016, p. 205) state that "the maturity can be defended as a level of engagement of the whole network and quality of management of the sustainable development in SC". In this study, maturity can be understood as the level of the organisation's ability to know how to plan, implement and control different types of sustainability issues/practices in its internal operations and in its SC to improve its sustainability performance.

The maturity levels highlight predictable patterns about the present and future changes of the object under study (i.e., organisation, individual, SC). There are several criteria to differentiate and characterize the maturity levels:

- Formalisation - is the degree to which, in an organisation, there are clear and established norms and procedures that focus on behaviours. Greater formalisation allows practices/processes to be programmable, controlled and continuously improved with a view to optimisation. As an organisation increases the level of formalisation, the level of maturity increases also (Hammer & Champy, 1993);
- Complexity - is the extent to which an organization uses practices (which include methods, techniques, tools, and procedures) that are more refined, detailed, or considered more advanced (Yimam, 2011). These practices involve not only more resources and capabilities, but also other stakeholders. As an organisation implements more advanced/complex and innovative practices, maturity increases (Srai et al., 2013; Amini & Bienstock, 2014);
- TBL approach – is the extent to which an organisation adopts the TBL perspective. As an organisation progressively emphasizes more than one TBL dimension either at the internal operations level, the SC level or in a broader organisational environment, maturity increases (Amini & Bienstock, 2014; Kurnia et al., 2014).
- Engagement - is the extent to which practices involve interaction with its SC partners and other stakeholders. As the organisation increases interaction and shares information, knowledge, and resources, leading to greater levels of sustainability collaboration with the various SC partners and other stakeholders its maturity increasesSrai et al., 2013; Amini & Bienstock, 2014; Rudnicka, 2016)
- Proactivity – is the extent to which the organization implements practices that aim not just to comply with legislation/regulations (compliance) but also to develop a proactive attitude towards sustainability (Amini & Bienstock, 2014).

Pigoso et al. (2013) and Xavier (2017) consider that the maturity level results from a combination of practices evolution levels with "how well a company applies" these practices (this is the practice implementation level (IL)). Pigosso et al. (2013) consider five evolution levels for ecodesign management practices. In the first level, ecodesign practices are considered necessary so that others that follow can be implemented. In this study, to develop the MM, we follow this approach defining the maturity levels as a combination of the evolution levels of sustainability practices and their implementation level (IL). We cross some of the previous criteria (i.e., complexity, TBL approach, involvement, proactivity) to differentiate the levels of evolution.

Defining the number of maturity levels is another fundamental element for a MM. There is no consensus or rule of thumb in the literature about the optimal number of maturity levels. In Table 1, this number ranges from three to six, with five being the number of maturity levels more used. We also propose a model with five levels. According to Srai et al. (2013, p. 17) this number allows "a sufficient level of granularity to permit differentiation between hierarchies of network maturity whilst still being accessible to the practitioner in terms of making informed choices during applied assessment phases of the work".

Appendix A reveals that some MM (e.g., Srai et al., 2013) do not present descriptors for the maturity levels, and when they exist, they are different for each MM. Regarding this issue, we consider it appropriate to follow the proposal of Edgeman and Eskildsen (2014). Thus, the following more generic descriptors are used: "Very low maturity", "Low maturity", "Moderate maturity", "High maturity", and "Very high maturity". The definition of each maturity level and individual descriptor result from the comparative analysis of the existing MM; they are presented in Appendix B and Appendix C. These levels represent the evolution of Sustainability MM for SC. The low maturity levels represent less complex sustainability practices' non-application or incomplete application of them. The higher levels of maturity represent the application of more complex practices and imply a more significant involvement of the SC partners and other stakeholders, addressing the three TBL dimensions.

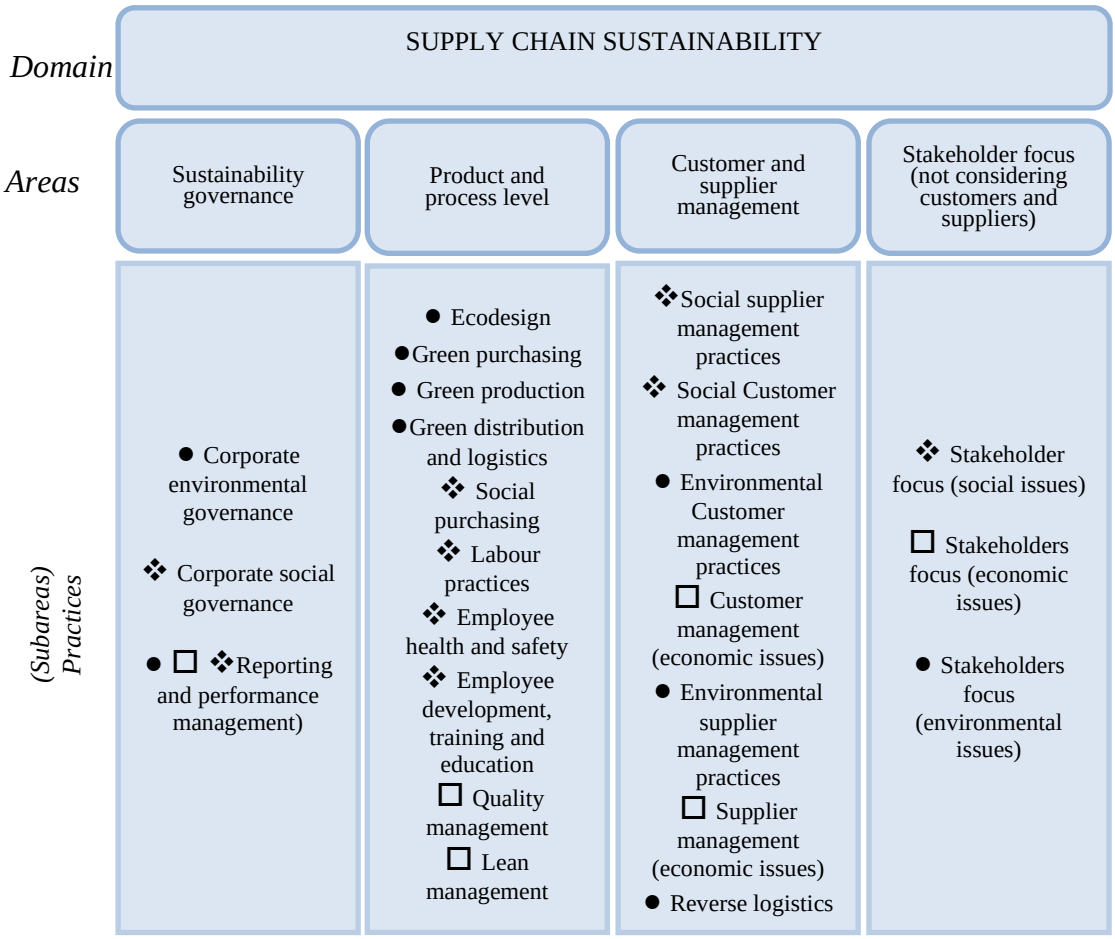
4.3 Populate

In this phase, it is necessary to identify *what* needs to be measured in the maturity assessment and *how* it can be measured (De Bruin et al., 2015).

4.3.1 What needs to be measured

De Bruin et al. (2005) suggest that an extensive literature review can be used to identify domain components and subcomponents (what needs to be measured). The MMs available in the literature address sustainability in a vast number and diversity of elements (Correia et al., 2017). To identify areas that are mutually exclusive and collectively exhaustive (De Bruin et al., 2005), three levels of analysis as proposed by Mani et al. (2015) were considered: i) the firm's operations (for example, where human safety, diversity and health and other issues are addressed); ii) the inter-organizational level where strong economic ties are found, involving suppliers and customers and consumers; iii) the external level, which involves other external stakeholders such as community, NGOs, regulators.

Sustainability practices can be grouped into critical areas considering similarities in features/characteristics. Correia et al. (2018) consider these essential components to assess the evolution of sustainability, addressing an intracompany perspective and the SC perspective. In our study, we consider four main areas: Sustainability governance, Product and process level, Customer and supplier management, and Stakeholder focus (Figure 3). Each area is broken down into a set of subareas (i.e., practices), which in turn are broken down into sub-practices that enable their operationalisation.



Note: ● Environmental issues; ☐ Economic issues; ❖ Social issues

Figure 3. MM domain, areas and practices

Each area of the proposed MM is briefly described as follows:

- ***Sustainability governance:*** focuses on the institutions, structures and mechanisms that guide, regulate and control the activities of stakeholders in the SC (Li et al., 2014). Appropriate structures, such as implementing management systems (e.g., ISO 14001, ISO 26000), guide sustainability strategy implementation. Governance mechanisms include control and reporting systems through which organisations structure their interaction straightforwardly and can include command structures and incentive systems (Boström et al., 2014; Lun et al., 2015; Formentini & Taticchi, 2016).
- ***Product and process level***: Organizations can adopt various practices related to products and processes to improve sustainability. Hynds et al. (2014) consider that achieving true sustainability means integrating TBL concerns into all aspects of the business levels of the organization (strategic, tactical and operational). Baumgartner (2013) highlights that implementing corporate sustainability in a balanced fashion requires its introduction at all business levels and in all business processes, so complexity is reduced, and changes are effective, efficient, and comprehensible. Karaosman et al., (2016) point out that a company's commitment and engagement with sustainability implies integrating social aspects at the product and process level.

- ***Customer and supplier management***: sustainability requires inter-organisational interactions among SC partners (Munajat & Kurnia, 2015). Supplier management comprises practices related to evaluating and controlling activities that integrate sustainability criteria (Marshall et al., 2014). It can include efforts with suppliers in planning and executing joint environmental and social solutions; or supporting suppliers to improve their sustainability performance (Sancha et al., 2016). Customer management reflects a company's focus on working with customers to better understand sustainability-related problems and issues from a downstream point of view. It involves monitoring activities to ensure that products are safe for the customer and to identify emerging issues that need to be addressed (Klassen & Vereecke, 2012).
- ***Stakeholder focus (not considering customers and suppliers)***: it includes business initiatives that are not directly related to the company's SC operations and that may involve regulatory stakeholders (e.g., governments, trade associations, informal networks, competitors) and community stakeholders (community groups, environmental organisations, other political lobbies) (Okongwu et al., 2013). Hyatt and Johnson (2016) and Albino et al. (2012) highlight the importance of these stakeholders to transition SC sustainability towards economic, social and environmental ends.

4.3.2. How it can be measured

The next step in MM development is to clarify how each area can be measured. The strategies followed by companies to integrate sustainability into their intra and inter-organizational process should be carefully and reasonably broken down into several practices to aid its comprehension (Hallstedt et al., 2010). Since sustainability practices refer to practices used by companies to help incorporate sustainability (Govindan et al., 2015) they can be used as proxies for each area. Sustainability practices are understood comprehensively as actions, procedures, techniques, and policies that can be implemented within the company or involving its partners in SC, such as suppliers, distributors, customers or end-users (Seuring & Muller 2008; Klassen & Vereecke, 2012). Identifying and systematising the practices to be considered for each area is an essential part of constructing a MM (Xavier, 2017; Xavier et al., 2020). To describe the practices' evolution process, either in the company or in its SC, sub-practices need to be identified by levels of evolution (Pigosso et al., 2013; Xavier, 2017).

Based on the literature review on sustainability MMs (e.g., Reefke et al., 2013; Paz et al., 2015; Rudnicka, 2016; Vernier et al., 2016; Subramania et al., 2017; Hynds et al., 2014; Kurnia et al., 2014; Srai et al., 2013; Gouvinhas et al., 2016, Machado et al., 2017), it was first suggested to distribute the sub-practices and their allocation by evolution levels. Table 3 presents examples of sub-practices for each area and their allocation to evolution levels after validation.

Table 3. Examples of sub-practices used in each area of the proposed MM and their distribution by levels of evolution

AREA: SUSTAINABILITY GOVERNANCE	Evol. Level
Practice: **Corporate environmental governance**	
Subpractices:	
Consideration of environmental issues in some functional areas (e.g., logistics, purchasing)	1
Data collection on environmental aspects	2
Environmental compliance and auditing programs in all departments	3
Commitment to GSCM from senior and middle-level managers	3
Obtaining ISO 14001 certification	4
(…)	
AREA: PRODUCT AND PROCESS LEVEL	
Practice: **Green purchasing**	
Subpractices:	
Materials that should not be used in products and should not be used in purchases are identified	1
Compliance with environmental legislation such as external purchasing directives	1
Suppliers are selected using environmental criteria (e.g., environmental competence, performance, ISO 14001)	2
Providing design specifications to suppliers that include environmental requirements for purchased items	3
Purchase of efficient materials / products in terms of energy/water consumption and non-polluting, toxic or dangerous	3
(…)	
AREA: CUSTOMER AND SUPPLIER MANAGEMENT	
Practice: **Social supplier management practices**	
Subpractices:	
Ensuring suppliers obtain OHSAS 18001 certification or other health and safety management system certification as SA 8000	3
Perform audits/has audit procedures for suppliers' internal management system related whit social issues, e.g., related to health and safety, appropriate labour working conditions)	3
Guidance and support (e.g., through training/education visits, technical support) to your suppliers to help them improve their social performance	4
Develop new product/process with suppliers that reduce health risks for consumers	5
(…)	
AREA: STAKEHOLDER FOCUS (NOT CONSIDERING CUSTOMERS AND SUPPLIERS)	
Practice: **Stakeholder focus (environmental issues)**	
Subpractices:	
(…)	
Development on its own initiative of programs for society related to environmental protection	3
Collaboration with universities and research institutions in the development of new environmental technologies or more environmentally friendly products	4
Innovative partnerships (e.g., NGOs and community groups) related to projects focused on environmental protection)	5

It is also necessary to develop evaluation scales that allow assessing maturity. Various types of scales may be used: 1) binary nominal scales - for 'yes' or 'no' decisions and responses and to facilitate the quantitative evaluation process (grades 0 or 1) (Hynds et al., 2014); 2) continuous scales, quantitative (e.g., increasing range 0-5) or qualitative, (e.g., low, medium, high) (Looy et., 2014). Similar to other authors (e.g., Pigosso et al.,

2013; Xavier et al., 2020), in this study, it is suggested to measure each sub-practice implementation level using a scale from 1 to 5, where 1 means "Not implemented or not fully implemented" and 5 means "The sub-practice is fully implemented and embedded in the company processes and continuously improved". Figure 4 presents the evaluation scale used in this study.

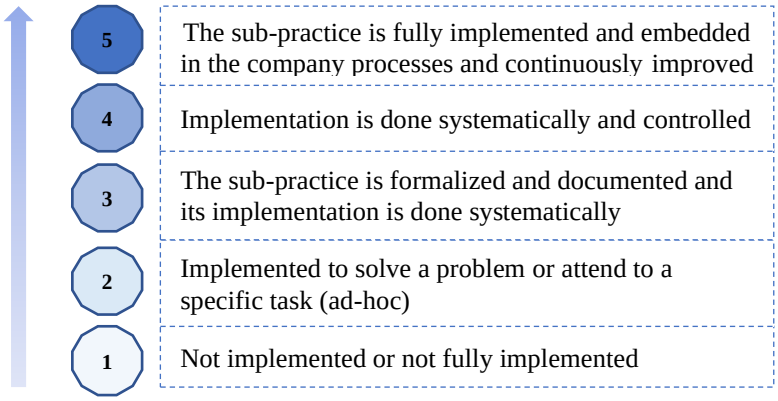


Figure 4. Implementation level of the Sustainability MM sub-practices

The discrimination criterion establishes the minimum number of practices for each maturity level and how to move from one maturity level to another. The literature presents different suggestions regarding this criterion (e.g., Hynds et al., 2014; Pigosso et al., 2013; Xavier et al., 2020). For our MM we adapted the proposal of Xavier et al. (2020). Figure 5 presents the matrix with the discrimination criteria for each maturity level. An area (e.g., Sustainability Governance) has maturity level 1 if less than 90% of its sub-practices associated with evolution level 2 present an implementation level below 3. For an area to have a maturity level 5, at least 90% of the sub-practices at evolution levels from 1 to 5, must have an implementation level greater than or equal to 3.

Sub-practices EL	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4	Maturity Level 5
5					≥90%*
4				≥90%*	≥90%*
3			≥90%*	≥90%*	≥90%*
2		≥90%*	≥90%*	≥90%*	≥90%*
1	≥90%*	≥90%*	≥90%*	≥90%*	≥90%*

Notes: ≥90% * means more than 90% of sub-practices with an implementation level greater than or equal to 3;
EL – Evolution Level

Figure 5. Matrix of maturity levels and discrimination criteria

4.4. MM Rational improvement

In the 1st stage of the validation process, face-to-face interviews with the experts were conducted. After the presentation and explanation of an initial version of the MM under development, the experts were invited to answer a set of questions, give comments and propose changes to improve the MM. The following aspects were discussed:

- Adequacy of the areas, practices and sub-practices of the MM;
- Allocation of sub-practices by levels of evolution;
- Number of maturity levels and description of the levels;
- Discrimination criteria to determine the maturity level.

A synthesis of the comments and suggestions for changes was made concerning the aspects mentioned. Figure 6 illustrates which elements from the initial MM rational were subject to changes, corrections, and improvements. In general, experts expressed a favourable position concerning the relevance of the areas and practices, the suggested discrimination criteria, and the number of maturity levels. There was no need to make changes to these MM elements.

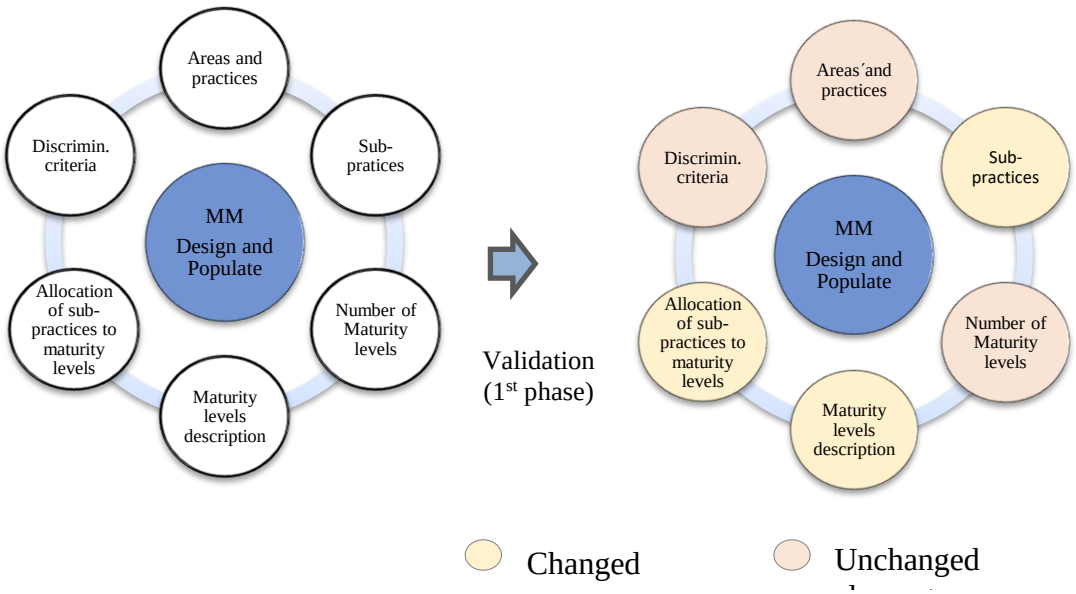


Figure 6. Results for the 1st stage of the validation process

However, concerning the sub-practices and based on the expert's comments and suggestions, of the 218 initial sub-practices, 83 were excluded to minimise overlapping concepts and ambiguities. Some sub-practices (20 sub-practices) were modified by changing the sentences or including examples to make them more straightforward and avoid difficulties in their interpretation.

This process resulted in a total of 135 sub-practices that compose the final version of the MM distributed by the 5 levels of evolution. This high number of sub-practices is due to the comprehensiveness of the model that contemplates a high number of intra and inter-organizational practices distributed by many areas and to the fact that the MM contemplates a TBL perspective. In the literature, other MM present equally high numbers of practices (e.g., Xavier, 2017). Attending to the expert's suggestions, some practices were changed from one level to another level of evolution. Of the 135 validated

practices, the evolution levels of 14 of them were modified.

Regarding the maturity levels, the experts mentioned: i) the need for greater clarity concerning some descriptions (change of expressions/words used); ii) the need to make the maturity levels more distinctive. Thus, some changes were introduced in the description of maturity levels to make them more straightforward and more distinctive. Appendix B describes the maturity levels for each MM area after the improvements. Appendix C describes the maturity level of the whole organisation and its SC (considering all areas) after implementing the interviewer's suggestions.

4.5. MM proposal

Using the results of the literature review and case studies contributions, Sustainability MM is proposed. Figure 7 illustrates this model.

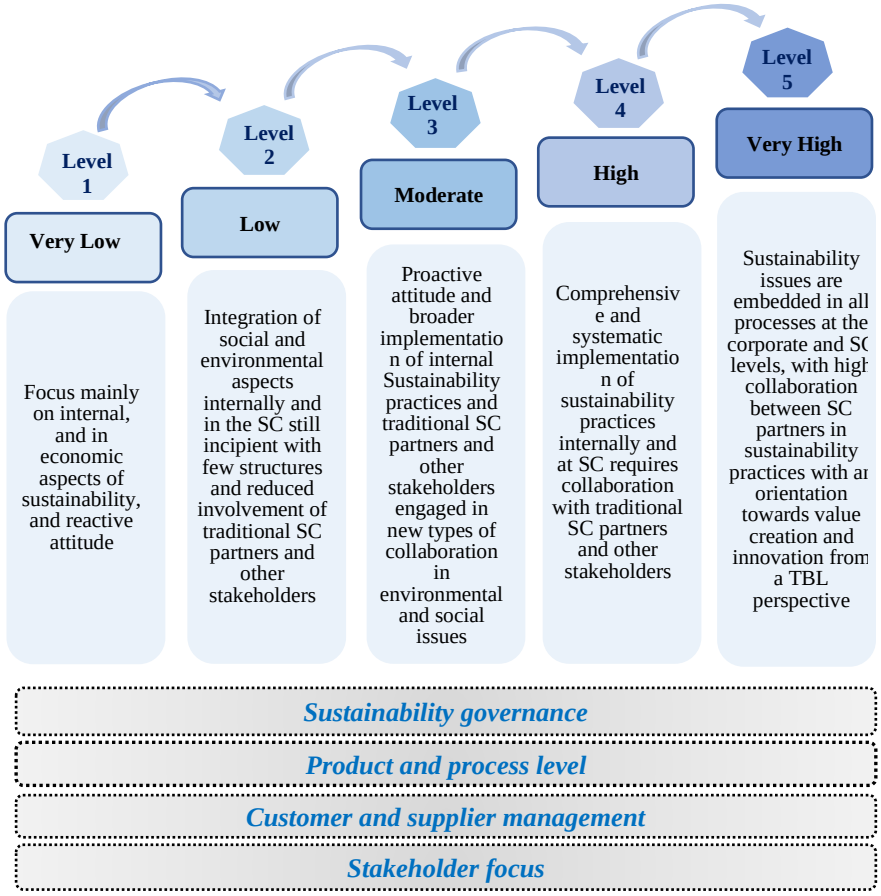


Figure 7. Sustainability Supply Chain Maturity Model (SSCMM) Proposal

4.6. Test

In the test phase, the improved version of the MM was operationalised in the five research companies. After the application of the MM, the companies were asked to evaluate the MM as a whole. The results of the application and evaluation of the MM are described in sections 4.61 and 4.62, respectively.

4.6.1 Application of the Maturity Model: discussion of results

To test the MM operationalization, a questionnaire was made to each company under study. Experts were asked to indicate the level of implementation for each of the 135 sub-practices that compose the MM. Based on this data set, each company's maturity levels were calculated as presented in table 4, table 5, table 6, table 7, and table 8.

Company 1

Of the various companies under study, Company 1 has the highest level of maturity in all areas: Level 4 in the Stakeholders focus area and Level 3 in the Product and process level, Customer and supplier management and Sustainability governance areas. The overall maturity level is Moderate (Level 3), indicating that more than 90% of the sub-practices in the evolution level 3 and above have an implementation level of 3 or above. The company also has already implemented (with IL≥3) other practices associated with the evolution levels 4 and 5 (64% and 63% respectively). Table 4 presents the maturity level of this company.

Table 4. Maturity Levels of the Company 1

Area Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
Stakeholder focus					
Customer and supplier management					
Product and process level					
Sustainability governance					
Company Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
All areas					
Total of practices (Nº)	22	27	32	29	25
Implemented practices with IL≥ 3 (N./%)	22/ 100%	26/ 96%	30/ 94%	19/ 66%	16/ 64%

Company 1 presents a Moderate maturity level (level 3) in the Sustainability governance area. This company has formal structures with responsibilities in sustainability management and clear guidelines and principles established in both the environmental and social areas, not only internally, but also directed towards the management of its partners in the SC and other stakeholders. Internally, the inclusion of environmental aspects in the various functional/departmental areas is a concern, and there are environmental programmes with procedures and objectives in these areas perfectly established and integrated. The implementation of an environmental management system

almost two decades ago has made it possible to raise awareness and structure the organisation internally, being an element of great importance in the environmental management of the company, in the implementation, control and improvement of the various initiatives/actions. Besides collecting environmental and economic information, the company collects social information that helps to define objectives, indicators and to evaluate performance in these areas. However, for the performance evaluation and reporting systems, internal information is essentially considered. The company is aware of the need to improve in this area. It has already begun to integrate information involving the SC and other stakeholders, but only in a more occasional manner or when there is a problem or because of the response to that problem. In terms of reporting involving the various dimensions of sustainability, this is only internal. If improved, these two aspects related to reporting and performance practices would enable the company to be positioned at a high level of maturity (Level 4).

In the area of Products and processes, Company 1 presents a Moderate level of maturity (Level 3). Sustainability practices are implemented in various areas of activity (Design, Production, Distribution, Quality, Human Resources, etc.) beyond compliance but without implying mobilization of resources and significant efforts by the company. The company implements (IL≥2) almost all (98%) of the practices included in this area (Product and process area), clearly standing out from the other companies. A more detailed analysis of the various practices and sub-practices in this area, reveals that the company has focused above all on the integration and consolidation of green production and quality management practices; and, social practices related to its workers, such as Employee development, Training and education, Employee health and safety, and Labour practices. These practices have the highest implementation levels (IL≥ 4). Even in these dimensions, there is still room for improvement, with sub-practices that need to be continuously improved. The company has a greater margin for progression in the practices of Green and social purchasing, and Green distribution and logistics as the company reactively implements some of the sub-practices.

The Customer and Supplier management area presents a Moderate level of maturity (Level 3). However, it should be noted that 86% of the practices associated with the next level present a high level of implementation (close to 90%) which means that the company in this area is very close to presenting a high level of maturity (Level 4). As a company whose production (90%) is largely for the automotive industry that is increasingly demanding for its suppliers, Company 1 has responding in the right way to the demands of its customers. It has focused on implementing practices/sub-practices aimed at improving quality and other parameters associated with the economic dimension, but also, and increasingly, environmental and social practices/sub-practices that involve communicating and interacting regularly with its customers. But the company already works collaboratively with its customers on different aspects (economic, environmental, and social) in areas such as Ecodesign or Cleaner production. Environmental and social practices involving customers started by being adopted only in relation to some customers, but they have progressively been extended to more customers requiring for that the use of increasingly large resources (time, skills, investments, structures). This is being mostly implemented in a systematic way and some are even being integrated into the company, in its processes (IL≥4). Regarding its suppliers, the company has developed relationships of proximity and trust that allow the implementation of not only economical but also environmental and even social practices, allowing to improve the impact of its suppliers and the company on these various areas

of sustainability. Some of these practices, which require working with its suppliers, are relatively recent, but increasingly important. However, the company still encounters some barriers that lead to some of these practices that imply a high sharing of resources and capacities not being implemented (for example, in reverse logistics). The company shows great concern and attention regarding sustainability with other stakeholders, such as the local community, presenting a high level of maturity (Level 4) in the Stakeholder area. Several practices of a collaborative nature have already been implemented. However, it is still crucial for the company to have a perspective of continuous improvement to be embedded in the processes.

Company 2

Table 5 presents the maturity levels for Company 2. As can be seen, the maturity levels for each of the areas, and the overall maturity level are Very Low (Level 1).

Table 5. Maturity Levels of the Company 2

Area Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
Stakeholder focus					
Customer and supplier management					
Product and process level					
Sustainability governance					
Company Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
All areas					
Total of Practices (Nº)	22	27	33	29	25
Implemented practices with IL≥ 3 (N./%)	21/ 95%	11/ 41%	12/ 38%	7/ 22%	3/ 13%

In the area of Sustainability governance, the level of maturity is very low (Level 1). The company's focus is on economic issues, with its main concern regarding environmental and social aspects being to comply with legislation/compliance. This focus is reflected in the absence of dedicated sustainability structures. For example, when it is necessary to respond to some request/requirement from its stakeholders (customers, suppliers, official bodies, etc.) or solve some problem in the environmental or social area, the existing management structures seek to solve these issues. One of the managing partners is ultimately responsible for managing and solving any problem in these areas. All decisions regarding implementing environmental and social practices are made by top management, and there are no defined policies regarding sustainability. The company does not have a TBL perspective on sustainability reflected in its performance evaluation systems. These systems focus on defining objectives and indicators of economic and financial nature,

integrating however some of environmental nature by collecting environmental data for this purpose. However, both environmental and social aspects are marginally considered in these systems. Also, in terms of reporting, the company focuses on economic and financial issues and occasionally integrates environmental information, but this information is not disclosed internally or externally.

In the area of Product and process level, the company has a very low level of maturity (Level 1). The company seeks to ensure that environmental and social legislation complies with production, design, purchasing, distribution and logistics, as well as employee health and safety, employee development and training and other working practices. The company is not very proactive in these areas, not implementing or implementing in an ad-hoc manner a significant amount of the more demanding practices (associated with higher levels of evolution) (with 45% of the sub-practices with IL<2). However, there is an effort to implement certain sub-practices, in particular in Quality management, Green production, Employee health and safety, and Labour practices, in a systematic and controlled way, and in some situations with a view to continuous improvement, but somewhat dispersed among the different levels of evolution.

Regarding the Customers and suppliers area, its level of maturity is also very low (Level 1). The company values the relationship and close contact with its customers maintaining customer satisfaction with an essentially economic focus. Involvement with these customers is limited when it comes to practices of an environmental or social nature. The sub-practices implemented involving customers represent only 31% of all customer management practices contemplated in the MM, and all of them are implemented in a systematic way (LI=3). There is significant work to be done regarding environmental and social sustainability concerning these partners. The involvement with its suppliers in these dimensions is also very reduced. The company limits itself to making a minimum effort in implementing practices with these partners. The focus is on maintaining relationships that allow the company to reach the best operational and economic performance. Only 21% (4 out of 19) of the supplier management sub-practices, all associated with the economic dimension of sustainability, are implemented in a systematic way (LI=3). The company is very focused on its internal operations, with little interest and effort in making a beneficial contribution to society. Although, focusing on the expectations and needs of its stakeholders (e.g., community), for example, by contributing with donations to some institutions, the implementation of sub-practices is very low (40% with LI = 3). It is limited to practices that do not require resources and more involvement of the company with the "other stakeholders". The company thus shows a level of maturity in this area that is also very low (Level 1). The company is still far from reaching the next maturity level (Level 2) as only 40% of the practices at this level present an implementation level higher than 3 (IL≥3). The company will have to develop a lot of effort globally and apply resources to advance sustainability in many areas, both internally and at the level of its SC.

Company 3

Table 6 presents the maturity level for company 3. Like the previous company, the maturity levels of each of the areas and overall are very low (Level 1).

Table 6. Maturity Levels of the Company 3

Area Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
Stakeholder focus					
Customer and supplier management					
Product and process level					
Sustainability governance					
Company Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
All areas					
Total of practices (Nº)	22	27	33	29	25
Implemented practices with IL≥ 3 (N./%)	21/ 95%	5/ 19%	7/ 22%	8/ 25%	5/ 20%

The very low maturity level (Level 1) in Sustainability governance reflects the low commitment to sustainability issues by management, whose attention has been focused in recent years on increasing capacity and technological innovation. The company does not define policies or have specific structures dedicated to sustainability management. A single person is responsible for areas such as quality management, legal compliance with environmental issues and workers' health and safety. This is considered a barrier to implementing other practices, such as collecting and processing environmental and social data, which does not occur systematically in the company. In the existing performance evaluation systems, some environmental and social data are included, but this happens very sporadically. The company reports on some sustainability aspects only to the top management. Being a family company, the most recent and succeeding generations in management have shown greater interest in these issues, but this has not yet been reflected in terms of a formal structure or control and reporting mechanisms or instruments/tools to control activities either internally or externally in terms of sustainability. In this field, the company still has a long way to go since only 25% of the practices allocated to this area are implemented in a controlled and systematic manner.

The maturity level in the Product and process level area is similar to the other areas: very low (level 1). The percentage of practices implemented in a controlled and systematic way (IL≥3) in this area is the lowest of all the companies analysed. Company 3 implements in this way (i.e., with IL≥3) only 27% of the sub-practices associated with this area. An analysis of the implemented sub-practices shows that the company has a reactive behaviour in almost all practices in this area (Ecodesign, Green Production, Distribution and logistics, Green and Social Purchasing, Employee health and safety, Employee development and training and labour practices). However, there is a more significant evolution in the implementation of Quality Management and Lean management practices (73% of the sub-practices with LI ≥3), denoting in these aspects greater proactivity of the company and mobilisation of resources. Practices are

implemented (with IL≥3) associated with higher levels of evolution. This behaviour is also registered with Employee health and safety practices. In general, at the Product and process level the concern is to implement practices related to economic and social issues, compared to environmental issues. Concerning the environmental dimension, the company seeks fundamentally to comply with legal obligations. There is a lot of room for progress in the areas of Sustainability governance and Product and Process level. The same happens concerning the Customer and supplier management area and Stakeholder focus area. These last areas present a very low level of maturity (Level 1).

Considering the Customer and supplier area, only 31% of the sub-practices of this area present an implementation level equal to or higher than 3 (IL≥3). Regarding SC partners, the company highlights the need (in order to keep its oldest customers and win new ones) to establish regular and close contacts with them and have, with some of them, greater involvement in areas related to the economic part (for example, to ensure the quality of the products, their specifications) and sometimes in the environmental area. In relation to suppliers, the company has very limited involvement with them in environmental and social aspects. The focus is on sub-practices that aim to ensure the good economic performance of the company (e.g., ensuring compliance with contracts, quality of materials, costs, delivery times, etc.).

The implementation of sub-practices in the Stakeholder focus area is also very low: only 30% of the sub-practices in this area have an implementation level equal to or higher than 3 (IL≥3). The sub-practices implemented by the company indicate that it pays attention to the demands and expectations of its stakeholders in terms of sustainability, but its involvement with other entities in sustainability practices is practically non-existent and the resources that are allocated to their implementation are also very low. Globally, the company's behaviour in various areas translates into a very low level of maturity (Level 1). If the company intends to progress in t sustainability, it will have to make efforts in all areas. As seen in figure 10, the company has made little progress in implementing more demanding and complex practices. The low percentages of implementation in the various levels of evolution show it (for example, only 21% of the sub-practices associated with level 2 have an IL≥3)

Company 4

Table 7 shows the maturity levels for company 4.

Table 7. Maturity Levels of the Company 4

Area Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
Stakeholder focus					
Customer and supplier management					
Product and process level					
Sustainability governance					

Company Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
All areas					
Total of Practices (Nº)	22	29	33	29	25
Implemented practices with IL≥ 3 (N./%)	20/ 91%	16/ 59%	18/ 56%	14/ 48%	6/ 24%

Company 4 presents a very low maturity level (Level 1) for three MM areas: Stakeholder focus, Product and process level and Sustainability governance. The area Customer and supplier management is more advanced in maturity. It presents the Level 2 (Low level) of maturity. Considering all areas of MM globally, the company registers a low level of maturity but has already implemented sub-practices associated with the other levels of evolution. To present a maturity level 2 the company will still have to systematically implement 29% of the sub-practices associated with this evolution level (i.e., for 90% of the sub-practices to have an IL≥3).

The maturity level registered in the Sustainability governance area for company 4 translates into the lack of structures, policies and the scarcity of instruments and mechanisms to manage sustainability issues. The company has no specific structures to deal with sustainability (from an integrated perspective). Environmental or social issues are the responsibility of several people in different areas (e.g. production department, quality department, administration department). These people are in charge of collecting environmental and social information, which is done for controlling the various measures that are implemented and for reporting to official/governmental entities. The existing performance evaluation systems do not yet integrate these environmental or social aspects. However, the company recognises that implementing this practice is advantageous and necessary in the future. The company's attention is turned towards its technological capacitation and the increase of its flexibility. Probably, for this reason, the maturity level of the Product and Process Level is also very low (Level 1). In this area, investments and resources have been directed mainly toward these objectives. The implementation of practices related to the environmental and social dimensions of sustainability in this area is being done in a limited way and seeking to comply with the requirements of the legislation. However, the company is proactive in terms of Environmental Production, Distribution and Logistics, Employee health and safety, Employee development and training and working practices and Quality management. In these practices, there are some sub-practices associated to levels of evolution above level 1 that shows a level of implementation equal or superior to 3. For example, in production, all sub-practices associated with levels 2 and 3 have an IL≥3. The company makes efforts and progresses in the implementation of more demanding and complex practices for various reasons. For example, in green production, the main reason is essentially to meet the demands of its customers.

The focus on customers also stands out in the management of its SC which contributes to the maturity level reached in the Customer and Supplier management area (Level 2). In fact, the company involves its customers and suppliers in social and environmental aspects in a proactive way, going beyond compliance with legislation/regulation but still without a high level of interaction or joint work. Although the maturity level is low (Level 2), 57% of the sub-practices associated with this area in MM are implemented at least in

a systematic or controlled way (i.e. have an IL≥3). This means that there is some proactivity and effort from the company in implementing sub-practices that require greater engagement with SC partners. However, particularly in the sub-practices related to suppliers and reverse logistics, the company will have to advance further, mobilise more resources and deepen the level of engagement to reach higher maturity levels. For example, the company will still have to implement (with IL≥3) 52% of the sub-practices associated with evolution level 3, to register the low maturity level (Level 3) in the Customers and suppliers management area.

Regarding the stakeholders' focus area, the maturity level is low (Level 2). Although the company is attentive to the demands and expectations of its stakeholders, the company provides regular support to some stakeholders in various initiatives (e.g., offering sponsorships to sports clubs). However, these sub-practices do not require significant resources or joint working between them and the company.

Company 5

Table 8 shows the maturity levels for Company 5. This company registers very low levels of maturity (Level 1), globally and for each of the areas.

Table 8. Maturity Levels of the Company 5

Area Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
Stakeholder focus					
Customer and supplier management					
Product and process level					
Sustainability governance					
Company Maturity level					
	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
Total of practices (Nº)	22	27	33	29	25
Implemented practices with IL≥ 3 (N./%)	22/ 100%	13/ 48%	15/ 47%	12/ 41%	4/ 16%

The inexistence of structures, guidelines and socio-environmental policies dedicated to sustainability is one of the reasons that justify the very low maturity level (Level 1) in sustainability governance (Level 1). There is no holistic approach to sustainability, and the economic dimension takes precedence over the remaining dimensions. In this company, environmental issues are the responsibility of the quality manager, and the human resources department manages social issues. Environmental issues are already included in the company's performance assessment tools and considered in the reporting to top management.

In the Product and process level area, the level of maturity is also very low (Level 1). The company recognises that its main objective is to comply with legislation, which it is not always able to do. Although the company presents a significant number of sub-practices implemented in this area (88% with IL≥2), many of them are implemented in a reactive way, to solve problems that arise and not in a systematic and controlled way (IL≥3). There is thus space to improve implementation in several areas (e.g., Ecodesign, Green and Social Purchasing, Employee health and safety, Employee development, training and education, Labour practices). It should also be noted that the company manages (with IL≥3) to implement some practices, for example in green production, that are more demanding in terms of resources, and more complex (associated with levels of evolution higher than level 1).

In the Customer and supplier management area, the maturity level is very low (Level 1). The sub-practices implemented in customers management aim to guarantee compliance with the legislation, and their focus is predominantly economic. Of all the sub-practices related to Customers management, only 27% (3 out of 11) have an implementation level equal to or higher than 3. The focus on supplier management is also fundamentally economic. In supplier management, the company implements punctually (IL=2) some (37%) sub-practices in the environmental and social scope. Still, it has already implemented some (with IL ≥3) over time that implies greater communication and involvement with its suppliers (associated with levels of evolution higher than level 1). When the relationship with suppliers translates into greater involvement, it is to ensure that the company can respond to demands and keep its customers satisfied.

Company 5 still registers a very low maturity level (level 1) for the Stakeholder focus area. Compared with the other companies analysed, the company has a lower percentage of sub-practices in this area (20%) with an implementation level equal to or higher than 3 (IL ≥3). Thus, this is an area where the company still has much to progress in terms of sustainability.

4.6.2. Presentation of the results of the validation of the Maturity Model

The assessment of the MM was performed by several criteria (i.e., the relevance of components, comprehensiveness of components, mutual exclusion of components, the sufficiency of maturity levels, the accuracy of maturity levels, ease of understanding, and, level of usefulness and practicality). This assessment was based on a short questionnaire adapted from Asah-Kissiedu et al. (2021). A five-point Likert scale using the levels: (5) Strongly agree, (4) Agree, (3) Neither agree nor disagree, (2) Disagree, (1) Strongly disagree.) (Appendix D).

All experts considered that the MM is comprehensive and suitable for assessing the maturity of SC. Regarding the relevance and comprehensiveness, all the experts (3 experts in level 5 and 2 experts in level 4 on the Likert scale) confirm that the areas, practices and sub-practices are relevant and cover all aspects of the MM domain. The same results are obtained concerning the maturity levels. The experts agree with maturity level's "Sufficiency" and "Accuracy". As for "Ease of Understanding" and "Usefulness and practicality", the results are also satisfactory (2 experts in level 5 and 2 experts in level 4 and 1 expert in level 3 of the Likert scale). Some concern was registered in relation

to the criterion "Ease of use" with 1 expert disagreeing that this criterion is checked. The experts consider that the comprehensiveness of the model makes it more difficult to obtain information since it is dispersed over various areas of activity. The remaining experts agree with the "Ease of use" (1 expert registers level 5 and the remaining 3 experts at level 4 on the Likert scale concerning this criterion).

5. Conclusion

The interest in using MMs as a tool helping the integration of sustainability in organisations and their SC has been growing, with several MMs being proposed in the literature. However, the literature on sustainability' MM remains unexplored, with only a few empirically validated models for practice and considering a holistic approach in terms of sustainability (i.e., considering environmental, social, and economic dimensions), and the SC level. Moreover, the previous sustainability MMs considering the SC level present several limitations (e.g., lack of information on how to reach and pass the maturity levels) making it difficult to understand how it works and its operationalisation (Correia et al., 2017; Meza-Ruiz et al., 2017; Santos et al., 2020).

This study proposes a Sustainability MM for SC. The proposed model allows the recognition of the current state of the organisation's capacity to integrate sustainability in its internal operations and corresponding SC and gives the support to achieve the following stages of evolution in this integration. It aims to mitigate the limitations identified in sustainability MM proposed in the literature. Thus, it contributes to going deeply into theoretical leans regarding the sustainability MM research area, an emerging area that needs to be developed (Correia et al., 2017).

For its development, the previous sustainability MM were reviewed to identify research gaps, the approaches used in developing the model and help define the scope of the MM to be proposed. An extensive literature review on corporate sustainability and SSCM was also performed to identify, among other aspects, the levels of MM to define and the components (areas) and subcomponents (practices) of the MM. The model was improved with a collaboration of five companies from the Portuguese moulmaking industry. Then, the model was applied to those companies for testing its validity, reliability and if it is user-friendly.

The model follows the trend in the literature to address sustainability with a TBL approach, and that is present in some of the previous Sustainability MM (in the SC level scope). Thus, the MM considers the economic, environmental and social dimensions simultaneously. However, it contributes to the Sustainability MM literature with a more comprehensive approach at the level of the elements (areas/practices) that compose the model. This research systematises intra and inter-organisational sustainability practices through a MM to provide a guide to the integration and evolution of sustainability maturity in SC. These sustainability practices are associated with various critical areas for sustainability and its different dimensions. Many of these practices considered in the proposed MM require the involvement and collaboration of the organisation with its SC partners and other stakeholders. This dimension, despite being of great importance for the sustainability of SC (Seuring & Müller, 2008; Liu et al., 2012; Tachizawa et al., 2014; Sancha et al., 2016) seems to be little explored in Sustainability MM considering the SC level proposed in the literature, and in that sense, this model contributes to filling this gap

by strengthening this aspect.

On the other hand, the proposed MM provides a guide for practitioners who want to use MMs to assess the level of maturity of their organisation and corresponding SC regarding sustainability. Since the maturity levels are associated with the implementation of sustainability practices, the self-evaluation through the model and identification of improvement actions is a task that may be performed with the collaboration of the managers/responsible for the various performance/functional areas (e.g., purchasing, production, logistics, etc.). It may contribute to their greater involvement and motivation in the assessment and improvement actions.

However, the model presents some limitations. The high number of practices to be evaluated can be considered a positive aspect because it illustrates the comprehensiveness of the model and its detail. However, it may represent a difficulty in evaluating the maturity levels' implementation and determination. Future work could analyse the possibility of developing software systems that support the MM application method and facilitate its use, for example, a computer application for information gathering and treatment or using the internet. On the other hand, the improvement and application of MM were carried out in SME belonging to a sector very dependent on the automotive industry and with a specific production strategy (use a make-to-order production strategy): the mouldmaking industry. As a result of applying MM to the several companies studied, it was found that many of them presented a very similar profile in terms of maturity, either in relation to the MM areas or in global terms. To increase the external validity of the model it is necessary that multiple studies be carried out in organisations with other characteristics (for example, size, position in the SC, etc.) and belonging to different activity sectors.

The development of further studies on Sustainability MM in supply chains is still an area to be explored. Given the complexity of this and other Sustainability MM for SC, as they involve different dimensions of sustainability, many areas of analysis and various SC partners, difficulties in their implementation should be explored deeply. Analyzing the barriers and facilitators to implementing this model may be an interesting research topic for future work. Another is to focus on monitoring the implementation of this type of model adopting a longitudinal analysis.

Acknowledgement

This work was funded by national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., Project UIDB/05037/2020

References

Albino, V., Dangelico, R. M., & Pontrandolfo, P. (2012). Do inter-organizational collaborations enhance a firm's environmental performance? a study of the largest U.S. companies. *Journal of Cleaner Production, 3,* 304-315. https://doi.org/10.1016/j.jclepro.2012.07.033

Amini, M., & Bienstock, C. C. (2014). Corporate sustainability: an integrative definition and framework to evaluate corporate practice and guide academic research. *Journal of Cleaner Production, 76,* 12-19. https://doi.org/10.1016/j.jclepro.2014.02.016

Asah-Kissiedu, M., Manu, P., Booth, C.A., Mahamadu, A.-M., & Agyekum, K. (2021) An Integrated Safety, Health and Environmental Management Capability Maturity Model for Construction Organisations: A Case Study in Ghana, *Buildings*, 11, 645. https://doi.org/10.3390/buildings11120645

Babin, R., & Nicholson, B. (2011). How green is my outsourcer? Measuring sustainability in global IT outsourcing. *Strategic Outsourcing: An International Journal*, 4, 47–66. https://doi.org/10.1108/17538291111108426

Baumgartner, R.J. (2013). Managing corporate sustainability and CSR: A conceptual framework combining values, strategies and instruments contributing to sustainable development. *Corporate Social Responsibility and Environmental Management*, 21, 258–271. https://doi.org/10.1002/csr.1336

Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, 13(4), 544-556. https://doi.org/10.46743/2160-3715/2008.1573

Becker, J., Knackstedt, R. & Pöppelbuß., J. (2009). Developing Maturity Models for IT Management – A Procedure Model and its Application. *Business & Information Systems Engineering*, 1(3), 212-222. https://doi.org/10.1007/s12599-009-0044-5

Benmoussa, R., Abdelkabir, C., Abd, A.& Hassou, M. (2015). Capability/maturity based model for logistics processes assessment. *International Journal of Productivity and Performance Management*, 64(1), 28- 51. https://doi.org/10.1108/IJPPM-08-2012-0084

Boström, M., Jönsson, A. M., Lockie, S., Mol, A. P., & Oosterveer, P. (2014). Sustainable and responsible supply chain governance: challenges and opportunities. *Journal of Cleaner Production*, 107, 1-7. https://doi.org/10.1016/j.jclepro.2014.11.050

Capaldi, N. (2005). Corporate social responsibility and the bottom line. *International Journal of Social Economics*, 32(5), 408-423. https://doi.org/10.1108/03068290510591263

Carter, C. R. & Easton, P. L. (2011). Sustainable supply chain management: evolution and future directions. *International Journal of Physical Distribution & Logistics Management*. 41(1), 46-62. https://doi.org/10.1108/09600031111101420

CEFAMOL (2022). Molde, 123, January 2022. Available at: https://www.cefamol.pt/index.php?id=85&idn=510 (accessed 05 May 2022)

Chaabane, A., Ramudhin, A., & Paquet, M. (2012). Design of sustainable supply chains under the emission trading scheme. *International journal of production economics*, *135*(1), 37-49. https://doi.org/10.1016/j.ijpe.2010.10.025

Chardine-Baumann, E. & Botta-Genoulaz, V. (2014). A framework for sustainable performance assessment of supply chain management practices. *Computers & Industrial Engineering*, 76, 138–147. https://doi.org/10.1016/j.cie.2014.07.029

Correia, E, Azevedo, S.G., & Carvalho, H. (2018). Proposal of a framework to construct a supply chain sustainability maturity model. 5th Euroma 4-6 Kassel (2018), Germany.

Correia, E., Carvalho, H., Azevedo, S.G. & Govindan, K. (2017). Maturity Models in Supply Chain Sustainability: A Systematic Literature Review. *Sustainability*, 9 (1) (64). https://doi.org/10.3390/su9010064

Correia, E., Garrido, S. & Carvalho, H. (2021). Online sustainability information

disclosure of mould companies, *Corporate Communications: An International Journal*, 26(3), 557-588. https://doi.org/10.1108/CCIJ-05-2020-0085

Cuenca, L., Boza, A., Alemany, M.M.E., & Trienekens, J.J.M. (2013). Structural elements of coordination mechanisms in collaborative planning processes and their assessment through maturity models: Application to a ceramic tile company. Computers in Industry, 66(8), 898–911. https://doi.org/10.1016/j.compind.2013.06.019

De Bruin, T., Freeze, R., Kaulkarni, U.& Rosemann, M. (2005).Understanding the Main Phases of Developing a Maturity Assessment Model. In Campbell, B, Underwood, J, & Bunker, D (Eds.) Australasian Conference on Information Systems (ACIS), November 30 – December 2, 2005, Australia, New South Wales, Sydney.

Dias-Sardinha & Reijnders (2005). Evaluating Environmental and Social Performance of Large Portuguese Companies: A Balanced Scorecard Approach. *Business Strategy and the Environment*, 14, 73–91. https://doi.org/10.1002/bse.421

Edgeman, R., & Eskildsen, J. (2014). Modeling and assessing sustainable enterprise excellence. *Business Strategy and the Environment*, *23*(3), 173-187. https://doi.org/10.1002/bse.1779

Estampe, D., Lamouri, S., Paris, J., & Brahim-Djelloul, S. (2013). A framework for analysing supply chain performance evaluation models. *International Journal of Production Economics*, 142, 247–258. https://doi.org/10.1016/j.ijpe.2010.11.024

Formentini, M., & Taticchi, P. (2012). Corporate sustainability approaches and governance mechanisms in sustainable supply chain management. *Journal of Cleaner Production*, 112, 1920-1933. https://doi.org/10.1016/j.jclepro.2014.12.072

Fraser, P., Moultrie, & Gregory, M. (2002). The use of maturity models/grids as a tool in assessing product development capability. *In Proceedings of the Engineering Management Conference*, 244- 249. https://doi.org/10.1109/IEMC.2002.1038431

Gilley, K., D. Worrell, & A. El-Jelly. (2000). Corporate Environmental Initiatives and Anticipated Firm Performance: The Differential Effects of Process-driven versus Product-driven Greening Initiatives. Journal of Management, 26 (6), 1199–1216. https://doi.org/10.1177/014920630002600607

Göçer, A., Vural, C. A., Halldorsson, A., & Fawcett, S.E. (2018) Sustainability Myopia: How A Lack of Visibility Stunts Sustainability Maturity. *5th International EurOMA Sustainable Operations And Supply Chains Forum.*

Golinska, P., & Kuebler, F. (2014). The method for assessment of the sustainability maturity in remanufacturing companies. *Procedia Cirp*, *15*, 201-206. https://doi.org/10.1016/j.procir.2014.06.018

Gouvinhas, R. P., Reyes, T., Naveiro,R., M., Perry, N., & Filho, E. R., (2016). A proposed framework of sustainable self-evaluation maturity within companies: an exploratory study. *International Journal on Interactive Design and Manufacturing*, 10(3), 319-327. https://doi.org/10.1007/s12008-016-0322-7

Govindan, K., Azevedo, S.G., Carvalho, H. & Cruz-Machado, V., (2015). Lean, green and resilient practices influence on supply chain performance: interpretive structural modeling approach. *International Journal of Environmental Science and Technology*, 12(1), 15-34. https://doi.org/10.1007/s13762-013-0409-7

Hallstedt, S., Ny, H., Robert, K.H. & Broman, G., (2010). An approach to assessing

sustainability integration in strategic decision systems for product development. *Journal of Cleaner Production*, 18, 703-712. https://doi.org/10.1016/j.jclepro.2009.12.017

Hammer, M. & Champy, J. (1993). Reengineering the corporation: A manifesto for business evolution. Nicholas Brealey, London.

Hassini, E., Surti, C., & Searcy, A. (2012). Literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics*, 140, 69-82. https://doi.org/10.1016/j.ijpe.2012.01.042

Hepper, E. L, Souza, O. T., Petrini, M. C., & Silva; C. E. L. (2017). Proposição de um modelo de maturidade para sustentabilidade corporativa. *Acta Scientiarum. Human and Social Sciences*, 9(1), 43-53. https://doi.org/10.4025/actascihumansoc.v39i1.33127

Hervani, A. A., Helms, M. M. , & Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An International Journal*, 12(4), 330–353. https://doi.org/10.1108/14635770510609015

Hubbard, G. (2009). Measuring Organizational Performance: Beyond the Triple Bottom Line. *Business Strategy and the Environment*, 18, 177–191. https://doi.org/10.1002/bse.564

Hyatt, D. G. & Johnson, J.L. (2016) Expanding boundaries: Nongovernmental organizations as supply chain members. *Elementa: Science of the Anthropocene*, 4, 1-14. https://doi.org/10.12952/journal.elementa.000093

Hynds, E. J., Brandt, V., Burek, S., Jager, W., Knox, P., Parker, J. P., ... & Zietlow, M. (2014). A maturity model for sustainability in new product development. *Research-Technology Management*, *57*(1), 50-57. https://doi.org/10.5437/08956308X5701143

Jayal, A. D., Badurdeen, F., Dillon Jr, O. W., & Jawahir, I. S. (2010). Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels. *CIRP Journal of Manufacturing Science and Technology*, *2*(3), 144-152. https://doi.org/10.1016/j.cirpj.2010.03.006

Karaosman, H., Morales-Alonso, G., & Brun, A. (2016). From a systematic literature review to a classification framework: Sustainability integration in fashion operations. *Sustainability*, *9*(1), 30. https://doi.org/10.3390/su9010030

Klassen, R. D., & Vereecke, A. (2012). Social Issues in Supply Chains: Capabilities Link Responsibility, Risk (Opportunity), and Performance. *International Journal of Production Economics*, 140 (1), 103–115. https://doi.org/10.1016/j.ijpe.2012.01.021

Klimko, G. (2001, November). Knowledge management and maturity models: Building common understanding. In *Proceedings of the 2nd European conference on knowledge management* (Vol. 2, pp. 269-278). Bled, Slovenia.

Kurnia, S., Rahim, M. M., Samson, D., & Singh, P. (2014). Sustainable supply chain management capability maturity: Framework development and initial evaluation. I*n Proceedings of the 22nd European Conference on Information Systems in Tel Aviv*, ECIS 2014, pp. 1-10.

Labuschagne, Carin, Alan C. Brent, & Ron P.G. van Erck. (2005). Assessing the Sustainability Performances of Industries. *Journal of Cleaner Production* 13(4), 373–385. https://doi.org/doi:10.1016/j.jclepro.2003.10.007.

Lasrado, L. A., Vatrapu, R., & Andersen, K. N. (2015, August). Maturity models development in is research: a literature review. In *IRIS Selected Papers of the Information Systems Research Seminar in Scandinavia* (Vol. 6, No. 6). New York: IRIS.

Liebetruth, T. (2017). Sustainability in performance measurement and management systems for supply chains. *Procedia engineering*, *192*, 539-544. https://doi.org/10.1016/j.proeng.2017.06.093

Looy, A. V., Backer, M. D., & Poels, G. (2014). A conceptual framework and classification of capability areas for business process maturity. *Enterprise Information Systems*, *8*(2), 188-224. https://doi.org/10.1080/17517575.2012.688222

Lozano, R. (2008). Envisioning sustainability three-dimensionally. *Journal of Cleaner Production, 16*(17), 1838-1846. https://doi.org/10.1016/j.jclepro.2008.02.008

Lun, Y.H.V., Lai, K., Wong, C. W.Y. & Cheng, T.C.E. (2015) Environmental governance mechanisms in shipping firms and their environmental performance, Transportation Research Part E, 78, 82–92. https://doi.org/10.1016/j.tre.2015.01.011

Machado, C. G., Lima, E. P., Costa, S. E. G., Angelis, J., J. & Mattioda, R. A. (2017). Framing maturity based on sustainable operations management principles. *International Journal of Production Economics*, 190, 3–21. https://doi.org/10.1016/j.ijpe.2017.01.020

Maier, A. M., Moultrie, J., & Clarkson, P. J. (2012). Assessing Organizational Capabilities: Reviewing and Guiding the Development of Maturity Grids. *IEEE Transactions of engineering management*, 59(1), 138-159. https://doi.org/10.1109/TEM.2010.2077289

Mani.V, Agrawal, R. & Sharma, V. (2015). Social sustainability practices in the supply chain of Indian manufacturing industries. *International Journal of Automation and Logistics*, 1(3), 211–233. https://doi.org/10.1504/IJAL.2015.071721

Marshall, D., McCarthy, L., Heavey, C. & McGrath, P. (2014). Environmental and social supply chain management sustainability practices: construct development and measurement. *Production Planning & Control: The Management of Operations*, 26(8), 2-19. https://doi.org/10.1080/09537287.2014.963726

Mettler, T. (2009). *A Design Science Research Perspective on Maturity Models in Information Systems,* https://www.alexandria.unisg.ch/publications/214531

Meza-Ruiz, I. D., Rocha-Lona, L., del Rocío Soto-Flores, M., Garza-Reyes, J. A., Kumar, V., & Lopez-Torres, G. C. (2017). Measuring business sustainability maturity-levels and best practices. *Procedia Manufacturing*, *11*, 751-759. https://doi.org/10.1016/j.promfg.2017.07.176.

Montiel, I., & Delgado-Ceballos, J. (2014). Defining and Measuring Corporate Sustainability: Are We There Yet?. *Organization & Environment*, 27 (2), 113-139. https://doi.org/10.1177/1086026614526413

Moultrie, J., Sutcliffe, L., & Maier, A. (2016). A maturity grid assessment tool for environmentally conscious design in the medical device industry. *Journal of Cleaner Production*, 122, 252-265. https://doi.org/10.1016/j.jclepro.2015.10.108

Müller, A., & Pfleger, R. (2014). Business transformation towards sustainability. *Business Research*, 7, 313–350. https://doi.org/10.1007/s40685-014-0011-y

Munajat, Q., & Kurnia, S. (2015). Towards Sustainability Framework Development: Identifying Organisational Capability for Sustainability Practices. In *PACIS* (p. 106).

Naini, S., Gholamreza, J., Aliahmadi, A. R., & Jafari-Eskandari, M. (2011). Designing a mixed performance measurement system for environmental supply chain management using evolutionary game theory and balanced scorecard: A case study of an auto industry supply chain. *Resources, Conservation and Recycling*, 55, 593–603. https://doi.org/10.1016/j.resconrec.2010.10.008

Neuhauser, C., (2004). A maturity model: does it provide a path for online course design?. *The Journal of Interactive Online Learning*, 3(1), 1-17.

Okongwu, U., Morimoto, R. & Lauras, M. (2013). The maturity of supply chain sustainability disclosure from a continuous improvement perspective. *International Journal of Productivity & Performance Management*, 62(8), 827-855. https://doi.org/10.1108/IJPPM-02-2013-0032

Oliveira, M.A. & Lopes, I. (2019). Evaluation and improvement of maintenance management performance using a maturity model. *International Journal of Productivity and Performance Management*, 69(3), 559-581. https://doi.org/10.1108/IJPPM-07-2018-0247

Paz, F. J., Kipper, L. M., & Frozza, R. (2015). Desenvolvimento de uma ferramenta para avaliação da maturidade para a sustentabilidade organizacional: uma proposição teórico-metodológica. *Tecno-lógica*, 19(1), 36-42. https://doi.org/10.17058/tecnolog.v19i1.5482

PBA (2019), Portuguese business association, available at: ttp://www.aeportugal.pt/Aplicacoes/SectoresEmpresariais/Top100.asp?IDSector518

Pigosso, D.C. A., Rozenfeld, H. & McAloone, T. C. (2013). Eco-design maturity model: a management framework to support ecodesign implementation into manufacturing companies. *Journal of Cleaner Production*, 59, 160-173. https://doi.org/10.1016/j.jclepro.2013.06.040

Pöppelbuß, J. & Röglinger, M. (2011). What makes a useful maturity model? A framework of general design principles for maturity and its demonstration in business process management. *In Proceedings of the European Conference on Information Systems (ECIS) Proceedings*, Helsinki, Finland, 9–11 June 2011.

Reefke, H., Ahmed, M. D., & Sundaram, D. (2014). Sustainable supply chain management—Decision making and support: The SSCM maturity model and system. *Global Business Review*, *15*(4_suppl), 1S-12S. https://doi.org/10.1177/0972150914550138

Robinson, H. S., Anumba, C. J., Carrillo, P. M., & Al-Ghassani, A. M. (2006). STEPS: a knowledge management maturity roadmap for corporate sustainability. *Business Process Management Journal*, 12(6), 793-808. https://doi.org/10.1108/14637150610710936

Röglinger, M., Pöppelbuß, J. & Becker, J. (2012). Maturity models in business process management. *Business Process Management Journal*, 18(2), 328–346. https://doi.org/10.1108/14637151211225225

Rudnicka, A. (2016). How to manage sustainable supply chain? The issue of maturity. *LogForum*, *12*(4), 203-211. https://doi.org/10.17270/J.LOG.2016.4.2

Salah, D., Paige, R., & Cairns, P. (2014, December). An evaluation template for expert review of maturity models. In *International Conference on Product-Focused Software Process Improvement* (pp. 318-321). Springer, Cham.

Sancha, C., Gimenez, C., & Sierra, V. (2016). Achieving a socially responsible supply chain through assessment and collaboration. *Journal of Cleaner Production*, *112*, 1934-1947. https://doi.org/10.1016/j.jclepro.2015.04.137

Santos, D. A., Quelhas, O. L. G., Gomes, C., F.S., Zotes, L. P., França, S. L. B., Souza, G. V. P. S, & Santos, S. S.C. (2020). Proposal for a maturity model in sustainability in the supply chain. *Sustainability*, *12*(22), 9655. https://doi.org/10.3390/su12229655

Sari, Y., Hidayatno, A., Suzianti, A., & Hartono, M. (2019, November). A systematic literature review for developing sustainability assessment tool: formulating the state of the art and future direction. In *IOP Conference Series: Materials Science and Engineering* (Vol. 703, No. 1, p. 012018). IOP Publishing.

Sari, Y., Hidayatno, A., Suzianti, A., Hartono, M., & Susanto, H. (2020). A corporate sustainability maturity model for readiness assessment: a three-step development strategy. *International Journal of Productivity and Performance Management*, *70*(5), 1162-1186. https://doi.org/10.1108/IJPPM-10-2019-0481

Schaltegger, S., & Burritt, R. (2014). Measuring and managing sustainability performance of supply chains: Review and sustainability supply chain management framework. *Supply Chain Management: An International Journal*, 19(3), 232-241. https://doi.org/10.1108/SCM-02-2014-0061

Schoch, K. W. (2016). Case study research. In Burkholder, Gary J., Cox, K. A., Crawford, L. M. (Eds.), *The Scholar-Practitioner's Guide to Research Design, 1st Edition* (pp. 227 – 241).

Searcy, C. & Elkhawas, D. (2012). Corporate sustainability ratings: an investigation into how corporations use the Dow Jones Sustainability Index. *Journal of Cleaner Production,* 35, 79-92. https://doi.org/10.1016/j.jclepro.2012.05.022

Searcy, C. (2012). Corporate Sustainability Performance Measurement Systems: A Review and Research Agenda. *Journal of Business Ethics*, 107, 239–253. https://doi.org/10.1007/s10551-011-1038-z

Seuring, S. & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, 16, 1699-1710. https://doi.org/10.1016/j.jclepro.2008.04.020

Siew, R. Y., Balatbat, M. C., & Carmichael, D. G. (2016). Measuring project sustainability maturity levela fuzzy-based approach. *International Journal of Sustainable Development*, *19*(1), 76-100. https://doi.org/10.1504/IJSD.2016.073680

Silvius, G., & Schipper, R. (2015). Developing a maturity model for assessing sustainable project management. *The Journal of Modern Project Management, 3*(1), 112-112.

Srai, J. S., Alinaghian, L. S., & Kirkwood, D. A. (2013). Understanding sustainable supply network capabilities of multinationals: A capability maturity model approach. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *227*(4), 595-615.

Standing, C., & Jackson, P. (2007). An approach to sustainability for information systems. *Journal of systems and Information Technology*. 9, 167–176. https://doi.org/10.1108/13287260710839247

Subramanian, J. A., Campos, J. K., & Wateau, E. (2017), "A maturity model for sustainable supply chain practices in the consumer goods industry", 4th International EurOMA Sustainable Operations and Supply Chains Forum (SOSCF), february 27-28, Milan, Italy

Taticchi, P., Tonelli, F., & Pasqualino, R. (2013). Performance measurement of sustainable supply chains. *International Journal of Productivity and Performance Management*, 62(8), 782-804. https://doi.org/10.1108/IJPPM-03-2013-0056

Verrier,B., Rose, B. & Caillaud, E. (2016). Lean and Green strategy: the Lean and Green House and maturity deployment model. *Journal of Cleaner Production*, 116, 150-156. https://doi.org/10.1016/j.jclepro.2015.12.022

Voss, C., Tsikriktsis, N., & Frohlich, M., (2002). Case research in operations management. *International Journal of Operational Production Management*, 22(2), 195-219. https://doi.org/10.1108/01443570210414329

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and software technology*, *54*(12), 1317-1339. https://doi.org/10.1016/j.infsof.2012.07.007

Xavier, A. F. (2017). Proposta de um modelo de maturidade para avaliação das práticas de eco-inovação nas organizações: ECO-MI, (PHD Thesis), Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Xavier, A., Reyes, T., Aoussat, A., Luiz, L., & Souza, L. (2020). Eco-innovation maturity model: A framework to support the evolution of eco-innovation integration in companies. *Sustainability*, *12*(9), 3773. https://doi.org/10.3390/su12093773

Yimam, A. H. (2011). Project management maturity in the construction industry of developing countries (the case of ethiopian contractors), (Master´s Thesis), University of Maryland, Maryland.

Yin, R. K. (2003). *Case Study Research: Design and Methods*, Sage, London.

Zhang, F., Rio, M., Allais, R., Zwolinski, P., Carrillo, T. R., Roucoules, L., ... & Buclet, N. (2013). Toward an systemic navigation framework to integrate sustainable development into the company. *Journal of cleaner production*, *54*, 199-214. https://doi.org/10.1016/j.jclepro.2013.03.054

Appendix A - Scope and maturity level of sustainability MM

Authors, Year	***Unit of Analysis***	**Scope - Sustainability Focus**		**Maturity levels (Number /descriptors)**
		Scope	Elements/characteristics considered	
Robinson et al., 2006	Process—knowledge management	Scope—TBL approach	Not Applicable	5/ Start-up, Take-off, Expansion, Progressive, Sustainability
Standing & Jackson, 2007	Process—information system management	Scope—TBL approach	Not Applicable	6/No. n-existent, Initial/ad hoc, Repeatable but intuitive, Defined process, Managed and measurable, Optimised
Babin & Nicholson, 2011	Company—IT outsourcing providers	Scope—Environmental sustainability	3 capabilities (Understand and adopt global sustainability standards. Anticipate and respond to stakeholder sustainability requests, Embed and develop sustainability capabilities within the organization)	3/Mature leaders, Aspirant, Early stage
Pigosso et al., 2013	Process—Eco-design	Scope—Environmental sustainability	8 elements resulting from 5 capabilities (deployment of eco-design practices: incomplete, ad hoc, formalized, controlled, improved) and 3 dimensions for eco-design implementation (implementation paths, company widening for implementation, knowledge level on eco-design)	5/ Level 1, Level 2, Level 3, Level 4, Level 5
Okongwu et al., 2013	Network	Scope—TBL approach	8 areas (Use of standards, Performance management—associated to governance; Life cycle management, Pollution management—associated to environment dimension of sustainability; Relationship management of suppliers, customers and society, Employee management—associated to social dimension of sustainability; Profitability management, and Economic value distribution management—associated to economic dimension of sustainability.	4/ Primeval, Initial, Intermediate, Advanced, Word Class
Srai et al., 2013	Network	Scope—TBL approach	5 clusters of capabilities (Sustainable Supply Network strategic design, Network connectivity, Network efficiency, Network process development and reporting, Network product and service enhancement) subdivided into 24 elements	5/ Not applicable
Edgeman & Eskildsen, 2014	Company	Scope—TBL approach	6 areas (Strategy and governance, Process implementation and execution, Financial results and refinement, Sustainability results and refinement, Innovation results, Human capital results and refinement) each one is subdivided in 4 key areas	5/Very low maturity, Low maturity, Moderate maturity, High maturity, Very high maturity

Golinska & Kuebler, 2014	Company—remanufacturing companies	Scope—TBL approach	3 dimensions (Economic, Ecological and Social performance) subdivided in 15 key areas (Energy Efficiency, Material Efficiency, Disposal and Recycling, Compressed Air, Emissions, Inventory, Scrap and Rework, Production Organisation, Production Disruptions, Quality Management, Workplace Design, Ergonomics and Safety, Training and Development of Employees, Innovation Management, and Corporate Image)	5/ Level 0, Level 1, Level 2, Level 3, Level 4
Hynds et al.., 2014	Process—new product development (NPD)	Scope—Environmental sustainability	2 dimensions (Strategy and Design Tools) subdivided in 14 areas (Corporate Sustainability Policy, Overall Sustainability Strategy, Government Policy and Regulation, Impact of Trends, Supply Chain, Green labelling, Sustainability Design for Environment (DfE), Specifications/Customer Insights, Life Cycle Assessment Process, DfE-Material and Part Selection, DfE-Supply Chain, DfE-Manufacturing Impact, DfE-Use Phase Impact, DfE-End of Life Impact)	4/Beginning, Improving, Succeeding, Leading
Kurnia et al., 2014	Network	Scope—TBL approach	6 capabilities (Sustainable data collection, Sustainability reporting, Sustainability benchmarking, Sustainability training, Sustainability risk analysis, Sustainability governance)	4/ Unaware, Unprepared, Committed, Advanced
Reefke et al., 2014	Network	Scope—TBL approach	Not Applicable	6/ Un-aware and Non-compliant, Ad-hoc and Compliance Basic, Defined and Compliance, Linked and Exceeds Compliance, Integrated and Proactive, Extended and Sustainability Leadership
Gouvinhas et al., 2016	Company – companies from various sectors	Scope—TBL approach	12 different categories of indicators (company's strategic vision, company's values, company's general policy, top management commitment, company relationship with stakeholders, company's purchasing policy, company's economic indicator performance, company's environmental indicator performance, company's social indicator performance, environmental communication, legislation, standards and company's "green" marketing procedures)	6/ Complete immature companies, Immature companies, Initial mature companies, Mature companies, Maturated and teaching companies, Integrated companies
Rudnicka, 2016	Network	Scope—TBL approach	6 drivers (knowledge, impact, social risk, environmental risk, cooperation, communication)	5/Starting, Aware, Aspiring, Sustainable business leaders, Masters of sustainability
Verrier et al., 2016	Process – production	Scope—Environmental sustainability	Not Applicable	5/ Initial, Managed, Defined, Quantitatively managed, Optimizing

Machado et al., 2017	Process – operations management	Scope—TBL approach	17 capabilities (Occupational Health & Safety Management, Social Accountability, Sustainability Business Case, LCA, D4S, Reverse Logistics, Closed Loop Supply Chain, Lean and green process, Eco-efficiency strategies, Cleaner Production, Quality & Environmental Management System, Sustainable Purchasing, Suppliers Development Program, Stakeholder engagement, Information System, Sustainable Marketing)	5/ Compliance and conformity, Operations' eco- efficiency, sustainability management system, network and stakeholder's integration, sustainable operations' integration
Subramanian et al., 2017	Network	Scope—TBL approach	6 groups of capabilities (Supplier-Buyer Relationship, Governance, Production, Distribution, Waste, Customer Relationship)	4/ Stage 0, Stage 1, Stage 2, Stage 3
Xavier et al., 2020	Process – Eco-innovation	Scope—Environmental sustainability	4 dimensions (resources, culture, structure, strategy)	5/Level 1, Level 2, Level 3, Level 4, Level 5
Santos et al., 2020	Network	Scope—TBL approach	4 dimensions subdivided in 14 subdimensions: Environment dimension (Environmental risk, Product portfolio, Tools); Social dimension (Internal, External, Social risk); economic dimension (Return and investment, Remanufacturing, Analysis of results); Cross (Innovation and technology, Supplying, Strategy, Stakeholders, Knowledge and performance)	5/Nonexistent; Aware; Intermediate; Advanced; Sustainable
Sari et al, 2021	Company	Scope—TBL approach	6 domains (SC driver (external); SC driver (internal); SC strategy; SC action; SC performance) subdivided in 29 subdomains/indicators	3 /Level 1 – Initial; Level 2- Managed; Level 3 - Optimised

Source: Updated from Correia et al. (2017)

Appendix B -Maturity levels for each area of MM

Maturity Levels

Areas	Level 1 Very low	Level 2 Low	Level 3 Moderate	Level 4 High	Level 5 Very high
Sustainability governance	No formal structures, or very incipient structures to manage and evaluate sustainability; Socio-environmental guidelines and policies do not exist or are too general; Reporting and performance management do not exist or have a very limited scope and focus on the economic dimension,	Formal structures dedicated to sustainability are still very incipient, and social and environmental guidelines and policies are defined only in some functional areas and consider SC in a very limited way; Reporting and performance covering social and environmental issues only internal and limited to top management	Formal structures were established, and internal social and environmental procedures were implemented in various functional areas; Internal reporting extended to the various management levels; Performance evaluation system includes SC, albeit in a timid manner	Sustainability-related management systems implemented and cross-functional cooperation; Comprehensive performance assessment system encompassing internal and SC aspects and incorporating various sustainability dimensions; Extended internal and external reporting with a focus on TBL	Management systems related to sustainability implemented and interconnected/integrated; Use advanced tools and performance assessment systems with an integrated approach to sustainability, considering TBL, SC and other stakeholders evidencing high commitment to sustainability.
References	a, b, c, e	a, b , c, e, f, g	a, b, c, e, f, g	a, b, c, e, f, g, h, i	b, c, e, f, g, h, i
Product and process level	The implementation of practices related to the environmental and social dimensions of sustainability in various areas (Design, Production, Distribution, Quality, Human Resources, etc.) is not done or these practices are applied in a very limited, defensive way and with the main objective of meeting legislation/regulation (compliance)	Implementation of sustainability practices is done in several areas (Design, Production, Distribution, Quality, Human Resources, etc.) going beyond compliance; mobilisation of resources and efforts aimed at sustainability is still limited	The integration of sustainability is done in the various areas (Design, Production, Distribution, Quality, Human Resources, etc.) proactively, seeking to minimise organisational impacts at environmental, social and economic levels; Significant efforts have already made with high mobilisation of resources and capacities	The implementation of sustainability practices in the various areas (Design, Production, Distribution, Quality, Human Resources, etc.) is carried out in a perspective of continuous improvement and following a life cycle approach; Very significant efforts in mobilising resources and capacities to implement highly complex practices.	The integration of sustainability in the various areas (Design, Production, Distribution, Quality, Human Resources, etc.) is constantly re-evaluated in a perspective of continuous improvement and innovation in terms of sustainability; Very demanding practices in terms of resources and capabilities.

Authors	a, b, c, e	a, b, c, e, f, g	a, b, c, e, f, g	a, b, c, e, f, g, h, i,	b, c, e, f, g, h, i
Customer and supplier management	Limited involvement with customers and suppliers in social and environmental aspects with concern for compliance with legislation/regulation and predominantly economic focus	Involvement of suppliers and customers in social and environmental aspects in a proactive way going beyond compliance with legislation/regulation, but still in a limited way, implying reduced communication and interaction between the company and SC partners	Involvement of suppliers and customers in social and environmental aspects with a predominance of monitoring/evaluation activities of their performance; Implementation of sustainability practices that require regular communication and high interaction between SC partners	The company encourages suppliers and customers to share sustainability objectives and to engage in collaborative practices in various areas and in the various environmental, economic and social aspects to improve sustainability performance; Communication and sharing of information involving sustainability issues is regular and fundamental.	Collaborative sustainability practices involve high mobilisation of resources and capacities of the company and SC partners, and involve innovation efforts and greater dissemination of sustainability in SC; Communication and sharing of information are continuous and high between the company and the SC partners
Authors	a, b, c, e	a, b , c, e, f, g	a, b, c, e, f, g	a, b, c, e, f, g, h, i,	b, c, e, f, g, h, i
Stakeholder focus (not considering customers and suppliers)	The company analyses and considers the demands and expectations of its stakeholders on issues related to sustainability in a very limited manner and on an ad hoc basis; The organization's efforts in relation to "other stakeholders" are reduced, involving company resources and capacities of little significance and do not contemplate joint work	A stakeholder analysis of their expectations and demands regarding sustainability is very limited; Regular communication and information from the company to most stakeholders includes sustainability issues in a very limited way; Sustainability initiatives directed to "other stakeholders" imply limited involvement of these stakeholders	Regular involvement of "other stakeholders" in issues related to sustainability but involving already significant resources and capacities of the company and the "other stakeholders".	Collaborative efforts between the company and "other stakeholders" on sustainability-related aspects imply very significant resources and capacities on both sides.	Collaboration between the company and "other stakeholders" on sustainability-related aspects implies very significant resources and capacities and is oriented towards innovation to provide more significant benefits for society
Authors	a, b, c, e	a, b, c, e, f, g	a, b, c, e, f, g	a, b, c, e, f, g, h, i,	b, c, e, f, g, h, i

Notes: a) Reefke et al. (2013); b) Paz et al. (2015); c) Rudnicka (2016); d) Subramania et al. (2017); e) Hynds et al. (2014); f) Kurnia et al. (2014); g) Srai et al. (2013); h) Gouvinhas et al. (2016); i) Machado et al. (2017)

Appendix C - Supply chain sustainability maturity levels

MM Level	Description	Authors
Level 1 Very low	Sustainability is not an important element of business strategy; Reporting and performance management are limited and focused on economic aspects; The mobilization of resources and efforts are very limited; The main objective is to meet legislation/compliance; Involvement with SC partners and other stakeholders in environmental and social practices is very limited and with a reactive attitude.	a, b, c, e
Level 2 Low	The concern with sustainability goes beyond complying with the applicable legislation but still with incipient and limited structures for internal sustainability reports and guidelines; The implementation of sustainability practices is done proactively in different areas of decision making but still in a limited manner; Awareness of the social and environmental aspects of SC with the integration of environmental and social issues into the SCM system but still in a limited manner; Sustainability practices at the SC level implying limited involvement of suppliers and, customers; Limited involvement with "other stakeholders".	a, b, c, e, f, g
Level 3 Moderate	Organisations are compliant with regulations but proactive on sustainability; Sustainability gains formal structures; Performance management integrates sustainability aspects and SC is included in these systems; More comprehensive internal sustainability reporting; Customers and suppliers are involved in new types of collaboration; Collaboration with "other stakeholders" on sustainability initiatives.	a, b, c, e, f, g
Level 4 High	Sustainability is considered a key business strategy and integrated into SC: suppliers, customers, and other stakeholders engage and collaborate on sustainability initiatives; Organisation and suppliers share information; Suppliers are encouraged to be aligned with sustainability objectives; Information sharing and interaction with customers areis fundamental; Sustainability are extent regularly to SC partners and other stakeholders. Demanding sustainability practices that imply a high degree of collaboration and/or demand request for resources; Comprehensive sustainability performance measurement system that includes different dimensions of sustainability; Internal and external reporting considering the TBL approach.	a, b, c, e, f, g, h, i,
Level 5 Very high	Sustainability is integrated into the business, and there is anticipation and proactive action; Sustainability issues are embedded at all levels and business processes; A full cycle of information exchange between SC partners and other stakeholders; High collaboration on sustainability practices from a TBL perspective are oriented toward value creation and innovation.	b, c, e, f, g, h, i

Notes: a) Reefke et al. (2013); b) Paz et al. (2015); c) Rudnicka (2016); d) Subramania et al. (2017); e) Hynds et al. (2014); f) Kurnia et al. (2014); g) Srai et al. (2013); h) Gouvinhas et al. (2016); i) Machado et al. (2017).

Appendix D - Questionaire to evaluate the final MM regarding its *Components*, *Maturity levels*, *easy of Understanding and Use*, and its *Usefulness and Practicality*

Answer the following questions using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree.

Assessment Criteria	***Level of agreement***				
	1	2	3	4	5
Components of the MM					
Areas are relevant to the MM domain (SC Sustainability) (*Relevance*)					
Practices are relevant to the MM domain (SC Sustainability) (*Relevance*)					
Sub-practices are relevant to the MM domain (SC Sustainability) (*Relevance*)					
Areas/practices/sub-practices cover all aspects impacting/ involved in the Domain (*Comprehensiveness*)					
Areas/practices/sub-practices are clearly distinct (*Mutual Exclusion*)					
Areas/practices/sub-practices are correctly assigned to their respective evolution level (*Accuracy*)					
Maturity Levels					
The maturity levels are sufficient to represent, all maturation stages of the MM domain (*Sufficiency*)					
There is no overlap detected between descriptions of maturity levels (*Accuracy*)					
Ease of Understanding					
The maturity levels are understandable					
The assessment guidelines (e.g., How to assess implementation level, how to assess Maturity levels) are understandable					
Ease of use					
The scoring scheme (i.e., calculate maturity levels) is easy to use					
The MM is easy to use					
Usefulness and Practicality					
MM is useful for assessing SC sustainability					
MM is pratical for use in industry					

Please provide suggestions, comments, and critics regarding the *Assessment criteria*:

Chapter 6

Conclusions and recommendations for future work

This chapter presents a summary of the contributions of this thesis, highlighting the main outputs obtained and how they are interconnected. The main results are presented and discussed, and theoretical and managerial implications are drawn. The conclusions are also used as a basis to outline future lines of research.

1. Thesis overview

Maturity Models (MMs) can constitute an essential tool in integrating sustainability into organisations and their SCs. The main objective of this thesis is to propose a Sustainability Maturity Model (MM) for SC. This objective has been broken down into several specific objectives. Figure 1 provides an overview of the thesis and its main results. After a first introductory chapter, Chapter 2 clarifies some concepts, highlights the importance of sustainability and its integration into CS, and proposes a framework for supply chain sustainability based on a set of main components. These components are the basis for the proposed maturity model (Chapter 5).

A systematic literature review on MM in the SC Sustainability domain (Chapter 3) allowed the identification of gaps in the literature and the identification of proposed MM and their key characteristics. A comparative analysis of these MM and their confrontation with the requirements/components of the framework proposed in the previous chapter represented essential insights into the design of the MM proposed in Chapter 5. To define the components to be integrated into the MM, it was necessary to identify the supply chain sustainability practices (and the sub-practices or specific practices to allow their operationalization) that are essential for organisations to adopt a Triple Bottom Line (TBL) approach. A literature review demonstrated the importance of systematizing these practices. The description of the sustainability dimensions made in Chapter 2 influenced this systematization that is made in Chapter 4. The empirical data collected based on a case study research method in five small and medium-sized Portuguese companies from the mouldmaking sector provided significant contributions that resulted in a framework that allows understanding of which practices should be used to address critical areas for Sustainability. The results obtained in this chapter, particularly the proposed framework, constitute important inputs for developing the MM proposed in Chapter 5. A six-step methodological approach was followed to develop the proposed Sustainability MM for CS (Chapter 5). Besides integrating the findings of the previous chapters and updating the literature review on sustainability in SC, the case study method (in the five mouldmaking companies) is also used in some phases of the MM development (for its improvement, application and validation).

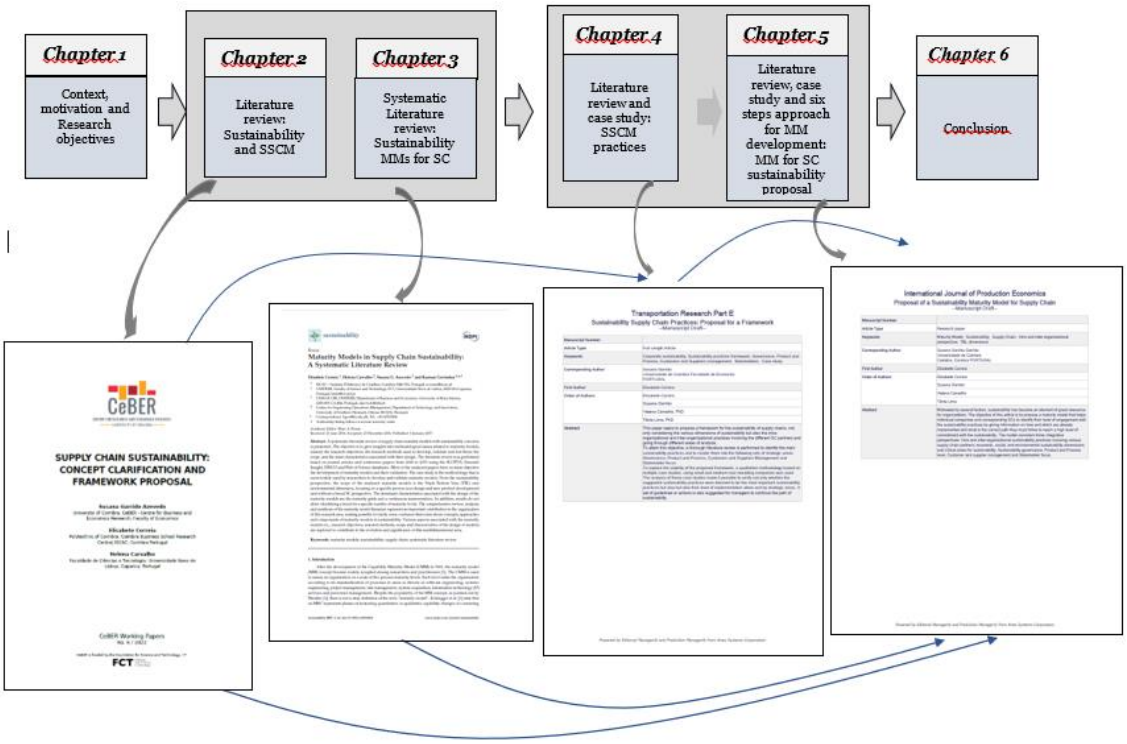


Figure 1. Thesis main outputs

2. Main conclusions

To achieve the objectives of sustainability, it is essential to consider its integration not only within the organisation but beyond organisational boundaries (Seuring & Muller, 2008; Gold et al., 2010). Therefore, sustainability in supply chain management has become an issue of focus in academic and business environments (Seuring & Muller, 2008), with different concepts and approaches related to sustainability.

These concepts were clarified through an analysis of the various definitions of Sustainable Supply Chain Management (SSCM), and a conceptual framework was proposed, allowing answer to the RQ1 (What is the meaning of Supply Chain Sustainability?) and fulfilling the first objective of the thesis. Based on this framework, we can identify the following essential components to manage and improve sustainability in SCs: a TBL approach, which considers the various dimensions of sustainability contemplated; the short and long-term perspectives; the expectations and needs of SC organisations and their stakeholders; and, integrate sustainability objectives at the intra and inter-organisational levels in the management of the various processes or flows of materials, information and capital between companies along the supply chain. These factors form the basis of the SC Sustainability MM proposed in our study.

Despite the great interest in issues related to Sustainability, the Systematic Literature Review (SLR) on Sustainability MMs shows that the interest in studying MMs in the sustainability area

is relatively recent compared to the studies on MMs in other areas. Moreover, the SLR allowed us to answer the RQ2 (What are the existing Sustainability MMs in the literature and their main characteristics?) and to reach the second objective of this thesis, which is to identify the various MM sustainability proposed in the literature and analyse the most relevant characteristics of these MMs. SLR concluded that the number of studies on Sustainability MMs is low, with only eleven papers identified in the SLR (between 2000 and 2015). Although the main objective of most of these studies is the MM development and validation, not much attention is always given to its validation, nor do some studies focus on the application of the already suggested MMs, which indicates that the area of Sustainability MMs is still incipient in terms of research and practice.

Considering the MMs analysed in SLR, it is noteworthy that some MMs focus only on the environmental sustainability dimension covering specific processes (e.g., eco-design, new product development) without a comprehensive SC perspective. Some MMs present a TBL approach considering the perspectives of the process, company, and network. The number of studies considering a TBL approach within the scope of supply chain sustainability is thus insignificant. Regarding design, there is a tendency to use maturity grids and a continuous representation. The MMs analysed did not show a trend regarding the number of maturity levels or the number of elements used to analyse/measure maturity (e.g., dimensions, areas, activities, practices). Depending on the scope of the MMs, there is a high diversity concerning these last elements. These can be grouped into critical success factors for sustainability in the SC. The factors identified are sustainability governance, standards and regulations, stakeholder focus, human resources management, customer management, environmental initiatives, supplier management, financial results and innovation.

More recently, other studies on MMs in the Sustainability domain have been published, which shows the growing interest in these instruments. The analysis of these MMs proves the trend towards using a TBL approach. It reinforces the results obtained in the SLR, namely regarding the shortcomings/limitations verified in the previous studies, such as lack of validation and details on specific sustainability aspects to measure and poor definition of each maturity level and how to reach and pass the maturity levels.

Several methodology proposals were analysed in the literature to answer the RQ3 (What approach/method to use to develop, validate and test the SC Sustainability MM?) and to achieve this thesis's third objective. A six-step methodology was chosen. According to the SLR, studies on sustainability MM adopt different research strategies for MM development and validation, such as content analysis, case study analysis, and mixed methods. The analysis of these studies and others later published led to the choice of the case study method to support some phases of the six-step methodology.

The SLR served as a basis, supplemented by more recent studies within Sustainability MMs and studies within the MMs literature, for identifying and defining the components of MM, which constitutes the fourth objective of this thesis. This objective was reached and allowed to answer

the RQ4 (What are the components to consider for the SC Sustainability MM, and in particular, what maturity levels to consider, and, which critical areas and sustainability practices are most relevant to integrate as components of the MM?). Five maturity levels were defined for the construction of the proposed Maturity Model defined, and the following descriptors were associated with them: Very low maturity, Low maturity, Moderate maturity, High maturity, and Very high maturity. We also considered previous studies on MM sustainability to describe each of these levels. This description was made for the four critical areas on which the model is based and considering the company as a whole.

Regarding the definition of the elements used to analyse/measure maturity (e.g., dimensions, activities, practices), the SLR proved insufficient since elements considered necessary in the SSCM literature were not correctly contemplated in the studies on the sustainability MMs analysed. Thus, we proceeded to identify the areas, practices and sub-practices as components of the MM based on the case study method. The empirical results allowed the identification of a significant number of practices and sub-practices grouped according to their similarities in features/characteristics by four critical areas for sustainability: sustainability governance, product and process, customer and supplier management, and stakeholder focus. The proposed framework considers a holistic perspective whereby the various dimensions of sustainability and the intra and inter-organisational practices involving the different SC partners are addressed. In addition to identifying the most relevant practices, the case study contributed to a better understanding of the factors that influence the implementation, or not, of sustainability practices, that is, the motivators/enablers/drivers and the barriers to their implementation.

The fifth objective of this thesis was reached by proposing a Sustainability MM for SC that was applied and validated. Since sustainability incorporates a temporal dimension as it implies a dynamic process of change (transformation) over time (Lozano, 2008), the MM can be an important instrument for the company and its CS as it allows tracking its progress towards sustainability efforts. To answer the RQ5 (What SC Sustainability MM should be proposed, and how can this model be applied and validated?), the proposed model recognises the current state of the organisation's capacity to integrate sustainability in its internal operations and corresponding SC and gives the support to achieve the following stages of evolution in this integration. Following the logic of maturity development, it assumes that an object (e.g., processes, companies, SC) can become more mature over time. The development path is traced through a sequence of levels and reaching each maturity level allows incremental improvements. The proposed model has five maturity levels defined for each of the critical areas of the model and globally for the company and its SC.

The proposed maturity model incorporates the insights developed within the scope of this thesis and other insights from relevant maturity approaches from corporate sustainability and SSCM literature. The proposed model maps organisational sustainability practices in various critical areas, making it possible to identify different maturity levels. Five maturity levels were defined.

The model aligns with the conceptual framework proposed in this thesis to clarify the SC sustainability concept (Chapter 2). In addition to the temporal dimension associated with MMs that assume an evolutionary perspective, the proposed MM considers three integrative perspectives: Intra and inter-organisational sustainability practices involving various supply chain partners; economic, social, and environmental sustainability dimensions; and critical areas for sustainability: Sustainability governance, Product and Process level, Customer and supplier management and Stakeholder focus.

The model provides information that determines maturity levels and how to progress from level to level. Thus, one of the shortcomings identified in previous models present in the literature, which is the lack of detail and information that makes their application difficult or impossible, is overcome. The application of the model in five companies allowed us to confirm its operationalisation, ease of use, and potential as a powerful benchmarking tool. The model was improved and validated by using the case study methodology. The lack of Sustainability MM validation had also been pointed out as a limitation of previous models that we believe has been overcome in our study. The possibility of operationalisation is essential because it enables managers to use these instruments.

There are several theoretical contributions of this thesis. The proposal for a sustainability MM for SC contributes to going deeply into theoretical leans regarding the sustainability MM research area, an emerging area that needs to be developed. It aims to mitigate the limitations identified in sustainability MM proposed in the literature regarding lack of information, details and validation. The model takes a holistic sustainability perspective, following a TBL approach already followed by previous Sustainability MMs (in the SC scope). However, it contributes to the Sustainability MM literature with a more comprehensive approach to the level of the elements (areas/practices) that compose the model. This research systematises intra and inter-organisational sustainability practices through the MM to guide the integration and evolution of sustainability maturity in SC. It also promotes the discussion of sustainability in SCs through the publication and dissemination of findings.

Moreover, the proposed MM provides a guide for practitioners who want to use MMs to assess the level of maturity of their company and SC regarding sustainability. It supports the practical application of sustainability principles. The MM can work as a descriptive tool since the effective integration of sustainability in SCs requires the evaluation of their maturity and identifying their strengths and weaknesses; used to support the identification of improvement actions and changes that lead to higher sustainability levels, being a prescriptive tool; and works as a comparative tool for benchmarking analysis.

3. Limitations and Future research lines

This study provides a basis for generating new research and disseminating knowledge about the MM for SC sustainability. Further research on this topic can help to consolidate the model and overcome the limitations of our study. The following are some suggested future research lines.

First, the development of further studies on SC Sustainability MMs is still an area that deserves to be explored deeply. As mentioned by Santos et al. (2021), studies on this type of model are necessary to understand organisations' strategies concerning sustainability, and they have the potential to provide new studies and models.

Although we consider that the SRL performed can be an important contribution to knowledge in this area, the few studies in the domain of SC Sustainability identified and analysed can be considered a limitation of our work. More recent studies on this topic should be explored to support the development of a MM. Also, academic papers were only considered. New studies that analyse the most recent works on sustainability MMs and consider other sources of information, such as websites, reports, and dissertations, could be a line of research to follow. As in different domains (e.g., digital technology transformation), entities such as consultants, and government entities, among others, have shown interest in this instrument. It would be interesting to analyse this type of organisation's possible sustainability proposals for MMs for SC.

The model application and validation are also considered a limitation of this study. The proposed model was applied and tested in Portuguese small and medium enterprises (SMEs) from the moulds sector. Further studies replicating the model in SMEs can contribute to a greater understanding of sustainability in this type of company, an underdeveloped research area (Kot, 2018).

As a result of applying MM to the several companies studied, it was found that many of them present a very similar profile in terms of maturity, either in the MM areas or in global terms, which may be related to the characteristics of the companies participating in the study. Other studies may also focus on replicating the proposed model in organisations with other characteristics (size, position in SC, different production strategies, etc.), organisations belonging to various sectors of activity, and other cultural and national realities.

Sustainability is recognised as a challenge in the mould sector to which the case studies belong. However, many companies seem to be just at the beginning of the sustainability integration process and do not have a holistic view of it (Correia et al., 2021), which may have influenced some options in MM design, for example, regarding the components (areas/practices/sub-practices; maturity levels). Different sectors of activity may have other factors influencing their sustainability behaviour (e.g., product and process characteristics or legislative requirements), which could translate, for example, into different sustainability practices to be considered as components of the model.

On the other hand, only a few companies have evaluated the model's components, which can also be considered a limitation of the study. Thus, more research is desirable, extending the analysis of the components of the proposed model, not only to different sectors and other cultural and national realities but to a more significant number of organisations. It will contribute to assessing the proposed model and its suitability and increasing its external validity. Furthermore, future research may focus on the (tangible) results of implementing the practices and on analysing how this aspect can be related to the proposed model.

Considering the scope of the proposed model (involving the different dimensions of sustainability and SC), with several areas of analysis and a very high number of Sustainability practices, difficulties in their implementation should be explored deeply. This scope may imply the involvement of different areas/professionals within organisations in evaluating the maturity levels' determination, making the model application more complex. Future work could analyse the possibility of developing software systems that support the MM application method and facilitate its use, for example, a computer application for information gathering and treatment or using the internet. In addition, analysing the barriers and facilitators to implement this model may be an interesting research topic for future work. Another one is to focus on monitoring the implementation of this type of model by adopting a longitudinal analysis.

References

Correia, E., Garrido, S. & Carvalho, H. (2021). Online sustainability information disclosure of mould companies, *Corporate Communications: An International Journal*, 26(3), 557-588. https://doi.org/10.1108/CCIJ-05-2020-0085

Gold, S., Seuring, S., & Beske, P. (2010). Sustainable supply chain management and inter-organizational resources: a literature review. *Corporate Social Responsibility and Environmental Management*, 17(4), 230–245. https://doi.org/10.1002/csr.207

Kot, S. (2018). Sustainable Supply Chain Management in Small and Medium Enterprises, *Sustainability*, 10, 1143. https://doi.org/10.3390/su10041143

Lozano, R. (2008). Envisioning sustainability three-dimensionally. *Journal of Cleaner Production, 16*(17), 1838-1846. https://doi.org/10.1016/j.jclepro.2008.02.008

Santos, D. A., Quelhas, O. L. G., Gomes, C., F.S., Zotes, L. P., França, S. L. B., Souza, G. V. P. S, & Santos, S. S.C. (2020). Proposal for a maturity model in sustainability in the supply chain. *Sustainability*, *12*(22), 9655. https://doi.org/10.3390/su12229655

Seuring M. & Müller S. (2008). Core issues in sustainable supply chain management – a delphi study. *Business Strategy and the Environment*, 17 (8), 455-466. https://doi.org/10.1002/bse.607

Appendix A – Interview Protocol

The interview protocol specifies how the interviews will be conducted. The interview protocol will be arranged in the following order:

1. Introduction of the researcher and the interviewee
2. Description of the study objective
3. Confidentiality Agreement
4. Questions

1. Investigator

The research work will be conducted by researcher Elisabete Correia, within the scope of her doctoral work in Management, to be developed at the University of Beira Interior and whose supervisor is Dr Susana Azevedo (University of Beira Interior) and as co-supervisor Dr Helena Carvalho (New University of Lisbon).

2. Introduction and description of the purpose of the study

The objective of this research work is to develop a Maturity Model that helps the company to integrate and manage supply chain (SC) sustainability. The model is developed based on the literature related to the topic, using consultations and improved by the companies' experiences, through the realization of case studies.

For the construction of the model, it is necessary to identify patterns in the integration and management of sustainability in the company and in its SC. We intend to know and understand how the company integrates sustainability in the company and its SC (in the various areas and organizational levels, in its processes and products, in activities that require relationships with its SC partners or other relevant stakeholders). Part of the study is the identification of sustainability practices considered most important for companies and their SC to achieve high levels of sustainability. Another objective is to establish an order regarding the adoption of these practices, establishing a relationship between each practice and a level of evolution. The interviews will constitute an important contribution to the development and refinement of the MM, which will be tested later.

3. Confidentiality agreement: procedures for data collection and analysis

- The entity of the interviewees and organizations will be kept confidential. They will not be disclosed without the prior written consent of the interested parties;
- All data resulting from the interview will remain in the researcher's database;
- The data associated with the case study may be published in publications (Thesis, Communications and Articles) as long as the confidentiality of the sources is maintained;
- The interviews will be recorded with the permission of the interviewees; if permission is refused, notes will be taken;
- The interlocutor reserves the right not to answer any question that he considers not relevant;

- The recordings/notes will be transcribed and synthesized by the researcher. The summaries will then be sent to the interviewee for approval.

4. Questions

The interviews must be carried out between June and October 2018 on agreed dates so as not to disturb the normal functioning of the company's activities.

The researcher must not influence his interlocutors, notably refraining from expressing opinions or biasing the interviews and the selection of documents to be analysed.

The questions to be asked are divided into four phases:

1. General information about the interviewee and organization;
2. Discussion, in a generic context, of the company's position on sustainability, the way in which this translates into the practices adopted in various decision/activity areas in the company and in the activities of its supply chain
3. Collection of information for the development and refinement of an MM
4. Application and final validation of the MM developed

Phase 1. **General information about the interviewee and organization**

General information about the interviewee

Name
Occupation
Contact: telephone contact and Email

General information about the company

Company Name
Email
Sector
Number and type of products in production
Total production in last 2 years
Volume of business in last 2 years
Main markets (domestic and external); % of production for the domestic market; % of production for the foreign market
Type of products
Number of employees
Position in the supply chain
Main Customers and Suppliers

General information about the respondent

Name
Occupation
Work experience and previous experience (number of years)
Contact: telephone contact and Email

***Phase* 2.** Discussion, in a generic context, of the company's position on sustainability, the way in which this translates into the practices adopted in various decision/activity areas in the company and in the activities of its supply chain.

Questions

- Is the issue of sustainability included in the company's business strategy? If yes, when did the company start to take this stance?
- How does the company manage these issues in terms of governance? Which practices do you consider to be most relevant in this area? For example, do you have specific structures and policies? Do you have an area responsible for managing sustainability issues? If so, what are its main functions?
- How are sustainability concerns integrated into the company's product and processes? What are the areas of activity (purchasing, production, logistics, etc.) and specific practices that you consider most relevant?
- Does the Company adopt practices that involve its SC partners? Can you specify practices involving customers?; What about practices involving suppliers?
- Does the company adopt practices related to the community/society? Which ones, and for what reasons?
- What motivations and barriers exist to the implementation of these practices?

Phase 3. Collection of information for the development and refinement of an MM

Questions

- What are the components to consider in the MM?
- Witch Areas/Practices/Sub-practices?
- How many maturity levels to consider?
- How can these levels be described?
- How to determine/evaluate maturity levels?
- What are the criticisms and suggestions to improve the MM?

The collection of more detailed information will be supported by specific questionnaires.

***Phase* 4**. Application and final validation of the MM developed

Question

- How do you evaluate the MM developed regarding *MM components*, *Ease of understanding*, *Usefulness and Practicality*?

The collection of more detailed information will be supported by a specific questionnaire.

Appendix B - Questionnaire – Sustainability Maturity Model for SC

This questionnaire is part of a research work that consists of developing a Sustainability Maturity Model for Supply Chain (Supply Chain – SC).

1. Prior information

A Maturity Model (MM) "is a conceptual framework composed of parts that describe the development of a particular area of interest over time" (Klimko, 2001). For the construction of our MM, it is necessary to identify the parts that constitute it (Areas/Dimensions) and patterns in the integration and management of sustainability in the company and SC.

Based on previous studies it was possible to identify the main Areas/Dimensions to consider, and the most relevant practices associated with them to integrate and manage. For the MM to describe the evolution of the process of integration of these practices in the company and its SC, these practices must be distributed in Evolution levels. The literature review allowed us to suggest the distribution of practices by Evolution levels. Based on the level of evolution and the level of implementation of each practice, it will be possible to determine the level of maturity for each area and globally.

Maturity levels represent states of maturity. Higher maturity levels mean higher levels of sophistication, formalization, complexity, collaboration, and a TBL (Triple-Bottom-Line) approach to sustainability. The literature review allowed characterizing the maturity levels for each of the MM Areas/Dimensions.

2. Questionnaire objectives

The main objective of the questionnaire is to obtain a consensus with experts regarding the parts that will constitute the proposed MM. In particular, we intend to reach consensus on the following aspects:

- The Areas and practices to consider in the MM;
- The sub-practices and level of evolution for each sub-practice;
- The number of maturity levels and their description;
- The criteria that will allow you to move from one maturity level to another;

3. Questionnaire Structure

This questionnaire is divided into six parts, as follows:

Part I – Areas and practices

Part II – Sustainability governance

Part III – Product and Process level

Part IV – Customer and supplier management

Part V – Stakeholder focus

Part VI – Final remarks and comments

Part I – Areas and Practices

1. Consider the following Areas and respective Practices to be considered as components of the MM.

AREAS	PRACTICES
AREA: Sustainability governance	Corporate environmental governance
	Corporate social governance
	Reporting and performance management
AREA: Product and process level	PRACTICES
	Ecodesign
	Green purchasing
	Green production
	Green distribution and logistics
	Social purchasing
	Labour practices
	Employee health and safety
	Employee development, training and education
	Quality management
	Lean management
AREA: Customer and supplier management	PRACTICES
	Social supplier management practices
	Social customer management practices
	Environmental customer management practices
	Customer management (economic issues)
	Environmental supplier management practices
	Supplier management (economic issues)
	Reverse logistics
AREA: Stakeholder focus (not considering customers and suppliers)	PRACTICES
	Stakeholder focus (social issues)
	Stakeholders focus (economic issues)
	Stakeholders focus (environmental issues)

Answer the following questions, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree. If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

Areas and practices	***Level of agreement***					***Comment(s)***
	1	**2**	**3**	**4**	**5**	
Number of areas						
Relevance of areas for the MM						
Relevance of Practices for the MM						

Part II - Sustainability governance

1. Maturity level

Consider the following maturity levels and respective characterization for the Area/Dimension.

Area: Governance				
Maturity levels				
Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
No formal structures, or very incipient structures to manage and assess sustainability; Very general and not yet formalized guidelines and socio-environmental policies; Non-existent or very limited reporting and performance management; Focus on the economic dimension.	Socio-environmental guidelines and policies defined for several functional areas but not connected and with a predominant focus on the economic dimension and considering SC in a very limited way; Limited internal reporting and sustainability goals	Formal structures established and internal socio-environmental procedures implemented; Clear and broadly defined sustainability goals and their progress assessed; Performance evaluation system includes SC still timidly; Extended internal reporting.	Implemented sustainability-related management systems and cross-functional cooperation; Comprehensive performance evaluation system encompassing internal and SC aspects; Comprehensive, systematic internal and external reporting.	Management systems related to sustainability implemented and interconnected/integrated; Use of advanced tools and Performance Assessment systems with an integrated approach to sustainability, considering the TBL, SC and other stakeholders.

Answer the following questions, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree. If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

Maturity level	***Level of agreement***					***Comment(s)***
	1	**2**	**3**	**4**	**5**	
Number of maturity levels						
Description of maturity levels						

2. Sub-pratices and Evolution level

The following table presents the sub-practices and the level of evolution for each one of them.

Regarding the level of evolution, indicate the level that you consider most appropriate (it may coincide with the level of evolution). As for practices, indicate the level of agreement, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree.

If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

AREA: *Sustainability governance*	*Evol. Level Sugest.*	*Indicate the Evol. Level most appropriate*					*Sub-practices: Level of agreement (1 to 5)*	*Comment(s)*
Sub-practices		1	2	3	4	5		
Environmental issues are considered in some functional areas (e.g., logistics, purchasing)	1							
There is an individual/working group with some responsibilities in the area of environmental sustainability	1							
Indicators traditionally linked to the economic dimension (e.g., financial, operational) are used in the evaluation of the company's performance	1							
The company does not report on sustainability	1							
The company does not have a person in charge or a working group with perfectly defined responsibilities in the area of sustainability	1							
The company has guidelines for environmental sustainability	2							
The company has guidelines for social sustainability	2							
The reporting of some aspects of sustainability is done to top management	2							
Data are collected on social aspects	2							
Data are collected on environmental aspects	2							
Internal performance evaluation systems integrate some social and/or environmental aspects (e.g., indicators, targets)	2							
Information to assess sustainability is collected in most internal organizational units	2							
Environmental objectives are defined at strategic level	2							
Social objectives are defined at a strategic level	2							
Environmental sustainability is part of the company's mission	2							
Social sustainability is part of the company's mission	2							
In the formal structure of the organization, an organizational unit/work group dedicated to managing the area of environmental sustainability is considered	3							
The company collects information related to sustainability performance from some of its supply chain partners	3							
Intermediate managers are committed to sustainability (social and environmental management)	3							
In the formal structure of the organization, an organizational unit/work group dedicated to managing the area of social sustainability is considered	3							
Environmental compliance and auditing programs in all departments	3							
Established a set of transparent, comprehensive and stringent ethical codes of conduct	3							

The sustainability reporting is done internally for top management, for other levels of management, and for employees	**3**							
Commitment to social SCM from senior and middle level managers	**3**							
Commitment to GSCM from senior and middle level managers	**3**							
The company sets environmental objectives for the supply chain and other stakeholders	**3**							
The company sets social objectives for the supply chain and other stakeholders	**3**							
Internal performance evaluation systems integrate social and/or environmental aspects related to the supply chain partners considered most important	**3**							
Obtaining ISO 14001 certification	**4**							
There are cross-functional cooperation practices for environmental improvements	**4**							
There are cross-functional cooperation practices for social improvements	**4**							
There is a commitment from everyone in the organization (management and workers) in relation to sustainability	**4**							
The company encourages the participation of its supply chain partners in environmental initiatives	**4**							
The company encourages the participation of its supply chain partners in social initiatives	**4**							
Internal and external sustainability reporting is done where some aspects (e.g., initiatives, performance) related to the supply chain are mentioned	**4**							
Sustainability aspects throughout the supply chain are considered in decision making	**5**							
The company gives equal importance to all three dimensions of sustainability in strategic decision making	**5**							
The company has an Integrated Management System, capable of integrating quality systems with health and safety, environmental management and social responsibility	**5**							
The company uses the services of an independent auditing body to certify the reliability of the reported information	**5**							
Sustainability reporting is done internally and externally, and integrates all dimensions of the TBL, and aspects related to supply chain and other stakeholders	**5**							
Various tools are used and combined (e.g., Life Cycle Analysis, risk analysis) for a more complete assessment of environmental sustainability	**5**							
Performance appraisal systems are used that integrate all elements of the TBL, and that integrate information regarding SC and other stakeholders (e.g., NGOs)	**5**							
The company encourages regular participation and collaboration with other stakeholders (NGOs, competitors, etc.) in initiatives to improve sustainability	**5**							
The company collaborates with government/sectoral bodies on issues related to legislation/regulation in socio-environmental areas	**5**							

Part III - Product and process level

1. Maturity level

Consider the following maturity levels and respective characterization for the Area/Dimension.

Area: Product and process level				
Maturity levels				
Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
The implementation of practices related to the environmental and social dimensions of sustainability in several areas (Design, Production, Distribution, etc.) are not applied or are applied in a very limited way and with the main objective of complying with legislation/regulation (compliance).	The implementation of sustainability practices is carried out in several areas (Design, Production, Distribution, etc.) going beyond compliance, but the focus is still predominantly internal; Mobilization of resources and efforts is limited.	The integration of sustainability is carried out in the various areas (Design, Production, Distribution, etc.) proactively, seeking to minimize organizational impacts at an environmental, social and economic level; Already significant efforts with high mobilization of resources and capacities.	The implementation of sustainability practices in the various areas is done from a perspective of continuous improvement and following a life cycle approach; Very significant efforts in terms of mobilizing resources and capacities.	The integration of sustainability in the various areas is constantly re-evaluated from a perspective of continuous improvement and innovation in terms of sustainability; Very demanding practices in terms of resources and capabilities.

Answer the following questions, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree. If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

Maturity level	***Level of agreement***					***Comment(s)***
	1	**2**	**3**	**4**	**5**	
Number of maturity levels						
Description of maturity levels						

2. Sub-pratices and Evolution level

The following table presents the sub-practices and the level of evolution for each one of them.
Regarding the level of evolution, indicate the level that you consider most appropriate (it may coincide with the level of evolution). As for practices, indicate the level of agreement, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree.

If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

AREA: ***Product and process level***	***Evol. Level Sugest.***	***Indicate the Evol. Level most appropriate***					***Sub-practices: Level of agreement (1 to 5)***	***Comment(s)***
Sub-practices		**1**	**2**	**3**	**4**	**5**		
Design								
Design considers regulations and policies to ensure compliance	**1**							
There are defined guidelines for the environmental design of products	**2**							
In design, the company focuses on incremental improvements in the environmental performance of existing products at specific stages of their life cycle	**2**							
The company uses an Ecodesign approach with consolidated practices and in a structured way	**3**							
Designing products for reuse, recycle, recovery of materials, components and parts	**3**							
Design of products for reduced consumption of material and energy	**3**							
Designing products/processes to avoid or reduce use of hazardous materials/substances	**3**							
Product design is simultaneously oriented towards reducing the overall environmental impact of the product (e.g., reduction of materials and energy) and increasing its useful life, from a life cycle perspective	**4**							
Ecodesign practices are systematically incorporated into product development	**4**							
In the design of the products, social sustainability criteria are incorporated	**4**							
The company has a TBL approach to Ecodesign	**5**							
The company extensively uses advanced Eco-design techniques and tools (e.g., Eco-design PILOT, LCA) tailored to your situation	**5**							
The company collaborates with suppliers and customers for environmental design on issues such as reducing material/energy consumption, waste, minimizing hazards, reuse, etc.	**5**							
Production								
The company implements techniques and procedures for waste reduction and damage control (e.g., use of filters and controls for emissions and discharges, wastewater treatment) required by legislation	**1**							
The company takes measures to reduce waste during production	**1**							
Reducing resource consumption during production	**2**							
The company favors the use in the production of environmentally friendly subsidiary and consumable materials (e.g., cleaning, maintenance)	**2**							

Optimization of process to reduce solid/liquid waste and generation of hazardous wastes and optimize material exploitation	**3**							
The company replaces its technology (means of production) with cleaner technologies/use of alternative energy sources	**3**							
Tools/systems are used to assess, control, and improve environmental aspects at the level of processes	**4**							
The company manages the disposal of waste in the production phase	**4**							
Maximizing use of renewable or recycled source materials for product manufacturing	**4**							
The company collaborates with its suppliers to improve their manufacturing processes in environmental terms	**5**							
The company collaborates with its customers to improve their manufacturing processes in environmental terms	**5**							
The techniques, procedures and technologies used in production are periodically reassessed to continuously improve environmental performance	**5**							
Purchasing								
The company identifies materials that should not be used in products and to avoid when purchasing	**1**							
Compliance with environmental legislation such as external purchasing directives	**1**							
The company is concerned about environmental issues with a focus on cost reduction	**1**							
There are guidelines/guidelines for purchasing and logistics that recommend that the environment be considered	**2**							
Ethical and human rights/welfare issues are considered in purchasing decisions	**2**							
Suppliers are selected using environmental criteria (e.g., environmental competence, performance, ISO 14001)	**2**							
The company purchase materials/products that are efficient in terms of energy and water consumption, and that are non-polluting, toxic or dangerous	**3**							
Providing design specification to suppliers that include environmental requirements for purchased items	**3**							
Consider ethical and human rights/welfare issues in our purchasing decisions	**3**							
Suppliers are selected using criteria that include ethical and social dimensions	**2**							
The company purchase materials/products that are easy to recycle or recycle, and recycled packaging	**4**							
There are ongoing education and training programs on environmental issues for purchasing staff	**4**							
There are ongoing education and training programs on social issues for purchasing staff	**4**							
The company involves its suppliers in its environmental procurement processes (e.g., informs, evaluates, collaborates)	**4**							
The company has a purchasing strategy that considers (in addition to economic aspects) social aspects	**5**							

The company has a purchasing strategy that considers (in addition to economic aspects) environmental aspects	**5**							
Distribution and logistics								
Transport is chosen based on cost and delivery time	**1**							
The company avoids the use of packaging produced with hazardous materials	**1**							
The company has a documented environmental policy in relation to logistics/transport	**2**							
Use of environmentally friendly transportation	**2**							
The company monitors the capacity and usage of its fleet	**2**							
We plan the routes of our vehicles in order to reduce environmental impacts	**3**							
The company has systems to reduce environmental impacts (e.g., for energy efficiency) in the warehouses	**3**							
The company seeks to use packaging that uses few materials in its production	**3**							
The company uses recyclable or reusable packaging/containers	**4**							
The company invests in vehicles designed to have lower environmental impacts	**4**							
Environmental improvement of packaging such as using ecological materials for primary packaging	**4**							
Optimization of transport mode and route selection, e.g., through statistical analysis	**5**							
Use of advanced tools/systems that enable product traceability (e.g., VMI), which may imply collaboration with supply chain partners	**5**							
Promoting transport sharing	**5**							
The company works with suppliers to reduce the impact of their logistics operations	**5**							
Employees								
The company focuses on safety and health measures in some of the most critical phases of the production process (e.g., manufacturing phase)	**1**							
The company provides its workers with protective and safety equipment	**1**							
The company provides training to its workers to comply with legislation, in traditional areas such as quality, human resources, marketing, etc	**1**							
Firm prohibit bonded labour and child labour	**1**							
The company focuses on complying with the safety and health aspects required by legislation	**2**							
The company carries out periodic health exams, and has other initiatives, in addition to what is required by legislation, to increase the health and well-being of workers	**2**							
The company provides training to its workers in techniques/methods and concepts related to sustainability (e.g., environmental area)	**2**							
The firm ensures that there is no discrimination against any employee on the grounds of racism, colour, religion, caste, gender, age, marital status, disability, and nationality	**2**							

The company carries out a detailed hazard identification and health risk assessment exercise	**3**							
Safe working conditions for employees in all areas of the company	**3**							
Fair compensation (living wage) to all employees	**3**							
The company has systems to assess worker job satisfaction	**3**							
The company seeks to improve and increase safety measures for its workers, visitors and contractors	**4**							
The company provides health care facilities for the employees	**4**							
An occupational health and safety management system is in place (OHSAS 18001)	**4**							
Educating and training people for skill development	**4**							
The company encourages most of its workers to participate in various activities (e.g., departmental communication meetings, human resources initiatives, recreational activities, etc.)	**4**							
The company uses advanced prevention and safety systems at work	**5**							
Sustainability-related criteria are included in employee performance assessment to reinforce the company's sustainability culture	**5**							
The company involves its workers in the implementation of new ideas and in continuous improvement initiatives in socio-environmental issues	**5**							
Quality and other operational practices								
The company keeps its shop floor well organized and clean	**1**							
Quality control/inspection techniques are used	**1**							
Quality improvement programs are implemented in some areas (e.g., production) of the organization	**2**							
Conducts preventive equipment maintenance	**2**							
Working to lower setup times in our plant (e.g., using Kaisen)	**3**							
Use statistical process control techniques to reduce process variance	**3**							
Quality management system/ISO 9000 certification	**3**							
To use a “Pull” production system	**4**							
To follow Just-in-time/Scientific inventory control technique consistently to keep inventory under control in the production environment	**4**							
The company implements several Lean practices (e.g., JIT, total preventive maintenance), controls and integrates them to minimize waste	**5**							
Efforts are made to optimize its processes by continuously improving its techniques/systems in an integrated perspective	**5**							

Part IV - Customer and Supplier management

1. Maturity level

Consider the following maturity levels and respective characterization for the Area/Dimension.

Area: Customer and Supplier management				
Maturity levels				
Level 1	**Level 1**	**Level 1**	**Level 1**	**Level 5**
Limited involvement with customers and suppliers in aspects related to the environmental and social dimension; Concern focused on compliance with legislation/regulation and predominantly economic focus	Involvement with customers and suppliers in aspects related to the environmental and social dimension goes beyond compliance with legislation/regulation; Sustainability practices involving customers and suppliers are limited Predominantly unilateral communication and information (directed by the company to SC partners)	High involvement with customers and suppliers in aspects related to the environmental and social dimension; Predominance of monitoring/evaluation activities of SC partners' performance and practices; Sustainability practices implemented require significant efforts; Exchange of information on sustainability issues with SC partners is of great importance	Involvement with customers and suppliers in issues involving the different dimensions of sustainability is of great importance; The company encourages suppliers and customers to share sustainability goals and engage in collaborative practices to improve sustainability performance; Communication and information sharing involving sustainability issues is regular and fundamental	Involvement with customers and suppliers in issues involving the different dimensions of sustainability is constant; Collaborative sustainability practices that require high mobilization of resources and capabilities of the company and SC partners, and involving innovation efforts and greater diffusion of sustainability in SC; Continuous communication and information sharing between the company and SC partners

Answer the following questions, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree. If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

Maturity level	***Level of agreement***					***Comment(s)***
	1	**2**	**3**	**4**	**5**	
Number of maturity levels						
Description of maturity levels						

2. Sub-pratices and Evolution level

The following table presents the sub-practices and the level of evolution for each one of them.

Regarding the level of evolution, indicate the level that you consider most appropriate (it may coincide with the level of evolution). As for practices, indicate the level of agreement, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree.

If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

AREA: ***Customer and Supplier management***	***Evol. Level Sugest.***	***Indicate the Evol. Level most appropriate***					***Sub-practices: Level of agreement (1 to 5)***	**Comment(s)**
Sub-practices		**1**	**2**	**3**	**4**	**5**		
Customer management								
The company conducts customer satisfaction surveys	**1**							
Ensuring the basic safety of our products for consumers, reducing health risks for them (e.g., avoid or reduce the use of hazardous materials/ contaminants/ nutrients)	**1**							
In communicating with its customers, the company provides limited information on issues related to environmental sustainability	**1**							
Our customers give us feedback on our quality and delivery performance	**2**							
The company adopts eco-labeling on products	**2**							
Information about product to users (such as labeling, info about ingredients, origin, potential dangers) to educate the user on how to properly use, consume and dispose of the product	**2**							
We frequently are in close contact with our customers	**3**							
The company promotes customer involvement in company quality programs	**3**							
Assess product misuse (with potential health hazards) encouraging consumers self-reporting	**3**							
Cooperation with customers for eco-design	**4**							
The company cooperates with customers in product innovation	**4**							
The company cooperates with customers to take back products	**4**							
Cooperation with customers for using less energy (fuel) during product transportation	**4**							
Customer involvement in company quality programs	**5**							
Cooperation with customers for cleaner production	**5**							
The company has a two-way communication strategy with customers with a strong presence of sustainability issues	**5**							
Our customers are directly involved in current and future product offerings	**5**							
Supplier management								

Suppliers are asked to guarantee compliance with legislation/technical standards relating to their products	**1**							
Request existing primary suppliers to provide evidence of all environmental licenses and permits	**1**							
The selection of suppliers is based on economic issues (e.g., costs, delivery times, etc.)	**1**							
Communication with suppliers is focused on economic issues (e.g., resolution of specific problems/issues such as pricing and others related to supply contracts, etc.)	**1**							
Assess the quality standard of suppliers (e.g., through ISO 9001 certification)	**2**							
Supplier delivers to our plant on a Just-in-time (JIT) basis	**2**							
The company asks suppliers for information about its environmental programs	**2**							
The company encourages suppliers to adopt stricter product design and safety specifications	**2**							
The company informs suppliers about the benefits of clean production and environmental technologies	**2**							
The company has guidelines on social issues for supplier management (e.g., code of conduct)	**2**							
Suppliers are involved in activities like quality month, supplier club, quality circle competition, supplier conference, energy and safety audits etc.	**3**							
Ensuring suppliers obtain OHSAS 18001 certification or other health and safety management system certification as SA 8000	**3**							
Perform audits/has audit procedures for suppliers' internal management system related whit social issues (e.g., related with health and safety, appropriate labour working conditions)	**3**							
Conduct regular environmental audits into suppliers' internal operations	**3**							
The company defines environmental criteria that suppliers must meet (e.g., waste reduction goals, use of recyclable/degradable/non-hazardous packaging, absence of certain chemicals in components)	**3**							
The company ensures that its suppliers have the ISO 14001 environmental management system certification	**3**							
The company provides funds to help suppliers purchase equipment for pollution prevention, wastewater, recycling, etc.	**4**							
The company guides and supports (through training/education visits, technical support) its suppliers to help them improve their environmental performance	**4**							
The company guides and supports (through training/education visits, technical support) its suppliers to help them improve their social performance	**4**							
The company supports and encourages suppliers to adopt advanced environmental technologies through regular training and monitoring programs	**4**							
The company facilitate our suppliers implement quality programs/TQM/Six sigma/TPM/TQC to build quality into the product	**4**							
The company requests/encourages key suppliers to attend seminars/meetings to update on policy/regulation issues involving environmental and social issues	**4**							

Joint product design with suppliers (e.g., design for reduced consumption of material/energy, design for recycle, design to avoid use of hazardous products, etc.)	**5**							
Cooperating with suppliers to reduce packaging/ eliminate packaging	**5**							
The company brings together industry suppliers (e.g., forums, meetings) to share their know-how and sustainability issues	**5**							
The company works with suppliers on systems to improve social performance (e.g., balancing work and family) across SC	**5**							
The company assesses environmentally friendly practices or social practices to 2nd level suppliers or requires its suppliers (1st level) to require their suppliers to comply with certain socio-environmental requirements (e.g., legislation)	**5**							
Develop new product/process with suppliers that reduces health risks for consumers	**5**							
The company works together with suppliers to reduce the environmental impact of their logistics operations	**5**							
The company collaborates with suppliers in areas such as production planning and coordination of production processes	**5**							
The company develops new products/processes/projects with the supplier while simultaneously considering the various dimensions of sustainability	**5**							
Reverse logistics								
The company follows the obligations imposed by legislation regarding the collection, disposal, recovery, recycling and reuse of end-of-life products and packaging.	**1**							
The company does not allocate specific resources (technological, financial, human) for reverse logistics	**1**							
The focus of reverse logistics is only placed on recapturing value	**1**							
The company has (documented) guidelines for the collection and recovery of used products and packaging	**2**							
The collection and recovery of used products and packaging from customers, and/or the return of products and packaging to suppliers is carried out occasionally	**2**							
The company labels its packaging in order to facilitate its recovery	**2**							
The company has clear guidelines and defined procedures regarding the return of packaging and products to suppliers	**3**							
The company has clear guidelines and defined procedures regarding the collection and recovery of used products and customer packaging	**3**							
The return of packaging to suppliers for reuse or recycling is done systematically	**3**							
Recovery of the company's end-of-life products or unwanted products and materials (for recycling, reuse, remanufacturing, repair)	**3**							
The return of packaging to suppliers for reuse or recycling is done in a systematic and controlled manner	**4**							

The collection of used or unwanted products from customers for recycling, material recovery or reuse is done in a systematic and controlled manner	**4**							
The company uses systems/tools that allow the collection and analysis of information regarding the collected/returned products and allow their management and decision-making in relation to them	**4**							
The company collaborates with the members of its supply chain and other entities to find new opportunities to value the products collected	**5**							
The company seeks to continually improve the process of returning packaging to suppliers for reuse or recycling, and has an approach that considers the various dimensions of sustainability	**5**							
The company seeks to continuously improve the process of collecting used or unwanted products from customers for recycling, material recovery or reuse, and has an approach that considers the various dimensions of sustainability	**5**							
The company collaborates with members of its supply chain and other entities to innovate in the collection, recovery and return processes of products and packaging and to find new opportunities to add value to the products collected.	**5**							

Part V - Stakeholder focus

1. Maturity level

Consider the following maturity levels and respective characterization for the Area/Dimension.

Area: Stakeholders focus				
Maturity levels				
Level 1	**Level 1**	**Level 1**	**Level 1**	**Level 1**
Limited analysis of the demands and expectations of "other stakeholders" on issues related to sustainability; Reduced efforts by the company in relation to "other stakeholders", involving less significant company resources and capabilities and without considering joint work; Limited communication with "other stakeholders" on sustainability-related issues.	Analysis of the demands and expectations of the "other stakeholders" in relation to sustainability made using specific instruments; Sustainability initiatives aimed at "other stakeholders" but implying limited involvement by them; Regular communication and information of the company with the "other stakeholders" in relation to issues related to sustainability.	Systematic assessment of the expectations and requirements of "other stakeholders" in relation to sustainability; Regular involvement of "other stakeholders" in sustainability-related issues involving already significant resources and capabilities on the part of the company and these "other stakeholders"	Collaborative efforts between the company and "other stakeholders" in aspects related to sustainability that imply very significant resources and capabilities on both sides; Communication and sharing of information with "other stakeholders" involving sustainability issues made using the most advanced technologies.	High collaboration between the company and "other stakeholders" in aspects related to sustainability and which implies very significant resources and capabilities, oriented towards innovation in order to provide greater benefits to society; Continuous search to improve and innovate in communication and information sharing with "other stakeholders" involving sustainability issues.

Anwser the following questions, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree. If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

Maturity level	***Level of agreement***					***Comment(s)***
	1	**2**	**3**	**4**	**5**	
Number of maturity levels						
Description of maturity levels						

2. Sub-pratices and Evolution level

The following table presents the sub-practices and the level of evolution for each one of them.

Regarding the level of evolution, indicate the level that you consider most appropriate (it may coincide with the level of evolution). As for practices, indicate the level of agreement, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree.

If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

AREA: ***Stakeholder focus (not considering customers and suppliers)***	***Evol. Level Sugest***	***Indicate the Evol. Level most appropriate***					***Sub-practices: Level of agreement (1 to 5)***	***Comment(s)***
Sub-practices		**1**	**2**	**3**	**4**	**5**		
The company identifies and analyzes the needs/expectations/requirements of its stakeholders (Official bodies, NGOs, etc.)	**1**							
Communication with most of its stakeholders (in addition to SC partners) such as official bodies, NGOs, etc., is done in relation to their objectives/projects/initiatives (with an economic focus) using traditional communication and information technologies	**1**							
Donates to philanthropic organizations	**1**							
The company only responds to requests made to it by the community and other stakeholders for support on sustainability issues	**1**							
The company uses specific methodologies/instruments for analyzing "other stakeholders" to clearly identify and document their expectations/requests/main objectives in relation to sustainability	**2**							
The company communicates regularly with most of the "other stakeholders" (official bodies, NGOs, etc.) and informs them of its environmental initiatives	**2**							
The company communicates regularly with most of the "other stakeholders" (official bodies, NGOs, etc.) and informs them of its social initiatives	**2**							
The company has some programs oriented to the benefit of society such as training and community development activities (employment promotion, health and hygiene, social inclusion, etc.)	**2**							
The company develops initiatives and programs for society related to environmental protection	**2**							
The company systematically assesses the expectations, requests/needs of "other stakeholders"	**3**							
The company defines an approach/strategy in terms of sustainability for each type of stakeholder, including "other stakeholders" besides suppliers and customers	**3**							
The company works with industry competitors to standardize social and environmental requirements for its suppliers and procurement items.	**3**							

The company collaborates on a regular basis with NGOs or other entities on issues such as the training of its human resources and/or the training/education of its customers and/or suppliers in environmental matters	**3**							
The company uses advanced communication and information technologies (e.g., Electronic Data Interchange, Customer Relationship Management, e-commerce, Business intelligence, etc.) with most of its stakeholders, including "other stakeholders" to obtain and share information on issues relevant to sustainability	**4**							
The company systematically and controlled assesses the expectations/requests/main objectives of its stakeholders, including "other stakeholders" in addition to suppliers and customers	**4**							
The company collaborates on a regular basis with NGOs or other entities on issues such as the training of its human resources and/or the training/education of its customers and/or suppliers in social matters	**4**							
The company collaborates with other stakeholders (such as universities, research institutions and others) in the development of new environmental technologies or more environmentally friendly products	**4**							
The company collaborates with government agencies in the management of end-of-life products and in the collection of products	**4**							
Communication with most of its stakeholders is done by looking for new forms of communication and information and the use of more advanced technologies, collecting and sharing information including on sustainability issues	**5**							
The company continuously evaluates and improves procedures to respond to the requests/needs and expectations of its stakeholders, including "other stakeholders", with regard to sustainability	**5**							
Innovative partnerships (e.g., NGOs and community groups) related with projects focused on environmental protection	**5**							
Innovative partnerships (e.g., NGOs and community groups) related with projects focused on social development and local education	**5**							

Part VI - Final remarks and comments

1. Global Maturity level

In addition to the possibility that maturity levels can be determined for each area, it is also considered that the model includes a global maturity level.

Supply chain				
Maturity levels				
Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Sustainability is not an important element of business strategy; Reporting and performance management are limited and focused on economic aspects; The mobilization of resources and efforts are very limited; The main objective is to meet legislation/compliance; Involvement with SC partners and other stakeholders in environmental and social practices is very limited and with a reactive attitude.	Concern to comply with applicable legislation in the various aspects of sustainability; Implementation of sustainability practices in different areas of decision making but the focus is mainly internal and is oriented towards the economic dimension; Awareness of the social and environmental aspects of SC with the integration of environmental and social issues into the SCM system but still in a limited manner; Sustainability practices at the SC level implying limited involvement of suppliers and, customers; Limited involvement with "other stakeholders".	Organisations are compliant with regulations but proactive on sustainability; Sustainability gains formal structures; Performance management integrates sustainability aspects and SC is included in these systems; More comprehensive internal sustainability reporting; Customers and suppliers are involved in new types of collaboration; Collaboration with "other stakeholders" on sustainability initiatives.	Sustainability is considered a key business strategy and integrated into SC: suppliers, customers, and other stakeholders engage and collaborate on sustainability initiatives; Organisation and suppliers share information; Suppliers are encouraged to be aligned with sustainability objectives; Information sharing and interaction with customers are fundamental; Sustainability are extent regularly to SC partners and other stakeholders; Demanding sustainability practices that imply a high degree of collaboration and/or demand request for resources.	Sustainability is integrated into the business, and there is anticipation and proactive action; Sustainability issues are embedded at all levels and business processes; A full cycle of information exchange between SC partners and other stakeholders; High collaboration on sustainability practices from a TBL perspective are oriented toward value creation and innovation.

2. Discrimination criterion

To move from one maturity level to another, the criterion to consider is that 90% of the sub-practices included in the level are formalized, documented and systematically implemented.

Considering the previous aspects, answer the following questions, using a scale of 1 to 5 where: (5) Strongly agree, (4) agree, (3) Neither agree nor disagree, (2) disagree, (1) Strongly disagree. If you want to leave a comment, suggestion/criticism in order to improve the MM, use the space indicated.

Maturity level and discrim. Crit.	***Level of agreement***					***Comment(s)***
	1	**2**	**3**	**4**	**5**	
Number of maturity levels						
Description of maturity levels						
Discrimination criterion						

Finally, if you wish to comment on the Areas/Dimensions, practices and sub-practices, maturity levels, or any other aspect of the MM, please use the space below. We appreciate all contributions that can help improve the MM and our work.

Thank you!

Appendix C- List of validated Maturity Model Practices and Sub-practices

C1. Practices code by MM area

AREAS	Code	PRACTICES
AREA: Sustainability governance	PRACTICES	
	PEN1	Corporate environmental governance
	PS1	Corporate social governance
	PRP	Reporting and performance management
AREA: Product and process level	PRACTICES	
	PEN2	Ecodesign
	PEN3	Green purchasing
	PEN4	Green production
	PEN7	Green distribution and logistics
	PS2	Social purchasing
	PS3	Labour practices
	PS4	Employee health and safety
	PS5	Employee development, training and education
	PE1	Quality management
	PE2	Lean management
AREA: Customer and supplier management	PRACTICES	
	PS6	Social supplier management practices
	PS7	Social costumer management practices
	PEN6	Environmental Costumer management practices
	PE4	Costumer management (economic issues)
	PEN5	Environmental supplier management practices
	PE3	Supplier management (economic issues)
	PEN8	Reverse logistics
AREA: Stakeholder focus (not considering customers and suppliers)	PRACTICES	
	PS8	Stakeholder focus (social issues)
	PE5	Stakeholders focus (economic issues)
	PEN9	Stakeholders focus (environmental issues)

C2. List of Maturity Model sub-practices by area and evolution levels (after validation)

Practices Code	Evol. Level	Sub-practices	References
AREA: Sustainability Governance			
PEN1	1	Environmental issues are considered in some functional areas (e.g., logistics, purchasing)	Adapted from Zhu et al. (2012); Zhu et al., (2013); Holt & Ghobadian (2009)
PEN1	1	There is an individual/working group with some responsibilities in the area of environmental sustainability	Okongwu et al. (2013); Kurnia et al. (2014); Sukitsch et al. (2015)
PRP	1	Indicators traditionally linked to the economic dimension (e.g., financial, operational) are used in the evaluation of the company's performance	Okongwu et al. (2013)
PEN1	2	In the formal structure of the organization, an organizational unit/work group dedicated to	Okongwu et al. (2013); Kurnia et al. (2014); Sukitsch et al. (2015)

		managing the area of environmental sustainability is considered	
PS1	2	In the formal structure of the organization, an organizational unit/work group dedicated to managing the area of social sustainability is considered	Okongwu et al. (2013); Kurnia et al. (2014); Sukitsch et al. (2015)
PRP	2	Internal performance evaluation systems integrate some social and/or environmental aspects (e.g., indicators, targets)	Adapted from Zhu et al. (2012); Zhu et al. (2013)
PS1	2	Data are collected on social aspects	Kurnia et al. (2014)
PEN1	2	Data are collected on environmental aspects	Kurnia et al. (2014)
PRP	2	The reporting of some aspects of sustainability is done to top management	Kurnia et al. (2014)
PEN1	3	Environmental compliance and auditing programs in all departments	Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2013); Kirchoff et al. (2016); Jia et al. (2015)
PEN1	3	Commitment to GSCM from senior and middle level managers	Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Jia et al. (2015); Gouvinhas et al. (2016)
PS1	3	Established a set of transparent, comprehensive and stringent ethical codes of conduct	Xavier (2017)
PS1	3	Commitment to social SCM from senior and middle level managers	Adapted from Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Zhu et al. (2013); Masoumik et al. (2014); Jia et al. (2015); adapted from Gouvinhas et al. (2016)
PRP	3	The sustainability reporting is done internally for top management, for other levels of management and for employees	Kurnia et al. (2014)
PEN1	4	Obtaining ISO 14001 certification	Zhu et al. (2007); Zhu et al. (2008); Azevedo et al. (2011); Zhu et al. (2012); Zhu et al. (2013); Liu et al. (2012); Kirchoff et al. (2016); Holt & Ghobadian, 2009; Xavier (2017)
PEN1	4	There are cross-functional cooperation practices for environmental improvements	Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Lun et al. (2015); Pinto (2014)
PS1	4	There are cross-functional cooperation practices for social improvements	Pinto (2014)
PRP	4	Internal performance evaluation systems integrate social and/or environmental aspects related to the supply chain partners considered most important	Okongwu et al. (2013)
PRP	4	Internal and external sustainability reporting is done where some aspects (e.g., initiatives, performance) related to the supply chain are mentioned	Okongwu et al. (2013)
PS1	5	The company has an Integrated Management System, capable of integrating quality systems with health and safety, environmental management and social responsibility.	Xavier (2017)
PRP	5	Performance appraisal systems are used that integrate all elements of the TBL, and that integrate information regarding SC and other stakeholders (e.g., NGOs)	Adapted from Okongwu (2013)
PRP	5	The company uses the services of an independent auditing body to certify the reliability of the reported information	Adapted from Okongwu et al. (2013)
PRP	5	Sustainability reporting is done internally and externally, and integrates all dimensions of the TBL, and aspects related to supply chain SC and other stakeholders	Kurnia et al. (2014); Srai et al. (2013)

PEN1	5	Various tools are used and combined (e.g., Life Cycle Analysis, risk analysis) for a more complete assessment of environmental sustainability	Sonnemann et al. (2015)
AREA: Product and process level			
PEN2	1	Design considers regulations and policies to ensure compliance	Adapted from Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Zhu et al. (2013); Jia et al. (2015); Kirchoff et al. (2016); Xavier (2017)
PEN2	2	In design, the company focuses on incremental improvements in the environmental performance of existing products at specific stages of their life cycle.	Pigosso et al. (2013)
PEN2	2	There are defined guidelines for the environmental design of products	Paulraj et al. (2017); Xavier (2017); Machado et al. (2015)
PEN2	3	Designing products for reuse, recycle, recovery of materials, components and parts	Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Zhu et al. (2013); Masoumik et al. (2014); Kirchoff et al. (2016)
PEN2	3	Design of products for reduced consumption of material and energy	Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Zhu et al. (2013); Jia et al. (2015); Kirchoff et al. (2016); Das (2017)
PEN2	3	Designing products/processes to avoid or reduce use of hazardous materials/substances;	Zhu et al. (2007); Zhu et al. (2008); Marshall et al. (2014); Jia et al. (2015); Vanalle & Santos (2014)
PEN2	4	Product design is simultaneously oriented towards reducing the overall environmental impact of the product (e.g., reduction of materials and energy) and increasing its useful life, from a life cycle perspective.	Pigosso et al. (2013)
PEN2	4	In the design of the products, social sustainability criteria are incorporated	Xavier (2017)
PEN2	5	The company extensively uses advanced Eco-design techniques and tools (e.g., Eco-design PILOT, LCA) tailored to your situation	Xavier (2017)
PN4	1	The company implements techniques and procedures for waste reduction and damage control (e.g., use of filters and controls for emissions and discharges, wastewater treatment) required by legislation	Adapted from Azevedo et al. (2011)
PN4	2	Reducing resource consumption during production	Jia et al. (2015); Vanalle & Santos (2014)
PN4	2	The company favors the use in the production of environmentally friendly subsidiary and consumable materials (e.g., cleaning, maintenance)	Azevedo et al. (2011); Shi et al. (2012); Machado et al. (2015); Subramanian et al. (2017)
PN4	3	Optimization of process to reduce solid/liquid waste and generation of hazardous wastes and optimize material exploitation	Rao & Holt (2005); Shi et al. (2012); Zhu et al., 2013; Masoumik et al. (2014); Machado et al. (2015)
PN4	3	The company replaces its technology (means of production) with cleaner technologies/use of alternative energy sources	Rao & Holt (2005); Azevedo et al. (2011); Masoumik et al. (2014); Dubey et al. (2016)
PN4	4	Maximizing use of renewable or recycled source materials for product manufacturing	Azevedo et al. (2011); Zailani et al. (2012); Marshall et al. (2014); Jia et al. (2015)
PN4	4	Tools/systems are used to assess, control, and improve environmental aspects at the level of processes	Adapted from Machado et al. (2015)
PN4	5	The techniques, procedures and technologies used in production are periodically reassessed to continuously improve environmental performance	Adapted from Machado et al. (2015)
PEN3	1	Compliance with environmental legislation such as external purchasing directives	Holt & Ghobadian (2009); Machado et al (2015)
PEN3	1	The company identifies materials that should not be used in products and to avoid when purchasing	Subramanian et al. (2017)

PEN3	2	Suppliers are selected using environmental criteria (e.g., environmental competence, performance, ISO 14001)	Thun & Müller (2010); Zhu et al. (2013); Hoejmose et al. (2014)
PS2	2	Suppliers are selected using criteria that include ethical and social dimensions	Adapted from Vachon & Klassen (2006); Rao & Holt (2005); Thun & Müller (2010); Miemczyk & Luzinni (2018)
PEN3	3	Providing design specification to suppliers that include environmental requirements for purchased items	Zhu et al. (2007); Zhu et al. (2008); Azevedo et al. (2011); Zhu et al. (2013); Paulraj (2011); Liu et al. (2012); Grekova et al. (2016); Das (2017); Miemczyk & Luzinni (2018)
PS2	3	Consider ethical and human rights/welfare issues formally in our purchasing decisions	Holt & Ghobadian (2009)
PEN3	3	The company purchase materials/products that are efficient in terms of energy and water consumption, and that are non-polluting, toxic or dangerous	Hsu et al. (2014); Machado et al. (2015)
PEN3	4	There are ongoing education and training programs on environmental issues for purchasing staff	Awaysheh & Klassen (2010); Hsu et al. (2014); Machado et al. (2015)
PS2	4	There are ongoing education and training programs on social issues for purchasing staff	Awaysheh & Klassen (2010); Adapted from Hsu et al. (2014); Machado et al. (2015);
PEN3	4	The company purchase materials/products that are easy to recycle or recycle, and recycled packaging	Liu et al. (2012); Machado et al (2015)
PS2	5	The company has a purchasing strategy that considers (in addition to economic aspects) social aspects	Adapted from Holt & Ghobadian (2009) and Machado et al (2015)
PEN3	5	The company has a purchasing strategy that considers (in addition to economic aspects) environmental aspects	Adapted from Holt & Ghobadian (2009) and Machado et al (2015)
PEN7	1	Transport is chosen based on cost and delivery time	Subramanian et al. (2017)
PEN7	1	The company avoids the use of packaging produced with hazardous materials	Holt & Ghobadian (2009); Subramanianet al. (2017)
PEN7	2	Use of environmentally friendly transportation	Azevedo et al. (2011); Shi et al. (2012); Subramanian et al. (2017)
PEN7	2	The company has a documented environmental policy in relation to logistics/transport	Holt & Ghobadian (2009); Azevedo et al. (2011)
PEN7	3	We plan the routes of our vehicles in order to reduce environmental impacts	Zhu et al. (2008); Shi et al., (2012); Zhu et al. (2013); Masoumik et al. (2014); Kirchoff et al. (2016); Subramanian et al. (2017)
PEN7	3	The company has systems to reduce environmental impacts (e.g., for energy efficiency) in the warehouses	Holt & Ghobadian (2009)
PEN7	4	Environmental improvement of packaging such as using ecological materials for primary packaging	Holt & Ghobadian (2009); Subramanian et al. (2017)
PEN7	4	The company invests in vehicles designed to have lower environmental impacts	Holt & Ghobadian (2009); Subramanian et al. (2017)
PEN7	5	Use of advanced tools/systems that enable product traceability (e.g., VMI), which may imply collaboration with supply chain partners	Adapted from Subramanian et al. (2017)
PS4	1	The company focuses on safety and health measures in some of the most critical phases of the production process (e.g., manufacturing phase)	Mani et al. (2015); Machado et al. (2015); Machado et al. (2017)
PS4	1	The company focuses on complying with the safety and health aspects required by legislation	Adapted from Gavronski et al. (2011), and Subramanian et al. (2017)
PS4	2	The company carries out periodic health exams, and has other initiatives, in addition to what is required by legislation, to increase the health and well-being of workers.	Mani et al. (2015); Machado et al. (2015) Machado et al. (2017)
PS4	3	The company carries out a detailed hazard identification and health risk assessment exercise	Mani et al. (2015); Machado et al. (2015); Machado et al. (2017)

PS4	3	Safe working conditions for employees in all areas of the company	Pullman et al. (2010); Machado et al. (2015); Machado et al. (2017)
PS4	4	The company provides health care facilities for the employees	Mani et al. (2015); Machado et al (2015); Machado et al. (2017)
PS4	5	An occupational health and safety management system is in place (OHSAS 18001)	Zhu & Zhang (2015); Mani et al. (2015); Machado et al (2015); Machado et al. (2017); Xavier (2017)
PS3	1	Firm prohibit bonded labour and child labour	Mani et al. (2015); Das (2017); Baliga et al. (2020)
PS5	1	The company provides training to its workers to comply with legislation, in traditional areas such as quality, human resources, marketing, etc.	Adapted from Baliga et al. (2020)
PS3	2	Fair compensation (living wage) to all employees	Pullman et al. (2010); Baliga et al. (2020)
PS5	2	The company provides training to its workers in techniques/methods and concepts related to sustainability (e.g., environmental area)	Zhu et al. (2012); Zhu et al. (2013); Jia et al. (2015); Xavier (2017)
PS3	3	The firm ensures that there is no discrimination against any employee on the grounds of racism, colour, religion, caste, gender, age, marital status, disability, and nationality	Mani et al. (2015); Baliga et al. (2020); Mani et al. (2020)
PS5	3	The company has systems to assess worker job satisfaction	Pullman et al. (2010); Marshall et al. (2014); Marshall et al. (2015)
PS5	4	Educating and training people for skill development	Baliga et al. (2020)
PS5	4	The company encourages most of its workers to participate in various activities (e.g., departmental communication meetings, human resources initiatives, recreational activities, etc.)	Mani et al. (2015); Subramanian et al. (2017)
PS5	5	Sustainability-related criteria are included in employee performance assessment to reinforce the company's sustainability culture	Xavier (2017)
PS5	5	The company involves its workers in the implementation of new ideas and in continuous improvement initiatives in socio-environmental issues	Subramanaian et al. (2017)
PE2	1	The company keeps its shop floor well organized and clean.	Patyal & Koilakuntla (2017); Machado et al. (2015); Machado et al. (2017)
PE1	1	Quality control/inspection techniques are used	Adapted from Yang (2013)
PE1	2	Conducts preventive equipment maintenance	Yang (2013); Filho et al. (2016); Patyal & Koilakuntla (2017); Green et al. (2019); Hussain et al. (2019); Baliga et al. (2020)
PE1	2	Quality improvement programs are implemented in some areas (e.g., production) of the organization	Yang (2013); Machado et al. (2015); Machado et al. (2017)
PE1	3	Use statistical process control techniques to reduce process variance	Yang (2013); Wu et al. (2015); Patyal & Koilakuntla (2017); Green et al. (2019); Baliga et al. (2020)
PE2	3	Working to lower setup times in our plant (e.g., using Kaisen)	Yang (2013); Filho et al. (2016); Baliga et al. (2020); Machado et al. (2015); Machado et al. (2017); Green et al. (2019)
PE1	3	Quality management system/ISO 9000 certification	Yang (2013); Shokri et al., (2014); Torugsa et al. (2013); Jabbour et al. (2014)
PE2	4	To use a “Pull” production system	Yang (2013); Baliga et al. (2020)
PE2	4	To follow Just-in-time/Scientific inventory control technique consistently to keep inventory under control in the production environment	Hussain et al. (2019); Das (2017)
PE2	5	The company implements several Lean practices (e.g., JIT, total preventive maintenance), controls and integrates them to minimize waste	Adapted from Hong et al. (2014)

PE1	5	Efforts are made to optimize its processes by continuously improving its techniques/systems in an integrated perspective	Adapted from Hong et al. (2014)
AREA: Costumer and Supplier management			
PE4	1	The company conducts customer satisfaction surveys	Filho et al. (2016); Hussain et al. (2019)
PE4	1	We frequently are in close contact with our customers	Kaynak & Montiel (2009); Filho et al. (2016); Hussain et al. (2019); Baliga et al. (2020)
PS6	2	Information about product to users (such as labeling, info about ingredients, origin, potential dangers) to educate the user on how to properly use, consume and dispose of the product	Baliga et al. (2020)
PE4	2	Our costumers give us feedback on our quality and delivery performance	Baliga et al. (2020)
PS7	3	Assess product misuse (with potential health hazards) encouraging consumers self- reporting	Klassen & Vereecke (2012)
PS7	3	Ensuring the basic safety of our products for consumers, reducing health risks for them (e.g., avoid or reduce the use of hazardous materials/ contaminants/ nutrients)	Marshall et al. (2014); Das (2017); Thong & Wong (2018)
PE4	3	Our customers are directly involved in current and future product offerings	Filho et al. (2016); Baliga et al. (2020)
PEN6	4	Cooperation with customers for using less energy (fuel) during product transportation	Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Zhu et al. (2013); Grekova et al. (2016)
PE4	4	Customer involvement in company quality programs	Panizzolo (1998)
PEN6	5	Cooperation with customers for eco-design	Zhu et al. (2008); Azevedo et al. (2011); Albino et al. (2012); Zhu et al. (2012); Shi et al. (2012); Zhu et al. (2013); Masoumik et al. (2014); Jia et al. (2015); Das (2017)
PEN6	5	Cooperation with customers for cleaner production	Zhu et al. (2008); Azevedo et al. (2011); Zhu et al. (2012); Zhu et al. (2013); Masoumik et al. (2014); Jia et al. (2015); Das (2017); Baliga et al. (2020)
PE3	1	Communication with suppliers is focused on economic issues (e.g., resolution of specific problems/issues such as pricing and others related to supply contracts, etc.)	Adapted from Yang (2013) and Machado (2015)
PE3	1	Suppliers are asked to guarantee compliance with legislation/technical standards relating to their products	Klassen & Vereecke (2012)
PE3	1	The selection of suppliers is based on economic issues (e.g., costs, delivery times, etc.)	Adapted from Miemczyk & Luzinni (2018)
PS6	2	The company has guidelines on social issues for supplier management (e.g., code of conduct)	Kaynak & Montiel (2009); Awaysheh & Klassen (2010); Baliga et al. (2020)
PE3	2	Assess the quality standard of suppliers (e.g., through ISO 9001 certification)	Yang (2013); Jabbour et al. (2014)
PEN5	2	Request existing primary suppliers to provide evidence of all environmental licenses and permits	Gavronski et al. (2011)
PS6	3	Ensuring suppliers obtain OHSAS 18001 certification or other health and safety management system certification as SA 8000	Klassen & Vereecke (2012); Marshall et al. (2014); Marshall et al. (2015); Mani et al. (2015); Croom et al. (2018); Thong & Wong (2018)
PS6	3	Perform audits/has audit procedures for suppliers' internal management system related whit social issues (e.g. related with health and safety, appropriate labour working conditions)	Awaysheh & Klassen (2010); Marshall et al. (2014); Marshall et al. (2015); Sancha et al. (2016); Mani et al. (2018); Tong

			& Wong (2018); Miemczyk & Luzinni (2018); Baliga et al. (2020)
PEN5	3	Conduct regular environmental audits into suppliers' internal operations	Paulraj (2011); Tate et al. (2012); Gavronski et al. (2011); Gimenez & Sierra (2013); Zhu et al. (2013); Marshall et al. (2014); Hoejmose et al. (2014); Tachizawa et al. (2015); Jia et al. (2015); Miemczyk & Luzinni (2018)
PEN5	3	The company ensures that its suppliers have the ISO 14001 environmental management system certification	Zhu et al. (2007); Zhu et al. (2008); Zhu et al. (2012); Shi et al. (2012); Zhu et al. (2013); Jia et al. (2015); Kirchoff et al. (2016)
PEN5	4	The company guides and supports (through training/education visits, technical support) its suppliers to help them improve their environmental performance	Gimenez & Sierra (2013), Tate et al. (2012); Liu et al. (2012); Tachizawa et al. (2015); Jia et al. (2015); Miemczyk & Luzinni (2018)
PS6	4	The company guides and supports (through training/education visits, technical support) its suppliers to help them improve their social performance	Awaysheh & Klassen (2010); Sancha et al. (2016)
PE3	4	The company facilitate our suppliers implement quality programs/TQM/Six sigma/TPM/TQC to build quality into the product/	Das (2017)
PE3	4	Supplier delivers to our plant on a Just-in-time (JIT) basis	Hussain et al. (2019); Mani et al. (2015); Baliga et al. (2020)
PEN5	5	Cooperating with suppliers to reduce packaging/ eliminate packaging	Thun & Müller (2010); Zhu et al. (2012); Gold et al. (2010); Zhu et al. (2013); Vanalle & Santos (2014)
PS6	5	Develop new product/process with suppliers that reduces health risks for consumers	Marshall et al. (2014); Marshall et al. (2015); Mani et al. (2015); Croom et al. (2018)
PEN5	5	The company works together with suppliers to reduce the environmental impact of their logistics operations	Kirchoff et al. (2016)
PEN5	5	The company collaborates with suppliers in areas such as production planning and coordination of production processes	Paulraj (2011)
PEN5	5	Joint product design with suppliers (e.g., design for reduced consumption of material/energy, design for recycle, design to avoid use of hazardous products, etc.)	Zhu et al. (2007); Holt & Ghobadian (2009); Vanalle & Santos (2014); Tachizawa et al. (2015)
PEN8	1	The company follows the obligations imposed by legislation regarding the collection, disposal, recovery, recycling and reuse of end-of-life products and packaging.	Hsu et al. (2016)
PEN8	2	The company labels its packaging in order to facilitate its recovery	Masoumik et al. (2014)
PEN8	3	Recovery of the company's end-of-life products or unwanted products and materials (for recycling, reuse, remanufacturing, repair)	Zhu et al. (2012); Zhu et al. (2013); Shi et al. (2012); Diabat et al. (2013); Masoumik et al. (2014)
PEN8	4	The company uses systems/tools that allow the collection and analysis of information regarding the collected/returned products and allow their management and decision-making in relation to them.	Adapted from Laosirihongthong et al. (2013)

PEN8	5	The company collaborates with members of its supply chain and other entities to innovate in the collection, recovery and return processes of products and packaging and to find new opportunities to add value to the products collected.	Adapted from Laosirihongthong et al. (2013)
AREA: Stakeholder focus (not considering customers and suppliers)			
PE5	1	The company identifies and analyzes the needs/expectations/requirements of its stakeholders (official bodies, NGOs, etc.)	Simas et al. (2013)
PE5	2	Communication with most of its stakeholders (in addition to SC partners) such as official bodies, NGOs, etc., is done in relation to their objectives/projects/initiatives (with an economic focus) using traditional communication and information technologies	Adapted from Simas et al. (2013)
PS8	2	Donates to philanthropic organizations	Carter & Jennings (2002); Baliga et al. (2020); Mani et al. (2015); Mani et al. (2020)
PS8	3	The company has some programs oriented to the benefit of society such as training and community development activities (employment promotion, health and hygiene, social inclusion, etc.)	Mani et al. (2015); Baliga et al. (2020); Mani et al. (2020)
PE5	3	Communication with most of its stakeholders is done by looking for new forms of communication and information and the use of more advanced technologies, collecting and sharing information including on sustainability issues	Adapted from Simas et al. (2013)
PEN9	4	The company develops initiatives and programs for society related to environmental protection	Klassen & Vereecke (2012)
PEN9	4	The company collaborates with other stakeholders (e.g., official entities) to innovate in the processes of collection, recovery and return of products and packaging and to find new opportunities to value the collected products	Adapted from Albino et al. (2012)
PEN9	4	The company collaborates with other stakeholders (such as universities, research institutions and others) in the development of new environmental technologies or more environmentally friendly products	Albino et al. (2012)
PS8	5	Innovative partnerships (e.g., NGOs and community groups) related with projects focused on social development and local education	Dahan et al. (2010); Klassen & Vereecke (2012); Das (2017)
PEN9	5	Innovative partnerships (e.g., NGOs and community groups) related with projects focused on environmental protection	Albino et al. (2012)

References

Albino, V., Dangelico, R.M., & Pontrandolfo, P. (2012). Do inter-organizational collaborations enhance a firm's environmental performance? A study of the largest U.S. companies. *Journal of Cleaner Production*, *3*, 304-315. https://doi.org/10.1016/j.jclepro.2012.07.033

Azevedo, S.G., Carvalho, H., & Machado, V.C. (2011). The influence of green practices on supply chain performance: A case study approach. *Transportation Research Part E*, *47*, 850–871. https://doi.org/10.1016/j.tre.2011.05.017

Baliga, R., Raut, R., & Kamble, S. (2020), The effect of motivators, supply, and lean management on sustainable supply chain management practices and performance: Systematic literature review and modeling, *Benchmarking: An International Journal*, *27*(1), 347-381.

https://doi.org/10.1108/BIJ-01-2019-0004

Carter, C.R. & Jennings, M.M. (2002). Logistics social responsibility: an integrative framework. *Journal of Business Logistics*, *23*(1), 145-80. https://doi.org/10.1002/j.2158-1592.2002.tb00020.x

Croom, S., Vidal, N., Spetic, W., Marshall, D., & McCarthy, L. (2018). Impact of social sustainability orientation and supply chain practices on operational performance. *International Journal of Operations & Production Management*, 38(12), 2344-2366. https://doi.org/10.1108/IJOPM-03-2017-0180

Dahan, N.M.; Doh, J.P., Oetzel, J., & Yaziji, M. (2010). Corporate-NGO Collaboration: Co-creating New Business Models for Developing Markets. *Long Range Planning*, *43*(2-3), 326-342. https://doi.org/10.1016/j.lrp.2009.11.003

Das, D. (2017). Development and validation of a scale for measuring Sustainable Supply Chain Management practices and performance. *Journal of Cleaner Production*, *164*(15), 1344-1362. https://doi.org/10.1016/j.jclepro.2017.07.006

Diabat A., Khodaverdi, R., & Olfat, L. (2013) An exploration of green supply chain practices and performances in an automotive industry. *The International Journal of Advanced Manufacturing Technology*, 68, 949–961. https://doi.org/10.1007/s00170-013-4955-4

Dubey, R, Gunasekaran, A, Papadopoulos, T, Childe, S.J., Shibin, K.T., & Wamba, S.F. (2017). Sustainable Supply Chain Management: Framework and Further Research Directions. *Journal of Cleaner Production*, 142(2), 20, 1119-1130, ttps://doi.org/10.1016/j.jclepro.2016.03.117.

Filho, M.G., Ganga, G.M.D., & Gunasekaran, A. (2016). Lean manufacturing in Brazilian small and medium enterprises: implementation and effect on performance. *International Journal of Production Research*, 54(24), 7523-7545. https://doi.org/10.1080/00207543.2016.1201606

Gavronski, I., Klassen, R.D., Vachon, S., & Machado do Nascimiento, L.F. (2011). A resource-based view of green supply management. *Transportation Research Part E: Logistics and Transportation Review*, *47*(6), 872–885. https://doi.org/10.1016/j.tre.2011.05.018

Gimenez, C. & Sierra, V. (2013). Sustainable Supply Chains: Governance Mechanisms to Greening Suppliers. *Journal of Business Ethics,* 116, 189-203. https://doi.org/10.1007/s10551-012-1458-4

Gold, S., Seuring, S., & Beske, P. (2010). Sustainable supply chain management and inter-organizational resources: a literature review. *Corporate Social Responsibility and Environmental Management*, 17(4), 230–245. https://doi.org/10.1002/csr.207

Gouvinhas, R. P., Reyes, T., Naveiro, R., M., Perry, N., & Filho, E. R., (2016). A proposed framework of sustainable self-evaluation maturity within companies: an exploratory study. *International Journal on Interactive Design and Manufacturing*, 10(3), 319-327. https://doi.org/10.1007/s12008-016-0322-7

Green, K.W., Inman, R.A., Sower, V.E., & Zelbst, P.J. (2019), Impact of JIT, TQM and green supply chain practices on environmental sustainability, *Journal of Manufacturing Technology Management*, 30(1), 26-47. https://doi.org/10.1108/JMTM-01-2018-0015

Grekova, K., Calantone, R.J., Bremmers, H.J., Trienekens, J.H., & Omta, S.W.F. (2016). How environmental collaboration with suppliers and customers influences firm performance: evidence from Dutch food and beverage processors. *Journal of Cleaner Production*, 112 (3), 1861-1871. https://doi.org/10.1016/j.jclepro.2015.03.022

Hoejmose, S.U., Grosvold, J., & Millington, A. (2014). The effect of institutional pressure on cooperative and coercive 'green' supply chain practices. *Journal of Purchasing & Supply Management*, *20*(4), 215–224. https://doi.org/10.1016/j.pursup.2014.07.002

Holt, D. & Ghobadian, A. (2009). An empirical study of green supply chain management practices amongst UK manufacturers. *Journal of Manufacturing Technology Management*, 20(7), 933 - 956. https://doi.org/10.1108/17410380910984212

Hsu, P. F., Hu, P. J. H., Wei, C. P., & Huang, J. W. (2014). Green purchasing by MNC subsidiaries: The role of local tailoring in the presence of institutional duality. *Decision Sciences*, *45*(4), 647-682. https://doi.org/10.1111/deci.12088

Hussain, M., Al-Aomar, R., & Melhem, H. (2019). Assessment of lean-green practices on the sustainable performance of hotel supply chains. *International Journal of Contemporary Hospitality Management*, *31*(6), 2448-2467. https://doi.org/10.1108/IJCHM-05-2018-0380

Jabbour, A.B.L.S., Jabbour, C., J. C., Latan, H., Teixeira, A.A., & Oliveira, J.H.C. (2014). Quality

management, environmental management maturity, green supply chain practices and green performance of Brazilian companies with ISO 14001 certification: Direct and indirect effects, *Transportation Research Part E: Logistics and Transportation Review*, 67, 39–51. https://doi.org/10.1016/j.tre.2014.03.005

Jia, P., Diabat, A., & Mathiyazhagan, K. (2015). Analyzing the SSCM practices in the mining and mineral industry by ISM approach. *Resources Policy*, 46, 76–85. https://doi.org/10.1016/j.resourpol.2014.04.004

Kaynak, H. & Montiel, I. (2009, August). The relationship between sustainable supply chain management and sustainable performance: an integrated framework In *Academy of Management Proceedings* (Vol. 2009, No. 1, pp. 1-6). Briarcliff Manor, NY 10510: Academy of Management.

Kirchoff, J.F., Tate, W.L., & Mollenkopf, D.A. (2016). The impact of strategic organizational orientations on green supply chain management and firm performance. *International Journal of Physical Distribution & Logistics Management,* 46(3), 269-292. https://doi.org/10.1108/IJPDLM-03-2015-0055

Klassen, R.D. & Vereecke, A. (2012). Social Issues in Supply Chains: Capabilities Link Responsibility, Risk (Opportunity), and Performance. *International Journal of Production Economics*, *140*(1), 103–115. https://doi.org/10.1016/j.ijpe.2012.01.021

Kurnia, S., Rahim, M.M., Samson, D., & Singh, P. (2014). Sustainable supply chain management capability maturity: Framework development and initial evaluation. *in Proceedings of the 22nd European Conference on Information Systems in Tel Aviv*, ECIS 2014.1-10. http://aisel.aisnet.org/ecis2014/

Laosirihongthong, T., Adebanjo, D., & Tan, K.C. (2013). Green supply chain management practices and performance. *Industrial Management & Data Systems*, 113(8), 1088 – 1109. https://doi.org/10.1108/IMDS-04-2013-0164

Liu, X., Yang, J., Qu, S., Wang, L., Shishime, T., & Bao, C. (2012). Sustainable Production: Practices and Determinant Factors of Green Supply Chain Management of Chinese Companies. *Business Strategy and the Environment*, 21, 1–16. https://doi.org/10.1002/bse.705

Lun, Y.H.V., Lai, K., Wong, C. W.Y. & Cheng, T.C.E. (2015) Environmental governance mechanisms in shipping firms and their environmental performance, Transportation Research Part E, 78, 82–92. https://doi.org/10.1016/j.tre.2015.01.011

Machado, C. G. (2015). *Developing a maturity framework for sustainable operations management* (Doctoral dissertation), Pontifical Catholic University of Paraná, Brasil.

Machado, C. G., Lima, E. P., Costa, S. E. G., Angelis, J., J. & Mattioda, R. A. (2017). Framing maturity based on sustainable operations management principles. *International Journal of Production Economics*, 190, 3–21. https://doi.org/10.1016/j.ijpe.2017.01.020

Mani, V., Agrawal, R., & Sharma, V. (2015). Social sustainability practices in the supply chain of Indian manufacturing industries. *International Journal of Automation and Logistics*, 1(3), 211–233. https://doi.org/10.1504/IJAL.2015.071721

Mani, V., Gunasekaran, A., & Delgado, C. (2018). Supply chain social sustainability: Standard adoption practices in Portuguese manufacturing firms. *International Journal of Production Economics*, 198, 149–164. https://doi.org/10.1016/j.ijpe.2018.01.032

Mani, V., Jabbour, C.J.C., & Mani, K.T.N. (2020). Supply chain social sustainability in small and medium manufacturing enterprises and firms' performance: Empirical evidence from an emerging Asian economy. *International Journal of Production Economics*, 227, 107656, https://doi.org/10.1016/j.ijpe.2020.107656

Marshall, D., McCarthy, L., Heavey, C., & McGrath, P. (2014). Environmental and social supply chain management sustainability practices: construct development and measurement. *Production Planning & Control: The Management of Operations*, 6(8), 673-690. https://doi.org/10.1080/09537287.2014.963726

Marshall, D., McCarthy, L., McGrath, P., & Claudy, M. (2015). Going above and beyond: how sustainability culture and entrepreneurial orientation drive social sustainability supply chain practice adoption, *Supply Chain Management*, *20*(4), 434-454. https://doi.org/10.1108/SCM-08-2014-0267

Masoumik, S.M., Abdul-Rashid, S.H., Olugu, E.U., & Ghazilla, R.A.R. (2014). Sustainable Supply Chain Design: A Configurational Approach, *The Scientific World Journal*, 2014.

https://doi.org/10.1155/2014/897121

Miemczyk, J. & Luzzini, D. (2018). Achieving triple bottom line sustainability in supply chains: The role of environmental, social and risk assessment practices. *International Journal of Operations & Production Management*, 39(2), 238-259. https://doi.org/10.1108/IJOPM-06-2017-0334

Okongwu, U., Morimoto, R., & Lauras, M. (2013). The maturity of supply chain sustainability disclosure from a continuous improvement perspective. *International Journal of Productivity & Performance Management*, 62(8), 827-855. https://doi.org/10.1108/IJPPM-02-2013-0032

Panizzolo, R. (1998). Applying the lessons learned from 27 lean manufacturers.: The relevance of relationships management. *International journal of production economics*, *55*(3), 223-240. https://doi.org/10.1016/S0925-5273(98)00066-8

Patyal, V. S. & Koilakuntla, M. (2017). The impact of quality management practices on performance: an empirical study, *Benchmarking: An International Journal*, 24(2), 511-535. https://doi.org/10.1108/BIJ-11-2015-0109

Paulraj, A. (2011). Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability. *Journal of Supply Chain Management*, 47(1), 19–37. https://doi.org/10.1111/j.1745-493X.2010.03212.x

Paulraj, A., Chen, I., & Blome, C. (2017). Motives and Performance Outcomes of Sustainable Supply Chain Management Practices: A Multi-theoretical Perspective. *Journal of Business Ethics*, 145, 239–258, https://doi.org/10.1007/s10551-015-2857-0

Pigosso, D.C. A., Rozenfeld, H. & McAloone, T. C. (2013). Eco-design maturity model: a management framework to support ecodesign implementation into manufacturing companies. *Journal of Cleaner Production*, 59, 160-173. https://doi.org/10.1016/j.jclepro.2013.06.040

Pinto, LA. M.J. (2014). O Impacto das práticas sustentáveis da Cadeia de Abastecimento no desempenho da empresa [Doctoral dissertation, Universidade de Aveiro]. Repositório institucional da Universidade de Aveiro. https://ria.ua.pt/handle/10773/13283

Pullman, M.E., Maloni, M.J., & Dillard, J. (2010). Sustainability Practices in Food Supply Chains: How is Wine Different? *Journal of Wine Research*, 21(1), 35-56, https://doi.org/10.1080/09571264.2010.495853

Rao, P. & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations & Production Management*, 25(9), 898 – 916. https://doi.org/10.1108/01443570510613956

Sancha, C., Gimenez, C., & Sierra, V. (2016). Achieving a socially responsible supply chain through assessment and collaboration. *Journal of Cleaner Production*, 112, 1934-1947. https://doi.org/10.1016/j.jclepro.2015.04.137

Shi, V.G., Koh, S.C.L., Baldwin, J., & Cucchiella, F. (2012). Natural resource based green supply chain management. *Supply Chain Management: An International Journal*, 17 (1), 54 – 67. https://doi.org/10.1108/13598541211212203

Shokri, A., Oglethorpe, D., & Nabhani, F. (2014). Evaluating sustainability in the UK fast food supply chain. *Journal of Manufacturing Technology Management*, 25(8), 1224 – 1244. https://doi.org/10.1108/JMTM-04-2013-0031

Simas, M. J. B. G. C., Lengler, J. F. B., & dos Santos António, N. J. (2013). Integration of sustainable development in the strategy implementation process: proposal of a model. *Corporate Governance*, 13(5), 511-526. https://doi.org/10.1108/CG-06-2013-0075

Sonnemann, G., Gemechu, E. D., Remmen, A., Frydendal, J., & Jensen, A. A. (2015). Life cycle management: Implementing sustainability in business practice. In *Life cycle management* (pp. 7-21). Springer, Dordrecht.

Srai, J. S., Alinaghian, L. S., & Kirkwood, D. A. (2013). Understanding sustainable supply network capabilities of multinationals: A capability maturity model approach. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *227*(4), 595-615.

Subramanian, J. A., Campos, J. K, & Wateau, E. (2017). A maturity model for sustainable supply chain practices in the consumer goods industry. 4th International EurOMA Sustainable Operations and Supply Chains Forum (SOSCF), february 27-28, Milan, Italy.

Sukitsch, M., Engert, S., & Baumgartner, R. J. (2015). The implementation of corporate sustainability in the European automotive industry: An analysis of sustainability reports. *Sustainability*, *7*(9), 11504-11531. https://doi.org/10.3390/su70911504

Tachizawa, E.M., Gimenez, C., & Sierra, V. (2015). Green supply chain management approaches: drivers and performance implications. *International Journal of Operations & Production Management*, 35(11), 1546 – 1566. https://doi.org/10.1108/IJOPM-01-2015-0023

Tate, W.L., Ellram, L.M., & Dooley, K.J. (2012). Environmental purchasing and supplier management (EPSM): Theory and practice. *Journal of Purchasing & Supply Management*, 18 (3), 173–188. https://doi.org/10.1016/j.pursup.2012.07.001

Thong, K. & Wong, W. (2018). Pathways for Sustainable Supply Chain Performance—Evidence from a Developing Country, Malaysia. *Sustainability*, 10, 2781, https://doi.org/10.3390/su10082781

Thun, J. & Müller, A. (2010). An Empirical Analysis of Green Supply Chain Management in the German Automotive Industry, *Business Strategy and the Environment,* 19, 119–132. https://doi.org/10.1002/bse.642

Torugsa, N.A., O'Donohue, W., & Hecker, R. (2013). Proactive CSR: An Empirical Analysis of the Role of its Economic, Social and Environmental Dimensions on the Association between Capabilities and Performance. *Journal of Business Ethics*, 115, 383–402. https://doi.org/10.1007/s10551-012-1405-4

Vachon, S. & Klassen, R.D. (2006). Extending green practices across the supply chain: The impact of upstream and downstream integration. *International Journal of Operations & Production Management,* 26 (7), 795-821. https://doi.org/10.1108/01443570610672248

Vanalle, R.M. & Santos, L.B. (2014). Green supply chain management in Brazilian automotive sector. *Management of Environmental Quality: An International Journal*, 25(5), 523 – 541. https://doi.org/10.1108/MEQ-06-2013-0066

Wu, L., Subramanian, N., Abdulrahman, M.D, Liu, C, Lai, K., & Pawa, K.S. (2015). The Impact of Integrated Practices of Lean, Green, and Social Management Systems on Firm Sustainability Performance—Evidence from Chinese Fashion Auto-Parts Suppliers, *Sustainability, 7*(5), 3838-3858. https://doi.org/10.3390/su7043838

Xavier, A. F. (2017). Proposta de um modelo de maturidade para avaliação das práticas de eco-inovação nas organizações: ECO-MI, (PHD Thesis), Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Yang, M.G. (2013). Developing a Focal Firm Sustainable Supply Chain Framework: Drivers, Orientation, Practices and Performance Outcomes [Doctoral dissertation, University of Toledo],

Zailani, S., Jeyaraman, K., Vengadasan, G., & Premkumar, R. (2012). Sustainable supply chain management (SSCM) in Malaysia: A survey. *International Journal of Production Economics*, 140(1), 330–340. https://doi.org/10.1016/j.ijpe.2012.02.008

Zhu, Q. & Zhang, Q. (2015). Evaluating practices and drivers of corporate social responsibility: the Chinese context. *Journal of Cleaner Production*, 100, 315-324. https://doi.org/10.1016/j.jclepro.2015.03.053

Zhu, Q., Sarkis, J., & Lai, K. (2007). Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production*, 15, 1041-1052. https://doi.org/10.1016/j.jclepro.2006.05.021

Zhu, Q., Sarkis, J., & Lai, K. (2013). Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices. *Journal of Purchasing & Supply Management, 19*(2), 106–117. https://doi.org/10.1016/j.pursup.2012.12.001

Zhu, Q., Sarkis, J., & Lai, K.H. (2012). Green supply chain management innovation diffusion and its relationship to organizational improvement: An ecological modernization perspective. *Journal of Engineering and Technology Management*, 29, 168–185. https://doi.org/10.1016/j.jengtecman.2011.09.012

Zhu, Q., Sarkis, J., Lai, K., & Geng, Y. (2008). The Role of Organizational Size in the Adoption of Green Supply Chain Management Practices. *Corporate Social Responsibility, and Environmental Management,* 15(6), 322–337. https://doi.org/10.1002/csr.173

Appendix D - Questionnaire – Implementation level of Sustainability sub-practices

Indicate the **level of implementation** in your company and SC of each of the sub-practices presented in the following tables. Consider a scale of 1 to 5 for implementation levels, where:

5	The sub-practice is fully implemented and embedded in the company processes and continuously improved
4	Implementation is done systematically and controlled
3	The sub-practice is formalized and documented and its implementation is done systematically
2	Implemented to solve a problem or attend to a specific task (ad-hoc)
1	Not implemented or not fully implemented

If you intend to leave a comment, use the space indicated.

Table 1. Implementation level of sub- practices in the ***Sustainability governance*** area

AREA: *Sustainability governance*	**Implementation Level**					**Comment(s)**
Sub-practices	**1**	**2**	**3**	**4**	**5**	
Environmental issues are considered in some functional areas (e.g., logistics, purchasing)						
There is an individual/working group with some responsibilities in the area of environmental sustainability						
Indicators traditionally linked to the economic dimension (e.g., financial, operational) are used in the evaluation of the company's performance						
In the formal structure of the organization, an organizational unit/work group dedicated to managing the area of environmental sustainability is considered						

In the formal structure of the organization, an organizational unit/work group dedicated to managing the area of social sustainability is considered						
Internal performance evaluation systems integrate some social and/or environmental aspects (e.g., indicators, targets)						
Data are collected on social aspects						
Data are collected on environmental aspects						
The reporting of some aspects of sustainability is done to top management						
Environmental compliance and auditing programs in all departments						
Commitment to GSCM from senior and middle level managers						
Established a set of transparent, comprehensive and stringent ethical codes of conduct						
Commitment to social SCM from senior and middle level managers						
The sustainability reporting is done internally for top management, for other levels of management and for employees						
Obtaining ISO 14001 certification						
There are cross-functional cooperation practices for environmental improvements						
There are cross-functional cooperation practices for social improvements						
Internal performance evaluation systems integrate social and/or environmental aspects related to the supply chain partners considered most important						
Internal and external sustainability reporting is done where some aspects (e.g., initiatives, performance) related to the supply chain are mentioned						
The company has an Integrated Management System, capable of integrating quality systems with health and safety, environmental management and social responsibility.						
Performance appraisal systems are used that integrate all elements of the TBL, and that integrate information regarding SC and other stakeholders (e.g., NGOs)						

The company uses the services of an independent auditing body to certify the reliability of the reported information						
Sustainability reporting is done internally and externally, and integrates all dimensions of the TBL, and aspects related to supply chain SC and other stakeholders						
Various tools are used and combined (e.g., Life Cycle Analysis, risk analysis) for a more complete assessment of environmental sustainability						

Table 2. Implementation level of sub- practices in the ***Product and process level*** area

AREA: *Product and process level*	**Implementation Level**					**Comment(s)**
Sub-practices	**1**	**2**	**3**	**4**	**5**	
Design considers regulations and policies to ensure compliance						
In design, the company focuses on incremental improvements in the environmental performance of existing products at specific stages of their life cycle.						
There are defined guidelines for the environmental design of products						
Designing products for reuse, recycle, recovery of materials, components and parts						
Design of products for reduced consumption of material and energy						
Designing products/processes to avoid or reduce use of hazardous materials/substances;						
Product design is simultaneously oriented towards reducing the overall environmental impact of the product (e.g., reduction of materials and energy) and increasing its useful life, from a life cycle perspective.						
In the design of the products, social sustainability criteria are incorporated						
The company extensively uses advanced Eco-design techniques and tools (e.g., Eco-design PILOT, LCA) tailored to your situation						

The company implements techniques and procedures for waste reduction and damage control (e.g., use of filters and controls for emissions and discharges, wastewater treatment) required by legislation						
Reducing resource consumption during production						
The company favors the use in the production of environmentally friendly subsidiary and consumable materials (e.g., cleaning, maintenance)						
Optimization of process to reduce solid/liquid waste and generation of hazardous wastes and optimize material exploitation						
The company replaces its technology (means of production) with cleaner technologies/use of alternative energy sources						
Maximizing use of renewable or recycled source materials for product manufacturing						
Tools/systems are used to assess, control, and improve environmental aspects at the level of processes						
The techniques, procedures and technologies used in production are periodically reassessed to continuously improve environmental performance						
Compliance with environmental legislation such as external purchasing directives						
The company identifies materials that should not be used in products and to avoid when purchasing						
Suppliers are selected using environmental criteria (e.g., environmental competence, performance, ISO 14001)						
Suppliers are selected using criteria that include ethical and social dimensions						
Providing design specification to suppliers that include environmental requirements for purchased items						
Consider ethical and human rights/welfare issues formally in our purchasing decisions						
The company purchase materials/products that are efficient in terms of energy and water consumption, and that are non-polluting, toxic or dangerous						
There are ongoing education and training programs on environmental issues for purchasing staff						
There are ongoing education and training programs on social issues for purchasing staff						

The company purchase materials/products that are easy to recycle or recycle, and recycled packaging						
The company has a purchasing strategy that considers (in addition to economic aspects) social aspects						
The company has a purchasing strategy that considers (in addition to economic aspects) environmental aspects						
Transport is chosen based on cost and delivery time						
The company avoids the use of packaging produced with hazardous materials						
Use of environmentally friendly transportation						
The company has a documented environmental policy in relation to logistics/transport						
We plan the routes of our vehicles in order to reduce environmental impacts						
The company has systems to reduce environmental impacts (e.g., for energy efficiency) in the warehouses						
Environmental improvement of packaging such as using ecological materials for primary packaging						
The company invests in vehicles designed to have lower environmental impacts						
Use of advanced tools/systems that enable product traceability (e.g., VMI), which may imply collaboration with supply chain partners						
The company focuses on safety and health measures in some of the most critical phases of the production process (e.g., manufacturing phase)						
The company focuses on complying with the safety and health aspects required by legislation						
The company carries out periodic health exams, and has other initiatives, in addition to what is required by legislation, to increase the health and well-being of workers.						
The company carries out a detailed hazard identification and health risk assessment exercise						
Safe working conditions for employees in all areas of the company						
The company provides health care facilities for the employees						

An occupational health and safety management system is in place (OHSAS 18001)						
Firm prohibit bonded labour and child labour						
The company provides training to its workers to comply with legislation, in traditional areas such as quality, human resources, marketing, etc.						
Fair compensation (living wage) to all employees						
The company provides training to its workers in techniques/methods and concepts related to sustainability (e.g., environmental area)						
The firm ensures that there is no discrimination against any employee on the grounds of racism, colour, religion, caste, gender, age, marital status, disability, and nationality						
The company has systems to assess worker job satisfaction						
Educating and training people for skill development						
The company encourages most of its workers to participate in various activities (e.g., departmental communication meetings, human resources initiatives, recreational activities, etc.)						
Sustainability-related criteria are included in employee performance assessment to reinforce the company's sustainability culture						
The company involves its workers in the implementation of new ideas and in continuous improvement initiatives in socio-environmental issues						
The company keeps its shop floor well organized and clean						
Quality control/inspection techniques are used						
Conducts preventive equipment maintenance						
Quality improvement programs are implemented in some areas (e.g., production) of the organization						
Use statistical process control techniques to reduce process variance						
Working to lower setup times in our plant (e.g., using Kaisen)						
Quality management system/ISO 9000 certification						

To use a “Pull” production system						
To follow Just-in-time/Scientific inventory control technique consistently to keep inventory under control in the production environment						
The company implements several Lean practices (e.g., JIT, total preventive maintenance), controls and integrates them to minimize waste						
Efforts are made to optimize its processes by continuously improving its techniques/systems in an integrated perspective						

Table 3. Implementation level of sub- practices in the **Costumer and Supplier management** area

AREA: Costumer and Supplier management	**Implementation Level**					**Comment(s)**
Sub-practices	**1**	**2**	**3**	**4**	**5**	
The company conducts customer satisfaction surveys						
We frequently are in close contact with our customers						
Information about product to users (such as labeling, info about ingredients, origin, potential dangers) to educate the user on how to properly use, consume and dispose of the product						
Our costumers give us feedback on our quality and delivery performance						
Assess product misuse (with potential health hazards) encouraging consumers self- reporting						
Ensuring the basic safety of our products for consumers, reducing health risks for them (e.g., avoid or reduce the use of hazardous materials/ contaminants/ nutrients)						
Our customers are directly involved in current and future product offerings						
Cooperation with customers for using less energy (fuel) during product transportation						
Customer involvement in company quality programs						
Cooperation with customers for eco-design						
Cooperation with customers for cleaner production						

Communication with suppliers is focused on economic issues (e.g., resolution of specific problems/issues such as pricing and others related to supply contracts, etc.)						
Suppliers are asked to guarantee compliance with legislation/technical standards relating to their products						
The selection of suppliers is based on economic issues (e.g., costs, delivery times, etc.)						
The company has guidelines on social issues for supplier management (e.g., code of conduct)						
Assess the quality standard of suppliers (e.g., through ISO 9001 certification)						
Request existing primary suppliers to provide evidence of all environmental licenses and permits						
Ensuring suppliers obtain OHSAS 18001 certification or other health and safety management system certification as SA 8000						
Perform audits/has audit procedures for suppliers' internal management system related whit social issues (e.g., related with health and safety, appropriate labour working conditions)						
Conduct regular environmental audits into suppliers' internal operations						
The company ensures that its suppliers have the ISO 14001 environmental management system certification						
The company guides and supports (through training/education visits, technical support) its suppliers to help them improve their environmental performance						
The company guides and supports (through training/education visits, technical support) its suppliers to help them improve their social performance						
The company facilitate our suppliers implement quality programs/TQM/Six sigma/TPM/TQC to build quality into the product						
Supplier delivers to our plant on a Just-in-time (JIT) basis						
Cooperating with suppliers to reduce packaging/ eliminate packaging						
Develop new product/process with suppliers that reduces health risks for consumers						
The company works together with suppliers to reduce the environmental impact of their logistics operations						

The company collaborates with suppliers in areas such as production planning and coordination of production processes						
Joint product design with suppliers (e.g., design for reduced consumption of material/energy, design for recycle, design to avoid use of hazardous products, etc.)						
The company follows the obligations imposed by legislation regarding the collection, disposal, recovery, recycling and reuse of end-of-life products and packaging.						
The company labels its packaging in order to facilitate its recovery						
Recovery of the company's end-of-life products or unwanted products and materials (for recycling, reuse, remanufacturing, repair)						
The company uses systems/tools that allow the collection and analysis of information regarding the collected/returned products and allow their management and decision-making in relation to them.						
The company collaborates with members of its supply chain and other entities to innovate in the collection, recovery and return processes of products and packaging and to find new opportunities to add value to the products collected.						

Table 4. Implementation level of sub- practices in the ***Stakeholder focus*** area

AREA: Stakeholder focus (not considering customers and suppliers)	**Implementation Level**					**Comment(s)**
Sub-practices	**1**	**2**	**3**	**4**	**5**	
The company identifies and analyzes the needs/expectations/requirements of its stakeholders (official bodies, NGOs, etc.)						
Communication with most of its stakeholders (in addition to SC partners) such as official bodies, NGOs, etc., is done in relation to their objectives/projects/initiatives (with an economic focus) using traditional communication and information technologies						
Donates to philanthropic organizations						
The company has some programs oriented to the benefit of society such as training and community development activities (employment promotion, health and hygiene, social inclusion, etc.)						

Communication with most of its stakeholders is done by looking for new forms of communication and information and the use of more advanced technologies, collecting and sharing information including on sustainability issues						
The company develops initiatives and programs for society related to environmental protection						
The company collaborates with other stakeholders (e.g., official entities) to innovate in the processes of collection, recovery and return of products and packaging and to find new opportunities to value the collected products						
The company collaborates with other stakeholders (such as universities, research institutions and others) in the development of new environmental technologies or more environmentally friendly products						
Innovative partnerships (e.g., NGOs, community groups) related with projects focused on social development and local education						
Innovative partnerships (e.g., NGOs, community groups) related with projects focused on environmental protection						