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Making transparency transparent: a systematic literature review to define and frame supply chain transparency in the context of sustainability

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Abstract

Supply chain transparency and its connection to sustainability is a current topic in supply chain management research. The term supply chain transparency is used very loosely in this discourse. Therefore, this article aims to clarify the understanding of supply chain transparency in the context of sustainability to enable future research. In a content analysis-based literature review, 92 peer-reviewed articles were identified in the intersection of sustainability, supply chains, and transparency. Only 30 articles contained a definition of transparency. Supply chain transparency was used and defined very differently among the researchers. By providing a general definition and framework of sustainable supply chain transparency, the term "supply chain transparency" gains more clarity. Three dimensions of transparency were identified: sustainable supply chain information, involved stakeholders, and perspective. The supply chain transparency research was conducted primarily in the context of the food and apparel industry. Transparency was characterized differently among the industries and was studied with different foci. Furthermore, the review revealed a focus of supply chain transparency research on the social dimension of sustainability. Additionally, a wide range of topics on supply chain transparency has been covered in the existing literature, and opportunities for future research are outlined. Future researchers are also encouraged to define transparency more clearly.

Keywords Supply chain transparency · Sustainability · Definition · Framework · Literature review

JEL Classification M10

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1 Introduction

Companies are increasingly exposed to pressure for more sustainable and transparent supply chains (Francisco and Swanson 2018) as they are held responsible for their suppliers' prevailing environmental and social conditions (Busse et al. 2017b). Various laws force companies in disparate areas from different geographical backgrounds to be more transparent. The Dodd-Frank Act, for example, requires companies to disclose their involvement in conflict minerals (Islam and van Staden 2018), and the California Transparency in Supply Chains Act has companies disclose a statement of their actions to help eliminate human trafficking and slavery in their supply chains (Lee et al. 2018).

Supply chain transparency is addressed as an important issue for supply chain management (Fraser et al. 2020), and Fritz (2020) frames the management of information and communication technologies as a part of sustainable supply chain management. The complexity of global supply chains can make this supply chain transparency difficult, costly, and time-consuming (Busse et al. 2017a; Doorey 2011; Fraser et al. 2020). In the last few years, new technologies (e.g., blockchain technology) and digital platforms (e.g., EcoVadis) have been discussed against this background as tools to support companies in assessing and exchanging sustainable supply chain information (Francisco and Swanson 2018; Fritz 2020). Still, a better understanding of supply chain transparency is needed to understand what information should be shared with the help of those technologies, as well as who should be involved in the sharing process.

The importance of transparency and sustainability in supply chains is not only being shown in practice but is also being reflected in current research on supply chains (Gardner et al. 2019; Jestratijevic et al. 2020; Sodhi and Tang 2019). For the purposes of this investigation, the traditional notion of sustainability comprising economic, ecological, and social aspects is complemented by the governance aspect, which has gained increasing attention in the business sustainability context (e.g. Fritz et al. 2017). Research concerning the connection of supply chain transparency and sustainability in supply chains is conducted with foci on different industries (e.g., apparel, food, conflict minerals) and different aspects of sustainability (economic, social, environmental, governance). Despite the ample research on supply chain transparency and sustainability, the relationship between these concepts remains unclear (Mol 2015). Results do not provide a clear picture when it comes to the direction of an effect, whether it is positive (e.g., Dubey et al. 2017) or negative (e.g., Gold and Heikkurinen 2018) or if there is any effect at all (e.g., Longoni and Cagliano 2018). In addition, the term supply chain transparency has been used very loosely in the discourse on sustainability and transparency (Gardner et al. 2019). This inconsistent use of the term makes it difficult to identify the factors that influence social, environmental, ecological, and governance issues in supply chains.

The lack of clarity concerning the term "supply chain transparency" and the absence of a consistent definition have also been pointed out by various other authors (e.g., Egels-Zandén et al. 2015; James and Montgomery 2017). Other

terms and concepts are intermingled with supply chain transparency (Sodhi and Tang 2019). In the literature about supply chain transparency and sustainability, visibility (e.g., Awaysheh and Klassen 2010; Sodhi and Tang 2019), disclosure (e.g., Birkey et al. 2018; Kraft et al. 2018), and traceability (e.g., Barling et al. 2009; Garcia-Torres et al. 2019) have been connected to or have even been used as synonyms for transparency. Still, there are different views on the relationship of transparency to the various named terms. Traceability, disclosure, and visibility are in some cases equated with transparency; sometimes they are seen as totally independent concepts, sometimes as part of transparency, and sometimes as prerequisites for transparency. For a deeper understanding of supply chain transparency and its influence on sustainability in supply chains (Mol 2015) or its benefits in general (Sodhi and Tang 2019), a better understanding of the concept of supply chain transparency is needed.

The research questions for this study are therefore:

1. What is the definition of supply chain transparency, and how is it used in the context of sustainability?
2. Is supply chain transparency in the context of sustainability a multidimensional concept? If so, what are its dimensions, and what practical implications come along with it?
3. Is transparency conceptualized differently across industries?

This research aimed to generate a clearer understanding of the concept of supply chain transparency and, thereby, to support future research on this topic. With this goal in mind, the present article is structured according to previous systematic literature reviews and guidelines (e.g., Akyuz and Gursoy 2020; Fisch and Block 2018; Hochrein et al. 2015). Section 2 describes the systematic literature review methodology and is followed by a presentation of the results and a discussion in Sect. 3. Section 4 offers a conclusion and an outlook on future research.

2 Research methodology

As suggested by Seuring and Gold (2012), a content analysis-based literature review is a useful method to generate knowledge in the field of supply chain management and was therefore conducted in this research. To address the research questions, the analysis was carried out in three stages (see Fig. 1). In the first stage, relevant literature was selected, and various supply chain transparency definitions were identified. In the second stage, those definitions were used to draft a supply chain transparency framework. In the third stage, this framework was further developed based on the full text of the relevant articles.
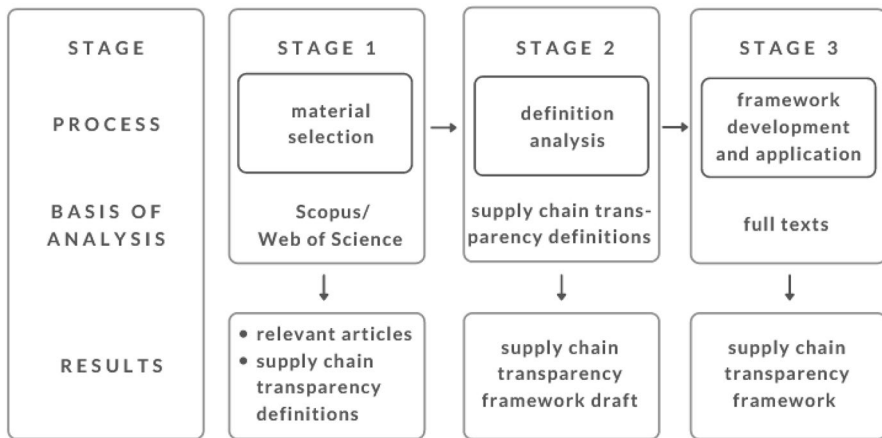
Fig. 1 Research process

2.1 Material selection

For literature reviews, it is crucial to have a material selection process that is "objective, valid and reliable" (Hochrein et al. 2015, p. 256). In order to do so, clear rules to include and exclude articles were established for each step. In the case of uncertainty regarding individual articles, they were discussed with two experts in the field of sustainability and supply chains at multiple meetings during the development process. The inclusion/exclusion criteria and the expert consultation ensured a consistent selection process. This procedure is recommended for studies conducted by a single researcher (Hochrein et al. 2015; King 2004; Nowell et al. 2017).

To identify the relevant articles, two databases were selected: Scopus and the Web of Science. As in previous studies (e.g., Ahi and Searcy 2013; Merino-Saum et al. 2020), the Scopus database was chosen due to its broad coverage of academic journals with economic, environmental, and social orientations. The Web of Science database was also selected due to its wide range of journals. The search was targeted at peer-reviewed articles in the English language at the intersection of transparency, supply chains, and sustainability and included articles published up to the end of 2020. To cover relevant aspects, the following search string was applied: (transparen*) AND (supplier OR "commodity chain" OR "supply chain" OR "demand chain" OR "value chain") AND (sustain* OR social OR environment* OR ecological*) using "Title-Abstract-Keywords" as the search category. The search resulted in 614 articles in Scopus and 219 articles in the Web of Science database. After eliminating duplicates, 645 distinct articles remained. As a common next step in systematic literature reviews, the articles were screened by title and abstract (e.g., Garcia-Torres et al. 2019). When an article did not address both sustainability and supply chain transparency, it was eliminated. Articles eliminated at this stage could be the result of a search criterion term being used in a different context, for example, when "environment" was used to describe surroundings or conditions instead of the natural world with regard to sustainability (e.g., Beulens et al. 2005; Chua et al.

2003) or when "transparency" referred not to supply chains but to a method used (e.g., Badi and Murtagh 2019; Lap et al. 2019). In cases of uncertainty, the abstract was read by another coder in order to generate an inter-rater reliability. The author read the remaining 271 articles in full. As a result, 131 relevant articles were identified. Those articles were identified as treating supply chain transparency as a central aspect or as one of the main aspects in the context of sustainability. According to their main focus on supply chain transparency and the presence of a definition of supply chain transparency, the articles were further divided into four groups. The material collection process, as well as the group classification, is shown in Fig. 2.

2.2 Definition analysis

As a result of the first research stage, 40 articles with definitions of supply chain transparency were identified (Groups 1 and 3). Articles with definitions included articles with the authors' own definitions and articles in which the authors cited a definition of transparency. All transparency definitions were analyzed to see how transparency was defined and framed in the context of sustainability in supply chains (RQ1) and as to whether transparency was understood as a multidimensional concept (RQ2).

Mayring (2015) points out that the building of categories is the center of content analysis. The categories can be developed deductively as well as inductively (Mayring 2015). In the current study, to analyze the definitions, an inductive approach was chosen. First, the individual elements of the definitions were coded using the software MAXQDA. After analyzing about half of the definitions, the categories were defined. Three possible dimensions of supply chain transparency were identified: sustainable supply chain information, the involved stakeholders, and the perspective of supply chain transparency (Fig. 8).

2.3 Framework development and application

Based on the dimensions identified in Stage 2 (as seen in Fig. 1), a framework was developed by verifying and specifying the dimensions on a full-text basis of all 131
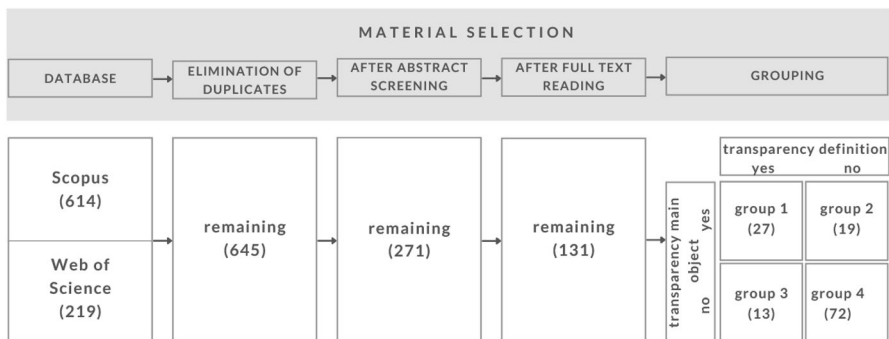

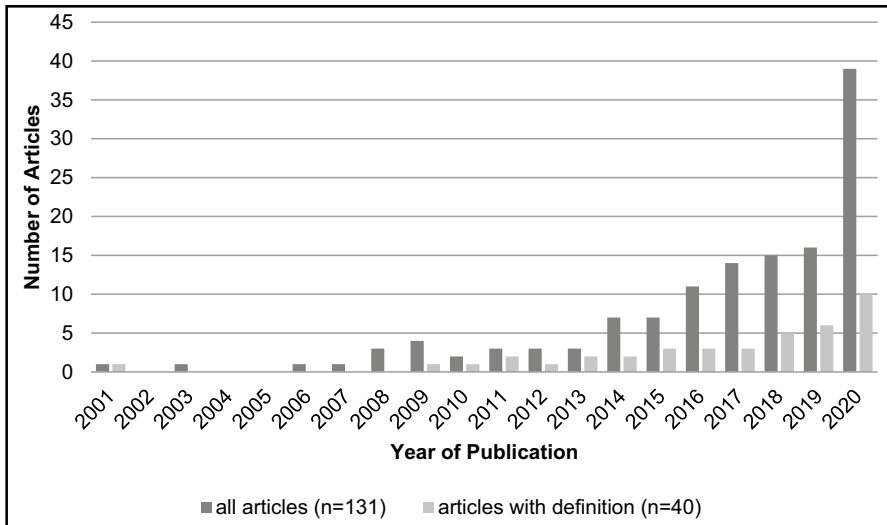**Fig. 2** Material selection process

Fig. 3 Distribution of reviewed articles according to the year of publication

of the relevant articles. At this stage, a deductive approach was chosen. To identify the characteristics of each dimension, preliminary considerations were made based on the supply chain transparency definition analysis as well as on other literature. For the first dimension, *supply chain information,* Gardner et al.'s (2019) classification was used. This classification consisted of six types of supply chain information: traceability, transaction, impact, activity, and effectiveness information. It shows the information needed to improve sustainability in supply chains (Gardner et al. 2019). After about 30 articles had been analyzed, the categories were adapted. The definitions of the categories were adjusted, and two additional categories were identified (see Sect. 3.2.1). The *sender* and *receiver* categories of the second dimension *involved stakeholder* were removed from the definitions, and a further subdivision of the different stakeholders was made based on Freeman (2010). For the third dimension *perspective,* the characteristics of *disclosure* and *visibility* were adopted from Kraft et al. (2020).

3 Results and discussion

3.1 Descriptive analysis

The descriptive analysis shows the distribution of the publications per year, the journals where most of the articles were published, and the industry foci of the articles. The reviewed articles were published between 2001 and 2019. Both the total number of relevant articles per year and the number of those containing a transparency definition are shown in Fig. 3. In the final years of the examined period, both numbers increased consistently. The sharp increase in 2020 can
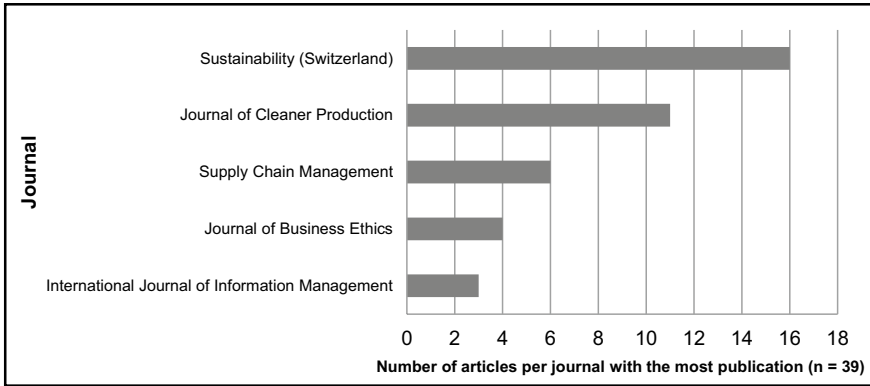
Fig. 4 Distribution of reviewed articles according to journal

Table 1 Industry focus

Industry focus	Number of articles (n = 131)
Agriculture/food	45
Apparel	22
Forest	5
Automotive	1
Electronic	1
Gem	1
Pharm	1
Outdoor equipment	1
Toys	1
Multiple industry foci	3
No industry focus	53

be attributed to the technical component considered in the science (e.g., blockchain) in addition to the normal increase of the topic transparency and sustainable supply chain management in general (e.g., Rajeev et al. 2017).

The four journals with the most publications are shown in Fig. 4. The 131 identified articles were published in 79 different journals, showing a wide range of topics concerning supply chain transparency and sustainability. In addition to the five journals shown in Fig. 4, 13 journals published two articles each, while 61 additional journals published only one article each from the sample.

Table 1 shows the industry foci of the articles. While 53 articles did not have an industry focus, two industries were predominant in the context of sustainability and supply chain transparency: the agriculture/food industry and the apparel industry.

3.2 A multidimensional framework of supply chain transparency

One of the goals of this article was to clarify the understanding of supply chain transparency. To do so, definitions of supply chain transparency were analyzed, and the use of supply chain transparency was examined on a full-text basis. Out of the 131 articles identified as relevant in the areas of transparency, sustainability, and supply chains, 40 of the articles defined transparency. As James and Montgomery (2017) have pointed out, there is no consistent understanding of supply chain transparency, meaning different approaches and angles have been taken when different authors use supply chain transparency. Eight articles discussed the meaning of supply chain transparency in the context of sustainability in greater detail (Egels-Zandén et al. 2015; Egels-Zandén and Hansson 2016; Gardner et al. 2019; James and Montgomery 2017; Kraft et al. 2018; Mol 2015; Sodhi and Tang 2019; Wognum et al. 2011) whereas the others provided only brief definitions of supply chain transparency.

From the coded content, three possible dimensions of supply chain transparency could be identified at first, as they appeared in most of the supply chain transparency definitions. These dimensions were *sustainable supply chain information*, *involved stakeholders*, and *perspective of sustaibable supply chain transparency*. An overview of the elements and their frequency of use is given in Table 2. The table also includes an example of the supply chain transparency definition with the respective element for a better understanding.

Based on the analysis of the complete texts, the dimensions of supply chain transparency were able to be verified. Each dimension contributes to different supply chain transparency impacts. Gardner et al. (2019) show the central importance of supply chain information by simply asking: "transparency of what?" (p. 3). They further state the dependency of supply chain information on the impact of supply chain transparency (Gardner et al. 2019). For the second dimension, involved stakeholders, Mol (2015) points to the fact that the impact

Table 2 Dimensions of sustainable supply chain transparency

| Dimensions	Example of definition
Sustainable supply chain information	"Supply chain transparency: the extent to which information about the companies, suppliers, sourcing locations (including mines) and processing conditions (cutting and treatment processes) is available to end consumers and to other companies in the supply chain." (Cartier et al. 2018, p. 216)
Involved stakeholders	"Transparency can be defined as the disclosure of information (Mol, 2015) which emphasizes the need for further communication from companies to inform and raise awareness with consumers." (James and Montgomery 2017, p. 11)
Perspective of sustainable supply chain transparency	"We propose that supply chain transparency comprises corporate disclosure of: i) the names of the suppliers involved in producing the firm's products (i.e., traceability), ii) information about the sustainability conditions at these suppliers, and iii) the buying firms' purchasing practices." (Egels-Zandén et al. 2015, p. 5) "Supply chain transparency can be defined as the degree to which a supply chain player has access to relevant information […]" (Bastian and Zentes 2013, p. 554)
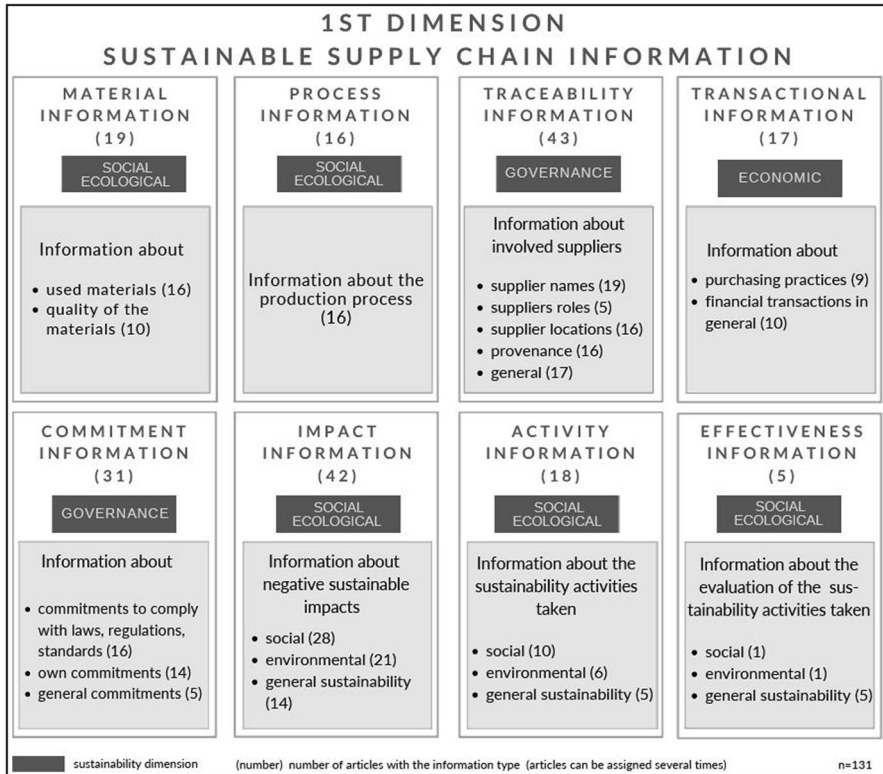
Fig. 5 Sustainable supply chain information typology and distribution among articles

of transparency can differ based on who is providing information to whom. The impact of supply chain transparency differs as well when looking at the third dimension of either processing information or, from the other side, providing information (Kraft et al. 2018). Each dimension is further elaborated in an individual section below.

3.2.1 Sustainable supply chain information

The analyzed literature shows that information is the reference object of supply chain transparency. Gardner et al. (2019) refer to this aspect by simply asking: "transparency of what?" (p. 165). Based on the supply chain transparency framework of Egels-Zandén et al. (2015), they identified six types of information that are needed to improve sustainability (Gardner et al. 2019).

The various kinds of supply chain information addressed in the identified articles were assigned to these six categories. It was found that information on the production process and the product itself regarding the quality and ingredients of the product were not included in the six information types from Gardner et al. (2019). These two missing categories were added. An overview of the identified supply chain information in the eight categories as well as identified subcategories is provided in Fig. 5. A further explanation of each information type is provided in the following narrative.

Material information provides information about the ingredients or components of a product and its quality. Product information refers to ecological and social sustainability. Most of the articles referred to general information about the ingredients of a product (e.g., Barling et al. 2009; Whitworth et al. 2017). This provides indirect information on the sustainability of products' ingredients or components because the information helps to analyze whether or not a product contains hazardous or unsustainable/sustainable materials. Four articles went further and dealt with information on ecological materials (Fritz et al. 2017; Viciunaite and Alfnes 2020; Wasner and Majchrzak 2013; Wognum et al. 2011), and three articles dealt with information on materials that allowed a direct link to unsustainable practices. If, for example, information on the use of conflict minerals is published, this allows a direct conclusion regarding unsocial practices (Fritz et al. 2017; Griffin et al. 2014; Islam and van Staden 2018).

Furthermore, information on the quality and safety of the products was included in 17 articles (e.g., Ko et al. 2018; Trienekens et al. 2012; Verhees et al. 2008). Fritz et al. (2017) associate information on quality and safety with the social dimension of sustainability.

Process information includes information about the production process in general. This refers to information on the methods of production (e.g., Barling et al. 2009; Bastian and Zentes 2013; Sodhi and Tang 2019), production plans (Zhu et al. 2018), and production volumes (Nyström et al. 2019). Information on the production process allows conclusions on sustainability practices. Information on sustainable production was explicitly named in two articles (Fritz et al. 2017; Wognum et al. 2011).

Traceability information covers the names of the involved suppliers, their roles, or the suppliers' locations, mainly referring to the raw materials' provenance. In the reviewed literature, contract information and information about the relationship were only addressed by Gardner et al. (2019). Traceability is seen as an enabler for sustainable supply chain management (Garcia-Torres et al. 2019). Therefore, traceability information can be attributed to the governance dimension of sustainability.

There are different views in the literature on how supply chain transparency and traceability are connected or whether they are, in fact, referring to the same concept. While Garcia-Torres et al. (2019) use traceability as an overarching construct in which transparency is part of the construct, Cartier et al. (2018) see it the other way around, such that traceability provides transparency. Traceability has also been seen as delivering specific information about a product's history, supply chain actors, and places (Gardner et al. 2019). Traceability was seen here as a part of transparency concerning specific supply chain information, such as supplier names, roles, and locations.

Transaction information refers to information about purchasing practices and other financial transaction information. The economic aspect of sustainability was named in 22 articles in the context of purchasing information (e.g., Egels-Zandén et al. 2015; Sodhi and Tang 2019; Verhees et al. 2008), as well as capital flows (Bastian and Zentes 2013), profits of supply chain members (Bastian and Zentes 2013; Verhees et al. 2008), production costs (Gold et al. 2017; Piercy and Rich 2015),

product prices (Fleury et al. 2016; Wognum et al. 2011), and information on the price to pay in order to avoid unsustainable practices (Islam and van Staden 2018).

Commitment information comprises information about social and ecological policies and commitments of specific supply chain actors. As a part of a company's strategy, complying with laws, regulations, standards, or norms and setting its own policies or goals can be associated with the governance aspect of sustainability. Companies within a supply chain may set their own policies or goals toward social or ecological changes. This includes codes of conduct (e.g., James and Montgomery 2017; Wasner and Majchrzak 2013), more sustainable sourcing strategies (e.g., Islam and van Staden 2018), or sustainable strategies in general (e.g., Fritz et al. 2017; Leadbitter and Benguerel 2014). Companies within a supply chain may decide to comply with sustainable standards or norms (e.g., Gardner et al. 2019; Sodhi and Tang 2019), management systems (e.g., Fritz et al. 2017; O'Rourke 2006), or certifications (Falcone and Imbert 2018; Kashmanian 2017), or they may inform about the pressure they are under to comply with laws or regulations (e.g., Barling et al. 2009; Fritz et al. 2017; Greer and Purvis 2016). Policy and commitment information also comprises information about non-compliance with a law, policy, or standard (e.g., Grimm et al. 2014; Kashmanian 2017).

Impact information covers information about sustainability impacts of the supply chain. "Impact information provides transparency around the sustainability of individual supply chain stages, and thus sets a baseline for assessing the performance of the actors involved" (Gardner et al. 2019, p. 165). In the considered literature, sustainability impacts, in general, were named 21 times, social impacts 44 times, and environmental impacts 36 times. Social impacts refer to the topics of human rights and working conditions (e.g., Barling et al. 2009; Birkey et al. 2018), wages (e.g., Egels-Zandén and Hansson 2016; James and Montgomery 2017), occupational health (e.g., Fritz et al. 2017; Kaur and Sharma 2018), and local communities (e.g., Fritz et al. 2017; Trienekens et al. 2012). Environmental impacts relate to the topics of greenhouse gas emission (e.g., Kashmanian 2017; Olson 2010), water (e.g., Linneman et al. 2015; Verhees et al. 2008), energy (e.g., Kashmanian 2017; Verhees et al. 2008), waste (e.g., Fritz et al. 2017; Trienekens et al. 2012), soil (e.g., Verhees et al. 2008), and biodiversity (e.g., Trienekens et al. 2012).

Activity information includes information about actions taken in order to become more sustainable. From a social aspect, it mainly refers to actions taken to improve working conditions, especially to prevent modern slavery (e.g., LeBaron et al. 2017), human trafficking (e.g., Birkey et al. 2018), or child labor (e.g., Fritz et al. 2017) within the supply chains. From an environmental aspect, it mainly refers to greenhouse gas emissions (e.g., Wasner and Majchrzak 2013), water (e.g., Linneman et al. 2015), energy (Fritz et al. 2017), waste (Fritz et al. 2017), and biodiversity (Kashmanian 2017).

Effectiveness information includes information on the evaluation of the actions taken and the progress of activities. This information type was reflected in only five of the viewed articles (e.g., Kashmanian 2017; Leadbitter and Benguerel 2014; Linneman et al. 2015).

If the sustainability aspects mentioned in all the information types are considered together, the economic aspect was named least frequently (found in 22 articles)

compared to the ecological (found in 48 articles) and social aspects (found in 55 articles). The finding that the economic aspect of sustainability was considered least is in line with earlier research on sustainability in general (White 2013). In existing research on sustainability and supply chains, the ecological aspect of sustainability was identified as the sustainability aspect receiving the most attention, and the fact that the social aspect has received too little consideration has been discussed (e.g., Ashby et al. 2012; Hochrein et al. 2015; Seuring and Müller 2008). Thus, the focus has seemed to shift from ecological aspects of sustainability toward social aspects when looking at supply chain transparency.

It seems that supply chain information concerns many topics (as can be seen in the previous section); however, clarity was still missing when looking at which supply chain tier or tiers the information refers. In most cases, supply chain information concerns not the entire supply chain but rather a specific part of it. This is particularly problematic because a partial consideration of supply chains can lead to the false impression that the given information in articles is related to the entire supply chain. A counter-example was provided by Sodhi and Tang (2019), who differentiated between information sharing at all tiers and information sharing at tier one. The reason for the mostly incomplete view of the supply chain is that companies have only a limited view of their supply chain (Kraft et al. 2018). Also, research in supply chain management rarely goes beyond the first-tier (Stevenson and Cole 2018), and the willingness to offer information about sub-suppliers is not a common approach in supply chain research (Grimm et al. 2014).

When looking at supply chain information, it must also be noted that information in the context of supply chain transparency is almost always directed downstream but not the other way. However, an exception was made by Feenstra and Hardesty (2016), who considered the sharing of upstream and downstream information.

3.2.2 Involved stakeholders

The exchange of supply chain information between different stakeholders, within or outside the supply chain, is essential to supply chain transparency. Which stakeholders are involved in the information transfer? Who sends information to whom? These are essential questions in order to consider how trustworthy the received information is and to address how the information is communicated to a specific stakeholder.

Stakeholder theory states that companies influence their stakeholders, and stakeholders can influence the companies (Freeman et al. 2010). Therefore, stakeholders play a key role in supply chain management, and the pressure from stakeholders has been identified as a primary driver for sustainable supply chain management (Seuring and Müller 2008). The engagement of stakeholders helps to influence and accept sustainable strategies made by decision-makers (Fritz et al. 2018). It is also important to note that each product has its own individual set of stakeholders (Fritz et al. 2018).

The second dimension of supply chain transparency deals with those stakeholders involved in the process of information sharing. Stakeholders can receive or share supply chain information. In some supply chain transparency definitions, the sender, receiver, or both are explicitly named. In some cases, supply

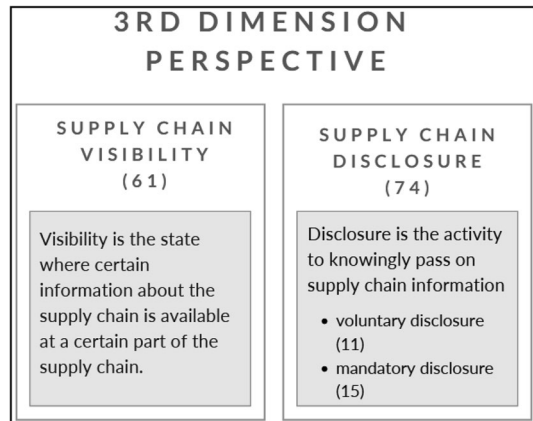**Fig. 6** Sender and receiver of sustainable supply chain information
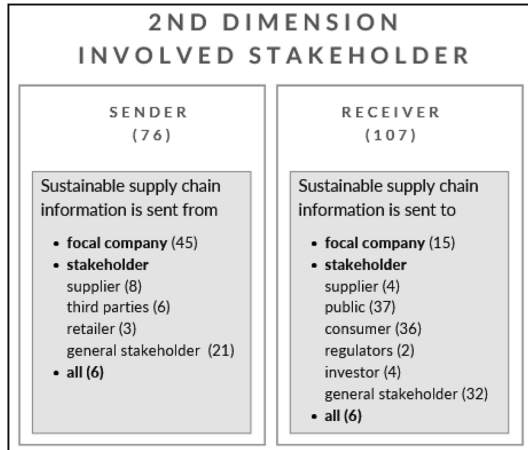
chain transparency is even named and categorized by the recipient of information. James and Montgomery (2017) differentiate between two types of supply chain transparency depending on whether or not the recipient of the information is within the supply chain. Internal supply chain transparency refers to sharing information within a supply chain, while external supply chain transparency applies to the disclosure of information to outside actors like the public (James and Montgomery 2017). Mol (2015), for example, differentiates supply chain transparency between "management transparency," the sharing of information within a company or with other companies; "regulatory transparency," the disclosure of information to regulators; "consumer transparency," the disclosure to consumer; and "public transparency," the disclosure to the broader public.

Figure 6 shows the distribution of senders and receivers of sustainable supply chain information. In the literature review, the sender was designated in 76 articles, and the receivers were addressed in 107 articles. When the stakeholder was not specified clearly, it is referred to as "general stakeholder".

When named, the sender of the supply chain information was most frequently the focal company. This could be due to the prevailing information asymmetries between different actors in the supply chain (Mol 2010). Supply chain transparency is seen as a way to shift power from a company to its stakeholders (Martinez and Crowther 2008). In contrast, consumers and the public were most often addressed as receivers of sustainable supply chain information in the literature. Due to the imbalance in the distribution of information, it is precisely these stakeholder groups that pressure for sustainable supply chain transparency in order to gain more information and more sustainability (Carter and Rogers 2008; Doorey 2011). In this context, supply chain transparency can be referred to as an instrument to hold powerful actors responsible (Dingwerth and Eichinger 2010). Based on the information received, individual consumers are able to protect their interests and make more conscious and sustainable choices, and collectively, NGOs can monitor sustainability conditions at production sites (Fung 2013; Laudal

Fig. 7 Perspective of supply
chain transparency

3RD DIMENSION
PERSPECTIVE

SUPPLY CHAIN
VISIBILITY
(6 1)

Visibility is the state
where certain
information about the
supply chain is available
at a certain part of the
supply chain.

SUPPLY CHAIN
DISCLOSURE
(7 4)

Disclosure is the activity
to knowingly pass on
supply chain information
- voluntary disclosure
  (11)
- mandatory disclosure
  (15)

2010). In this role, NGOs also function as so-called watchdogs and reveal information that companies do not want revealed (Meixell and Luoma 2015).

With the advent of various technologies in the area of supply chain management, such as blockchains, the focus on individual actors sending and receiving information is also slowly shifting to involve all the actors in the supply chain as participants in both sending and receiving information (e.g., Jæger and Mishra 2020; Kumar et al. 2020; Lahkani et al. 2020).

3.2.3 Perspectives of supply chain transparency

The third dimension deals with the perspective of supply chain transparency. Even when discussing the same supply chain and what information is shared, supply chain transparency is never the same depending on one's viewpoint. Supply chain transparency is different for various users and also depends on the purpose of supply chain transparency (Gardner et al. 2019). A particular perspective of supply chain transparency deals with conveying or using sustainable supply chain information for various tasks. Supply chain visibility refers to a state in which specific information about the supply chain is available. A second emphasis is the particular act where information is knowingly conveyed. Based on Kraft et al. (2018), these two concepts of the perspective dimension will be called "supply chain visibility" and "supply chain disclosure." Fig. 7 shows the distribution of the supply chain transparency perspective "visibility" and "disclosure" in the relevant literature.

Supply chain disclosure is often equated with supply chain transparency (e.g., Sodhi and Tang 2019). While some authors only use the term disclosure when information is passed from a company to the public (Ang et al. 2012; Marshall et al. 2016) or specific stakeholders, such as investors (Kalkanci and Plambeck 2015) or customers (Kraft et al. 2020; Polinsky and Shavell 2012); others use disclosure to describe a more general form of passing information to various actors (Kraft et al. 2018). In the following, supply chain disclosure is used according to the more general approach. Supply chain disclosure is sharing supply chain information with others within and/or outside the supply chain. Furthermore, disclosure can be described

by two subcategories: mandatory and voluntary disclosure (e.g., Kalkanci et al. 2016). Voluntary disclosure refers to information given freely without being pressured by stakeholders or the public or forced by legislation. When there is pressure or force for passing on information, the term mandatory disclosure is used (Kalkanci and Plambeck 2015). A total of 15 articles focused on mandatory disclosure and 11 on voluntary disclosure. Also, the other 53 articles did not explicitly state if the information was given freely or if it was mandated. The articles focused on mandatory disclosure were written in the context of the California Transparency in Supply Chains Act (e.g., Lee et al. 2018; New 2015), the Dodd-Frank Act (e.g., Griffin et al. 2014; Islam and van Staden 2018), the UK Modern Slavery Act (e.g., Limoncelli 2017; Stevenson and Cole 2018), or the Australia's Modern Slavery Act (Ford and Nolan 2020; Redmond 2020).

Supply chain visibility is discussed as the state in which certain information about the supply chain is available at a specific part of the supply chain (Kraft et al. 2018). Some authors limit this concept to describe the availability of supply chain information to a certain actor within a supply chain, such as suppliers, focal companies, or customers (Barratt et al. 2011; Busse et al. 2017a, b; Kraft et al. 2018); however, other authors take a broader approach and refer to visibility as also including the availability of information to external stakeholders (Morgan et al. 2018) or the public (Egels-Zandén and Hansson 2016). It has also been discussed how supply chain visibility is gained. For example, information can be obtained actively by pushing for, demanding, or requesting information (e.g., Sodhi and Tang 2019; Valkokari et al. 2014; Zhu et al. 2018); in contrast, information can be provided by others without prompting, and therefore, visibility is achieved passively (e.g., Awaysheh and Klassen 2010; Cartier et al. 2018). In the following, supply chain visibility is used to describe a state in which supply chain information is available to specific actors within or outside the supply chain.

Sodhi and Tang (2019) see supply chain visibility as a preliminary stage in sharing information. Because visibility requires the previous disclosure of information and in order to disclose information, supply chain visibility is needed, it seems apparent that the two concepts are mutually dependent. It was not further discussed in most of the articles if or how disclosure and visibility were connected to transparency. An exception was Kraft et al. (2018), who reported seeing disclosure and visibility as the two dimensions of transparency. The view by Kraft et al. (2018) was adopted here, so that visibility and disclosure were seen as aspects of supply chain transparency.

While most of the definitions focused either on visibility (e.g., Bastian and Zentes 2013; Cattermole 2016; Trienekens et al. 2012; Wognum et al. 2011) or disclosure (e.g., Gardner et al. 2019; James and Montgomery 2017; Wasner and Majchrzak 2013), some authors also took both perspectives into account (e.g., Egels-Zandén and Hansson 2016; Kraft et al. 2018; Whitworth et al. 2017).

As has been shown, supply chain transparency has been defined and used in multiple different ways in the context of sustainability. While there are many different angles and approaches, three general dimensions of supply chain transparency could be identified. Those dimensions and their characteristics constitute the framework for sustainable supply chain transparency shown in Fig. 8. Therefore, supply chain

Fig. 8 Sustainable supply chain transparency framework

transparency should be defined by referring to all three dimensions, and a clearer picture should be provided of the actual content of the used form of supply chain transparency. Using this framework, supply chain transparency can be defined as the visibility and disclosure of sustainable supply chain information to stakeholders within and outside the supply chain.

3.3 Sustainable supply chain transparency and different industries

As shown in Table 1, the food and fashion industries were the industries most addressed in supply chain transparency research in our sample. This stands in contrast to the findings of Hochrein et al. (2015), who showed that supply chain management research was conducted in a wide field of industries and had no clear focus on specific industries. To address the third research question and therefore show whether supply chain transparency was conceptualized differently among various industries, the use of supply chain transparency in the most frequently mentioned industries was analyzed.

Table 3 Supply chain transparency and industries

Dimensions with characteristics	All (%)	Agriculture/ Food (%)	Apparel (%)
Total amount	131 (100)	47 (100)	24 (100)
Sustainable supply chain information			
Material information	34 (26)	19 (40)	3 (13)
Process information	29 (22)	21 (45)	3 (13)
Traceability information	73 (56)	33 (70)	16 (66)
Transactional information	22 (17)	12 (26)	3 (13)
Commitment information	47 (36)	13 (28)	12 (50)
Impact information	65 (50)	20 (43)	13 (54)
Activity information	34 (26)	8 (17)	8 (33)
Effectiveness information	11 (8)	2 (4)	1 (4)
Involved stakeholder			
Sender			
Focal company	38 (29)	8 (17)	10 (42)
Supplier	5 (4)	2 (4)	1 (4)
Third Party	6 (5)	1 (2)	–
Retailer	3 (2)	–	–
General stakeholder	20 (15)	9 (19)	1 (4)
All	6 (5)	3 (6)	–
Receiver			
Focal company	26 (20)	4 (9)	4 (17)
Supplier	4 (3)	2 (4)	–
Public	37 (28)	6 (13)	7 (29)
Consumer	46 (35)	20 (42)	10 (42)
Investors	4 (3)	–	1 (4)
Stakeholder general	31 (24)	7 (15)	1 (4)
All	6 (5)	3 ()	–
Perspective			
Disclosure	74 (56)	19 (40)	14 (58)
Mandatory	15 (12)	3 (6)	2 (8)
Voluntary	11 (8)	2 (4)	2 (8)
Visibility	61 (47)	25 (51)	8 (33)

In Table 3, the distribution of the characteristics among the supply chain transparency dimension is shown.

When looking at the food industry, the dimension of supply chain information focused on particular areas:

- Traceability with the characteristics of provenance to determine the origin of a product
- Product information with its ingredients as well as its quality
- Process information

- Financial information

In most cases, senders and receivers of this information were unspecified supply chain actors and for receivers additonally consumer. The third dimension takes into account the characteristics of visibility and disclosure.

When looking at the apparel industry, most articles focused on disclosure from companies to consumers or the public. The dimension of supply chain information focused on the subcategories of traceability, policy and commitment, impact, and activity (where the last three showed a clear focus on the social aspect of sustainability).

Scandals in recent years in both the food and apparel supply chains have in particular led to increased attention not only in practice but also in research on transparency. External stakeholders have pressured industries for more transparency in order to prevent such scandals in the future. The different characteristics of supply chain transparency among those two industries can be explained by the different characteristics of the problems and injustices of their supply chains. Most of the time, scandals in the food industry affect the end consumer and their health. Examples of scandals include contaminated milk powder in China or the salmonella outbreak from peanuts in the USA leading to sickness and the death of consumers, as addressed by Sun et al. (2017), showing the importance of quality and safety in food supply chains (Bastian and Zentes 2013). This reflects the focus of the articles on production and product information, as well as traceability information.

In contrast to the food industry, the scandals in the apparel industry have mainly affected the workers within the supply chain and not primarily consumers. A frequently mentioned example of a scandal in regard to apparel supply chains is the collapse of the Rana Plaza building (e.g., James and Montgomery 2017). Companies experience pressure from consumers and NGOs to address these issues and improve their supply chains. This explains why supply chain transparency in the context of apparel focuses on the disclosure to consumers and the public of traceability information in addition to impact, policy, and commitment information.

3.4 Information and communication technology for supply chain transparency

Companies have been increasingly forced to collect and share sustainable supply chain information. This challenges companies in two ways: first, they have to obtain sustainable supply chain information, and additionally, they are confronted with large amounts of data that they have to manage (Montecchi et al. 2019). In order to overcome those challenges and address sustainability in their supply chains, the implementation of digital tools has been discussed in recent years (e.g., Frehe and Teuteberg 2017; Venkatesh et al. 2020). The growing importance of this topic has also been reflected in the research literature. Of the 38 relevant articles in 2020, 16 were concerned with digital tools. There were 11 articles that dealt with blockchain technology (e.g., Guo et al. 2020; Kamble et al. 2020; Venkatesh et al. 2020), three articles were concerned with the IoT (Cui et al. 2020;

Jæger and Mishra 2020; Khan et al. 2020), and two articles focused on digital approaches in general (Ebinger and Omondi 2020; Kittipanya-ngam and Tan 2020).

When looking at the three dimensions of sustainable supply chain transparency, it is noticeable that specific aspects of supply chain transparency are taken into account. First, supply chain information is mainly concerned with traceability information (e.g., Makkar and Costa 2020). Second, as mentioned above, the focus on individual actors sharing and receiving information shifts toward the participation of all involved actors in the transfer of supply chain information (e.g., Jæger and Mishra 2020; Kumar et al. 2020; Lahkani et al. 2020), and third, both perspectives of supply chain transparency, disclosure and visibility, are considered (e.g., Ebinger and Omondi 2020).

Many advantages are seen in the technical tools, for example, that the information transfer and processing will be much easier and safer (Ahl et al. 2020) and that activities can be monitored with the help of the tools in order to check effectiveness (Venkatesh et al. 2020), as well as decision-making based on the gained information (Guo et al. 2020). However, the disadvantages of high costs and high effort for the implementation of those tools remain (Venkatesh et al. 2020).

4 Conclusion and suggestions for future research

Although supply chain transparency is no longer a new topic to operations management and is also being discussed in many different contexts in the field of (sustainable) supply chain management, there is still a lack of clarity about what exactly is meant by the term and how it can be defined (Egels-Zandén et al. 2015; James and Montgomery 2017). This literature review reveals how different the understanding of supply chain transparency is among authors, that a distinction should be made between the individual aspects of supply chain transparency, and that sustainable supply chain transparency is conceptualized differently among industries. Therefore, a sustainable supply chain transparency definition that refers to terms such as visibility, disclosure, and traceability is proposed, and a sustainable supply chain transparency framework was developed in this study.

Sustainable supply chain transparency is the visibility and disclosure of sustainable supply chain information between actors within and outside the supply chain. This definition reflects the three dimensions of sustainable supply chain transparency: sustainable supply chain information, involved stakeholders, and the perspective of visibility and/or disclosure. The first dimension, sustainable supply chain information, refers to the reference object of supply chain transparency, asking "transparency of what?" (Gardner et al. 2019, p. 165). The second dimension refers to the stakeholder involved in the information transfer process, asking who sends the information to whom? Or who receives the information from whom? The third dimension clearly determines what viewpoint is taken as the unit of analysis by asking: What information is a company conveying (disclosure) or what does a company know about the supply chain (visibility)?

4.1 Implications for research

The objective of this research was to draw scholarly attention to the use of the term "supply chain transparency" in the context of sustainability and precise and conscious handling of it in future research. Supply chain transparency as defined here should not be used as a general term. This can be done by adapting definitions of supply chain transparency to the context of the specific research. Those individual definitions should refer to the three dimensions of supply chain transparency and therefore consider what information is disclosed by whom and will be visible to whom. Also, studies should be clear about what information is shared, which supply chain tier is covered, and to what tiers the supply chain information extends. Furthermore, it needs to be taken into account that supply chain transparency is conceptualized differently among industries.

However, a limitation must be acknowledged that the proposed sustainable supply chain transparency framework results from a literature review and thus would benefit from further empirical research. This could be done, for example, through the Delphi method or a multiple case study approach. Nevertheless, once the framework has been tested, verified, and further developed, it can serve as a starting point for further research in the field of sustainable supply chain transparency and sustainable supply chain management.

With the help of the framework, a measurement tool for sustainable supply chain transparency could be developed, which could extend the work of Morgan et al. (2018). Furthermore, the uncertainties of the relationship between supply chain transparency and sustainability can be investigated in depth. An examination could help determine which factors influence the relationship between transparency and sustainability positively or negatively and which do not affect this relationship.

Also, the literature review revealed further shortcomings in sustainable supply chain management research. First, the upstream information flow should be considered, instead of only considering the downstream information flow. Secondly, the existing research was mainly limited to first-tier suppliers (Grimm et al. 2014), so research should go beyond the first tier or acknowledge the difficulties in doing this. Thirdly, the literature review shows that little is known about companies' internal processes related to supply chain transparency and its management. Future research can focus on supply chain operations in which senders send sustainability-related information. In addition to this topic, future research should consider strategic elements regarding the decision to share some information and keep other information less visible and the effects of outside pressure and the internal response to it.

4.2 Implications for practice

This research also has several implications for practitioners. Particularly given current political developments, for example, at the European level with the EU taxonomy and in Germany with the Supply Chain Act, the topic of transparency, especially collecting the right sustainable information and the obligation

to disclose certain sustainability information, transparency is a very present issue for companies. While the literature review revealed how difficult it is to gain supply chain visibility beyond tier one due to the complexity of supply chains (Stevenson and Cole 2018), companies are increasingly forced to collect and share sustainable supply chain information. The sustainable supply chain transparency framework can function as a guide for companies. First, companies should obtain a clear picture of which sustainable supply chain information (first dimension) the company is forced to reveal or wants to voluntarily disclose (third dimension) to specific stakeholders (second dimension). Secondly, the company needs to identify what required sustainable supply chain information is already visible to them (third dimension) and what information it needs to obtain. While more and more digital tools are being developed to help with the management of information flows in supply chains, the current literature also highlights the major problems with the implementation of those digital tools (Wamba and Queiroz 2020). In addition, the sustainable supply chain transparency framework can be an orientation point in order to configure and extend those digital tools.

While it is important to gain visibility and share sustainable supply chain information with others, it is also essential to use sustainable supply chain information internally to set sustainable goals, take actions to boycott or "buycott" certain suppliers, or to avoid supply chain risks. A clear definition should contribute to solving these transparency-related issues.

Data availability The dataset was generated by two licensed databases and thus cannot be made accessible.

Declarations

Conflicts of interest The authors declared that they have no conflict of interest.

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