

Review

Maturity Models in Supply Chain Sustainability: A Systematic Literature Review

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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.

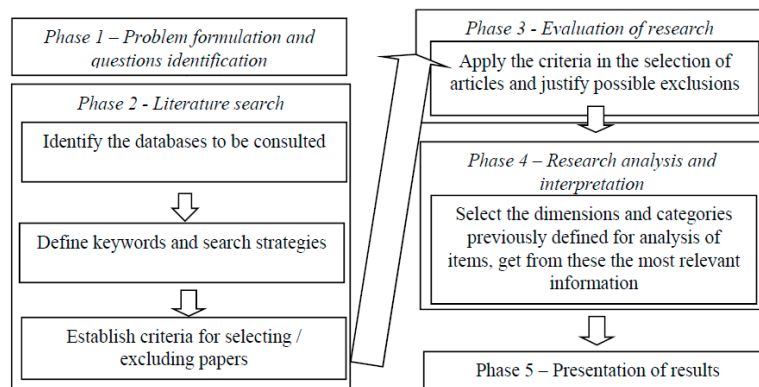


Figure 1. Literature review approach.

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 Pflieger [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.

Keywords	Database	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”
	Development	Develop, adapt or create a new MM
Research objectives	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 <i>n</i>
	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], Srari et al. [65], Kurnia et al. [45], and Reefke et al. [19].

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

Domain	Year				Total
	2000	2001–2005	2006–2010	2011–2015	
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	<ul style="list-style-type: none"> • Standing and Jackson [66] • Reefke et al. [19] • Edgeman and Eskildsen [67] 		
	Surveys	<ul style="list-style-type: none"> • Hynds et al. [68] 	<ul style="list-style-type: none"> • Hynds et al. [68] 	
	Action research	<ul style="list-style-type: none"> • Pigosso et al. [1] 	<ul style="list-style-type: none"> • Pigosso et al. [1] 	
Empirical	Case studies	<ul style="list-style-type: none"> • Golinska and Kuebler [69] • Kurnia et al. [45] • Srai et al. [65] • Robinson et al. [70] 	<ul style="list-style-type: none"> • Kurnia et al. [45] • Srai et al. [65] • Robinson et al. [70] 	
		Content analysis	<ul style="list-style-type: none"> • Okongwu et al. [64] 	<ul style="list-style-type: none"> • Okongwu et al. [64]
		Mixed methods	<ul style="list-style-type: none"> • Babin and Nicholson [71] 	<ul style="list-style-type: none"> • 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 approach 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]. Pigozzo 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 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 clustered in 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.

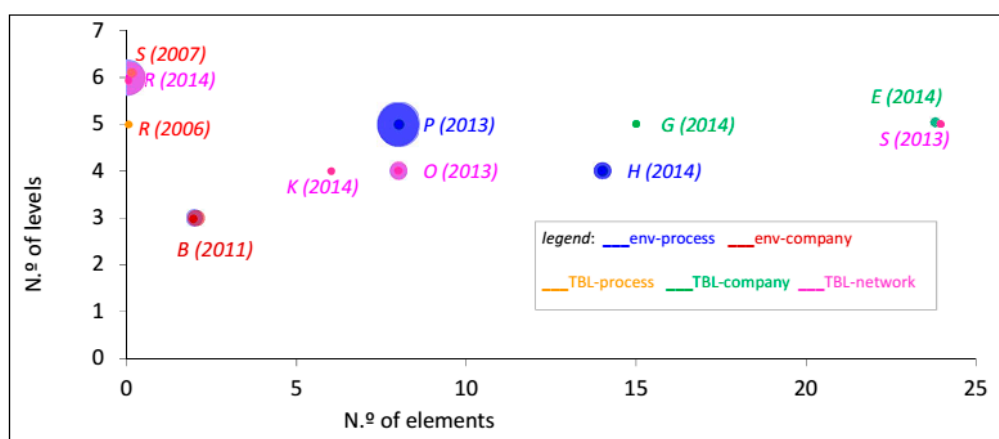


Figure 2. Maturity models overview. Legend: *B* (2011)—Babin and Nicholson [71]; *E* (2014)—Edgeman and Eskildsen [67]; *G* (2014)—Golinska and Kuebler [69]; *H* (2014)—Hynds et al. [68]; *K* (2014)—Kurnia et al. [45]; *O* (2013)—Okongwu et al. [64]; *P* (2013)—Pigosso et al. [1]; *R* (2014)—Reefke et 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 necessary 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 Poeppebuss 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
	Embed and develop sustainability capabilities	[71]
Sustainability governance	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.

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