

Article

Sustainable Supply Chain Management—A Conceptual Framework and Future Research Perspectives

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Abstract: Sustainable operations and sustainable supply chain management (SSCM) have become a highly relevant topic for scientific research and management, as well as policy-making practice. Despite surging growth in extant research, the need for theoretical and conceptual substantiation persists, and large opportunities for further research remain unexploited. This paper responds to the need for a conceptual foundation and, therefore, aims at providing a structured agenda for future research areas in SSCM. Based on an abductive reasoning approach, SSCM constructs and concepts are gathered from existing literature and recombined into a comprehensive conceptual SSCM framework. Areas and directions for future SSCM research, as suggested in earlier studies, are summarized, positioned in the framework, and outlined to stimulate further SSCM research activities. To overcome the lack of holistic research in the field, sophisticated techniques and integrated systems to support decision-making are required to tackle related issues' complexity. Therefore, this paper's contribution lies in the synthesis of state-of-the-art literature to provide a more comprehensive view of SSCM. Researchers may find promising recommendations and a suitable foundation for future studies, while practitioners may find helpful orientation and guidance for decision- and policy-making.

Keywords: supply chain management; operations management; sustainability

1. Introduction

Within the past three decades, business and commerce management had to extend its scope from mere optimization of economic performance to sustainable development that “meets the needs of the present generation without compromising the ability of future generations to meet their own needs” [1]. In this context, the narrow, bottom-line perspective that exclusively focuses on economic objectives has been broadened to a *triple-bottom-line* (TBL) approach that also considers an environmental and social dimension [2]. Thus, sustainability in decision making requires resolving conflicts between multiple economic, environmental, and social factors, or (less often) enables exploiting the complementarity of different TBL criteria [1]. The economic dimension includes financial and non-financial targets, while socio-environmental objectives aim to amplify positive or mitigating negative ecological impacts and improve social aspects. In this line, many firms face problems when striving for a transformation toward sustainability and may need to find trade-offs between certain dimensions of the TBL [3]. However, solely applying a win-win perspective to manage the TBL leaves little room for radical shifts in business practices, as it restricts strategic options to those that immediately can be connected to a profit logic [4].

Rooted in forestry about three centuries ago [5], the sustainability concept nowadays is linked nearly to all micro- and macro-economic areas [6]. *Supply chain management* (SCM), defined as the “integration of business processes from end users through original suppliers that provides products, services, and information that add value for customers” [7] (p. 2), is a business area in which sustainability has gained high relevance. SCM has become a source of competitive advantage for firms and enterprises from various industry sectors. Its tasks aim to configure and operate an efficient and effective supply chain (SC), thereby covering the full range of strategic, tactical, and operational issues within a single company and across different firms. Originally, SCM was perceived as a process-oriented and customer-focused business discipline in which material flows are directed from upstream suppliers to downstream customers. More recently, the concepts of reverse logistics and closed-loop SCM have complemented the traditional perception of a “forward SC” through product-recycling aspects and the recovery of scarce materials [8,9]. However, purely economic reasons can motivate asset recovery and recycling; thus a “return SC” is not necessarily a sustainable one. Thus, the socio-ecological dimensions need to be emphasized in the explanation of sustainable supply chain management (SSCM), which is comprehended as “the management of material, information, and capital flows, as well as cooperation among companies along the supply chain, while taking goals from all three dimensions of sustainable development, i.e., economic, environmental, and social, into account, which are derived from customer and stakeholder requirements” [10] (p. 1700).

As illustrated in Figure 1, SSCM research’s relevance has seen strong, unbroken growth in the past few years. A simple comparison of the number of studies published since 1990 illustrates that the research topics *sustainability*, *supply chain*, and *sustainable supply chain*, respectively, all emerged since the 1990s. However, while the more focused *sustainability* and *supply-chain* topics became popular in the first years of the 2000s, the integrated *sustainable supply chain* topic gained greater awareness about 5–10 years later. Accordingly, every third paper on *sustainability* or *supply chain* has been published before 2009, while more than 90% of all papers on *sustainable supply chain* have been published after 2009.

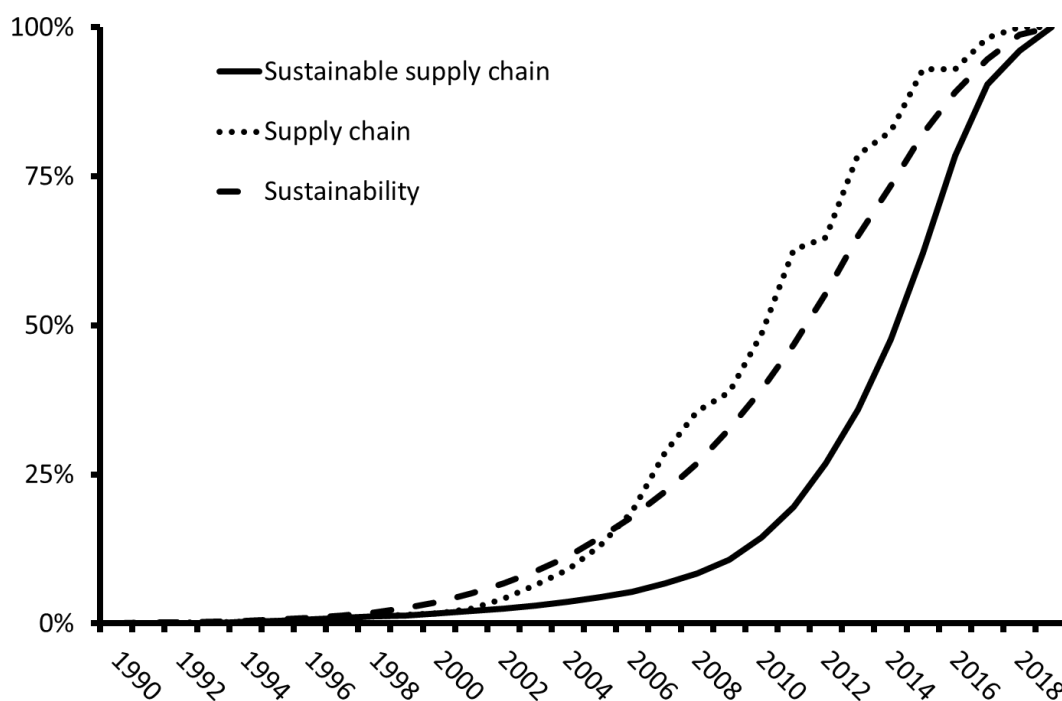


Figure 1. Distribution of manuscripts over time (own representation). Note: This figure depicts the cumulative distribution function of the number of manuscripts over time as determined Google Scholar search based on the key words “sustainable supply chain” (17,700 search results), “sustainability” (6,029,780 results), and “supply chain” (1,150,000 results). Year 2019 is recorded until October 12.

An exemplary collection of SSCM reviews listed in Table 1 already shows the broad range of methods, application areas, and foci in SSCM research. For a comprehensive review of SSCM literature reviews, we refer to the work of Carter and Washispack [11] or Martins and Pato [12]. Recent studies also have been published, e.g., in the Special Issue by the journal *Sustainability* on “Sustainable Operations and Supply Chain Management” (e.g., [13]). Other literature reviews recently published in the journal *Sustainability* provide an up-to-date overview of drivers for SSCM as well as inter-organizational supply chain practices for sustainability [14,15]. The present study contributes to this debate.

Table 1. Selected SSCM reviews.

Review Paper	Focused Method	SCM Focus	TBL Focus	Application Context
Ansari and Kant [16]	frameworks	SCM	holistic	unfocused
Bai et al. [17]	unfocused	SCM	holistic	China
Bastas and Liyanage [18]	unfocused	intraorg. and SCM	holistic	Quality management
Beske et al. [19]	unfocused	SCM	holistic	Food industry
Brandenburg et al. [20]	models	SCM	holistic	unfocused
Carter and Rogers [21]	unfocused	SCM	holistic	unfocused
Carter and Washispack [11]	meta-review	SCM	holistic	unfocused
Cheng et al. [22]	unfocused	Policy	green	Public procurement
Dekker et al. [23]	models	SCM	holistic	unfocused
Duarte and Cruz-Machado [24]	bus. models	SCM	environ.	unfocused
Eskandarpour et al. [25]	models ⁽³⁾	SCM	holistic	unfocused
Gold et al. [26]	empirical ⁽²⁾	SCM	holistic	unfocused
Golicic and Smith [27]	empirical ⁽¹⁾	SCM	holistic	unfocused
Khalid and Seuring [28]	unfocused	SCM	holistic	base of pyramid
Liu et al. [29]	unfocused	service ops.	holistic	service ops.
Martins and Pato [12]	meta-review	SCM	holistic	unfocused
Meixell and Luoma [30]	empirical	SCM ⁽¹⁾	holistic	unfocused
Rajeev et al. [31]	unfocused	SCM	holistic	unfocused
Rebs et al. [32]	models ⁽⁴⁾	SCM	holistic	unfocused
Sarkis et al. [33]	theories	SCM	holistic	unfocused
Seuring and Müller [10]	unfocused	SCM	holistic	unfocused
Tang and Zhou [34]	models	SCM	holistic	unfocused
Toubolic and Walker [35]	theories	SCM	holistic	unfocused
Ülgen et al. [15]	unfocused	interorg. SCM	holistic	interorg. SC
Yawar and Seuring [36]	frameworks	SCM	social	unfocused
Zorzini et al. [37]	theories	SCM	social	unfocused

⁽¹⁾ Regression analyses. ⁽²⁾ Case studies. ⁽³⁾ Optimization models. ⁽⁴⁾ System dynamics models.

Accordingly, the SSCM subject leaves room for future research. In addition to studies that analyze particular sustainability aspects or specific application contexts with regard to, e.g., the focused SC segment or industry sector, SSCM research requires more conceptual development and theoretical foundation. Comprehensive SSCM frameworks may help researchers broaden their SSCM studies’ scope and view, as well as help practitioners improve supply chains’ sustainability and, thus, provide additional substantiation of academic work and management practice. A strategic way to deal with sustainability issues is accordingly based on the adoption of (best managerial) practices addressing sustainability issues in SCs. This approach can be framed through the recently emerging theoretical lens of the practice-based view (PBV) and its extension toward the supply chain practice view (SCPV), which distinctly focuses on imitable practices that are easily transferable and, thus, help facilitate sustainable development within entire industry sectors [38]. In this line, the present study aims at stimulating future research activities by providing a structured agenda as well as promoting more contemporary approaches in SSCM research.

The paper at hand represents a contribution in this regard. A reference framework is developed that combines TBL dimensions with SC structures, and then processes and links them to related decision areas and resulting implications for risk and performance. The framework is conceptualized

from earlier, well-known, highly recognized SSCM studies' constructs and concepts [10,21,23,34], and is based on SCM characteristics formed and explained through prominent SCM researchers' highly cited studies [7,39–42].

Sections 2 and 3 summarize selected papers to build the foundation of the framework presented therein. In Section 4, SSCM constructs and principal SCM characteristics are distilled from extant literature and recombined into a comprehensive SSCM framework. Future research perspectives identified in extant literature are summarized in Section 5. The paper ends with summarized findings and concluding remarks given in Section 6.

2. Theoretical Foundations

2.1. Terminology

This section briefly outlines SCM's basic terminology and principal characteristics. For a comprehensive introduction, the reader is referred to in-depth SCM reviews (see, e.g., [40–42]). An SC comprises organizations and individuals (organizations and individuals in the SC include suppliers, manufacturers, distributors, or service providers) that are “directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer” [40] (p. 4). Thus, process orientation, customer focus, and collaboration represent SCM's three defining characteristics [42]. Schmenner and Swink [39] expressed the process orientation through the theory of swift and even flow within the supply network. The customer focus is reflected in the traditional perspective of a “forward SC”, which is oriented toward ultimate consumers of finished goods or services as taken by, e.g., Cooper et al. [7], but also in the more recently identified “reverse SC”, in which former customers become suppliers and vice versa [43]. Long-, medium-, and short-term decisions on sourcing, manufacturing, and distribution must be made to enable appropriate cooperation among linked partners [44]. Seuring [45] explained that decisions on network configuration, as well as on SC operation, must be made during each phase of the product's life cycle. Ivanov [46] emphasized the need to integrate strategic, tactical, and operational SCM levels to optimize overall SC performance.

The economic SC performance criteria correspond to efficiency, effectiveness, and financial success [47]. Traditionally, efficiency is related to cost reduction, while effectiveness aims to improve customer service [40]. According to White [48], non-financial facets of operational efficiency comprise quality, flexibility, delivery dependability, and speed. Recent studies explain that financial success is expressed through increases in shareholder value [49]. These heterogeneous performance criteria make SCM a complicated task. However, the complexity is increased through SC dynamics and exemplified through the bullwhip effect and other types of uncertainties that can be caused by external and internal factors on the demand or supply side [50,51]. Information variability and vagueness elicit SC risks, i.e., threats of unwanted events with harmful impacts that must be mitigated [52,53].

2.2. Theoretical Lenses in Sustainable Supply Chain Management

SSCM reviews (see Table 1) often propose theoretical frameworks that summarize relevant antecedents, practices, and routines, as well as their relationships and interdependencies. Despite several early calls for building a more comprehensive (S)SCM theory, e.g., by Carter and Rogers [21], an urgent need remains for theoretical foundations in SSCM research [35]. Toubolic and Walker [35] considered the integration of discrete social sustainability concepts into SCM as the biggest challenge thus far. According to Carter and Easton [54], as well as Toubolic and Walker [35], most theoretical SSCM studies use popular theories from other disciplines, such as stakeholder theory [55], institutional theory [56], and transaction-cost theory [57], as well as the resource-based view (RBV) [58] and natural resource-based view (NRBV) [59]. The (N)RBV explains that a firm can achieve or maintain a long-term competitive advantage through valuable, rare, hardly imitable, and non-substitutable (VRIN) resources if the firm's environment remains relatively unchanged. For companies to achieve strategic temporary

or even long-term competitive advantages in dynamic markets [60], the concept of *dynamic capabilities* (DCs) was derived from the transformation of the RBV and NRBV into dynamic settings of complex systems, such as sustainable SCs [19]. In addition, the use of SSCM in specific industry contexts were examined through those theoretical lenses, e.g., the application of DCs in the logistics and food industry [61,62].

More recently, the emergence of the PBV [63] and its extension toward the SCPV [64] have become more relevant for building a more comprehensive (S)SCM theory. The PBV focuses on “imitable practices or activities [...] amendable to transfer across firms” [63] (p. 1249) and, thus, can be acknowledged as a theoretical micro-foundation for these frameworks. The SCPV, introduced by Carter et al. [64], particularly reflects SC practices that reach across firm boundaries and extend the PBV’s notion for explaining firm performance toward understanding several SC partners’ performance outcomes. Regarding TBL performance, even stronger rationales exist for companies and their SC partners to implement and spread sustainability-related practices that are easy to imitate and widely accessible, rather than seek a competitive advantage [38].

Besides the attempt to incorporate popular theories from other disciplines to facilitate theory development, others see the need to build a theory of a (sustainable) SC itself from within the discipline. For instance, Carter et al. [65] built on the structural foundation of an SC as a network acting as a complex, adaptive system of physical, financial, and information flows. Building on this, but also being grounded on the PBV or SCPV, we synthesize selected SSCM review papers to build a more comprehensive reference frame for SSCM.

3. Sustainable Supply Chain Management

As outlined in Section 2, an SC is determined and characterized by structures that the infrastructure and organization within the SC provide, as well as processes linked to physical, financial, and information flows across the SC. Based on these foundations and related efforts to build a theory in SSCM, a short survey given by selected SSCM reviews reveals recent findings, current gaps, and future prospects of related research. Four review papers, two about conceptual and empirical studies [10,21] and two with a clear focus on formal models [23,34], are selected based on criteria of relevance, i.e., the number of citations, and the broadness or focus of their scope. These four studies serve as basis for the SSCM framework conceptualized in Section 4 and, thus, are briefly summarized in the following subsections.

3.1. Carter and Rogers’ Research

Based on a comprehensive review of related literature, Carter and Rogers [21] conceptualized a framework that links sustainability to SCM. The framework is validated through expert interviews with SC managers from companies in Germany and in the U.S. The authors provided an SSCM definition and identify various application areas. Furthermore, their study reveals a relationship between the integration of sustainability into SCM and long-term economic success.

Carter and Rogers [21] explained that a micro-economic perspective on sustainability is needed to determine an organization’s role in the broad, macro-economic understanding of sustainable development. The authors identified four supporting facets—risk management, transparency, strategy, and culture—to link SCM to the TBL. In this context, risk is viewed as socio-ecological harm that may arise from a company or SC’s products, services, and operations, and that needs to be managed through contingency planning, supply disruptions, and outbound SC concepts. Carter and Rogers [21] related SSCM transparency to stakeholder engagement, e.g., in green marketing, and to supplier operations, e.g., in common auditing, and emphasized the possibility of improving transparency through vertical and horizontal coordination. Moreover, the authors stress that culture requires a deeply ingrained organizational citizenship oriented toward values and ethics. Carter and Rogers [21] viewed sustainability as part of an integrated strategy for every firm and SC.

Carter and Rogers [21] emphasized that SSCM can strengthen economic SC performance, e.g., through social sustainability or effective resource adaptation. The study explains that vertical

coordination within the SC can improve its economic performance under uncertainty or resource dependency, and that SSCM implementation can make an SC less imitable. The study's practical implications include the call for strengthening environmental and social efforts in SCM.

3.2. Seuring and Muller's Research

Seuring and Müller [10] reviewed 191 SSCM papers published between 1994 and 2007 to analyze and assess SSCM research developments and trends, as well as propose a conceptual framework for SSCM based on their analysis. The study shows that the environmental dimension clearly dominates SSCM research (140 papers), while only about every fourth reviewed paper focuses on social factors or elaborates on the whole TBL of sustainability. Seuring and Müller [10] showed that empirical studies (123 papers) dominate SSCM research compared with theoretical or conceptual research (68 papers) and formal SSCM models (21 papers).

Seuring and Müller [10] explained that government and legal authorities, as well as customers and other stakeholder groups, can trigger SSCM through pressures and incentives. Norm strategies such as (supplier-related) performance and risk management or product-related sustainability help propagate SC sustainability, while higher costs and complexity and a lack of communication represent major barriers for SSCM implementation. The study shows that improving inter-organizational communication and establishing monitoring and reporting tools or other management systems may support performance and risk management. In addition, training or integrating sustainability into corporate policy may be helpful in this regard. Seuring and Müller [10] explained that product sustainability, which can be assessed through life cycle assessment (LCA), may improve environmental or social quality, thereby satisfying customers and strengthening a firm's competitive advantage in the market.

The authors concluded that SSCM must consider a wider range of issues and a broader set of performance objectives, especially socio-environmental targets. Thus, they recommend looking at longer parts of the SC and strengthening cooperation among SC partners to establish and maintain a sustainable SCM. Sustainability performance may need to exceed minimum thresholds, reflect required tradeoffs between conflictive objectives, or strive for win-win(–win) situations from complementary TBL aims.

3.3. Dekker et al.'s Research

A review of green logistics and SCM models presented by Dekker et al. [23] is based on a framework that comprises decision phases, physical drivers, and environmental impacts. In this framework, decision phases are categorized as design, planning, and control. Physical drivers include facilities, transportation, and inventory, while green impacts are related to metrics and methodologies. Environmental performance is linked to emissions of carbon dioxide and other greenhouse gases or energy consumption from manufacturing, transportation, and storage processes. They explained that green SCM models can support decisions on physical SC infrastructure, e.g., to establish, operate, or close warehouses, ports, or terminals, or to determine such facilities' type, number, and location. Additionally, environmentally conscious SC design models reflect not only sourcing aspects or determination of production and distribution concepts, but also choice of transportation means, speed, and capacities. Green SC planning and control are related to pricing and emission trading, as well as to determining capacity plans over a midterm horizon or the inclusion of ecological factors in procurement and trading processes.

The study shows that transportation-related models are related preferably to emissions of carbon dioxide and other greenhouse gases. Economic criteria—particularly cost, quality, and speed—influence choice of transportation mode (air, land, or sea freight, among other means of transportation) and environmental emission factors that are sublinear in equipment size. Intermodal shipments that combine various types and equipment sizes and different fuel types—e.g., combustion, electric, or hybrid—represent further decision options in green transportation models.

Regarding product-related inventory, Dekker et al. [23] detected that energy and water consumption in manufacturing, transportation, and storage of goods must be taken into account over

the whole product life cycle. Furthermore, primary and secondary packaging, as well as returnable transportation items, must be considered.

3.4. Tang and Zhou's Research

Based on a comprehensive review of related studies, Tang and Zhou [34] classified and summarized recent Operations Research/Management Science (OR/MS) developments and identified several gaps and future perspectives in this research area. The authors based their study on a profit–planet–people ecosystem. This framework views the SC as a core element that ranges from suppliers and manufacturers to distributors and retailers and that is linked to producers and consumers representing the people dimension. The SC's profit dimension is related to consumer-related prices and producer-related costs. The SC, as well as producers and consumers, deplete natural resources such as water, air, crude oil, wood, metals, or land and dispose of wastes and emissions. These input and output factors represent the ecosystem's planet dimension.

In their review, Tang and Zhou [34] classified literature according to five pillars of sustainable operations: product design, technology selection, reverse operations, network structure, and integration of operations with environmental and societal factors. The authors found that product design is highly relevant for sustainable development, but related OR/MS research is limited, and green product design issues most often are related to product remanufacturability. Furthermore, socio-ecological factors need to be considered when choosing SC technologies and processes because consumers and legal authorities nowadays pay more attention to environmental protection and corporate social responsibility (CSR). Product cannibalization, competition among manufacturers, and incentives for collection and recycling are identified as reverse operations' principal topics. In sustainable SC (re-)design, decisions must be made regarding facilities' location and links and product flows among the facilities, as well as transportation mode. Most often, objectives are related to cost and carbon emissions, either by formulating a single objective function that internalizes the environmental target through cost of emissions or by defining a multi-objective function that measures carbon emissions as an externalized ecological goal. Other non-economic factors under consideration are related to regulation schemes, e.g., emission taxes or cap-and-trade, and their impacts on operational performance, pollution control, consumer surplus, and social welfare.

4. Reference Framework for SSCM

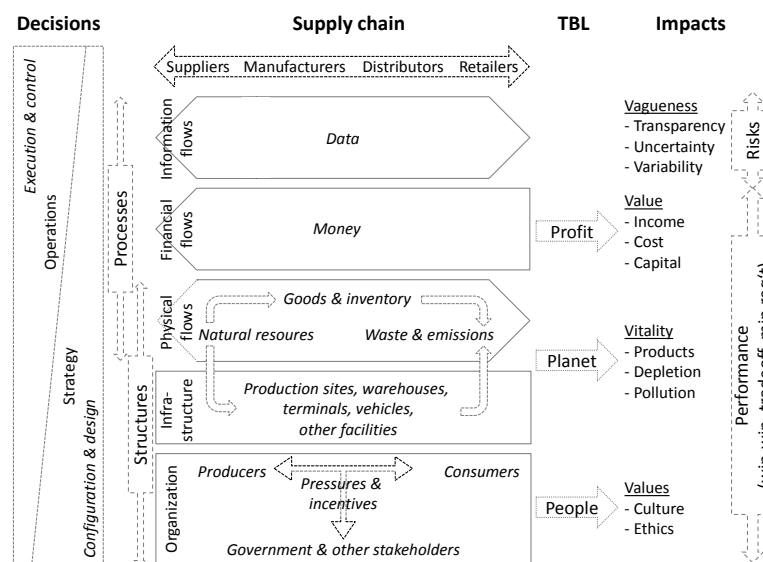
Conceptual research has stimulated theory development in (S)SCM and the generation of research propositions thus far (e.g., [21]). The present study also is conceptual and grounded in abductive reasoning [66]. Thus, the coding categories were built according to the frequency with which they occurred in the examined papers. Following the two-step analysis approach of Eisenhardt [67], the SSCM practices and routines were analyzed deductively in the first step, and cross-case patterns were investigated inductively in the second step. In total, 17 SSCM constructs based on the aforementioned practices are derived from the four studies described in Table 2. Table 2 lists these constructs, which are used as components of the SSCM framework displayed in Figure 2.

Based on the abductive reasoning approach, further advances in SSCM theory can be achieved by exploring relations between known SSCM constructs [66]. The literature review and the summarized findings presented in Section 2 illustrate that the SSCM frameworks presented thus far focus on different SSCM facets. Thus, a more comprehensive SSCM frame of reference can be designed by linking digested SCM characteristics and gathered SSCM constructs. To increase the framework's validity, further comparisons with literature were conducted. In this line, the main areas of the framework are supplemented by recent empirical findings. As illustrated in Figure 2, the reference frame comprises four main areas: supply chain, TBL, SCM decisions, and resulting impacts on sustainability performance and risk. Each area is described in detail in the following subsections.

Table 2. SSCM constructs gathered from [10,21,23,34]

Construct	[21]	[10]	[34]	[23]
Performance	X			
Culture, values and ethics	X			
Risk management	X	X		
Transparency	X			
Strategy	X	X		
SSCM triggers		X		
Stakeholder groups		X		
Goods and products		X		X
Profit, planet and people	(X)	(X)	X	
Consumers and producers		(X)	X	
Natural resources			X	
Waste and emissions			X	
Win-win, tradeoff, min. perf.		X		
Physical infrastructure			X	X
Decision phases			X	X
Network design and configuration			X	X
Control				X

X, Construct explicitly mentioned in the paper; (X), Construct implicitly addressed in the paper.

**Figure 2.** An SSCM reference framework (own representation).

4.1. Supply Chain Area

The SC is conceptualized through an end-to-end approach ranging from suppliers via manufacturers and distributors to retailers that serve ultimate consumers of finished goods. Its foundations are grouped into structures and processes. Structures represent the network's physical and organizational fundamentals. The organizations connected within and related to the SC comprise not only producers and consumers, but also governmental authorities and other stakeholders linked through pressures and incentives that foster network sustainability. The infrastructure comprises property, plant, and equipment, i.e., physical assets such as production sites, warehouses, terminals, vehicles, and other facilities needed to operate the SC.

The SC structures are linked through processes comprising physical, financial, and information flows within the network. Physical flows include goods and inventory generated through operational SC activities (usually) forwarded from suppliers to consumers (or—less often—returned from consumer markets). Furthermore, physical flows include natural resources consumed and waste

and emissions released through transformation, transportation, and storage processes. Physical flows represent the main interface between structures and processes because products and infrastructure have physical properties, and both are related to the consumption of natural resources and the release of waste and emissions. Financial money flows, usually directed upward from consumer markets to suppliers, and bidirectional information data flows shared among upstream and downstream SC partners complement the process foundation.

With regard to information flows, related knowledge management and reflexive control routines promote the transition toward more sustainable SC structures [19,61]. Generating, accessing, and assessing information about SC members support transparent and reliable processes as well as the adaption to (cleaner or sustainable) technologies [36]. Besides IT-driven routines, communication and training help to establish a firm culture for sustainability. Recent empirical studies in the food and chemical industry identified monitoring practices such as sustainability certification and audits to increase transparency and reduce SC risks [38,62]. Further, transparency is seen as a prerequisite for traceability, which is less often applied thus far for SC sustainability.

4.2. TBL Area

SCM can be linked clearly to each of the three TBL dimensions, and these links are outlined briefly in this subsection. Tang and Zhou [34] explained that the sustainability TBL comprises the profit dimension, which is measured through price and cost; the planet dimension, which is affected by consumption of non-renewable input and disposal of unwanted output; and the social dimension, which comprises producers and consumers linked in the supply network. Since SCM affects the economic performance of all firms in the network, they strive for collaboration to increase all SC actors' financial success jointly. Cooperation between all partners is required to generate sales by serving customers—and, ultimately, consumers—on time and in full, providing high-quality products and services. Cost reduction and efficient use of fixed and working capital represent further economic objectives that can be achieved through collaborations between SC partners with flexibility, resilience, and responsiveness from their SCs.

Ecological aspects must be taken into account in SCM to protect the natural environment from damage caused by consumption of natural resources and other input factors and by waste emissions and other harmful or unwanted output factors. In addition to environmentally conscious SC processes, product sustainability is a decisive factor for SSCM. Products' sustainability can be improved through the use of environmentally friendly raw materials and through recycling, remanufacturing, or at least careful disposal of used items and their components. In line with Gong et al. [13], these practices can be subsumed under the label “green production and innovation” to facilitate a sustainable supply chain's performance.

Sustainable SCs' social dimension comprises all actors ranging from suppliers of raw materials to producers and service providers to retailers, and ultimately consumers of finished goods and services. It also covers societal aspects that result from government and other stakeholders that are not part of, but are affected by, the SC and that, therefore, may trigger SC sustainability through pressures and incentives to which SC actors are directly or indirectly exposed. Actions and strategies to manage social issues in SCs are related to communication, compliance, and supplier-development strategies and, thus, can shape SSCM's social and economic impacts [36].

Only a few researchers have empirically studied tensions and paradoxes between single TBL areas in sustainable operations and supply chain management so far. Such a perspective however points to iterative or cyclical actions, such as continuous improvement processes, that may transform a situation such that interrelated demands can be pursued simultaneously without necessarily having to resolve the actual tension [68]. For instance, Rizzi et al. [69] studied the so-called “Abilene paradox” where increased pressures to improve performance and reduce risk, resistance to change, and strategic myopia can easily impair inter-organizational interactions and thus prevent potentially innovative networks from pressuring public investments in green supply chains.

4.3. Decisions Area

SSCM decisions are complex tasks to design the supply network and plan, execute, and control operations therein. Decisions on structures and processes are made when establishing a new SC structure or adapting an existing one, e.g., in capacity extension or restructuring projects, but also when changing a company's organizational form, integrating new actors into the network, or modifying cooperation between existing partners. Such long-term decisions are considered strategic. In contrast, operation and control decisions are made to execute or modify processes within the SC structure that remain unchanged. These medium- or short-term decisions are perceived as operational, and all these decisions are preceded and prepared by SC planning activities.

The use of specialized techniques for sustainable optimization of complex systems such as SCs, accordingly, enables decision-makers to conduct evaluations on the operational, tactical, or strategic level. Myriad approaches focus on different SSCM sub-areas, such as vehicle routing, facility planning, network design, or layout planning (see, e.g., [20]). Such planning approaches use a variety of static and dynamic models, as well as mathematical approximation methods and heuristics, to solve this task. In the specific SSCM context, Seuring [70] particularly identified life-cycle assessment (LCA), equilibrium models, multi-objective optimization (e.g., MCDA), and the analytical hierarchy process (AHP) as the most widely used techniques. Responding to external pressures, especially the adoption of LCA can be seen as proactive environmental action on a strategic level [71].

In recent years, the use of computer-aided simulations and experiments support decision-making in SSCM. Simulation approaches such as *system dynamics* (SD) simulation were not only applied in environmental and sustainability contexts, but also increasingly in SSCM (see, e.g., [32] for a review of related literature). In this line, different possible scenarios to solve a problem can be explored. A simple option to implement SD is the development of a *causal loops diagram* (CLD), which represents the general picture of a complex system. For instance, Gruchmann et al. [72] applied participatory systems mapping to fill knowledge gaps for required DCs in SSCM. Answering the question of how logistics service providers can contribute to creating more sustainable production and consumption systems, the authors built a CLD within several workshops describing relevant variables and their causal relations with each other. Further, Rebs et al. [73] studied the effects of stakeholder influences on SSCM performance with means of a SD simulation model addressing SSCM DCs.

4.4. Impacts Area

SSCM decisions about processes and structures result in performance and risk impacts along the TBL of sustainability. These SSCM impacts fall into four categories: value, vitality, variability, and vagueness.

The financial value—traditionally measured through income, cost, and capital requirement—mainly is affected by monetary flows within the network. Economic performance includes non-financial objectives such as quality and flexibility, which are viewed as antecedents of financial success and contributors to economic value creation. Ecological consequences, i.e., resource depletion or pollution through waste and emissions, usually are caused by SC infrastructures and physical flows across them. Thus, these consequences are primarily product-related. However, environmental implications from product use, which occur outside the SC, are not an integral part of this framework. Social implications mainly stem from decisions about the network organization, thereby reflecting the people dimension and its culture, ethics, and other (intangible and non-financial) values. Relationships between economic, environmental, and social goals are conflictive or complementary. Conflictive aims either elicit tradeoffs between different targets of equal importance or the need to ensure that a minimum performance threshold for a criterion of subordinate relevance is achieved while optimizing an objective with higher priority. Complementary targets may lead to win-win(-win) situations in which a firm or SC may optimize one sustainability aspect that implicitly improves another factor.

The vagueness of data, which are transmitted through information flows, is the origin of risks, i.e., threats arising from unwanted results or events, to which the supply network is exposed. Such risks arise from data uncertainty or variability, as well as missing transparency about structures and

processes. Uncertainties are inherent SCM characteristics that SC managers on all decision-making levels must take into account. In addition, the SC permanently is exposed to risks that endanger SC performance. As a consequence, continuous and effective risk management is required to reduce uncertainties, anticipate unwanted events, and mitigate resulting risks. Related approaches could be reflected by innovative concepts such as *corporate digital sustainability* (CDR).

5. Current Gaps and Future Perspectives on SSCM Research

Future SSCM research needs to take a broader look at the supply network when analyzing SC sustainability [10]. Reflecting the alignment of a focal firm with its upstream and downstream SC partners and including market forces in studies represent promising directions for SSCM research [34]. Tang and Zhou [34] detected the need for quantitative models to support a firm's strategic alignment with its upstream and downstream SC partners, especially in the context of sourcing and procurement. In addition, the macro-economic perspective of sustainability research needs to be complemented by studies based on a micro-economic view, e.g., in the context of SCM [21].

Regarding TBL dimensions, one of the biggest SSCM research gaps is the clear focus on the planet dimension, which widely omits social or societal factors [34]. A holistic perspective that reflects the three TBL dimensions' interrelations is required to overcome this shortfall in SSCM research [10]. Furthermore, only a few researchers have studied SSCM paradoxes while other foci, such as the win-win paradigm, still dominate the analysis of sustainability-related issues [74]. Accordingly, applying a tension perspective in SSCM research is a promising future research avenue, at least for empirical studies [3,4].

The area of decisions also offers broad opportunities for further qualitative and quantitative SSCM research. Sophisticated tools and integrated systems are needed to support making SC decisions that gain further complexity when all three TBL dimensions are taken into account. By now, decision-support models for SSCM most often focus on environmental aspects while social factors are seldom taken into account [10,34,70]. Sustainable SC (re-)design requires reflecting environmental factors and social aspects when locating facilities and establishing transportation links for product flow within the network [34]. Sustainable execution and control include choices between various transportation modes, means, and capacities under consideration for all three TBL dimensions [23].

In addition to decision-support methods, further SSCM research may increase understanding of and knowledge about the decision-making processes, relationships, and interplay between involved and affected stakeholder groups and these groups' differing interests. Interplay between stakeholder groups and their SSCM triggers, which is well-explained through conceptual frameworks, needs to be measured and compared through quantitative studies and mathematical models that enable numerical evaluations and formal assessments of these causal relationships [10].

Regarding SSCM impacts, longitudinal studies and life cycle analyses are recommended to assess a supply network's long-term sustainability performance [10,21,70]. Studying sustainability's performance implications in inter-organizational supply networks represents another future perspective for SSCM research [70]. Carter and Rogers [21] suggested developing scales and metrics for all TBL dimensions to measure and manage sustainability performance. Moreover, future SSCM research could elaborate on measurement and management of sustainability risks, which can be viewed as an SC-related socio-ecological threat [10,21].

Future SSCM models that analyze SSCM impacts should not be limited to a determination of tradeoffs between the three TBL dimensions, as they also could help examine how to achieve win-win opportunities or ensure a minimum socio-ecological SC performance [70]. Since SSCM models fall into single-objective approaches that internalize non-economic targets through a single cost function and multi-objective techniques that measure and compare economic factors and externalized non-economic criteria [34], both approaches' similarities and differences need to be analyzed more comprehensively and in greater detail.

Regarding SSCM research design, a lack of theoretical foundation is observed in empirical studies [10,54] and in model-based research [70]. Establishing a theoretical foundation represents

a future perspective for SSCM research [10], e.g., by applying PBV or SCPV as a theoretical lens. Although many SSCM models have been published, model-based SSCM research still represents a promising SSCM research area [10,34,70]. In particular, models that provide a better representation of the supply network, e.g., by applying graph theory or control theory, might enable a more advanced theory on the supply chain [65]. The consideration of social aspects represents another promising direction for SSCM research [20,70]. In addition to future perspectives in model-based SSCM research as described above, Seuring [70] emphasized the need to ensure scientific rigor when formal SSCM models are empirically substantiated or tested.

6. Summary and Conclusions

Sustainability has become a key factor in operations and supply chain management, thus the sustainability TBL must be taken into account when analyzing and improving operations and related managerial decision-making using environmental and social criteria [33]. Thus, related tasks' complexity has grown considerably such that implementation of sustainable policies in SCs is a significant challenge for businesses [65,75]. Stimulated by these circumstances, SSCM research has become highly relevant as indicated through a growing number of formal models [20], reference frames [16], and empirical studies [30]. However, the scientific area still emerges, and various directions offer potential for future research.

To refine existing frameworks, as well as inform theoretical underpinnings, the present study presents a conceptual framework in Section 4. This framework offers a comprehensive view on SSCM and outlines its complexity by investigating relevant practices addressing sustainability issues in SCs. It also illustrates how an SC's structures and processes are integrated into the components of its natural, social, business, and political environments. Decisions on strategy and operations are assigned to SC constructs, and resulting SSCM risk and performance impacts are grouped into four categories: value, vitality, variability, and vagueness. In this line, our conceptual framework explicitly addresses concepts such as CDR, which complements the TBL by suitable practices including data ethics and data security. In this respect, the theoretical lenses of PBV and SCPV allow for describing possible antecedents, practices, and routines, as well as performance outcomes.

The framework may serve as a conceptual foundation for SSCM in scientific research, and it mirrors future SSCM research perspectives. SSCM research opportunities include decision-support methods and tools and approaches to measure and manage sustainability performance and risks in the SC, as well as sustainability triggers and SSCM policies' causal relationships in the presence of various stakeholder groups and their influences on SC actors. The framework also contributes to managerial practice. Decision- and policy-makers may find the framework helpful in their attempts to broaden the scope of actions to establish SCs that are managed and operated in a truly sustainable way. Particularly, future studies on vagueness are promising for SSCM researchers and practitioners and can be recommended as they may combine the mega-trends of sustainability and digitalization.

Despite providing valuable insights, a conceptual and qualitative study is not without limitations. Due to the application of a focused literature review based on an exemplary literature sample, not all available literature has been incorporated into the development of the conceptual model. This limitation generally perceived in conceptual and qualitative research allows for no generalization of the findings. Accordingly, future research needs to test the proposed framework, i.e., by using survey research.

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