*sustainability*

MDPI

*Article*

# Proposal for a Maturity Model in Sustainability in the Supply Chain

**Davidson de Almeida Santos [1,*], Osvaldo Luiz Gonçalves Quelhas [1], Carlos Francisco Simões Gomes [1], Luis Perez Zotes [1], Sérgio Luiz Braga França [1], Guilherme Vinagre Pinto de Souza [1], Robson Amarante de Araújo [1] and Sheila da Silva Carvalho Santos [2]**

[1] Department of Production Engineering, Fluminense Federal University, Niterói 24210-240, Brazil; osvaldoquelhas@id.uff.br (O.L.G.Q.); cfsg1@bol.com.br (C.F.S.G.); lpzotes@gmail.com (L.P.Z.); sfranca@id.uff.br (S.L.B.F.); guilhermevps@id.uff.br (G.V.P.d.S.); robsonadea@gmail.com (R.A.d.A.)

[2] Celso Suckow da Fonseca Federal Center for Technological Education, Rio de Janeiro 20271-204, Brazil; sheila.santos@cefet-rj.br

* Correspondence: dasantos@id.uff.br

Received: 1 October 2020; Accepted: 18 November 2020; Published: 19 November 2020


**Abstract:** Sustainability has become a relevant element for organizations due to several motivators: companies adopt sustainability practices in need for regulatory compliance, anticipation of regulatory changes, understanding of limited natural resources, and a desire to limit expenditure associated with resource consumption and waste disposal. Thus, this article aims to identify the gaps present in maturity models, present an integrator theoretical model that considers the characteristic elements of the models present in the literature and affects the level of maturity in sustainability. The construction of the integrator theoretical model was based on the following stages: research questions; theoretical framework on Supply Chain Management; sustainability and concept of maturity model; maturity models and performance measurement systems; interpretation/analysis of research; and construction of the integrator theoretical model. The literature review was carried out in the Scopus and Web of Science databases. The main conclusions: maturity models focus on only one aspect or are excessively broad and do not include in detail the elements necessary to measure the level of maturity in sustainability. The proposed model aims to mitigate these gaps with the addition of the cross-sectional dimension, which offers an integrated and holistic view in relation to the other dimensions.

**Keywords:** green supply chain; performance measurement system; maturity model

## 1. Introduction

The increase in the level of complexity of the products and services offered to consumers and the fluctuation of prices together with the changeability of financial markets and global policies have led to an increase in risks related to supply chain practices. Thus, organizations aim to reduce costs, improve the quality of services offered to customers, and increase the reliability and efficiency of operating systems with consequent reduction of delivery time of products in the market [1].

Given this context, the concept of Supply Chain Management (SCM) emerged and gained importance in the organizational scenario worldwide. At the same time, concerns grew about the growing degradation of the planet and the legacy left to future generations. Therefore, there is growing concern about the damage caused to the environment by production systems. In addition, there is widespread concern about the social responsibility of industry enterprises. This culminated in the consolidation of the concept of Triple Bottom Line (TBL), addressing the necessary balance between results in the financial, social, and environmental dimensions of companies [2].

The CSCMP [3] defines SCM as the planning and management of all activities involved in purchasing and procurement, conversion, and all logistics management activities. In an equally relevant way, it also adds coordination and collaboration with partners, who can be suppliers, intermediaries, third-party service providers, and customers. Essentially, the SCM integrates supply and demand management in and between companies.

The distribution chain, or supply chain, corresponds to the set of processes required to obtain materials, to add value to them according to the design of customers and consumers, and to make the products available to the place (where) and to the date (when) customers and consumers desire them [4].

With the effects of globalization growing in all markets and supply chains it is increasingly common for companies to acquire their products from different countries. However, the pressure and action of nongovernmental organizations and regulatory entities for companies to prove that their products are being manufactured and processed according to acceptable social and environmental standards also grows. The dissemination of sustainability reports, as provided for in the United Nations Global Compact (2013), serves as an instrument to consolidate the transparency and sustainability of what is being offered in the market. This disclosure presents, among others, what governance criteria are also being adopted in SCM [1].

Govindan, Soleimani and Kannan [5] claim that organizations have begun to become more environmentally conscious in their supply chain operations, and the greening process has guided supply chain practices into new ways of thinking in line with green standards.

The topic of sustainability in the context of Supply Chain Management (SCM) has been discussed using a variety of terms in the literature. The two terms that are most adherent to the concepts of sustainability and SCM are Green Supply Chain Management (GSCM) and Sustainable Supply Chain Management (SSCM) [5].

Based on the studies of [5], the main definitions for GSCM are based on the following aspects:

- Environmental management throughout the supply chain process.
- Achieving the objectives of profit and market share, while decreasing the risks and environmental impacts.
- Management of purchases, materials, and production directed towards the reduction of environmental impacts.
- Use of reverse logistics.
- Integrating environmental thinking into SCM, including product design, supply and material selection, manufacturing processes, delivery of the final product to consumers, as well as managing the end of the product's life after its useful life.

The GSCM as the sum of the following elements: green purchasing; green materials management/manufacturing; green marketing/distribution; and reverse logistics [6].

The GSCM presumes the minimization or preferably the elimination of negative effects of supply chain operations on the environment. Companies have to increase their capacity on GSCM activities based not only on emerging environmental regulations, but also on companies' enthusiastic policies on environmental practices [7].

The logical structure of this article was organized according to the evolutionary concept of first, in the introduction to develop more generic aspects of the traditional supply chain and in the chapter of theoretical references concepts were formulated about the sustainable supply chain.

The connection between sustainability and the supply chain provides the emergence of the concept of the sustainable supply chain, which has been expanded to understand the closed-loop supply chains and TBL thinking. The TBL concept was created in the 1990s by business consultant John Elkington to describe the economic, environmental, and social value of the investment that can accumulate outside a company's financial result [1]. The definition of Hervani et al. [6] adds the transparent integration of

the social and environmental dimension of an organization and economic objectives to the concept of sustainable supply chain.

The closed-loop supply chain can be defined as the result while considering the direct supply chain and reverse supply chain. In this case, downstream flow (raw material; manufacturing; focal company; distribution and consumer) is integrated into the upstream flow (involving the following activities: test collection; disassembly; disposal; reuse; repairment; refurbishing; reconditioning; remanufacturing; and recycling) [5].

The organizations that adopt sustainable SCM, for the most part, were motivated by various factors such as pressure from consumers and other stakeholders (workers, investors, and trade unions) sensitive to global environmental concerns and compliance with legal requirements established by governments. However, there are organizations that practice sustainable SCM aiming at reducing costs, improving both their organizational reputation and overall performance, and/or gaining competitive advantage [8].

The environmental issue in the SCM should be considered as a potential source of competitive advantage and should be a stimulus for innovation. In addition, commercial resources should be allocated more efficiently and should not only be a requirement for compliance with environmental rules applied to production systems [9].

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 a prescriptive 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 [10].

The proposed model establishes, through the TBL concept, the integration of the models present in the literature. Another important point is the proposition of a fourth dimension in relation to the dimensions present in the TBL. The new dimension offers a holistic vision in relation to the other dimensions (environmental, economic, and social). The fourth dimension proposed in the model is in line with the perspective of integration between the dimensions proposed in the [11,12] studies.

SSCM is supply chain planning and decision-making that incorporates economic, social, and environmental sustainability dimensions. Sustainable supply chain initiatives support manufacturing companies and industries in their sustainable development [11].

The connection of this study with other work focused on SSCM is related to the integrative perspective that allowed the interface between existing models with the insertion of a new dimension for the TBL concept.

The relationship with other SSCM related studies is described below:

- Environmental dimension, the relationship is established with the studies of [8,13–18].
- Social dimension, the relationship is established with the studies of [8,13,16].
- Economic dimension, the relationship is established with the studies of [1,19].
- Transversal dimension, the relationship is established with the studies of [13–15,19–25].

The study presents how a maturity model is structured in sustainable supply chains and what relationship can be seen between maturity models and performance measurement systems in supply chains. As a result, a theoretical model was developed that relates maturity levels in sustainability with supply chain performance measurement systems.

This work is organized in four parts. After this introductory section, the theoretical framework of this work is presented. At its beginning, the themes of supply chain management, sustainability, maturity model concept, maturity models in sustainability, and performance measurement systems are presented, offering theoretical support for the construction of the maturity model in sustainability in the supply chain. After the theoretical framework, the methodology used in the study is described, followed by the presentation of the hypothetical-conceptual model of the research. Finally, the considerations of

the work are outlined, as well as the proposition of some relevant issues that may be useful to guide future research on the subject.

## 2. Theoretical Framework

The theoretical framework will address the following topics: the definition of sustainability and its relevance to organizations; a brief description of maturity models and performance measurement systems researched in the literature.

### *2.1. Sustainability: Definition and Relevance for Organizations*

Sustainability began to be debated after the publication of the *Brundtland* Commission (World Commission on Environment and Development, 1987), which presented sustainable development as one that "meets the needs of the present without compromising the capacity of future generations to meet their own needs" [20]. The sustainable policy in organizations translates into actions aimed at the economic use of resources, respecting the environment, and providing ergonomics and safety in activities in order to minimally impact the region where their facilities are located [17].

Since then, sustainability has become a global concern and many organizations, concerned about the future, have begun reviews of their operations and supply chains considering the environmental and social impacts of their production chains. These actions amounted to the concept of SSCM that refers to the management of flows of materials, information and capital, in addition to cooperation between elements along the supply chain, considering the economic, environmental, and social dimensions for customer service and other stakeholders [8].

Sustainability has been defined in three major dimensions (environmental, social, and economic) and should overcome organizational boundaries, including transparency of supplier operations, risk management, and improve stakeholder engagement.

The development of the supply chain in the past, the production and operation of the supply chain consume a significant amount of energy and resources, produces a vast variety of products and polluting waste. Thus, there is an increase in pressure for environmental protection. Another relevant point is the pressures exerted by consumers in relation to the necessity of environmental preservation [26].

Based on the context described above, the image of a modern supply chain is composed by the development of ecological and sustainable aspects. It can be assumed that the search for SSCM results from the needs of the modern world, and the efficiency and care for natural resources contribute not only to improving the image of the organization, but also to reducing waste, innovation, generating profits, and building a competitive advantage [27].

The objective of sustainable development is to formulate a program that integrates several levels of action, which was often considered separately before, based on moral reflection on responsibility with the environment. The dedication to implement environmental and social measures for sustainable performance, supporting current and future generations, greatly expands transparency in supply chain management in moral, economic, legal, social, and technical performance attributes. [28].

Several drivers lead companies to adopt sustainability practices, including the need for regulatory compliance or anticipation of regulatory changes, understanding of limited natural resources, consumer interest and demand, or a desire to limit expenses associated with resource consumption and waste disposal [12].

The organizational sustainability (connection between sustainability and organization) presents the following characteristics: (1) economic focus, (2) environmental focus, (3) social focus, (4) stakeholder focus, (5) volunteer focus, (6) resilience focus, and (7) long-term focus [29].

The creation of coordinated supply chains through the voluntary integration of economic, environmental, and social projects consider the main interorganizational business systems designed for an effective management of materials, information, capital flow associated with the acquisition, production and distribution of services, with the aim of meeting the requirements of stakeholders,

thus, seeking to increase profitability and to ensure the competitive advantage of the organization in the short, medium, and long term [30].

In the definitions that relate sustainability and supply chain, only 14% explicitly consider the three dimensions of the TBL concept. Another important point is the fact that most definitions (64%) that relate sustainability or green and supply chain focus on the environmental dimension [29], reinforcing the need for studies integrating the three dimensions.

The relationship between the concept of closed-loop supply chains and green supply chains occurs as the former understands the need for integration between direct and reverse flow, seeking to restore to the production cycle or establish an appropriate environmental destination for all material that constitutes itself as an element of a product. In relation to the second concept, this refers to minimizing the environmental impacts generated by supply chains (including how the material will be returned to the production cycle or directed to an environmentally appropriate destination).

### *2.2. Maturity Model Concept*

The maturity models emerged parallel to the first quality management studies and their use was a huge step towards performance improvement approaches [31]. One of the most widespread models today is the Capability Maturity Model Integration (CMMI), which, in five steps, provides improvement sequences, as well as a basis for assessing the maturity of the deployment of specific projects or organizations. The goal is to be adjustable to the various needs and approaches [32].

The maturity model to be a conceptual structure composed of parts that describe the development of a particular area of interest over time [33].

A maturity model represents a set of structured levels of management capacity that characterize the performance of an organization [34,35].

Table 1 summarizes the maturity models in supply chain sustainability found in the surveys.

### *2.3. Supply Chain Performance Measurement Systems: Relevant Concepts, Aspects and the Relationship with Maturity Models*

#### 2.3.1. Concepts

For Neely [39], the concept of performance measurement refers to a process that dimensions the action and the measurement corresponds to the quantification process and the action is what leads to performance. He also states that performance measurement is the process of measuring the efficiency and effectiveness of the action.

To Bourne et al. [40], the performance measurement system is a multidimensional set of performance measures that will be applied in the planning and management stages of a business.

Three similarity points in the concepts of a performance measurement system [41]:

- Measures of performance, and support infrastructure.
- Functions of performance measurement systems: measuring performance, managing strategy, exercising communication, influencing behavior, and providing learning and improvement.
- Processes of performance measurement systems: selection and development of measures; data collection and manipulation; information management; performance assessment and review of the system.

According to Hald and Mouritsen [42], the measurement system acts as a central factor in SCM, contributing to the improvement in its performance. The performance measurement system must present a balanced structure, which is aligned with the strategy defined by the focus company. In addition, the supply chain performance measurement system is influenced by four elements: conflict and objection (political/social/commercial tensions, perceptions and decisions of the actors); technical challenges (relationships between measures and links with other relevant systems); attitudes and commitment (lack of interest and egocentric attitude); and alignment (alignment with the strategy, alignment with organizational characteristics, and alignment with product characteristics).

**Table 1.** Summary of supply chain sustainability maturity models found in the literature.

| Authors | Description of the Model |
| --- | --- |
| [23] | Establishes five levels of maturity of knowledge management, and the high level of maturity is directly related to the ability to implement the principles of sustainability. |
| [20] | Integrates sustainability with the systems area and is based on Control Objectives for Information and related Technology (COBIT) concepts; presents six levels of maturity. |
| [13] | Presents three relevant dimensions in relation to sustainability and four levels of maturity. |
| [25] | Focuses on the sustainability of providers offering Information Technology (IT) at the global level; represents a robust way to identify, classify, and evaluate the sustainability capacity of these providers. |
| [33] | Aggregates some practices that integrate the environmental eco-design process in the development of related products and processes. |
| [15] | Adopts a network and a Triple Bottom Line (TBL) perspective that allows for a systematic analysis and evaluation of practices that support sustainable operations; considers five capacity groups and five maturity levels. |
| [1] | Aims to improve knowledge about the maturity levels achieved by organizations by communicating sustainability initiatives to companies that might or might not be involved in the supply chain. |
| [14] | Focuses on the development of new products. |
| [8] | Focuses on evaluating capabilities to implement sustainable supply chain practices; identifies four categories of organizations that differ in the status of their respective maturity levels in Sustainable Supply Chain Management (SSCM) capabilities. |
| [17] | Focuses on the sustainability of remanufacturing for companies using the TBL approach. The goal of the maturity model is to identify the potential for optimizing resource utilization. |
| [30] | Presents six maturity levels, and for each of the levels a description, goals and requirements are provided. |
| [19] | Proposes a system of sustainable business excellence that emphasizes the financial stability of the company while addressing social and environmental challenges. The model considers six elements, called 'compass dimensions' (from strategy and governance to the results of human capital), and five levels of maturity. |
| [16] | Presents six drivers: knowledge; impact; social risk; environmental risk; cooperation, and communication; includes five levels of maturity. |
| [18] | Establishes an important relationship between lean waste and associated green impacts and presents five maturity levels. |
| [36] | Structured based on six levels of maturity, namely: completely immature companies; immature enterprises; companies at initial maturity; mature enterprises; mature/education enterprises and integrated enterprises. |
| [37] | Establishes management principles for the maturity framework based on sustainable operations. |
| [22] | Assesses the level of sustainable management of the supply process within an organization; addresses the question of how sustainable purchasing practices are effectively used as a leverage effect for sustainable development; includes five phases and five management dimensions. |
| [21] | Is based on the Capability Maturity Model Integration (CMMI) through which you want organizations to gradually implement and improve, through different levels of maturity, governance and green IT management. |
| [24] | Uses as reference the CMMI model and the maturity levels specified by [32]; considers five levels of maturity that include the interorganizational relationship of the supply chain and the relevant societal aspects. |
| [38] | Aims to perform the organizational integration of sustainability outlined in the concepts of TBL through quality management and supply chain. |

According to Hald and Mouritsen [42], performance measurement systems can have the following scopes: supply-oriented performance measurement system; internal performance measurement system; or consumer-centered measurement system. Such aspects can occur simultaneously in a supply chain.

Table 2 presents a summary related to the main theme of study present in the supply chain measurement systems found in the literature.

**Table 2.** Summary of supply chain performance measurement systems researched in the literature.

| Authors | Main Features |
| --- | --- |
| [43] | Balances financial measurement methods and projected physical measurements (productivity, lead times, quality, customer service, turnover rates, etc.) |
| [44] | Integrates internal and external improvement based on supply chain compression into four areas: planning, supplying, making/assembling, and delivering. |
| [45] | Establishes the evolution of the cost-effectiveness (basic) level performance measurement system for integration (integration of the performance measurement system, considering the supply chain as a whole). |
| [46] | Presents the three elements that should be present in a performance measurement system: resource measures (R), output measures (O), and flexibility measures (F). |
| [47] | Adopts a systemic perspective to explain the challenges and opportunities related to the application of supply chain metrics. |
| [48] | Aligns financial and nonfinancial metrics with the four areas of the supply chain, namely: planning, supplying, making/assembling, and delivering. |
| [49] | Merges Balanced Scored Card (BSC)-related concepts and supply and chain management produced the Balanced Supply Chain Scorecard (BSCS). |
| [50] | Develops a BSC for Supply Chain Management (SCM) and illustrates the ways BSC was developed and applied in small and medium-sized enterprises. Structured in four perspectives: financial; performance for the customer; innovation/learning; and performance for the internal business perspective. |
| [51] | Develops a system and performance measurement based on BSC and Supply Chain Operations Reference (SCOR) for the case of small and medium enterprises. |
| [52] | Analyzes the development of a value-based performance measurement concept in supply chains by means of a case study of the packaging industry. |
| [53] | Considers three components of the model related to the supplier evaluation system, namely: strategic alignment, configuration process and execution. |
| [54] | Creates and verifies a supply chain measurement framework for the manufacturing industry. The aforementioned measurement structure is linked to four indicators: order book analysis; profitability; time; and management analysis. |
| [55] | It examines how the use of a new performance measurement system influences the SCM and what kind of impacts the new system has on supply chain performance. The impacts of a performance measurement system under the supply chain can be categorized as: (1) impacts on people's behavior; (2) impacts on organizational capabilities; and (3) impacts on performance. |
| [56] | Explores the prerequisites for the performance measurement system to support buyer-vendor relationships and value co-creation. For this, some prerequisites must be met: the non-financial perspective of the measurement and the nonstandard nature of the measurement. |

#### 2.3.2. Relationship between Maturity Models and Supply Chain Performance Measurement Systems

Supply chains are relevant to the performance of organizations in the market. Theories and methods that contribute to the improvement of its management are important elements for research.

Performance measurement systems are component elements of supply chain management. It is essential that the systems and models developed incorporate the alignment between performance measurement systems and their maturity at the levels of supply chain management. In [57], the existence of a relationship between the maturity of the performance measurement system and the maturity of supply chain management has been identified.

#### 2.3.3. Performance Measurement Systems and their Maturity

Due to synergies between supply chain organizations, theories, methods, and instruments that contribute to the exercise of management practices become necessary.

Performance measurement systems are a supporting element in the management of the supply chain of organizations, providing information to support decision-making [58].

The conceptual basis for performance measurement systems is applied to the "organizational" approach. However, there is a need for review and adequacy of this knowledge already built for the supply chain management area [58].

Performance measurement systems are critical factors in the evolution of supply chain management, and studies on this theme are required. The evolution of supply chain management can lead to the evolution of performance measurement systems. One example is the adoption of programs for quality awards fostered the evolution of organizations' performance measurement systems [59].

Maturity increases with the improvement of the implemented practices and technologies used to manage the supply chain [57–61].

As for the maturity of performance measurement systems, elements of performance measurement systems that change as maturity increases [59].

## 3. Methodology

The scientific method adopted for the present work was the deductive method, since the work aims to construct a model based on pre-existing theories, opting for theoretical propositions established from the conclusions drawn from the reorganization of these parts. In the deductive method, from an existing theory, observations and conclusions are formed in relation to a given subject [62].

The comparison between the inductive and deductive method is centered on the following aspect: in the inductive method a theory is generated based on observations and conclusions. On the other hand, observations and conclusions are formed in relation to a given subject from an existing theory [62].

The research stages were delineated based on the contributions of [10,63–67]. For this article, the following steps were defined: (1) identification of research questions; (2) development of the theoretical framework in relation to SCM, sustainability and the concept of maturity model; (3) research in the literature on maturity models and supply chain performance measurement systems; (4) interpretation and analysis of the research; and (5) delineation of the stages and construction of the proposed theoretical model.

In the stage of identification of research issues, the questions that guided the research were: how a maturity model is structured in sustainable supply chains and the relationship between maturity models and performance measurement systems in sustainable supply chains.

In the stage of development of the theoretical framework in relation to SCM, a sustainability and maturity model was carried out in order to present an overview of the relevant aspects present in the literature and in studies conducted for this purpose in the last 20 years. Thus, the objective was to better understand these aspects for the construction of the theoretical framework in which the model is anchored.

In the research stage in the literature regarding maturity models and supply chain performance measurement systems, an extensive survey of the models of maturity in sustainability in the supply chain was carried out in the SCOPUS and Web of Science scientific databases, using the following keywords: 'maturity'; 'sustainability'; and 'maturity model' combined with: 'environment'*; 'social'; 'multiple attribute decision making'; 'decision making'; 'multiple objective decision making'; 'multiple objective decision aiding'; and 'multiple decision aiding'. For the measurement systems in the supply chain, the research was also carried out in the Scopus and Web of Science scientific databases, using the following keywords: 'performance measurement system' and 'supply chain'. The keywords mentioned above were combined with: 'sustainability; 'environment'*; and 'social'. The research

strategy was to select documents that contained in the title, abstract, or keywords several combinations of these elements.

The models of maturity in sustainability were researched in the scientific bases in the period 2006 to 2020. Performance measurement systems were researched in the scientific bases from 1989 to 2020. The difference in the period determined for the research is related to the specific characteristics of each theme.

In the interpretation and analysis stage of the research, after the selection of articles referring to maturity models in sustainability and supply chain performance measurement systems, a detailed reading was performed with the objective of extracting the elements necessary for the construction of the theoretical model to measure the level of maturity in sustainability of the supply chain.

Finally, the stage of design of the stages for the construction of the proposed theoretical model was carried out: identification of the limitations present in the models of maturity in sustainability in the supply chain; construction of the basic theoretical model; classification of performance measurement systems at the level of maturity in the basic theoretical model; proposal of the theoretical model; and elaboration of the script of interviews.

The article was developed based on the steps presented in Figure 1.

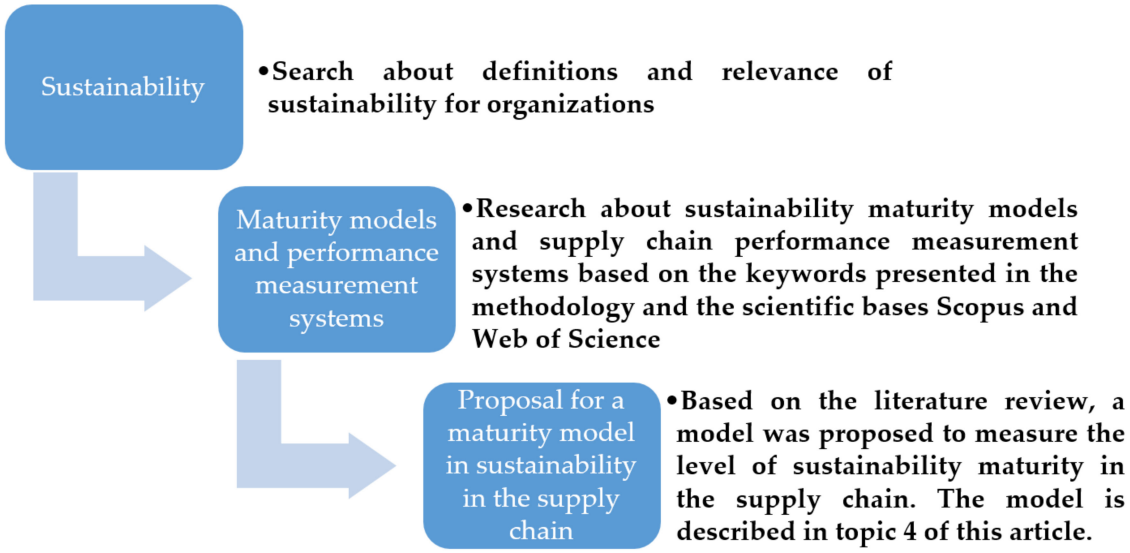


**Figure 1.** Stages of development of the article.

## 4. Proposal for a Maturity Model in Sustainability in the Supply Chain

The development of the model was carried out from the steps described below.

### *4.1. Identification of the Limitations of Sustainability Models in the Supply Chain*

The first stage refers to the analysis and recognition of the main limitations present in the models of maturity in sustainability in the chain and supplies, with the objective of adding them to the proposed theoretical model.

Table 3 presents the main limitations identified in the models of maturity in sustainability in the supply chain that have been mapped in the literature.

**Table 3.** Limitations identified in sustainability maturity models.

| Models | Limitations Identified |
| --- | --- |
| [23] | Focus on only one aspect of the supply chain (knowledge management) and the model does not clarify how alternatives could be prioritized for permanence or elevation of the level of maturity. |
| [20] | Emphasis on only one aspect of the supply chain (information systems), low level of detail of the characteristic elements of the model, absence of a method for prioritizing clear actions for permanence or elevation of the level of maturity and the lack of a practical application to prove or adjust the premises of the model. |
| [13] | Generic approach to economic sustainability, with the insertion of a series of elements that do not present a clear relationship with the economic dimension of the TBL. In addition, this model uses the analytical research method [10]. In this case, there was no finding or adjustment of its theoretical postulates. Another important point is that the model does not elucidate the means for permanence or elevation of the maturity level. |
| [25] | Focus on one aspect of the supply chain (assessing IT vendor capacity at the global level) and the model does not clarify how alternatives could be prioritized for permanence or elevation of maturity level. |
| [33] | The model is concentrated in only one aspect of the supply chain (eco-design) and the absence of a method for identifying the order of priorities of the actions to be performed for permanence or elevation of the level and maturity. |
| [15] | Absence of direct relationship of the characteristic elements of the model with the dimensions determined in the TBL concept. Remembering that this concept is truly relevant for the understanding of organizational sustainability. Another relevant point is that the model does not establish a method to list the alternatives to be prioritized for the permanence or elevation of the maturity level. |
| [1] | Focus on only one aspect of the supply chain (investigating the maturity levels achieved by organizations in reporting their supply chain sustainability initiatives) and the absence of a method to determine which aspects should be prioritized for the permanence or elevation of the maturity level. |
| [30] | The model does not clearly present its characteristic elements. In addition, this model uses the analytical research method [10]. In this case, there was no proof or adjustment of its theoretical premises. Another significant aspect is the absence of a method for prioritizing clear actions for permanence or elevation of the maturity level. |
| [19] | It does not distribute the characteristic elements in the dimensions contemplated in the TBL. The model uses the analytical method [10], providing the absence of proof or adjustment of its conjectures. Another relevant point is that the model does not clarify how alternatives could be prioritized for permanence or elevation of the maturity level. |
| [14] | This model focuses on only one aspect of the supply chain (development of new products) and does not clarify how the alternatives could be prioritized for permanence or elevation of maturity level. |
| [8] | The distribution of SSCM capabilities is not aligned with TBL dimensions. In addition, it is noted the absence of characteristic elements linked to the economic dimension. Another relevant point is the absence of a method that establishes the order of priority of some actions for the permanence or elevation of the maturity level. |
| [17] | Model focused exclusively on the process of remanufacturing and absence of a method to determine which aspects should be prioritized for the permanence or elevation of the maturity level. |
| [16] | Lack of clear description of the characteristic elements; analytical method [10], that is, the theoretical postulates are not proven or adjusted according to a given context and the lack of alternatives for permanence or elevation of the maturity level. |
| [18] | The use of the analytical method [10], the focus on only one aspect of the supply chain (lean and green practices) and the absence of clear actions to remain or raise the level of maturity. |
| [36] | Absence of a clear description of the characteristic elements of the model and the absence of a method for prioritizing actions for permanence or elevation of the maturity level. |
| [37] | Absence of a clearer description of the characteristic elements of the model and no clear actions for permanence or elevation of the maturity level. |
| [22] | The model focuses only on one aspect of the supply chain (evaluation of the maturity level of the supply process). In addition, the model does not present a method for determining the order of priority of actions for the permanence or elevation of the maturity level. |
| [21] | Model focused exclusively on IT management focused on the issue of sustainability. Another relevant point is that the model does not establish a method to determine the possibilities to be prioritized for the permanence or elevation of the maturity level. |
| [24] | The model focuses only on one aspect of the supply chain (knowledge management) and does not clearly present how some actions could be prioritized for permanence or elevation of the level of maturity. |
| [38] | The model focuses only on one aspect of the supply chain (the integration of quality management with GCS concepts) and the absence of a method to determine the order of priority of actions for permanence or elevation of the maturity level. |

### *4.2. Construction of the Basic Theoretical Model*

The survey of the limitations of the maturity models in sustainability of the supply chain provided the evaluation of the practical application of the model in order to prove or adjust its theoretical postulates as well as the scope of the model, in order to contemplate a diversity of characteristic elements and the prioritization of actions for permanence or elevation of the maturity level. This occurs in such a way that the proposed model aimed to address such gaps.

The construction of the initial theoretical model took place through the framing of the 150 (one hundred and fifty) characteristic elements mapped from the models of maturity in sustainability found in the literature, in each of the proposed dimensions: environmental, social, economic, and transversal. The environmental, social, and economic dimensions are related to the TBL concept, and the cross dimension refers to the characteristic elements of the models of maturity in sustainability that present a holistic relationship with the organization and with the other three dimensions (environmental, social, and economic) simultaneously. After this categorization process, the characteristic elements were regrouped again, now in subdimensions. This grouping was performed based on the direct relationships between the characteristic elements. Another relevant point is that this grouping will allow for a clearer understanding of which specific areas should be prioritized for improvement actions, since each subdimension will have a set of characteristic elements.

The following are the dimensions and subdimensions, the maturity levels and the description of the characteristic elements that make up the sub dimensions.

Table 4 presents the dimensions and subdimensions of the initial theoretical model.

**Table 4.** Dimensions and sub dimensions of the initial theoretical model.

| Dimensions | Subdimensions |
|---|---|
| Environmental | Environmental risk |
| | Product portfolio |
| | Tools |
| Social | Internal |
| | External |
| | Social risk |
| Economic | Return and investment |
| | Remanufacturing |
| | Analysis of results |
| Cross | Innovation and technology |
| | Supplying |
| | Strategy |
| | Stakeholders |
| | Knowledge and performance |

#### 4.2.1. Description of the Subdimensions of the Environmental Dimension

The environmental risk subdimension is composed of six characteristic elements: emissions to the atmosphere, water, and soil; hazardous waste; waste minimization; sustainability risk analysis; "carbon punch," and biodiversity. The characteristic elements are described below:

- Emissions to the atmosphere, water, and soil: emissions to the atmosphere, water, and soil due to corporate activities [13].
- Hazardous waste: hazardous waste and waste due to business activities [13].

- Waste minimization: global product lifecycle/example management service system integrated with business strategy [15].
- Sustainability risk analysis: risk analysis in supply chains occurs for both environmental and social aspects, if cost and implementation risks arising from the application of sustainability practices are fully assessed with partners [8,16].
- "Carbon punch": evidence of reconfiguration of operations to minimize the "carbon footprint" [15].
- Biodiversity: implementation of actions aimed at reducing impacts on biodiversity [13,15].
- The product portfolio subdimension is composed of four characteristic elements: resources (materials, energy, and recycling); Life Cycle Assessment Process (LCA); remanufacturing and material and parts selection. The characteristic elements are described below:
- Resources (materials, energy, and recycling): use of renewable and nonrenewable resources and energy through the company, including recycled resources [13].
- LCA: evaluation of whether the life cycle assists in the decision-making process of designers and in their cost and degree of efficiency. It also considers: selection of a sustainable production process; alternatives by designing teams aiming to reduce environmental impacts during the use of the product or service by the customer; and whether the evaluation of products are designed to facilitate disassembly, recycling, and reuse at the end of life [14].
- Remanufacturing: evaluation of loss of production materials due to defective products and shavings; use of some procedure to reduce the use of materials and standardized procedure that supports the environmentally correct use of resources. Considers the creation of production and packaging waste in the company. It also evaluates the use of long air in the production process; the amount of compressed air consumption, liquid infrastructure and compressor technology; identification and rapid correction of vulnerabilities and periodic review of the compressed air network to detect vulnerabilities and leaks [17].
- Material and parts selection: reduction of environmental impact through material selection [14].
- The tools subdimension is composed of one characteristic element: lean and green practices. The characteristic element is described below:
- Lean and green practices: use of lean tools (5S; Andon; Just in Time, Kanban; Poka-Yoke; Single Minute Exchange of Die (SMED); and Total Productive Maintenance (TPM) to reduce environmental impact [18].

#### 4.2.2. Description of the Subdimensions of the Social Dimension

The internal subdimension is composed of four characteristic elements: motivation and encouragement; health and safety; ergonomics and safety; development of human capital. The characteristic elements are described below:

- Motivation and encouragement: active involvement and exemplary management function in sustainability issues for employees. Awareness of the need's demands, and motivation factors of employees to implement sustainability in a sufficiently conscious way in the organization. Management support to act in a sustainable manner and the development of incentive and reward systems [13].
- Health and safety: safety and assurance so that there are no health and safety risks when working within/for the organization. No negative impact on the physical health of employees at any time. Operation of programs to prevent employees from preventing hazards and generally staying healthy [13].
- Ergonomics and safety: describe the way physiology takes care of body functions. It involves how a person interacts with their immediate work area and how people react to environmental conditions. With regard to safety, the organization must ensure the physical integrity of workers in the execution of their activities [13].

- Development of human capital: development of human capital for sustainability-related issues through specific programs such as continuing education, mentoring or training. A broad cross-cutting education in order to become aware of the different challenges and issues of corporate sustainability [8,13].
- The external subdimension is composed of three characteristic elements: ethical behavior and human rights, no controversial activity, and corporate citizenship. The characteristic elements are described below:
- Ethical behavior and human rights: ethical behavior in relation to sustainability, basic assumptions and principles relating to cooperation in the organization and behavior towards (external) stakeholders. In relation to sustainability, the important elements are a culture of respect, fair rules and behavior within an organization and an equitable distribution of wealth and results, consideration of the ideals and needs of stakeholders. No harm to employees, or with regard to their religious convictions, sex, nationality, color, disability, or age [13].
- No controversial activity: lack of participation in organizations that are mostly defined as unsustainable. Absence of use or sale of assets and own assets for unsustainable activities [13].
- Corporate citizenship: be a good corporate citizen on a national level, conservation of subsidiaries in the country and establishment of economic power of a country, as well as an increase in the lifestyle of society. Support for stakeholders and their issues at regional level; participation or creation of sustainability-related activities for the local community. Guidance on future generations without exploring the present (or nature) [13].
- The social risk subdimension is composed of one characteristic element: sustainability risk analysis. The characteristic element is described below:
- Sustainability risk analysis: risk analysis in supply chains. Cost and implementation risks arising from the application of sustainability practices are fully assessed with partners. Risk assessment is for both environmental and social aspects. With regard to environmental risks, the company must evaluate the impacts of the production process on the community [8,16].

#### 4.2.3. Description of the Subdimensions of the Economic Dimension

The return and investment subdimensions are composed of two characteristic elements: return and investment in sustainability, and management of the distribution of economic value. The characteristic elements are described below:

- Return and investment in sustainability: return and investment made in order to leverage issues involving sustainability [19].
- Management of the distribution of economic value: there is a broader scope of spending from supply chain suppliers (include fair trade throughout the chain) [1].
- The return and investment subdimension is composed of two characteristic elements: return and investment in sustainability; management of the distribution of economic value. The characteristic elements are described below:
- Inventory: costs related to the calculation of materials in stock and related to the remanufacturing process [17].
- Scrap and rework: costs related to materials that cannot be used in the production process and the activities that need to be performed again, depending on if the product does not present the parameters and characteristics defined in the project design [17].
- Organization of production: costs related to the internal organization of the plant to achieve sustainability [17].
- The analysis and results subdimension are composed of one characteristic element: financial results associated with sustainability efforts. The characteristic element is described below:

- Financial results associated with sustainability efforts: evaluation of the means used by the organization to determine the efforts directed towards sustainability. In addition, there is an assessment of the impact of expenditure on sustainability [19].

#### 4.2.4. Description of the Subdimensions of the Cross Dimension

The innovation and technology subdimension is composed of two characteristic elements: information systems and sustainable innovation. The characteristic elements are described below:

- Information systems: the sustainability practices of the information system are used in an integrated manner. For this, the organization is fully committed to sustainability and is oriented towards the continuous improvement of green IT practices implemented through detailed performance reports, exhaustive use of sustainability metrics, and management of the innovation process in sustainability [20,21].
- Sustainable innovation: sustainable innovation implies that it occurs regularly and systematically for the company's efforts, that is, it is purposely incorporated into the business culture and contributes to the financial stability of the organization. In addition, the organization should promote the integration of network knowledge with sustainable lean practices and total quality of global industry standard. The organization should aim to lead the sector in sustainable technologies and disruptive sustainable innovation [15,19]. The result of sustainable innovation is the generation of a differentiated product in all elements of sustainability. Design priority for sustainability in all new disruptive technologies. Industry Leader [15].

The supply subdimension is composed of three characteristic elements: purchase, sustainability risk analysis for supply, and supplier commitment program. The characteristic elements are described below:

- Purchase: considers sustainability in procurement and the supply chain. Relationship with suppliers focused on sustainability. Whether the acquisition strategy is reviewed regularly, examined externally, and directly linked to the program and environmental management system of organizations. In this case, a detailed review is carried out to determine future priorities and a new strategy is developed beyond this framework [13,22].
- Sustainability risk analysis for supply: best practices shared with other organizations and key sustainability performance indicators agreed with key suppliers [22].
- Supplier commitment program: suppliers recognized as essential for the implementation of the sustainable supply strategy of organizations and best practices shared with partner organizations. There are measures used to guide the organizational sustainable development strategy. Progress formally measured with partner organizations. The presence of independent audit reports available in the public domain and the simple measures based on the performance of all aspects of the level of leadership are put into practice and delivered [22].
- The strategic subdimension is composed of five characteristic elements: corporate governance; strategic and business vision; management of the portfolio of projects and programs; positioning and strategic marketing; collaboration. The characteristic elements are described below:
- Corporate governance: transparency in all its activities to improve the relationship with its stakeholders [13].
- Strategic and business vision: implementation of goals and results defined by the client. The way sustainability fits into the organization's mission and vision; the relevance of the TBL to the result and the way sustainability measures and metrics are reported [14,15].
- Management of the portfolio of projects and programs: integrated value chain plus external benchmarking [15].
- Positioning and strategic marketing: leadership strategy in the customer-centric sector and supported by a sustainable product service system [15].

- Collaboration: good cooperation and active collaboration with various trading partners. Work on common programs and networks on innovative products and technologies. Exchange of information and knowledge [13].
- The stakeholder subdimension is composed of one characteristic element: management of the relationship of suppliers, customers, and society. The characteristic element is described below:
- Management of the relationship of suppliers, customers, and society: the relationship management scheme goes beyond upstream and downstream partners to include managing the impact of operations on communities [1].
- The stakeholder subdimension is composed of six characteristic elements: knowledge management; processes; sustainability reports; global sustainability standards; sustainability benchmarking and sustainability training. The characteristic elements are described below:
- Knowledge management: activities and approaches to maintain knowledge related to sustainability in the organization. Methods to plan, develop, organize, maintain, transfer, apply, and measure specific knowledge and improve the organizational knowledge base. Knowledge management is institutionalized throughout the organization for the dissemination of issues involving sustainability. Checks organizational processes are improved based on formal evaluation procedures that consider aspects of sustainability [13,23,24].
- Processes: clear processes and roles are defined so that business activities are conducted efficiently and that each employee knows what the organization expects from it. Adapting process management to sustainability needs to systematically implement corporate sustainability. Integration of sustainability in everyday business life [13].
- Sustainability reports: considers the presence of sustainability in the company's reports, whether in a separate sustainability report or integrated into the corporate report. The formulation of performance indicators in the three dimensions and some metrics on the activities of supply chain suppliers [1,13]. Collection of internal and external data. Data is collected from most members of the supply chain. Data on environmental and social aspects are collected [8].
- Global sustainability standards: participation in all items of Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP), ISO 14000, and ISO 26000, United Nations Global Compact. Commitment to sustainability standards. Creative development of new sustainable capacities [25].
- Sustainability benchmarking: internal and external benchmarking. The comparison is made between multiple organizational units over time and between members of the supply chain. The scope of benchmarking is both for environmental and social aspects [8].
- Sustainability training: training of internal and business partners. Training given to internal managers, supervisors and business partners involved in sustainability practices. Training focuses on environmental and social aspects [8].

The proposed theoretical model has five levels of maturity, namely: nonexistent, conscious, intermediate, advanced, and sustainable. In the next topics each of the previously mentioned levels will be described.

#### 4.2.5. Description of the Level of Nonexistent Maturity

The level of maturity nonexistent is described below:

Environmental Risk

- The company is unaware of emission laws and regulations for air, water, and soil and does not present specific targets to reduce these emissions [13].
- The company is unaware of laws and regulations regarding hazardous waste and does not present specific targets for the issue of hazardous waste [13].
- The company is totally indifferent and does not take any specific action to minimize waste generation [15].

- Lack of cost risk analysis and implementation of sustainable practices throughout the supply chain [8,16].
- For the "carbon footprint", initial/unstrategy sensitization [15].
- The company is unaware of the laws and regulations related to biodiversity [13].

Product Portfolio

- For the use of resources are not considered any criteria [13].
- There is no LCA in relation to the products marketed by the company [14].
- The company does not take any specific action in relation to remanufacturing [17].
- Design teams' design does not consider material selection as an alternative to reduce environmental impacts [14].

Tools

- The company does not adopt any lean tool (5S; Andon, Just in Time, Kanban; Poka-Yoke; SMED, and TPM to reduce environmental impacts) [18].

Internal

- The motivation of employees to achieve sustainability objectives has no impact under it [13].
- Health and safety are not considered in the company [13].
- The work environment does not consider environmental impacts that may negatively influence people's performance. With regard to security, the organization does not invest in actions that aim to preserve the physical integrity of its employees. Workplace design does not positively influence the ergonomics, attitudes, motivation, and behavior of staff [13].
- In relation to sustainability, no general and specific measures for the development of human capital are defined [13].

External

- Human rights are not respected and there are no codes and guidelines, as well as no common corporate/within-organization behavior [13].
- There is no statement against controversial activities [13].
- The company is unaware of the concept of corporate citizenship [13].

Social Risk

- No sustainability risk analysis [8].

Return and Investment

- Innovation is irregular and generally activity-based, with little or no formal process guidance. It is generally regarded as a necessity and rarely or never directed towards forecasting [19].
- Information not available regarding the management of economic value distribution [1].
- There is no control in relation to remanufacturing-related inventory [17].
- There is no control regarding scrap/rework related to remanufacturing [17].
- The company does not invest in the plant's internal physical arrangement to achieve sustainability [17].
- The company does not consider the possibility of financial reports focused on sustainability-oriented efforts [19].

Remanufacturing

- There is no control in relation to remanufacturing-related inventory [17].

- There is no control regarding scrap/rework related to remanufacturing [17].
- The company does not invest in the plant's internal physical arrangement to achieve sustainability [17].

Analysis and Results

- The company does not consider the possibility of financial reports focused on sustainability-oriented efforts [19].

Innovation and Technology

- The organization does not take into account sustainability and no green IT practice is defined [21].
- The company generally has little or no awareness of sustainability-related innovation opportunities [19].

Supply

- Simple sustainable delivery policy in force approved by the strategic level of the organization [22].
- The main contracts begin to include general sustainability criteria [22].
- Key suppliers focused on the commitment and views on the intended supply policy [22].

Strategic

- The company is unaware of the concept of corporate governance [13].
- Internal business plan in relation to strategic and business vision [15].
- Based on internal knowledge regarding the management of the portfolio of projects and programs [15].
- Basic reports of corporate social responsibility not highlighted in the marketing literature [15].
- The company does not take any action in relation to the collaboration process [13].

Stakeholders

- Information not available for managing the relationship of suppliers, customers, and society [1].

Knowledge and Performance

- With regard to knowledge management, there is an incipient increase in awareness of the benefits for business improvement [23].
- The company does not adopt the perspective of the vision of processes in its management [13].
- No sustainability-related report [8].
- No participation in global sustainability standards [25].
- Sem Benchmarking [8].
- No sustainability training [8].

#### 4.2.6. Description of the Level of Conscious Maturity

The level of maturity conscious is described below:

Environmental Risk

- The company is aware of the existence of emission laws and regulations for air, water, and soil. However, it does not have specific targets for reducing these emissions [13].
- The company is aware of the existence of laws and regulations regarding hazardous waste. However, it does not present specific targets for the issue of hazardous waste [13].

- The company recognizes the relevance but does not take any specific action to minimize waste generation [15].
- The company develops internal and sporadic analyses of cost risks and implementation of sustainable supply chain practices [8,16].
- For the "carbon footprint", the complete measurement of the "carbon footprint" occurs for high volume/high environmental impact products through carbon [15].
- The company is aware of the laws and regulations relating to biodiversity but is not in compliance with them. The most relevant impacts on biodiversity are not yet identified and considered [13].

Product Portfolio

- For the use of resources, only economic and technical criteria are considered [13].
- The company is structuring forms, still in the initial stages, of construction of the LCA [14].
- For remanufacturing, manufacturing processes are considered during the project and design teams reduce the impact of products by choosing a more sustainable production process. Design teams' design still does not seek to minimize the impact of the product or service while it is in use by the customer. Design teams' design still does not consider what will happen to the product at the end of its useful life and the products are not yet designed to facilitate disassembly, recycling, and end-of-life reuse [17].
- Design teams' design considers material selection as an alternative to reducing environmental impact. However, these alternatives are not implemented [14].

Tools

- The company adopts one of the lean tools (5S; Andon, Just in Time, Kanban; Poka-Yoke; SMED and is unaware of the concept of TPM for reducing environmental impacts) [18].

Internal

- The motivation of employees to achieve sustainability objectives is not focused or has a dysfunctional impact on sustainability [13].
- Health and safety are respected to the extent of the legal obligation [13].
- The work environment considers some environmental impacts that may negatively influence people's performance. With regard to safety, the organization invests seasonally in actions that aim to preserve the physical integrity of its employees. Workplace design does not positively influence the ergonomics, attitudes, motivation, and behavior of staff [13].
- Regarding sustainability, the company is still structuring some general measures for the development of human capital [13].

External

- Human rights are generally respected, but there are no codes and guidelines, as well as no common corporate/within-organization behavior [13].
- The declaration against controversial activities is under preparation [13].
- Corporate citizenship is not focused on the organization [13].

Social Risk

- Risk analysis in preparation for internal sustainability practices. The implications of cost and implementation risks in selected organizational units are evaluated. Objective of the risk analysis: one aspect of TBL [8].

Return and Investment

- Innovation remains erratic, but with an emerging process orientation. The portfolio of innovation projects combines need-centric projects and opportunity-based projects [19].
- Economic value (in the form of dividends) distributed only to shareholders [1].

Remanufacturing

- The remanufacturing inventory process exists, but is not sufficiently transparent [17].
- The remanufacturing-related scrap/rework control process exists, but is not sufficiently transparent [17].
- The company prepares a plan for the realization of investments in internal physical arrangement of the plant to achieve sustainability [17].

Analysis and Results

- The company is evaluating the possibility of building reports to determine the efforts directed towards sustainability.

Innovation and Technology

- The organization takes sustainability into account and conducts green IT practices in the most critical aspects related to sustainability [21].
- Sustainability-related innovation is typically driven by short-term problems and is seen as a necessity rather than profit opportunity [19].

Supply

- Review and strengthen sustainable supply policy, in particular taking into account supplier involvement [22].
- Main sustainability risks assessed and used for prioritization [22].
- Start of the general program of supplier involvement, with the participation of managers of the strategic level [22].

Strategic

- Corporate governance is focused on a mandatory structure [13].
- Business planning process in force for medium-term objectives in relation to strategic and business vision [15].
- Independent portfolio management in all business units in relation to project and program portfolio management [15].
- Repeated/consistent reports between business units with alignment with strategy and vision [15].
- The company is not an active partner in network diagrams [13].

Stakeholders

- For management of the relationship of suppliers, customers, and society, a relationship of seller and traditional buyer, without any evaluation of suppliers or development program [1].

Knowledge and Performance

- Development of knowledge management strategy and definition of work. Characterized by knowledge management structure, need for resources, barriers, and risks [23].
- Absence of sustainability issues in the definition of processes [13].
- Internal reports are under construction [8].

- Internal structuring to enable participation in one of the global sustainability standards (GRI, CDP, ISO 14000 and ISO 26000, United Nations Global Compact) [25].
- Start of implementation of internal benchmarking [8].
- Under construction, training aimed at sustainability [8].

#### 4.2.7. Description of Intermediate Maturity Level

The level of maturity intermediate is described below:

Environmental Risk

- The company follows some laws and regulations relating to emissions to air, water, and soil. However, it is still structuring specific targets to reduce these emissions [13].
- The company follows some laws and regulations regarding hazardous waste. However, it is still structuring specific targets for the issue of hazardous waste [13].
- The company irregularly adopts some specific actions to minimize waste generation [15].
- The company develops internal and supplier analyses in relation to cost risks and implementation of sustainable supply chain practices [8,16].
- With regard to the "carbon footprint", the evaluation of manufacturing sites from switching to renewable sources/implementation of the smart grid [15].
- Compliance with biodiversity laws and regulations. The most relevant impacts on biodiversity are identified and considered [13].

Product Portfolio

- For the use of resources, economic and technical criteria are considered and/or partially the environmental/social criteria. Resource efficiency is measured for some business processes [13].
- LCA data are incorporated into the decision-making by the design teams, but the LCA process is not yet well established [14].
- For remanufacturing, manufacturing processes are considered during the project and design teams reduce the impact of products by choosing a more sustainable production process. Design teams seek to minimize the impact of the product or service while in use by the customer. Design teams design still do not consider what will happen to the product at the end of its useful life and the products are not yet designed to facilitate disassembly, recycling, and end-of-life reuse [17].
- Design teams' design implement consistent alternatives to reduce the environmental impact of products through material selection. However, the cost is still high for the company [14].

Tools

- The company adopts three of the lean tools (5S; Andon, Just in Time, Kanban; Poka-Yoke; SMED and is in the initial phase of application of the concept of TPM for reducing environmental impacts) [18].

Internal

- In several areas of the organization, measures are defined to encourage motivation for sustainability [13].
- Health and safety are respected to the extent of the legal obligation. Health and safety measures are established when dangerous situations or specific accidents occur. The deployment is more reactive than systematically planned [13].
- The work environment considers some environmental impacts that may negatively influence people's performance. With regard to security, the organization invests irregularly in actions that

aim to preserve the physical integrity of its employees. Workplace design essentially influences staff ergonomics [13].
- Some general measures for the development of human capital are defined in relation to sustainability [13].

External

- Human rights are respected. The main rules of behavior within the organization are challenged [13].
- The company declares to be aware to those who sell its products [13].
- Certain corporate citizenship projects are initiated or supported (mainly in monetary terms). Rarely presents a relationship between projects and the corporate business [13].

Social Risk

- Risk analysis for internal sustainability practices. The implications of cost and implementation risks in selected organizational units are evaluated. Risk analysis: environmental [8].

Return and Investment

- Innovation processes are well documented, and innovation is expected to be effectively realized. Supply chain members are selected in part based on their ability to accelerate or contribute to innovation efforts. Innovation is seen as an element to the contribution of the financial health of companies and overcome the perception of being cost neutral to be based on opportunities [19].
- Awards and rewards awarded to employees [1].

Remanufacturing

- Existence of indicators for processes implementation of isolated optimization methods in relation to inventory for remanufacturing [17].
- Existence of indicators for processes implementation of isolated optimization methods in relation to scrap and rework for remanufacturing [17].
- The company makes sporadic investments in the factory's internal physical arrangement to achieve sustainability [17].

Analysis and Results

- The company is in the reporting phase for the investigation of efforts directed to sustainability [19].

Innovation and Technology

- Green IT practices are clearly defined, established, and managed in different business areas, contributing to sustainability in and through IT [21].
- The company is between an initial and intermediate phase of incorporating systematic and reapplicable innovation processes (innovation projects intentionally linked to the strategy and opportunities of corporate social and environmental responsibility). Some projects will be cost-based, others cost-neutral, and other revenue generators expected to have balanced overall financial performance [19].

Supply

- Transform sustainable supply policy into a strategy that addresses risk, process integration, marketing, supplier engagement, review, and measurement process. Strategy approved by the strategic level [22].
- All contracts are assessed for general sustainability risks and management actions and risks managed throughout all phases of the supply process are identified [22].

- Program oriented to the involvement of suppliers, promoting continuous improvement of sustainability. There is a two-way communication between the buyer and the supplier with incentives [22].

Strategic

- The company is focused on mandatory and voluntary corporate governance structures [13].
- Long-term strategic plan linked to the defined needs of the client, conducted by the focal company, with results communicated to the network between companies in relation to strategic and business vision [15].
- Regarding the management of the portfolio of projects and programs, linked through the strategic marketing function, but without interdependencies. Value chains of the mapped and understood program(s); internal benchmarking; integration of customers and feedback on supplier quality [15].
- Corporate social responsibility reports incorporating all elements of the TBL and limited in relation to the dimensions of sustainability (energy efficiency and effectiveness; use of resources; minimization of waste; "carbon footprint"). Some integration with customer specifications [15].
- Communication and collaboration with the most relevant business partners (supplier, customer) [13].

Stakeholders

- For the management of the relationship of suppliers, customers, and society, an active program of evaluation and development of suppliers upstream and downstream [1] is in place.

Knowledge and Performance

- Increased visibility of initiatives and leadership in knowledge management. Characterized by a structured approach to implement and modify management directed to barriers and risks [23].
- The most relevant sustainability issues are respected in the relevant business processes [13].
- Limited internal reports. The reports are only for top management. The scope of the report: only one aspect of the TBL [8].
- Participation in three items related to global sustainability standards (GRI, CDP, ISO 14000 and ISO 26000, United Nations Global Compact) [25].
- Limited internal benchmarking. Comparison of environmental performance with the goal set by top management. The scope of benchmarking is only for a single aspect of the TBL [8].
- Limited internal training. Training given to the main business managers to generate awareness about sustainability. Training focused on one aspect of TBL [8].

#### 4.2.8. Description of the Advanced Maturity Level

The level of maturity advanced is described below:

Environmental Risk

- The company complies with emission laws and regulations for air, water, and soil. In addition, it presents specific and conservative emission reduction targets [13].
- The company operates and complies with laws and regulations regarding hazardous waste. In addition, it presents specific and conservative targets for the issue of hazardous waste [13].
- The company regularly adopts some specific actions to minimize waste generation [15].
- The company develops internal and supplier analyses with key distributors in relation to cost risks and implementation of sustainable supply chain practices [8,16].
- For the "carbon footprint", map the network to the coverage area based on the configuration of operations [15].

- Biodiversity and organizational impact on it in strategy, policy, and processes are considered [13].

Product Portfolio

- For the use of resources economic, technical and/ or environmental/social criteria are considered. Resource efficiency is measured for business processes; targets are set for resource management. The principles of sustainability are partially considered [13].
- LCA data is incorporated into decision-making by design teams and the LCA process is efficient and well established. However, LCA still has a high cost for the company [14].
- For remanufacturing, manufacturing processes are considered during the project and design teams reduce the impact of products by choosing a more sustainable production process. Design teams seek to minimize the impact of the product or service while in use by the customer. Design teams' design considers what will happen to the product at the end of its useful life and the products are not yet designed to facilitate disassembly, recycling, and end-of-life reuse [17].
- Design teams' design has consistent alternatives to reducing the environmental impact of products through material selection. However, it still adopts the financial cost as the main criterion for the selection of material [14].

Tools

- The company adopts five of the lean tools (5S; Andon, Just in Time, Kanban; Poka-Yoke; SMED and is in the final phase of application of the concept of TPM for reducing environmental impacts) [18].

Internal

- In most areas of the organization, measures are defined to encourage motivation for sustainability. Top management has an exemplary sustainability role [13].
- Health and safety are systematically planned and implemented in most areas of the company. Activities are defined to avoid long-term health and safety risks [13].
- The work environment considers all environmental impacts that may negatively influence people's performance. With regard to security, the organization regularly invests in actions that aim to preserve the physical integrity of its employees. Workplace design essentially influences staff ergonomics [13].
- Some specific measures for the development of human capital are defined in relation to sustainability [13].

External

- There is the definition of corporate codes and guidelines on the (internal) behavior of the entire organization [13].
- The organization knows whom it sells its products to and establishes measures to reduce controversial activities [13].
- Corporate citizenship is systematically planned and conducted (monetary and nonmonetary commitment). There is a link between the projects and the corporate business [13].

Social Risk

- Rigorous analysis of internal sustainability practices. Risks of costs and implementation of changes arising from changes introduced in the structure and organizational processes evaluated internally. Risk assessment: environmental [8].

Return and Investment

- Although innovation efforts are carried out as projects, innovation is routine and culturally rooted, resulting in a clear contribution to the company's financial performance [19].

- Investment in the development of supply chain partners (suppliers) [1].

Remanufacturing

- Implementation of advanced methods of optimization for inventory in the remanufacturing process [17].
- The company makes regular investments in the plant's internal physical arrangement to achieve sustainability [17].

Analysis and Results

- The company has some reports to determine the efforts directed to sustainability. In addition, there is an assessment of the impact of expenditure on sustainability [19].

Innovation and Technology

- Green IT within organizations is properly managed and governed, performing the monitoring, evaluation and measurement of green IT practices implemented, through a set of sustainability metrics established for this purpose [21].
- The implications of sustainability are an important and thoughtful consideration in most innovation efforts. Sustainability-based innovation efforts cover most business domains and are well understood with financial performance. Some innovations for sustainability processes and results are benchmarking of quality and considered as good practices by nature [19].

Supply

- Review and strengthen the sustainable supply strategy, recognizing in particular the potential of new technologies. Try to link the strategy to environmental management programs and systems and include it in the company's overall strategy [22].
- Detailed sustainability risks assessed for high impact contracts and implemented sustainability governance contracts/projects. [22].
- Sustainability audits and supply chain improvement programs in place. Key suppliers oriented to intensive development. Achievements are formally recorded [22].

Strategic

- The company is focused on mandatory and voluntary corporate governance structures. Other measures aimed at ensuring corporate transparency [13].
- Implementation of external benchmarking in internally driven goals in relation to strategic and business vision [15]. Sustainability in the process of insertion in the mission and vision of the organization; the concept of TBL begins to achieve profound relevance for the result and sustainability measures and metrics are reported regularly and consistently [14].
- Limited understanding of the overlapping of elements of the value chain between project portfolios in relation to project and program portfolio management [15].
- Fully managed positioning with clear plan to achieve the best supply of product service systems in the sector [15].
- Communication and collaboration with stakeholders on sustainability issues [13].

Stakeholders

- To manage the relationship of suppliers, customers, and society, upstream and downstream partners are tracked and/or trained in occupational health and safety, child labor and/or human rights programs [1].

Knowledge and Performance

- Improvement of the performance of activities related to knowledge management. Characterized by an increase in emphasis on the specific use of qualitative and quantitative methods to measure and monitor the performance of knowledge management and justify knowledge management initiatives [23].
- Relevant sustainability issues are respected in business and support processes [13].
- Broader internal reports. Both for top management and for all management layers. Increased transparency in reports. Scope of reports: environmental and social [8].
- Participation in all items of GRI, CDP, ISO 14000 and ISO 26000, United Nations Global Compact [25].
- Strict internal benchmarking. The comparison is made between several organizational units over time and in relation to the goals established by the high management level. The scope of benchmarking refers to environmental and social aspects [8].
- Broader internal training. Training (environmental and social) given to leading business managers and supervisory staff to develop awareness of sustainability about making information-based and sustainable decisions [8].

4.2.9. Description of the Level of Sustainable Maturity

The level of maturity sustainable is described below:

Environmental Risk

- The company complies with emission laws and regulations for air, water, and soil (e.g., evaluation of the best techniques). Ambitious emission reduction targets are set [13].
- The company operates and complies with laws and regulations regarding hazardous waste. Ambitious targets are set for the issue of hazardous waste [13].
- For waste minimization, the Global Product Lifecycle/Example Management Service System integrated with the business strategy [15].
- The cost and implementation risks arising from the application of sustainability practices are fully assessed with all supply chain partners [8,16].
- Evidence of reconfiguration of operations to minimize the "carbon footprint" [15].
- Notable activities and approaches are implemented in order to reduce the organizational impact on biodiversity [13].

Product Portfolio

- For the use of resources a combination of economic, technical, environmental, and social criteria is considered. Resource efficiency is controlled for all processes. The long-term resource management strategy is aligned with the principles of sustainability [13].
- LCA data are incorporated into the decision-making by the design teams and the LCA process is well established, efficient, and inexpensive [14].
- For remanufacturing, manufacturing processes are considered during the project and design teams reduce the impact of products by choosing a more sustainable production process. Design teams seek to minimize the impact of the product or service while in use by the customer. Design teams' design considers what will happen to the product at the end of its useful life and the products are designed to facilitate disassembly, recycling, and end-of-life reuse [17].
- Design teams' design has consistent alternatives to reducing the environmental impact of products through material selection. The company adopts both the financial and environmental cost as well as criteria for the selection of materials [14].

Tools

- The company adopts all lean tools (5S; Andon, Just in Time, Kanban; Poka-Yoke; SMED and fully applies the concept of TPM for reducing environmental impacts) [18].

Internal

- Senior management has an exemplary role when it comes to sustainability issues. Employees are efficiently supported by appropriate incentives and motivations (monetary and nonmonetary). Because of this, the principles of sustainability are internalized and change behavior [13].
- The health and safety approach supports organizational goals toward sustainability. It is systematically planned and deployed throughout the enterprise. Activities are defined to avoid long-term health and safety risks and are consequently improved [13].
- The work environment considers all environmental impacts that may negatively influence people's performance. With regard to security, the organization regularly invests in actions that aim to preserve the physical integrity of its employees. Workplace design positively influences the ergonomics, attitudes, motivation, and behavior of staff [13].
- Various education programs and measures are offered. Every employee is trained in sustainability issues [13].

External

- The organization is known as a noncontroversial operating company. It shows credibility in that it offers and follows possibilities to avoid the negative use of its products, based on the requirements of stakeholders [13].
- Corporate citizenship is systematically planned and conducted (monetary and nonmonetary commitment) and focused on long-term commitment. Most employees are integrated into the process. There is a link between the organization's projects and the corporate business [13].

Social Risk

- Risk analysis in supply chains. Cost and implementation risks arising from the application of sustainability practices are fully assessed with partners. Risk assessment is directed to environmental aspects [8].

Return and Investment

- Revenue related to innovation is of strategic importance to the company and significantly guides reinvestment (with quantifiable expected return) in the research and development strategy. Most innovation efforts are based on previously established planning, with many projects based on long-term trends and opportunities. The innovation, research, and development strategy is directly linked to the economic aspects of sustainability [19].
- There is a broader scope of spending on supply chain suppliers (including fair trade throughout the chain) [1].

Remanufacturing

- Implementation of advanced optimization methods in operator/worker management and include the optimization of processes in daily work for the issue of inventory in remanufacturing [17].
- Implementation of advanced optimization methods in operator/worker management and include the optimization of processes in daily work for the issue of scrap/rework in remanufacturing [17].
- The company makes regular investments and presents a specific budget for the internal physical arrangement of the plant with the objective of achieving sustainability [17].

Analysis and Results

- The company has specific reports for the investigation of efforts directed to sustainability. In addition, there is an assessment of the impact of expenditure on sustainability [19].

Innovation and Technology

- The organization is fully committed to sustainability and is oriented towards the continuous improvement of green IT practices implemented through detailed performance reports, exhaustive use of sustainability metrics and management of the sustainability innovation process [21].
- All innovation efforts explicitly incorporate sustainability considerations. The supplier selection process includes evaluating their ability to collaborate on sustainability issues related to efforts for business innovation through the TBL. The company is an industry leader in sustainability innovation efforts and results [19].

Supply

- The strategy is regularly reviewed, examined externally and directly linked to the program and environmental management system of organizations. A detailed review is carried out to determine future priorities and a new strategy beyond this framework is developed [22].
- Best practices shared with other organizations and key sustainability performance indicators agreed with key suppliers [22].
- Suppliers recognized as essential for the implementation of the sustainable supply strategy of organizations. Best practices shared with other/peer organizations [22].

Strategic

- The company is focused on mandatory and voluntary corporate governance structures. Other measures aimed at ensuring corporate transparency. Proactive commitment to the strictest rules [13].
- Implementation of goals and results defined by the client in relation to strategic and business vision [15]. Sustainability fits into the organization's mission and vision; the concept of TBL has deep relevance to the result and sustainability measures and metrics are reported regularly and consistently [14].
- Integrated value chain with external benchmarking in relation to project and program portfolio management [15].
- Leadership strategy in the customer-centric sector and supported by a sustainable product service system [15].
- Communication and collaboration with stakeholders. The company has a leading role and proactivity in creating these sustainability-related networks [13].

Stakeholders

- To manage the relationship of suppliers, customers, and society, the relationship management scheme goes beyond upstream and downstream partners to include the management of the impact of operations on communities [1].

Knowledge and Performance

- Sustain the performance of activities related to knowledge management. The expectation regarding knowledge management is to compose the normal routine, disseminated within the organization, as well as to be an integral part of organizational culture, employee behavior, business processes, and product development [23].

- Sustainability issues are respected in business and support processes in a sufficiently efficient manner. Roles and responsibilities are defined [13].
- Internal and external reports. External reporting may involve reporting to regulators and the general public. Scope of reports: environmental and social [8].
- Participation in all items of GRI, CDP, ISO 14000 and ISO 26000, United Nations Global Compact. Commitment to sustainability standards. Creative development of new sustainable capacities [25].
- Internal and external benchmarking. The comparison is made between multiple organizational units over time and between members of the supply chain. The scope of benchmarking is both for environmental and social aspects [8].
- Training of internal and business partners. Training given to internal managers, supervisors, and business partners involved in sustainability practices. Training focuses on environmental and social aspects [8].

### *4.3. Classification of Performance Measurement Systems at Maturity Level in the Basic Theoretical Model*

At this stage, the performance measurement systems were aligned with the maturity levels determined in the initial theoretical model. For the realization of this alignment, the relationship of the characteristics present in the measurement systems and the level of maturity in sustainability were adopted as a criterion, justifying the reasons why each proposal is suitable for a given evolutionary stage.

The proposal of Andersson et al. [43] presents as a central characteristic the presence of five perspectives that allow the integration of different measurements into a global supply chain strategy. In view of the above, the proposal is more adherent to more advanced levels in terms of sustainability, namely: advanced and sustainable.

The Supply Chain Operations Reference (SCOR) proposal includes two perspectives for improvement: internal (internal processes) and external (partner-related processes), which include a broad view of the supply chain. In this case, SCOR is more adherent to more advanced levels in terms of maturity in sustainability in the supply chain, such as: advanced and sustainable [44].

Van Hoek's proposal (1998) suggests the evolution of the level of cost-effectiveness for integration. In this way the proposal can be inserted in one of the following levels: conscious, intermediate, advanced, or sustainable [45].

Beamon's (1999) proposal focuses on resource performance measures focused on financial aspects and customer-driven output measures. In view of the above, the proposal is more adherent to the conscious level [46].

Holmberg's proposal (2000) highlights the need to integrate the performance measurement systems of the organizations that make up the supply chain. Another relevant point is that the supply chain should be considered as an organization. Given the integrated perspective of the supply chain, Holmberg's proposal can be inserted at one of the levels: intermediate, advanced, or sustainable [47].

The proposal of Gunasekaran, Patel, and Tirtiroglu (2001) presents metrics for the three levels of an organization (strategic, tactical, and operational). Metrics are focused on financial, customer, and production aspects [48]. Compared to Beamon's proposal (1999), there is an advance in the approach by organizational levels and characteristics of metrics. In view of the above, this proposal is more adherent to intermediate or advanced levels [46].

The proposals of Park et al. [49] and Bhagwat and Sharma [50] adapt BCS to the supply chain. Due to the characteristics of the proposals, they are related to more evolved levels such as: advanced and sustainable.

The proposal of Hervani, Helms and Sarkis [6] makes an adaptation of the concepts present in the BSC to issues related to sustainability. In view of the above, the proposal presents greater adherence to the sustainable level.

The proposal of Thakkar et al. [51] merges two concepts: BSC and SCOR. Based on the adjustments already made this proposal is more adherent to the advanced and sustainable levels.

The proposal of Hofmann and Locker [52] is focused exclusively on financial aspects with regard to the measurement of performance in the supply chain. Therefore, the proposal is more adherent to the first levels of maturity. In this case, it is more linked to the conscious level.

The proposal of Luzzini, Caniato and Spina [53] is focused on assessing the impacts of the suppliers' performance measurement system on end-customer satisfaction. Due to this specific focus, this proposal is directed to the first levels of maturity. In this case, it is more linked to the conscious level.

Sillanpää's (2015) proposal is exclusively focused on the manufacturing industry, addressing four basic indicators: order book analysis, profitability, time, and management analysis. In view of the above, this proposal is also linked to the initial levels of maturity, that is, it is linked to the conscious level [54].

The proposal by Laihonen and Pekkola [55] assesses the impacts of a performance measurement system under the supply chain can be categorized as follows: (1) impacts on people's behavior, (2) impacts on organizational capabilities, and (3) impacts on performance. Another relevant point is the exchange of knowledge between organizations. Because of these perspectives that offer a more integrated view of the supply chain, this proposal is more adherent to the advanced and sustainable levels.

Jääskeläinen and Thitz's (2018) proposal assesses the prerequisites for the performance measurement system to support buyer-supplier relationships and value co-creation. Based on the similarity with the proposal proposed by Luzzini, Caniato and Spina [53], the proposal of Jääskeläinen and Thitz (2018) is also more adherent to the conscious level [56].

Figure 2 below illustrates the result of the classification of performance measurement systems in relation to the maturity levels of the proposed theoretical model.

| Maturity levels / Performance measurement systems | Nonexistent | Aware | Intermediate | Advanced | Sustainable |
|---|---|---|---|---|---|
| [43] | | | | ■ | ■ |
| [44] | | | | ■ | ■ |
| [45] | | ■ | ■ | ■ | ■ |
| [46] | | ■ | | | |
| [47] | | | ■ | ■ | ■ |
| [48] | | | ■ | ■ | |
| [49] | | | | ■ | ■ |
| [50] | | | | ■ | ■ |
| [6] | | | | | ■ |
| [51] | | | | ■ | ■ |
| [52] | | ■ | | | |
| [53] | | ■ | | | |
| [54] | | ■ | | | |
| [55] | | | | ■ | ■ |
| [56] | | ■ | | | |

**Figure 2.** Result of the classification of performance measurement systems in relation to the maturity levels of the proposed theoretical model. The blue colored cells represents maturity level of the proposed theoretical model.

The adequacy of the performance measurement system to the level of maturity in sustainability will help the company to identify processes that require improvements that will contribute to the evolution in the level of maturity in sustainability in the supply chain. Another important point is that the company will be able to evaluate whether or not the measurement system is adherent to the level of maturity in sustainability, allowing the monitoring of processes in the supply chain to occur more effectively.

### *4.4. Proposed Theoretical Model*

The proposed theoretical model is the result of a wide literature research and aims to mitigate the limitations identified in other models of maturity in sustainability. For this, five levels of maturity (nonexistent, conscious, intermediate, advanced, and sustainable) and four dimensions (environmental, social, economic, and transversal) were structured. The proposed dimensions aim to align the model with the TBL concept, plus one more element. The cross dimension establishes a holistic view of the organization and integrated with the other dimensions. Another relevant point refers to the alignment of the maturity levels of the theoretical model with the performance measurement systems in the supply chain. Table 5 presents the description of the proposed theoretical model.

**Table 5.** Description of the final theoretical model.

| | |
|---|---|
| **Nonexistent** | **Environmental**: The company does not carry out actions focused on environmental issues; **social**: absence of internal and external planning for the dissemination of sustainability; **economic**: the innovation process is irregular and the action directed to remanufacturing and analysis and results and **cross-cutting**: the company does not act on the issues that integrate the three previous dimensions. Absence of a supply chain performance measurement system. |
| **Aware** | **Environmental**: The company presents an initial awareness of environmental issues; **social**: an internal and external planning still incipient for the dissemination of sustainability; **economic**: the innovation process is irregular, but with an emerging orientation and initial advances in terms of remanufacturing and analysis and results; the company presents an initial awareness of the issues that make up the three previous dimensions. Performance measurement systems: [45,46,52–54,56]. |
| **Intermediate** | **Environmental**: The company follows some laws and regulations related to emissions, waste and biodiversity. The issue of the 'carbon footprint' is now being assessed; **social**: a reactive internal and external planning that assesses the issue of health and safety from the perspective of legal obligation; **economic**: the innovation process is documented, existence of indicators related to remanufacturing and reporting to measure the efforts directed to sustainability and **transversal**: the company presents an important advance in terms of planning and execution in the issues that integrate the three previous dimensions. Performance measurement systems: [45,47,48]. |
| **Advanced** | **Environmental**: The company passes complies with laws and regulations related to emissions, waste and biodiversity (conservative targets for emissions and waste). The issue of the 'carbon footprint' advances significantly and the company adopts five of the *lean tools;* **internal** and externally structured planning that systematically assesses the issue of health and safety. Corporate codes and guidelines on (internal) behavior and corporate citizenship are systematically planned; **economic**: the innovation process is routine, advanced optimization methods for remanufacturing and some reports to gauge sustainability and **cross-cutting** efforts: the company advances in a structured and planned way in terms of innovation and technology; the sustainable delivery strategy is reviewed and strengthened; sustainability advances in terms of mission and business vision; *stakeholder* relationship management is significantly advanced and knowledge and performance in terms of sustainability close to full consolidation. Performance measurement systems: [6,43–45,47–51,55]. |
| **Sustainable** | **Environmental**: The company passes complies with laws and regulations related to emissions, waste and biodiversity (ambitious targets for emissions and waste). And evidence of reconfiguration of operations to minimize the 'carbon footprint' and the adoption of all *lean* tools; **social**: education programs and measures are offered and sustainability is disseminated from the strategic level; **economic**: return and investment; remanufacturing and analysis and results reach their maximum level in terms of sustainability and **transversal**: effective integration of all sub-divisions with corporate strategy. Performance measurement systems: [6,43–45,47–51,55]. |

### *4.5. Discussion and General Considerations about the Model*

The theoretical model proposed in this study aims to reduce the gaps identified in the models present in literature (topic 4.1). The Table 6 is related to elements described in Table 3.

**Table 6.** Proposed theoretical model in relation to the limitations identified in the models presented in the literature.

| Proposed Theoretical Model | Limitations Identified in the Models Presented in the Literature |
| --- | --- |
| The proposed theoretical model focuses on the dimensions present in the TBL and the insertion of a fourth dimension (transversal), focusing on an integrated and holistic perspective of the other dimensions. | The focus is presented on only one aspect of the supply chain. |
| The proposed theoretical model has a direct relationship with the concepts present in the TBL. | There is a lack of direct relationship between the characteristic elements of the model and the dimensions determined in the TBL concept. |
| Due to the integrated perspective of the proposed theoretical model, characteristic elements of other models present in the literature were inserted. | The approach is somewhat generic when it comes to economic sustainability, with the insertion of a series of elements that do not present a clear relationship with the economic dimension of the TBL. |
| Due to the hybrid and integrative characteristic, the proposed theoretical model establishes an interface between analytical and empirical models. | The models use the analytical research method [6]. In this case, there was no proof or adjustment of its theoretical premises. |
| The proposed theoretical model clearly describes the characteristic elements present in the dimensions, as well as the maturity levels suggested in the model. | The model does not clearly display its characteristic elements. |

Another relevant point to be considered in relation to maturity level assessment is related to overcoming organizational (strategy, structure, resources, and culture) and operational (lack of models, methods, and support tools) barriers in order to implement eco-innovation in their products, processes, and projects [68,69].

Thus, the involvement of all organizational levels (strategic, tactical, and operational) and stakeholders is necessary for the implementation of a culture focused on sustainability [70].

In the comparison of the proposed model in relation to the other models, the difference is the inclusion, in the transversal dimension, of the innovation and technology component. According to Kusi-Sarpong, Gupta and Sarkis [71] there is a gap in studies that relate sustainability and innovation [72].

The proposed model can be applied to companies of various segments, because the focus is broad and contemplates the three dimensions present in the TBL and the insertion of a fourth dimension that presents a holistic/integrated vision of the other dimensions (environmental, social, and economic).

The application of the model will contemplate the topics below:

- Compliance with laws and regulations concerning emissions to air, water, and soil, with specific targets for these issues. In addition, you should consider compliance with laws and regulations concerning hazardous waste (e.g., assessment of best techniques).
- Minimization of hazardous waste.
- Risks of cost and implementation of sustainable practices with the entire supply chain.
- "Carbon footprint".
- Biodiversity.
- Use of resources (materials, energy, and recycling) and selection of parts/materials considered specific criteria.

- LCA is incorporated in its development. In this case, it is relevant to consider aspects of remanufacturing.
- Use of tools linked to the lean concept to reduce environmental impacts.
- The strategic level of organizations has an exemplary function with regard to sustainability issues and the incentives and motivations (monetary and nonmonetary) are appropriate.
- The health and safety approach supports organizational goals towards sustainability.
- Environmental impacts that negatively influence employee performance.
- Specific programs for training employees in issues involving sustainability.
- Definition of corporate codes and guidelines on (internal) behavior throughout the organization.
- The company demonstrates credibility to the extent that it offers and follows possibilities of avoiding the negative use of its products, based on the requirements of the interested parties.
- Corporate citizenship is systematically planned and conducted (monetary and nonmonetary commitment) and focused on long-term commitment.
- Analysis of cost risks and implementation of sustainable practices with the entire supply chain.
- Innovation-related revenue is of strategic importance to the company and significantly guides reinvestment (with quantifiable expected returns) in the strategy of research and development. Most innovation efforts are based on pre-established planning, with many projects based on long-term trends and opportunities.
- Evaluation of supply chain supplier spending, with the inclusion of fair trade throughout the chain.
- Evaluation if the organization maintains a permanent control of parts and materials used for the remanufacturing process.
- Cost evaluation for materials that will no longer be reused and activities that need to be performed again.
- Costs related to the internal physical arrangement of the plant to achieve sustainability.
- Evaluation of the existence of specific reports for the measurement of efforts towards sustainability.
- Assessment of whether the company is oriented toward green IT practices.
- Sustainable innovation is widespread throughout the company, partners and supply chain relationships. The result of sustainable innovation is linked to the supply of a sustainable product in all its aspects.
- Environmental criteria for the purchasing process.
- Focus on sustainability in the relationship with suppliers.
- Procurement strategy regularly reviewed and linked to the company's environmental system.
- Evaluation of the sharing of best practices with other organizations and key performance indicators agreed with suppliers.
- The organization rewards suppliers recognized as essential for the implementation of the sustainable sourcing strategy.
- Evaluation of mandatory and voluntary corporate governance structures.
- Sustainability fits the mission and vision of the company
- Integration of the value chain.
- Implements external benchmarking.
- Industry leadership strategy that is customer focused and based on a sustainable product service system.
- Communication and collaboration with stakeholders.
- Proactive trend monitoring and behavior.
- Relationship goes beyond upstream and downstream supply chain partners to include managing the impact of operations on communities.
- Customer needs addressed by the design team.
- In the company–client relationship, value is added for both parties.

- Systematic and comprehensive activities for knowledge management related to sustainability.
- Sustainability issues present in business and support processes.
- Defined roles and responsibilities.
- Corporate communication in relation to sustainability issues.
- Collection of internal and external data. Data is collected from most members of the supply chain.
- Participation in all GRI, CDP, ISO 14000 and ISO 26000 items, United Nations Global Compact.
- External and internal benchmarking, involving environmental and social issues.
- Training given to internal managers, supervisors and business partners involved in sustainability practices.
- The organization presents five perspectives for its performance measurement system: internal performance within units (e.g., materials management, production, distribution), external performance among the different units of the company; external performance of the whole company in relation to customers; supplier performance in relation to the company and relationship between logistics performance and the performance of the whole company.
- The performance measurement system focuses on four basic processes: planning (demand/supply planning and plan infrastructure), supply (sourcing/acquisition of materials), do (production execution) and deliver (demand management, order management, warehouse management, transportation management, facility management, and delivery infrastructure).
- The performance measurement system operates from four perspectives: financial, customer, business process (internal and external), and learning and growth, focused on the supply chain.
- The performance measurement system operates from four perspectives focused on sustainability issues: financial (examples: revenues from "green" products and avoiding costs with environmental actions), customer (examples: functional eco-efficiency of the product and green products), business process (examples: greenhouse gas emissions, energy consumption, and accidents and spills) and learning/growth (examples: community complaints, functions with environmental responsibilities, and emergency response programs).
- The performance measurement system merges two concepts: BSC and SCOR. In this case, four basic processes and four perspectives for the supply chain are considered.
- The level of maturity in sustainability in the supply chain will be evaluated based on the topics presented above. These items represent an essential roadmap for the application of the proposed model. Another important point is the scope of the items considered in terms of sustainability.

## 5. Conclusions and Recommendations

For theory, the development of studies of maturity in sustainability in supply chains has the potential to generate a more comprehensive vision (internal and external to the chain) and to drive the development of new theories and maturity models necessary to understand the practices and strategies found in the different economic sectors with their respective supply chains. For practice, the relevance of the applicability of this maturity model is emphasized to support the decisions of the managers of the production chain aiming at its sustainability.

This work, of theoretical and exploratory character, sought to lay the foundations for the construction of an integrative model of maturity for supply chain management. Another aspect to be pointed out as a driver of originality and innovation refers to the validation of the model, which may have positive effects and repercussion in increasing the competitiveness of the supply chain (internal and in the market).

Based on the proposed maturity model, it is thought that it is possible to develop a research instrument (questionnaire) that will allow us to verify, in future research, whether the determination of the level of maturity in sustainability has the ability to lead organizations and their supply chains to go through evolutionary processes, verified by maturation and performance over time. There are pressing needs to justify such investigation, as there may be situations in which the determination of the level of

maturity is not able to promote greater economic performance. The validation of models such as this may have positive effects and repercussions on increasing the competitiveness of an economic sector.

The proposed theoretical model is the result of a literature review on the maturity models in supply chain sustainability. The abovementioned review allowed the construction of a model that aims to mitigate the limitations identified in the models researched in the literature.

The survey of the characteristic elements present in the models of maturity in sustainability, led to an important advance in the studies in relation to the level of evolution of sustainability in the chain and supplies. Through this survey, a new dimension was added to the TBL concept. The cross-sectional dimension that is related to the other three dimensions (environmental, social, and economic) simultaneously. The conceptual advance with the addition of the cross-sectional dimension allowed an integrative view of the other three dimensions (environmental, social, and economic).

The proposed theoretical model will need to be applied in several segments in order to offer new elements to suit the particularities inherent to each segment and business model.

Another relevant point is the proposition of alternatives or methods that allow the ordering of which actions are to be engendered to raise the level of maturity in sustainability of a supply chain.

The present study presented as restrictive factors: lack of adequacy of the model to some specificities of certain business segments; the assessment of the level of maturity in sustainability occurs for the supply chain as a whole and not for a specific business process and the lack of consolidated theories that address in a more structured way the issue of sustainability in the supply chain.

The development of maturity studies in sustainability in supply chains has the potential to generate a more comprehensive vision and then drive the development of new theories and maturity models necessary to understand the practices and strategies of different organizations. Based on the above in this work, some questions are presented for future work: verifying whether the more homogeneous processes facilitate the creation of a specific roadmap for each company; analyze the costs of implementing a maturity model in production systems; analyze barriers and facilitators for the implementation of a monitoring project based on maturity levels in sustainability. Although the relevance of the potential for applicability of this maturity model is emphasized, both in relation to contemporary business practices and also in relation to the conceptual theoretical perspective on the subject, the limitations characteristic of this article should be highlighted. It is important to emphasize the need to complement this work through more comprehensive studies to prove the proposals presented. It is recommended to replicate this model in different realities. Finally, it is possible to affirm that this theoretical essay can contribute to a theoretical and conceptual deepening in the research area, allowing the development of a new conceptual model of research, expanding and complementing the studies focused on the theoretical aspect of transaction costs.

**Author Contributions:** Conceptualization, D.d.A.S.; Formal analysis, D.d.A.S., O.L.G.Q. and C.F.S.G.; Investigation, D.d.A.S., O.L.G.Q. and C.F.S.G.; Methodology, D.d.A.S., O.L.G.Q., C.F.S.G., L.P.Z., S.L.B.F. and S.d.S.C.S.; Project administration, D.d.A.S.; Resources, D.d.A.S. and C.F.S.G.; Supervision, O.L.G.Q. and C.F.S.G.; Validation, D.d.A.S., O.L.G.Q., L.P.Z., S.L.B.F., G.V.P.d.S., R.A.d.A. and S.d.S.C.S.; Visualization, D.d.A.S.; Writing—original draft, D.d.A.S., O.L.G.Q. and C.F.S.G.; Writing—review & editing, D.d.A.S., O.L.G.Q., C.F.S.G., L.P.Z., S.L.B.F. and S.d.S.C.S. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

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

## References

1. Okongwu, U.; Morimoto, R.; Lauras, M. The maturity of supply chain sustainability disclosure from a continuous improvement perspective. *Int. J. Prod. Perform. Manag.* **2013**, *62*, 827–855. [CrossRef]
2. Lopes, L.J.; Pires, S.R.I. Green supply chain management in the automotive industry: A study in Brazil. *Bus. Strat. Environ.* **2020**, *29*, 2755–2769. [CrossRef]
3. Council of Supply Chain Management Professionals (CSCMP). Available online: http://cscmp.org/ (accessed on 26 May 2020).

4. Bertaglia, P.R. *Logística e Gerenciamento da Cadeia de Abastecimento*, 2nd ed.; Saraiva: São Paulo, Brazil, 2009; pp. 32–33.
5. Govindan, K.; Soleimani, H.; Kannan, D. Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. *Eur. J. Oper. Res.* **2015**, *240*, 603–626. [CrossRef]
6. Hervani, A.A.; Helms, M.M.; Sarkis, J. Performance measurement for green supply chain management. *Benchmarking: Int. J.* **2005**, *12*, 330–353. [CrossRef]
7. Uygun, Ö.; Dede, A. Performance evaluation of green supply chain management using integrated fuzzy multi-criteria decision making techniques. *Comput. Ind. Eng.* **2016**, *102*, 502–511. [CrossRef]
8. Kurnia, S.; Rahim, M.M.; Samson, D.; Prakash, S. Sustainable supply chain management capability maturity: Framework development and initial evaluation. In Proceedings of the European Conference on Information Systems (ECIS), Tel Aviv, Israel, 9–11 June 2014.
9. Kumar, R.; Chandrakar, R. Overview of green supply chain management: Operation and environmental impact at different stages of the supply chain. *Int. J. Eng. Adv. Technol.* **2012**, *1*, 1–6.
10. Correia, E.; Carvalho, H.; Azevedo, S.G.; Govindan, K. Maturity Models in Supply Chain Sustainability: A Systematic Literature Review. *Sustainability* **2017**, *9*, 64. [CrossRef]
11. Roy, V.; Schoenherr, T.; Charan, P. The thematic landscape of literature in sustainable supply chain management (SSCM). *Int. J. Oper. Prod. Manag.* **2018**, *38*, 1091–1124. [CrossRef]
12. Elkington, J. Enter the triple bottom line. In *The Triple Bottom Line: Does It All Add Up?* Henriques, A., Richardson, J., Eds.; Earthscan: London, UK, 2004.
13. Baumgartner, R.J.; Ebner, D. Corporate sustainability strategies: Sustainability profiles and maturity levels. *Sustain. Dev.* **2010**, *18*, 76–89. [CrossRef]
14. Hynds, E.J.; Brandt, V.; Burek, S.; Knox, P.; Parker, J.P.; Zietlow, M.; Schwartz, L.; Taylor, J.; Jäger, W. A Maturity Model for Sustainability in New Product Development. *Res. Manag.* **2014**, *57*, 50–57. [CrossRef]
15. 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]
16. Rudnicka, A. How to manage sustainable supply chain? The issue of maturity. *LogForum* **2016**, *12*, 203–211. [CrossRef]
17. Golinska, P.; Kuebler, F. The Method for Assessment of the Sustainability Maturity in Remanufacturing Companies. *Procedia CIRP* **2014**, *15*, 201–206. [CrossRef]
18. Verrier, B.; Rose, B.; Caillaud, E. Lean and Green strategy: The Lean and Green House and maturity deployment model. *J. Clean. Prod.* **2016**, *116*, 150–156. [CrossRef]
19. Edgeman, R.; Eskildsen, J. Modeling and Assessing Sustainable Enterprise Excellence. *Bus. Strat. Environ.* **2014**, *23*, 173–187. [CrossRef]
20. Standing, C.; Jackson, P. An approach to sustainability for information systems. *J. Syst. Inf. Technol.* **2007**, *9*, 167–176. [CrossRef]
21. Patón-Romero, J.D.; Baldassarre, M.T.; Rodriguez, M.; Piattini, M. Maturity model based on CMMI for governance and management of Green IT. *IET Softw.* **2019**, *13*, 555–563. [CrossRef]
22. Tchokogué, A.; Nollet, J.; Merminod, N.; Paché, G.; Goupil, V. Is Supply's Actual Contribution to Sustainable Development Strategic and Operational? *Bus. Strategy Environ.* **2018**, *27*, 336–358. [CrossRef]
23. Robinson, H.; Anumba, C.; Carrillo, P.; Al-Ghassani, A. STEPS: A knowledge management maturity roadmap for corporate sustainability. *Bus. Process. Manag. J.* **2006**, *12*, 793–808. [CrossRef]
24. Batista, L.; Dora, M.; Toth, J.; Molnár, A.; Malekpoor, H.; Kumari, S. Knowledge management for food supply chain synergies – a maturity level analysis of SME companies. *Prod. Plan. Control.* **2019**, *30*, 995–1004. [CrossRef]
25. Babin, R.; Nicholson, B. How green is my outsourcer? Measuring sustainability in global IT outsourcing. *Strat. Outsourcing: Int. J.* **2011**, *4*, 47–66. [CrossRef]
26. Gong, R.; Xue, J.; Zhao, L.; Zolotova, O.; Ji, X.; Xu, Y. A Bibliometric Analysis of Green Supply Chain Management Based on the Web of Science (WOS) Platform. *Sustain.* **2019**, *11*, 3459. [CrossRef]
27. Zimon, D.; Tyan, J.; Sroufe, R. drivers of sustainable supply chain management: Practices to alignment with un sustainable development goals. *Int. J. Qual. Res.* **2020**, *14*, 219–236. [CrossRef]
28. Zimon, D.; Tyan, J.; Sroufe, R. Implementing Sustainable Supply Chain Management: Reactive, Cooperative, and Dynamic Models. *Sustainability* **2019**, *11*, 7227. [CrossRef]

29. 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]
30. Reefke, H.; Ahmed, M.D.; Sundaram, D. Sustainable Supply Chain Management—Decision Making and Support: The SSCM Maturity Model and System. *Glob. Bus. Rev.* **2014**, *15*, 1–12. [CrossRef]
31. Estampe, D.; Lamouri, S.; Paris, J.-L.; Brahim-Djelloul, S. A framework for analysing supply chain performance evaluation models. *Int. J. Prod. Econ.* **2013**, *142*, 247–258. [CrossRef]
32. Kovacheva, T.; Todorov, N. Optimizing software development process: A case study for integrated Agile-CMMI process model. In Proceedings of the 2011 IEEE EUROCON—International Conference on Computer as a Tool, Lisbon, Portugal, 27–29 April 2011; pp. 1–2.
33. Pigosso, D.C.A.; Rozenfeld, H.; McAloone, T.C. Ecodesign maturity model: A management framework to support ecodesign implementation into manufacturing companies. *J. Clean. Prod.* **2013**, *59*, 160–173. [CrossRef]
34. Aboelmaged, M.G. Linking operations performance to knowledge management capability: The mediating role of innovation performance. *Prod. Plan. Control.* **2014**, *25*, 44–58. [CrossRef]
35. 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]
36. Gouvinhas, R.P.; Reyes, T.; Naveiro, R.M.; Perry, N.; Filho, E.R. A proposed framework of sustainable self-evaluation maturity within companies: An exploratory study. *Int. J. Interact. Des. Manuf. (IJIDeM)* **2016**, *10*, 319–327. [CrossRef]
37. Machado, C.G.; De Lima, E.P.; Da Costa, S.E.G.; Angelis, J.J.; Mattioda, R.A. Framing maturity based on sustainable operations management principles. *Int. J. Prod. Econ.* **2017**, *190*, 3–21. [CrossRef]
38. Bastas, A.; Liyanage, K. Setting a framework for organisational sustainable development. *Sustain. Prod. Consum.* **2019**, *20*, 207–229. [CrossRef]
39. Neely, A. The performance measurement revolution: Why now and what next? *Int. J. Oper. Prod. Manag.* **1999**, *19*, 205–228. [CrossRef]
40. Bourne, M.; Neely, A.; Mills, J.; Platts, K. Implementing performance measurement systems: A literature review. *Int. J. Bus. Perform. Manag.* **2003**, *5*, 1–24. [CrossRef]
41. Franco-Santos, M.; Kennerley, M.; Micheli, P.; Martinez, V.; Mason, S.; Marr, B.; Gray, D.; Neely, A. Towards a definition of a business performance measurement system. *Int. J. Oper. Prod. Manag.* **2007**, *27*, 784–801. [CrossRef]
42. Hald, K.S.; Mouritsen, J. The evolution of performance measurement systems in a supply chain: A longitudinal case study on the role of interorganisational factors. *Int. J. Prod. Econ.* **2018**, *205*, 256–271. [CrossRef]
43. Andersson, P.; Aronsson, H.; Storhagen, N.G. Measuring logistics performance. *Eng. Costs Prod. Econ.* **1989**, *17*, 253–262. [CrossRef]
44. Stewart, G. Supply-chain operations reference model (SCOR): The first cross-industry framework for integrated supply-chain management. *Logist. Inf. Manag.* **1997**, *10*, 62–67. [CrossRef]
45. Van Hoek, R.I. "Measuring the unmeasurable"—Measuring and improving performance in the supply chain. *Supply Chain Manag. Int. J.* **1998**, *3*, 187–192. [CrossRef]
46. Beamon, B.M. Measuring supply chain performance. *Int. J. Oper. Prod. Manag.* **1999**, *19*, 275–292. [CrossRef]
47. Holmberg, S. A systems perspective on supply chain measurements. *Int. J. Phys. Distrib. Logist. Manag.* **2000**, *30*, 847–868. [CrossRef]
48. Gunasekaran, A.; Patel, C.; Tirtiroglu, E. Performance measures and metrics in a supply chain environment. *Int. J. Oper. Prod. Manag.* **2001**, *21*, 71–87. [CrossRef]
49. Park, J.H.; Lee, J.K.; Yoo, J.S. A framework for designing the balanced supply chain scorecard. *Eur. J. Inf. Syst.* **2005**, *14*, 335–346. [CrossRef]
50. Bhagwat, R.; Sharma, M.K. Performance measurement of supply chain management: A balanced scorecard approach. *Comput. Ind. Eng.* **2007**, *53*, 43–62. [CrossRef]
51. Thakkar, J.; Kanda, A.; Deshmukh, S. Supply chain performance measurement framework for small and medium scale enterprises. *Benchmarking Int. J.* **2009**, *16*, 702–723. [CrossRef]
52. Hofmann, E.; Locker, A. Value-based performance measurement in supply chains: A case study from the packaging industry. *Prod. Plan. Control.* **2009**, *20*, 68–81. [CrossRef]
53. Luzzini, D.; Caniato, F.; Spina, G. Designing vendor evaluation systems: An empirical analysis. *J. Purch. Supply Manag.* **2014**, *20*, 113–129. [CrossRef]

54. Sillanpää, I. Empirical study of measuring supply chain performance. *Benchmarking Int. J.* **2015**, *22*, 290–308. [CrossRef]
55. Laihonen, H.; Pekkola, S. Impacts of using a performance measurement system in supply chain management: A case study. *Int. J. Prod. Res.* **2016**, *54*, 5607–5617. [CrossRef]
56. Jääskeläinen, A.; Thitz, O. Prerequisites for performance measurement supporting purchaser-supplier collaboration. *Benchmark. Int. J.* **2018**, *25*, 120–137. [CrossRef]
57. Frederico, G.F.; Martins, R.A. Modelo para alinhamento entre a maturidade dos sistemas de medição de desempenho e a maturidade da gestão da cadeia de suprimentos. *Gest. Prod.* **2012**, *19*, 857–871. [CrossRef]
58. Neto, M.S.; Pires, S.R.I. Medição de desempenho em cadeias de suprimentos: Um estudo na indústria automobilística. *Gest. Prod.* **2012**, *19*, 733–746. [CrossRef]
59. Morgan, C. Structure, speed and salience: Performance measurement in the supply chain. *Bus. Process. Manag. J.* **2004**, *10*, 522–536. [CrossRef]
60. Lockamy, A., III; McCormack, K. Linking SCOR planning practices to supply chain performance. *Int. J. Oper. Prod. Manag.* **2004**, *24*, 1192–1218. [CrossRef]
61. Ayers, J.B.; Malmberg, D.M. Supply chain systems: Are you ready? *Infor. Strategy Exec. J.* **2002**, *19*, 18–27.
62. Bell, E.; Bryman, A.; Harley, B. *Business Research Methods*, 5th ed.; Oxford University Press: New York, NY, USA, 2018; pp. 20–25.
63. 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]
64. Briner, R.B.; Denyer, D. *Handbook of Evidence-Based Management: Companies, Classrooms and Research Systematic Review and Evidence Synthesis as a Practice and Scholarship Tool*, 1st ed.; Oxford University Press: New York, NY, USA, 2012; pp. 112–129.
65. 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]
66. Yatskovskaya, E.; Srai, J.S.; Kumar, M. Integrated Supply Network Maturity Model: Water Scarcity Perspective. *Sustainability* **2018**, *10*, 896. [CrossRef]
67. Rauch, E.; Unterhofer, M.; Rojas, R.A.; Gualtieri, L.; Woschank, M.; Matt, D.T. A Maturity Level-Based Assessment Tool to Enhance the Implementation of Industry 4.0 in Small and Medium-Sized Enterprises. *Sustainability* **2020**, *12*, 3559. [CrossRef]
68. Xavier, A.; Reyes, T.; Aoussat, A.; Luiz, L.; De Souza, L.M. Eco-Innovation Maturity Model: A Framework to Support the Evolution of Eco-Innovation Integration in Companies. *Sustainability* **2020**, *12*, 3773. [CrossRef]
69. Yang, J.Y.; Roh, T. Open for Green Innovation: From the Perspective of Green Process and Green Consumer Innovation. *Sustainability* **2019**, *11*, 3234. [CrossRef]
70. Aarstad, J.; Jakobsen, S.-E. Norwegian Firms' Green and New Industry Strategies: A Dual Challenge. *Sustainability* **2020**, *12*, 361. [CrossRef]
71. Kusi-Sarpong, S.; Gupta, H.; Sarkis, J. A supply chain sustainability innovation framework and evaluation methodology. *Int. J. Prod. Res.* **2019**, *57*, 1990–2008. [CrossRef]
72. Carter, C.R.; Rogers, D.S. A framework of sustainable supply chain management: Moving toward new theory. *Int. J. Phys. Distrib. Logist. Manag.* **2008**, *38*, 360–387. [CrossRef]