Addressing sustainability information needs along supply chains

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Abstract

Purpose – Gaining a better understanding of various actors' information demands and developing suitable approaches to fulfilling them is key in managing sustainability performance in supply chains. Sustainability thereby creates different levels of uncertainty and equivocality. This paper investigates the challenges in managing sustainability information flows along several nodes in the supply chain.

Design/methodology/approach – A multiple case study approach explores the various sustainability information needs along different nodes of supply chains. For this, three automotive triads are investigated, each comprising an original equipment manufacturer, a first-tier supplier and a second-tier supplier.

Findings – The results reveal that fulfilling information demands presents a substantial challenge to each of the three actors, albeit a different one in each case: whereas focal companies seek to figure out what information may be relevant to sustainability performance, their direct suppliers struggle to develop suitable approaches for enabling second-tier suppliers to generate and provide such information.

Practical implications – Depending on the level of uncertainty and equivocality, companies are supported in approaching sustainability information needs by applying individual or collective processing mechanisms. Decisions on such mechanisms and organisational structure can help to allocate resources according to the degree of challenges to achieve a fit between information needs and mechanisms.

Social implications – Reducing uncertainty and equivocality related to sustainability information provides a powerful approach to improving the sustainability performance along supply chains.

Originality/value – Having identified sustainability information challenges, the paper analyses and develops a typology of potentially useful approaches.

Keywords Multi-tier supply chain management, Corporate sustainability, Information processing, Sustainable supply management

Paper type Research paper

1. Introduction

Dispersed supply chains have been subject to numerous scandals related to violating human rights, workers' safety, and the natural environment and have thus presented a significant threat for a number of major high-profile companies. All of the above sustainability issues increase the complexity of managing supply chains and in turn pose the challenge, of processing growing information demands arising from various internal and external stakeholders, not only for focal companies but also for suppliers upstream. As a result,

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managing different sustainability issues and related information needs along extended multi-tier supply networks has become an increasingly important task and responsibility for corporations (Mena *et al.*, 2013). Providing such sustainability-related information in turn helps companies to position as a credible and profitable organization (Simmonds *et al.*, 2018). This requires the availability of high-quality data and information across different organizational functions.

Information related to the organization's environmental and social impact across the value chain, in particular, is key to measuring sustainability performance (Mura *et al.*, 2018). Yet, extant research has hardly investigated this importance in the pursuit of improving information flows to enable improved sustainability performance along the supply chain. The increased information demands and thus increased attention given to sustainability information pose, however, two major decision-making issues. On the one hand, the absence of relevant information poses the challenge of identifying and gathering such information, thereby creating *uncertainty (*Foerstl *et al.*, 2018*)*. On the other hand, information abundance presents the opposite challenge – as available information may be conflicting or, at least, *ambiguous* (Arvidsson and Johansson, 2019). The body of literature that addresses these issues is founded in information processing (IP) theory (Daft and Lengel, 1986; Daft and Macintosh, 1981; Huber, 1990; Spickett-Jones and Kitchen, 2003; Zelt *et al.*, 2018). In the IP context, *uncertainty* refers in to the absence of information and *equivocality* stresses the potential ambiguous, conflicting, and multiple interpretation of meaning (Daft and Lengel, 1986; Daft and Macintosh, 1981).

Scholarship has only recently taken up an IP perspective for investigating supply chains (Bode *et al.*, 2011; Gattiker, 2007;). As extant research in the area underscores, IP along supply chains in particular is worth investigating as information flows need to be processed across corporate functions, business boundaries and also along multiple tiers. Information processing comprises gathering, interpreting and transferring relevant information not only along supply chain actors but also to and with interested parties (Li and Lin, 2006).

Information is one of the three flows managed across supply chains – belonging to the tripartite supply chain management (SCM) mission to process materials, money and information along supply chains (Sarkis, 2012). Sustainability accounting research, in turn, has highlighted the importance of investigating how information flows are altered and exposed to potentially different interpretations between the nodes (Bode *et al.*, 2011; Silva and Schaltegger, 2019).

Sustainability information (SI), in particular, has been scarcely available for processing between the different nodes of the supply chain network (Mason-Jones and Towill, 1997; Sezen, 2008; Sauer and Seuring, 2017). Examples of SI include information related to the sourcing of conflict minerals, water use along a product's life-cycle, and working conditions in supply chains. In managing each issue, a company needs different information to satisfy information needs across supply chains. This in turn requires information from various nodes along their supply chains. Thus, businesses are confronted with emerging and diversified sustainability-related information needs resulting from and furthermore requiring interactions (also new forms) with different actors in- and outside of supply chains (Carter and Rogers, 2008; Foerstl *et al.*, 2018). These emerging SI needs render decision-making processes more uncertain with the conclusions drawn from different information sources often related to an increased ambiguity (Khanna and Anton, 2002).

Against the above backdrop, a major issue that arises for business is, approaching SI needs at different nodes of the supply chain (Busse *et al.*, 2017; Foerstl *et al.*, 2018). To contribute to the understanding of this issue, this paper raises the question of what SI needs arise both in a focal company and upstream and how these needs can be addressed.

For this, this study explores the challenges as well as practical and potential approaches to manage sustainability-related uncertainty and equivocality resulting from processing SI. In addressing this gap, this study uses a triadic lens on three supply chains in the automotive sector to investigate and apply a multi-case study to elaborate IP theory in regard to sustainability in supply chains (Ketokivi and Choi, 2014). The empirical approach adopted traces information needs along three nodes in three different supply chains, each consisting of an original equipment manufacturer (OEM), a first-tier supplier and a second-tier supplier. Subsequently, this research also endeavours to shed light on the antecedents influencing the use of information processing mechanisms and structures.

This study's theoretical contribution is threefold. First, by looking at the information requirements to improve sustainability performance of supply chains, it is shown what SI related uncertainty and equivocality mean in the context of supply chains. Second, the paper analyses various approaches to reduce SI needs in the supply chain triad. Third, the authors identify and categorise structural mechanisms to decrease sustainability-related uncertainty and equivocality.

The rest of the paper is organised as follows. Section 2 introduces to the IP perspective, synthesizes existing knowledge on IP mechanisms and strategies, and pinpoints how sustainability reshapes companies' information demands in view of sustainability and supply chains. Section 3 provides a detailed account of how the empirical investigation was conducted. Section 4 presents and discusses the observations in the triads researched. The concluding section refers to the problem described above while providing an outlook to future challenges and sketching a path for further research.

2. State of research

Research in the area of how supply chain nodes interact and what it means for the corresponding information needs is scarce but is present in various discussions in the field of supply chain management. A theoretical perspective that has a high level of explanatory power in this domain is conveniently presented by the body of literature on information processing (Galbraith, 1974; Radner, 1993). Furthermore, the theoretical perspective has been subject to scientific scrutiny and development for four decades (Eppler and Mengis, 2004); at the same time, it has proven to be suitable for analyzing supply chain management issues (Bode *et al.*, 2011; Busse *et al.*, 2017).

Therefore, this section addresses the following key aspects to elaborate upon the conceptual background of this research. Section 2.1 discusses how upstream sustainability requirements influence the supply chain. Section 2.2 then elaborates on the two key principles of IP, namely, uncertainty and equivocality. Section 2.3 provides an overview on how IP mechanisms address different IP challenges.

2.1 Extended information requirements for managing sustainability issues

With society and business growing increasingly aware of sustainability issues, such sustainability issues have modified the way supply chains function in several ways (Linton *et al.*, 2007). These effects can be summarized in the following categories.

Ecological and social themes – in addition to economic ones – require an extended set of sustainability criteria and are typically used in the definition of requirements, supplier selection and evaluation (Zimmer *et al.*, 2016). As a result, these *extend the spectrum of issues* to be considered. The wider set of sustainability criteria poses several challenges for the provision and use of information. These challenges arise as an extended information provision on more information sources and more information providers within each source. Examples include a supplier providing bundled information to their buying firm, yet this information has been compiled from various sources within the supplying company: the environmental officer may be providing information on legal compliance, the purchasing officer may be providing information related to the procurement practices, etc. (Schaltegger *et al.*, 2015).

A second set of challenges is related to the *additional nodes* along supply chains. Sustainability aspects affect not only first-tier suppliers but also upstream tiers (Gualandris *et al.*, 2015). In the context of supplier integration, in particular, sustainability criteria are often taken into account when companies collaborate closely on different activities; for example, in product development processes requiring information exchange between different actors (Wolf, 2011).

In addition, the network of various supplying and buying firms has been referred to as an extended supply chain, where relative to its position in the supply chain, an actor needs to manage sustainability-related information and operative processes not only along but also *across its supply chain* (Gualandris *et al.*, 2015). The network perspective not only includes the role of suppliers in the value creation process, but it also highlights the influence of non-traditional supply chain partners (Crespin-Mazet and Dontenwill, 2012; Gualandris *et al.*, 2015). This, in turn, can require that buying firms collaborate with different kind of actors, such as non-profit and non-governmental organizations, government, trade unions, multi-stakeholder initiatives or certification institutions (Crespin-Mazet and Dontenwill, 2012). The range of these collaborative activities is as broad as the spectrum of actors (Murray *et al.*, 2010). Most commonly, companies engage with different stakeholder groups in the context of sustainability evaluation and verification processes (Gualandris *et al.*, 2015). The extended supply chain network further complicates the information demands, as issues raised by one supply chain partner may need to be dealt with the help of information provided by another supply chain actor. As a result, addressing sustainability information requires further and different processes, activities and supplier management practices (Akhavan and Beckmann, 2017). Supplier management practices include the development and the monitoring of processes to secure sustainability compliance across the supply chain (Harms *et al.*, 2013; Seuring and Müller, 2008). These activities can be summarized under the term of sustainable supply management (SSM) referring to:

> [. . .] the consideration of environmental, social, ethical and economic issues in the management of the organization's external resources in such a way that the supply of all goods, services, capabilities and knowledge that are necessary for running, maintaining and managing the organization's primary and support activities provide value not only to the organization but also to society and the economy (Miemczyk *et al.*, 2012, p. 491).

This includes also the gathering and interpreting of sustainability-related information from supply chain partners.

Having reviewed the effects of sustainability aspects on the information flows in supply chains, the following section adopts an information processing perspective and elaborates on the role of uncertainty and equivocality.

2.2Information processing: uncertainty and equivocality

The multi-faceted discussion around the key importance of information in the decision-making process dates back to the 1970s (Daft and Macintosh, 1981; Galbraith, 1974). Researchers and practitioners have ever since recognised making informed decisions as a factor of decisive importance in managerial practice. In view of its reliability, information ranges from static and tacit (e.g. regular order, product specification) to dynamic and ambiguous (e.g. changes in forecasts, requirements or environment) (Storto, 2008). To support decision-making processes effectively, managerial information needs to be low in both uncertainty and ambiguity.

Information processing refers to the gathering, interpretation and synthesis of information in the context of organizational decision making (Tushman and Nadler, 1978). The extant body of related literature (Benner and Tushman, 2015; Rothman *et al.*, 2017) identifies two factors – uncertainty and equivocality – as the major determinants of information processing needs and practices.

The definition of *uncertainty* as the absence of information has persisted in organization theory (Tushman and Nadler, 1978; Downey and Slocum, 1975; Benner and Tushman, 2015). In the context of decision-making, uncertainty arises from the nature of the firm as a social system and as such it has two types of sources – external ones and internal ones. External sources of uncertainty are those originating in the environment, whereas internal ones are related to the coordination and fulfilment of tasks within the company's boundaries. Also in relation to sustainability issues, the higher the uncertainty (e.g. due to unpredictable events), the more information is required to make a decision with a beneficial outcome. Ideally, abundance of information tends to reduce uncertainty. However, the additional information requires a substantial revision of organizational strategies and mechanisms to reduce uncertainty.

On the other hand, too much information may lead to a "messy, unclear field", in which additional information may have several interpretations and thus not contribute to reducing uncertainty (Daft and Lengel, 1986, p. 554). The concept of *equivocality*, therefore, stresses the potential ambiguous, conflicting, and multiple interpretation of meaning (Daft and Macintosh, 1981). As a result, decision makers tend to reduce equivocality by defining and creating an answer rather than by learning the answer from the collection of additional data (Weick, 1979). This presents a particular challenge in managing sustainability, as personal and collective beliefs play a decisive role in decision-making related to sustainability (Van Marrewijk and Werre, 2003). Varying sustainability issues with complex facts and an increasing number of stakeholders tend to increase the perceived equivocality (Lewis, 2004).

To overcome decision-making issues arising from managers' inability to cope with uncertainty and equivocality, research has sought after solutions to develop adequate information processing mechanisms, which in turn increase the information processing capacity of the organization (Daft and Lengel, 1986; Tushman and Nadler, 1978; Galbraith, 1974). The following section discusses research on these mechanisms.

2.3 Information processing mechanisms

Organizational design research points out several general approaches (i.e. applicable beyond the context of sustainable supply chain management) for dealing with uncertainty and equivocality within the organization. In general, if uncertainty increases, structural approaches are needed to coordinate IP actions across interdependent tasks. Design strategies integrate IP mechanisms to support decision-making within specified organizational roles and functions by reducing inter-organizational communication (Galbraith, 1974). For routine tasks rules and programs allow execution of interdependent activities. Organizational hierarchies help to create a comprehensive perspective and are used in tasks with increased uncertainty where rules do not apply. Assigning sub-goals helps to plan and break down task performance for the sake of attaining organizational goals and coordinate decision-making (Galbraith, 1974).

In the pursuit of an improved understanding of both internal processes and complex environmental factors, corporations collect, interpret, and synthesize information from inside and outside the organization (Tushman and Nadler, 1978). With respect to the above, Daft and Lengel (1986) suggest various information processing mechanisms (Table I). These

Mechanism	Description	Media	Main purpose
Rules and regulation	Objective knowledge base to handle routine and well understood phenomena	Written procedures and standards via intranet	Reduce uncertainty
Formal information systems	IT systems to provide and exchange data for result and performance analysis	IT systems	Reduce uncertainty
Special reports	Gather data and diffuse it to responsible members via studies and surveys	Written documents	Reduce uncertainty
Planning	Personal planning targets and goals of action and comparison of data to check performance	Face-to-face, written, numeric documents, IT systems	Reduce equivocality and uncertainty
Direct contact	Exchange of views, subjective information, and objective data horizontally and vertically across structures	Personal and impersonal	Reduce equivocality
Integrators	Boundary spanning activity to overcome conflicting interpretation by transmitting data	Face-to-face, telephone	Reduce equivocality
Group meetings	Discussion in teams, task forces, or committees to achieve common understanding	Face-to-face	Reduce equivocality

Source: Adapted from Daft and Lengel (1986)

Table I. Overview of information processing media and structural mechanisms

mechanisms aim to address either uncertainty or equivocality individually or both IP challenges simultaneously.

Depending on the degree of uncertainty and equivocality for different interdependent tasks, the two categories represent a continuum rather than a pre-determined categorization. In this vein, dealing, for example, with equivocality relates to complex and rich information which requires immediate feedback mechanisms (e.g. face-to-face meetings) to handle such rich information (Daft and Lengel, 1986).

Yet, organizational roles and functions often face contexts where the complexity of tasks raises, as the environment is dynamic and non-routine, and organizational tasks are interdependent (e.g. in the case of increasing SI needs). Such conditions result in an increased need to process information and design strategies and structural mechanisms to reduce uncertainty and equivocality (Galbraith, 1974; Tushman and Nadler, 1978). The two generic strategies to respond to the increased IP needs are to either reduce the need for IP or to increase the IP capacity to support organizational design strategies.

Reducing IP needs can be approached by creating slack resources or self-contained tasks, whereby *slack resources* refer to physical resources to absorb internal and external IP overload avoiding interdependence between sub-units (Sharfman *et al.*, 1988). *Self-contained tasks* can be used to restructure organizational structures to reduce the amount of required IP mechanisms and output because labor is not as divided or specialized. On the other hand, organization can increase their capacity to process information by investments in information systems or lateral relations (Galbraith, 1974). *Investments in information systems* refer to the formalization and codification of information which increases the capacity to process more information effectively and efficiently, as long as the information is unambiguous. *Lateral relationships* provide the organization with decision-making processes without reorganizing formal structures. Information is processed across functions depending on the level of uncertainty between individuals but also on different group levels (Galbraith, 1974).

Recent research has set on a journey to explore specific IP-related issues in sustainable supply chain management (Foerstl *et al.*, 2018). Related contributions identify three types of SSM-related uncertainty: task uncertainty, source uncertainty, and supply network uncertainty (Busse *et al.*, 2017). To deal with the various sources of uncertainty, companies seek to develop tailor-made approaches (Foerstl *et al.*, 2018; Busse *et al.*, 2017). However, the additional equivocality that occurs in the context of sustainability issues (Sharfman *et al.*, 2009) has not been addressed sufficiently to resolve the aforementioned issues (Vilko *et al.*, 2014).

The above literature overview reveals that research has recognized this as an issue, albeit an under-researched one. Its importance in the pursuit of processing information flows to enable improved sustainability performance in the supply chain has in particular remained largely under-investigated.

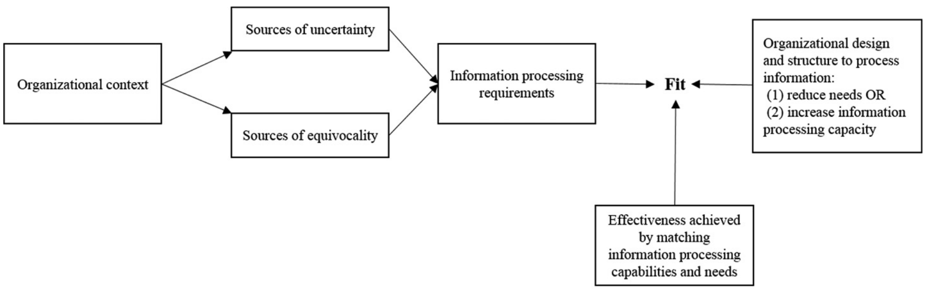
This study therefore seeks to empirically identify sustainability-related information needs along the lower supply chain and, secondly to identify the organizational design strategies and mechanisms to reduce them or to increase the capacity to deal with them on the other hand (Figure 1). This issue's significance is highlighted by the assumption that sustainability-related information needs could create an overload for an organization if there is mismatch between the IP capacity of the organization's structure and the different needs. With the information processing model in mind, sustainability generates high uncertainty and equivocality at different nodes of the supply chain. This in turn requires adequate IP strategies to reduce SI needs or increase the IP capacity.

3. Research approach

3.1 Research design

To fill in the remaining research gap on how SI is processed to integrate sustainability into SCM processes, a multiple case study strategy was conducted. As this approach demonstrates strengths in addressing 'how' and 'why' questions in particular (Yin, 2017), it was considered highly suitable for advancing the understanding of:

- the aforementioned sustainability information processing activities; and
- the strategies and mechanisms the various actors along supply chains adopt in integrating sustainability information.



Source: Based on Tushman and Nadler (1978), Daft and Lengel (1986)

Figure 1. Information processing model and organizational design

As discussed in Section 2, addressing sustainability issues increases uncertainty and equivocality, thus resulting in differently rich and complex IP activities, communication media and structural mechanisms. This requires deepening the understanding of multi-tier supply networks interactions in SI processing in the pursuit of decreasing uncertainty and equivocality. Therefore, a theory elaboration approach (Fisher and Aguinis, 2017; Ketokivi and Choi, 2014) is considered highly suitable for reconciling IP theory within the empirical setting of sustainability's influence on information-related interactions and activities and a cross-boundary perspective.

To enhance research validity and reliability throughout the research design, several established criteria on case study rigor (Ketokivi and Choi, 2014; Yin, 2017) were adopted. Table II gives an overview of how these were applied in the research conducted.

3.2 Case selection

The multiple-case design was applied for literal replication covering three triads in the automotive sector and treating each SC as an observatory unit of analysis, whereas the information-processing related interactions along SCs were the embedded unit of analysis (Mena *et al.*, 2013; Yin, 2017).

In the course of exploring corporate practice, representatives of the automotive industry were approached for several reasons. The automotive sector is a dynamic market and has multiple sustainability-related impacts at each step of a vehicle's life cycle. Owing to serial production and outsourcing of a vast array of production steps, automotive supply chains are highly complex and face notable external expectations and strict regulations (Koplin *et al.*, 2007; Lee, 2011). In that sense, the automotive sector represents a dynamic environment for intense relationships with suppliers and high value generation along the

Table II. Overview of measures employed to ensure research validity and reliability

Criterion	Research design	Case selection	Data collection	Data analysis
Construct validity	Interview guideline was developed through intensive literature review	N/A	Multiple sources of information Multiple interview partners for each case	Establishing a chain of evidence
Internal validity	Theoretical framework	N/A	Recording aspects that might reveal alternative explanations	Triangulation of multiple data sources Discussion between coders and authors Cross-case analysis for pattern matching
External validity	Sampling in automotive SCs	Description of cases and their situation	N/A	Analytic generalization by advancing theoretical concepts
Reliability	Developing case study protocol per case	N/A	Developing case study database	Measuring inter-coder reliability

Source: Yin (2017)

supply chain (Donada *et al.*, 2016). From a multi-tier perspective, looking at the buyer–supplier–supplier triad, extant literature is still sparse regarding the relationship dynamics within complex supply chains (Mena *et al.*, 2013; Busse *et al.*, 2017).

The sampling strategy followed a convenient and snowball sampling approach (Marshall, 1996). For this, the researchers first approached potential interviewees (sustainability management, SCM) in major automotive companies and their suppliers. To limit extraneous variation, the geographic range was limited to companies with headquarters in Germany and Austria (Foerstl *et al.*, 2015). This supports the control of factors related to legal and cultural boundaries (Mena *et al.*, 2013). Based on the replication purpose of this multiple-case design, context factors should not limit the explanatory substance of the findings. Each triad consists of an original equipment manufacturer (OEM), a first-tier (T1) and a second-tier (T2) supplier as illustrated in Figure 2. The triads cover different car component and manufacturing machinery supply chains. Figure 2 also provides an overview of the three triads including data sources, number of employees, and relationship between the tiers. To distinguish the supply chains and their respective nodes throughout this paper, the three supply chains are called A, B and C. Focal companies are denoted with a subscripted F, the first-tier and the second-tier suppliers are marked with subscripted 1 and 2 accordingly.

3.3Data collection and analysis

Based on the case study protocol, an interview agenda was developed and subsequently discussed and validated with external researchers and a procurement expert from the SSM field. The interview agenda was used to support semi-structured interviews with sustainability managers in addition to procurement representatives and with sales and executives at the second-tier supplier. In each triad, at least one person interacting with suppliers, customers, and other stakeholders was interviewed. Interviewees were selected according to their expertise on sustainability and role in the supply network. Interviews lasted between 45 and 70 min and were conducted face to face and via telephone between

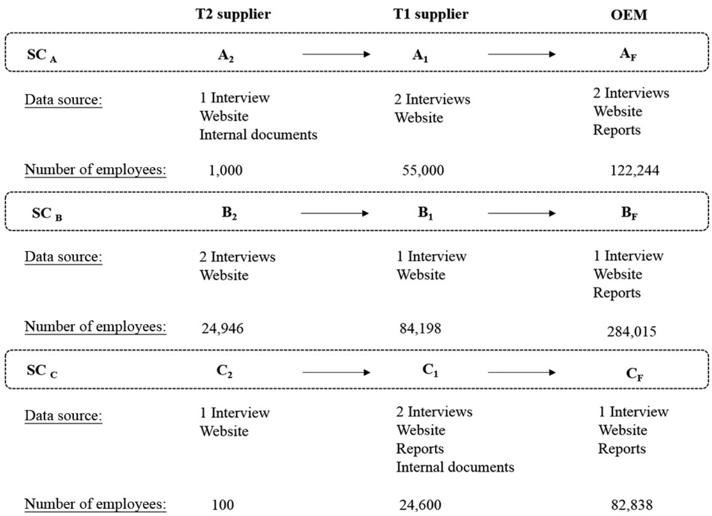


Figure 2.
Overview of triads including and data used

July 2016 and January 2017. Thereafter, the interviews were transcribed and unclear or missing issues were clarified by follow-up correspondence with the interviewed partners.

For the sake of increased result validity, the study design covered data triangulation from multiple sources. For this, several alternative data sources were used in addition to the interviews:

- corporate materials such as sustainability reports and other publicly available information;
- internal documents whenever accessible; and
- additional external materials such as industry initiatives on sustainability assessment.

To identify information processing interactions in an iterative process, standard coding procedures and analytic strategies were adopted (Yin, 2017; Miles *et al.*, 2013). The successive data analysis followed an abductive approach, starting with a coding list based on an initial theoretical framework which was extended and modified in the first coding round based on the data obtained (Miles *et al.*, 2013). A rigid chain of evidence (Yin, 2017) was thereby constructed to reveal the role of information processing within sustainable supply management processes. Subsequently, data were analyzed and coded in two further iterations. The qualitative data processing software MAXQDA was used to store, code, structure and retrieve the data throughout the iterative data analysis process. Subsequently, the researcher team conducted debriefs with peer researchers, which helped to verify the validity of the conclusions. Coding results were discussed and compared to improve inter-coder reliability.

Drawing on a cross-case analysis, the following section presents the results from the three case studies for the purpose of understanding how and why information processing activities vary depending on purpose, input, media and structural mechanisms. For this, the authors looked for common patterns shared between the three triads, to elaborate theory on IP mechanisms in the context of SSM.

4. Findings and discussion

Having acknowledged extant research on the IP challenges in managing a supply chain's sustainability performance, data was collected as described in the previous section. This section presents the rich results and discusses them.

Section 4.1 lays the foundation by analyzing the scope of information needs and the sources of information uncertainty (Section 4.1.1) and equivocality (Section 4.1.2) of the different supply chain nodes in the researched companies. Section 4.2 discusses the approaches adopted in the pursuit of increasing information processing capacity and reducing SI needs to deal with uncertainty and equivocality. Section 4.3 presents and discusses organizational structures and design strategies to processing SI and supporting identified IP mechanisms along supply chains. Finally, Section 4.4 provides a summary of how the different findings relate to each other in perspective of IP theory.

4.1 Scope of information needs

As demonstrated in Section 2, additional complexity is introduced to the supply chain management when sustainability issues are considered. Building on the IP concept, and specifically on the context's influence on sources of information needs, sustainability raises different SI needs for the various actors in the supply chain triad. As the investigation reveals, first and second-tier suppliers (T1 and T2) are heavily confronted by information needs posed by customers or regulation bodies, whereas OEMs seem to be addressed by the broader supply chain environment. In particular, NGOs, as a representative of society, approach OEMs to get transparent information on unintended negative outcomes along the entire supply chain. Although companies are not in an explicit contractual relationship with NGOs or 'society', as their agents they are expected to be able to report certain SI pertaining to their supply chains.

To better grasp the effects of SI needs on SCM practices, the following sections shed light on the various sources of uncertainty and equivocality as they diverge upstream the supply chain. Using the triadic perspective, findings are presented by starting from the OEM perspective and illustrating the differences along the supply chain nodes up to T2.

4.1.1 SI needs and uncertainty. As collected data reveals, various SI needs provoke uncertainty along the supply chains. Sustainability-related considerations significantly alter the type of required information. This refers to information that has typically and previously not been provided and exchanged between the supply chain nodes. The evidence collected in the investigated triads shows that in addition to monetary and material-related information, information on social and environmental-related issues is rendered relevant and various actors along the supply chain require that OEMs provide such information.

From an OEM perspective, SI needs play several roles with regards to uncertainty. OEM B_F reported that the various stakeholders' information demands require that they generate such information in the first place. Yet, generating such information presents a challenge as it is not readily retrievable. For instance, looking into sustainability issues such as child labor and working standards, the company has collected information on upstream suppliers that had previously been unknown to the company. Therefore, the OEM B_F has been subjected to uncertainty as to how to obtain, interpret and communicate such information. In other cases, however, OEMs are exposed to additional uncertainty as to sustainability information is needed for a market positioning. Furthermore, pressure stemming from various stakeholder demands (such as NGOs, industry initiatives or customers) was reported to increase SC uncertainty.

SI-related uncertainty was also observed to be passed down to suppliers, with direct (first-tier) suppliers being the first addressees. As supplier B_1 reports, it can be practically observed that as long as certain drivers are present, especially on the customer end, companies are forced to react accordingly. Supplier C_1 reported that the accumulation of drivers – political, financial and market-related – resulted in an organized company effort to collect and analyze information to reduce uncertainty originating from the supply chain. Supplier A_1 reported similar experience and added that the OEM is mostly the main driver in shaping SI needs. The latter propagate and define important topics such as carbon emission throughout production processes as well as human rights in the upstream supply chain. This generates additional information needs to be analyzed and channeled by different actors inside and across corporate boundaries. The role of customer demands is similarly present at the level of second-tier suppliers, however differing in the scope and in the necessity to pass on SI needs further upstream. This was particularly reported by the smaller T2 suppliers A_2 and B_2. External (sustainability) reporting was identified as a further source of increased SI needs. OEM B_F brought up the example of conflict minerals reporting. It was reported that the company is engaged in a diversity of related initiatives and approaches (such as CFSI reporting guidelines).

Irrespective of the supply chain position, researching the three triads revealed that recent regulations have created information needs regarding supply chain sustainability performance. As scandals in the past have shown that insufficient liability along supply chains has created unintended outcomes on human and environmental resources, regulatory institutions and politics have increasingly entered the governance arena to target such uncertainties in the supply chain (Sancha *et al.*, 2015).

It was also observed that further supply chain stakeholders also present an additional source of SI-related uncertainty. Prior research points out that additional stakeholders, typically not involved in the supply chain itself, have increasingly initiated interaction with companies (Carter and Rogers, 2008; Gualandris *et al.*, 2015). As a consequence, companies face additional SI needs to be promptly addressed in SCM decisions, whereby the scope of uncertainty can be expected to depend on the actual source of the raised information need.

4.1.2 SI needs and equivocality. With regard to managing sustainability issues, data shows that different stakeholder expectations appear to be a predominant source of equivocality. The evidence collected supports the expectation that there are numerous actors raising sustainability issues. Supranational organizations such as the United Nations, as well as NGOs, sustainability ratings, regulation and global trends bring sustainability challenges to the table and companies need to analyze the status quo and possible approaches to anticipate and react to them.

Evidence for this was presented by supplier B_1, who reported that the publishing of the UN Guiding Principles on Human Rights influenced their corporate practices. At the same time, other stakeholders such as the Dow Jones Sustainability Index have started analyzing information regarding supply chain management. In addition, several NGOs published reports on human right violations that raised the societal awareness for the issue. As a result, OEM A_F also had to address these issues promptly to gather and synthesize respective information. The different perspectives on the same issue described above exemplify the second major challenge in SI – that of equivocality. Focal company B_F yet shed light on the issue from another perspective. In this case, first-tier suppliers are involved in appraising sustainability issues. However, information on what is important to other stakeholders – such as shareholders or customers – is not available.

For the purpose of making sense of the diverse information requirements, the sample companies first assess the relevance and urgency of stakeholder expectations and then interpret the meaning within the organization. Typically, the companies conduct materiality analyses to prioritize SI needs. Thus, decisions as to what SI to process depend on the perception whether an issue affects the organizational situation and whether the exchange of views leads to a common understanding while also decreasing equivocality. This is particularly challenging in the context of SCM as new market entrants are raising additional expectations to be addressed (Crespin-Mazet and Dontenwill, 2012 . Evidenced for this is presented by the observation that companies:

> [. . .] exchange information [between functions] on current issues including enquiries from associations or rating organizations. They exchange information on issues popping up in the media and try to get an assessment about what they have to take more seriously and what can be ignored. (company AF).

The aggregated analysis of all three SC triads reveals that companies deal with different sources of uncertainty and equivocality (Table III) and adopt different approaches to process SI. In the triads investigated, OEMs typically face the broader organizational environment requesting SI and transparency on supply chains. On the other hand, T1 and T2 suppliers, who may have either role (T1 or T2) in different supply chains, deal with the different customer SI needs and subsequently assess what information to gather from the supply chain and what not, as this may overload the supply chain's information channels. By doing so, suppliers are confronted with the interpretation and assessment of ambiguous SI that customers or the OEM pass on.

In approaching SI-related uncertainty and equivocality, companies adopt different design strategies and mechanisms. Even though certain mechanisms could be expected to be more effective in managing either uncertainty or equivocality. However, the investigation revealed that such a classification is not straightforward. As discussed in the following two sections, it seems that certain interdependencies exist which create a dynamic interplay in the use of IP mechanisms to process SI-related uncertainty and equivocality.

As a consequence, the spectrum of identified approaches to manage increased SI needs helps to build a deeper understanding of how IP mechanisms are used within the strategies to reduce the SI needs or to increase the IP capacity to handle such additional SI needs.

4.2 IP capacity and approaches to reduce SI needs

OEMs and suppliers adopt different IP mechanisms to manage additional SI needs. To analyze these, this section first sheds light on how uncertainty can be reduced along the supply chain by increasing IP capacity.

As the case studies reveal, the companies researched in this sample have developed approaches to increase their information-processing capacity. Related to sustainability-related task, source, and SC uncertainty (Busse *et al.*, 2017) the buying firms, specifically OEMs and first-tier suppliers, establish different mechanisms to gather additional SI from their suppliers. These mechanisms include procedures, *de facto* standards, and formal information systems, which are typically used to reduce uncertainty. The procedures cover self-assessment questionnaires, information on sustainability certifications and acknowledgement of supplier code of conducts. Such procedures are mainly used to gather information during task performance (sourcing sustainably) and increase the capacity to handle task and source uncertainty as data and information was collected efficiently.

A further approach to manage sustainability information demands was observed to be the establishment of vertical information systems. This method was reported to bring along one main advantage – it helps to reduce costs on both the buyer and the supplier side, and allows for the efficient processing of SI. Supplier A_1 reported that automotive suppliers need to disclose all materials used to manufacture components for vehicles using the International Material Data System (IMDS). Initiated by several leading European automotive OEMs in the early 2000s, the IMDS has emerged to reduce the increasing reporting requirements related to raw materials and has thus become a widely accepted tool also to manage environmental regulatory requirements.

To reduce SSM uncertainties to a manageable level, all three of the researched OEMs establish lateral relations (Canzaniello *et al.*, 2017) to increase their IP capacity. On an inter-organizational level, such lateral relations and processes were reported to be increasingly implemented by strategic alliances. Different buying companies form alliances to share

OEM	T1 supplier	T2 supplier
SI related uncertainty		
Transparency demands regarding value chain	Customer SI needs on sourcing and supply chain	Partly customer SI needs on sourcing and supply chain
SI related equivocality		
Making sense of diverse stakeholder expectations	Assessment and understanding of OEM SI needs (to be passed on)	Partly assessment of customer SI needs

Table III. Summary of SI needs contributing to uncertainty and equivocality resources and capabilities used in SSM practices; this is also done to reduce sustainability-related uncertainty throughout the supply chain. Evidence for this is, the fact almost all German, Austrian and other European OEMs in the automotive sector use the sustainability self-assessment questionnaires developed by CSR Europe. CSR Europe aims to reduce source and task uncertainty as it standardizes SI across supply chains. This potentially influences the SI needs passed on upstream the supply chain, as also equivocality was reduced with regard to the content of such a standardized questionnaire. The suppliers in this sample appreciate such an industry standard to transfer SI efficiently to their customers. At the same time, it was questioned whether it is possible to enforce sustainable requirements along supply chains, as usually contractual relations only exist with T1 suppliers.

Based on the above described mechanisms that are used by the sampled companies to reduce SI needs, it can be inferred that in the field of SSM, uncertainties can be approached by inter-organizational collaboration. Doing so allows for efficient and effective processing of SI across supply chains, thus potentially increasing the IP capacity of the whole triad.

It is important to note that in most cases, the information needs must be unambiguous for organizations to develop mechanisms to reduce uncertainty. This requires, that companies have already been able to clarify what sustainability means to them (reduced equivocality) and have identified the requirements they seek to impose on their supply chain partners. However, the sustainability and SCM context show that the means to reduce sustainability-related equivocality *within* organizations are limited. As a consequence, structural mechanisms and information processing activities are applied on the inter-organizational level to reduce SI needs *across* company boundaries. Evidence for this is provided by *CSR Europe*'s self-assessment questionnaire. Starting with a European Working Group on Supply Chain Sustainability in 2012, the researched OEMs developed SI sharing and aggregation, which led to the creation of common procedures to gather SI from suppliers – a self-assessment questionnaire.

From an IP perspective, lateral relations can be said to have helped to increase the capacity to process and coordinate information, which in turn helps to handle increased SI needs and reduce related equivocality (cf. Galbraith, 1974). OEM A_F reported that initiatives and cooperations with other OEMs have contributed to standardizing sustainability assessments throughout the sector. Furthermore, participating in initiatives such as the Aluminum Stewardship Initiative has strengthened these assessments and legitimized their approaches. The Aluminum Stewardship Initiative, which was started in 2012 as international multi-stakeholder approach to set industry standards and to certify certain sustainability aspects in aluminum supply chains supported the company's perception of relevant SI demands. Notably, in this context OEMs (OEM A_F, OEM C_F) do not consider NGOs a "dangerous opponent" (as they have previously done) but rather regard them as an information source to increase their own IP capacity. Interpreting the above suggests that such alliances support the reduction of perceived equivocality, as ambiguous information is aligned to a shared understanding of what is requested and what sustainability aspects mean in the context of SCM.

In conclusion, with regard to sustainability-related equivocality the sample showed that there is a strong need to increase the capacity to process information across the supply network – specifically the lateral relations with external actors as well as company-internal relations with other functions and business units (Canzaniello *et al.*, 2017; Galbraith, 1974). Standardization and codification of SI reduce costs related to sustainability-related uncertainty by aggregating an increasing amount of SI across supply chain nodes.

4.3 Organizational design strategies in managing IP overload

In dealing with the IP challenges introduced by considering sustainability, the researched companies also, in addition to the approaches described in Section 4.2, adopt various organizational design strategies to overcome uncertainty and equivocality resulting from increased SI needs. In this section, the OEM solutions are presented first and then followed by showing differences on the T1 and T2 levels.

Additionally, the sampled OEMs have independently established intra-organizational structures to embed and integrate sustainability. All three OEMs have a dedicated corporate sustainability department and a council consisting of representatives from various corporate functions. The responsibilities and hierarchical positions of the councils vary from company to company. From an IP perspective, such sustainability departments have an integrator role (Daft and Lengel, 1986), and are thus not involved in other (strictly) functional tasks. The researched sustainability departments generally use their lateral relations to gather, aggregate and accumulate SI from outside (NGOs, regulatory parties, supranational organizations, such as the United Nations, or sustainability ratings, indices, and multi-stakeholder initiatives) and inside the company, assess its relevance and diffuse and share it with affected functions, which in relation to SSM refers to supplier management or procurement. This happens in group meetings, direct contact with different stakeholders, trainings and integration in formalized procedures.

Whereas the investigated T1 suppliers organize their activities in a similar fashion and have installed sustainability officers or teams, on the T2 level, it was the sales department who was the main recipient of sustainability requirements from the first-tier supplier and, in specific cases, also from the OEM. T2 supplier A_2 did have an environmental, health, and safety (EHS) officer who directs SI to the organization whenever relevant sustainability-related laws and regulations need to be considered. However, the company operates cross-functionally with different corporate functions, who interpret and assess SI to decide on how to integrate SI into product development. Supplier A_1 reported that customers downstream are interested in SI for reducing risks via product specification and formal information systems. However, customers seem restrained with regard to innovations proposed by suppliers, if supply reliability and global market leadership are not secured.

The medium-sized T2 supplier C_2 understands sustainability as long-lasting relationships with its customers, thereby fulfilling some of its customer's requirements – especially in terms of economic sustainability and stability. This understanding is distinct from the other companies in this study's sample. With regard to its customer-orientation C_2 integrates, if required, SI from customers into machinery design to address eco-efficiency principles. For this, C_2 gathers information from various sources such as industry fairs, journals or seminars and interprets it by means of cross-functional project teams.

From an IP perspective, the mission of organizational structuration and coordination is to reduce complexity and to allocate resources for managing interdependent tasks and related needs and to keep the IP capacity on an efficient cost-benefit level (Daft and Lengel, 1986; Tushman and Nadler, 1978). As a consequence, standardization and formalization of SI can be inferred to reduce SI needs as the above results demonstrate that standardization and codification of SI is a common approach in a number of situations. Defined rules, programs and standards form an established response to phenomena which allow routinized handling (Daft and Lengel, 1986). For a buying firm, this comprises the formulation, transfer and control of requirements to suppliers in a standardized way. The investigated companies typically integrate specifications into contracts, gather information about and from suppliers via formalized procedures using standardized documents, and accumulate it on developed sourcing platforms and software solutions (such as SAP) using formal information systems (e.g. IMDS). Such mechanisms highlight that managing SI uncertainty can be approached by tools that are highly efficient and that simultaneously help save costs and lower organizational efforts to reduce SI needs.

In this respect, buying firms tend to standardize sustainability requirements for suppliers on an intra-organizational level. In most cases, companies have defined a code of conduct for suppliers, established policies, and supplier selection criteria to obtain the requested SI from suppliers. Such standardized sustainable sourcing activities help to formalize corporate values and support decisions by translating stakeholder expectations into guiding principles (Busse *et al.*, 2017). From an IP theory perspective, companies at hand were observed to deploy formal information systems and media which provide a controllable amount of information that is lower in richness and uncertainty. This allows companies to standardize IP needs provided that sources of SSM uncertainty were manageable. In this vein, formalization can significantly reduce SI-related uncertainty.

Applying IP theory to the above discussed approaches, the strategies, the structures, and the role of the actors along the three supply chains are matched now. Table IV shows the organizational design strategies and structures used at the different supply chain nodes. Table IV provides an overview of how the researched organizations have allocated the various IP tasks to various corporate functions and how the IP tasks contribute to reducing uncertainty or equivocality.

Related to supply chain topics, the researched companies assign different structural and governance mechanisms to process SI within the organization and across the organization

Table IV.
Implementation overview of different organizational design structures to process SI within and across company boundaries

Organizational structures	What IP task does it fulfill?	With whom does the interaction take place?	Where in the SC is it implemented? T2	T1	OEM
Sustainability organization (incl. board)	Organize and navigate SI flows, defining reporting standards,	Internally: different corporate functions	–	A1, C1	all
Sustainability department/office/ coordinator	Aggregate and assess SI needs, accumulate SI from different functions and report to different stakeholders accordingly	Internally: different corporate functions Externally: NGOs, regulatory bodies, personal contacts in other companies, multi-stakeholder initiatives	B2	A1 C1	all
Task force/*ad hoc* Team	Interpret and assess SI needs related to supply chain issues with high societal attention, identify which SI is needed and how to reduce issue specific equivocality and uncertainty	Internal and external stakeholders depending on sustainability issue	–	–	all
Project teams/ panels	Assess and formalize SI flows regarding different SI needs	Internal stakeholders from different functions	B2	A1 C1	all
Sustainability manager within supplier management/ procurement	Integrate defined SI needs into supplier relation processes and activities to gather relevant SI from the supply chain	Internally: sustainability function/coordinator, other interfaces Externally: suppliers, industry associations, CSR Europe Forum	B2	A1 C1	all

boundaries. For example, for the purpose of interpreting, assessing and aggregating SI on recent and controversial sustainability issues, i.e. such that are subject to high equivocality, the investigated OEMs launch *ad hoc* task forces incorporating specialists from different functions. SI discussed in these task forces was observed to cover issues substantially affecting the product (e.g. renewable materials, electro mobility) or highly rated risks such as suspicious cases related to environmental or social sustainability impacts in the supply chain.

It is also interesting to note that, as opposed to B_2, suppliers B_1, as well as the T2 suppliers A_2 and C_2 do not pass on SI to the supply chain and have no standardized procedures yet in place to gather SI from suppliers.

Boiling down the insights from how IP flows are organized through organizational structures, the examples of the supplier C_1 (induced by the former holding company) and of the three OEMs reveal an interesting observation: if sustainability management is perceived as a strategic issue, structural mechanisms are designed to coordinate SI through hierarchy, shared goals, and IP media according to the level of uncertainty and equivocality. Based on this observation, it can be proposed that sustainability issues are transferred upstream to suppliers when either an important customer demands certain information or when the company has its own business motivation.

What was identified to potentially play a significant role on the design and deployment of mechanisms to handle SI-related uncertainty and equivocality is the maturity of sustainability issues. Depending on the maturity of an issue in terms of its definition, potential solution identification, stakeholder analysis and so on, organizations might use single corporate solutions or go for inter-organizational approaches to reduce complexity (Bennett *et al.*, 2013). Hence, the authors propose that the level of perceived equivocality of different actors depends on the maturity of a sustainability issue. In other words, the perceived relevance and importance of a sustainability issue varies over time and varies by organization, largely depending on which stakeholder has decided to put this SI requirement on its agenda. From an IP theory perspective, participation in initiatives such as the Aluminum Stewardship Initiative supports the argument that standardization is a suitable approach for handling SI-related uncertainty in an efficient manner once equivocality is reduced for a critical number of stakeholders. It also shows that increasing the IP capacity is only effective and efficient, if the used IP mechanism matches the IP needs (Foerstl *et al.*, 2018).

As underlined by both the OEMs and the first-tier suppliers, it is crucial to harmonize the understanding and operationalization of sustainability issues to create an improvement throughout the supply chains. Using personal communication on an intra- and inter-organizational level helps to reduce confusion and clarifies the understanding and expectations with regard to sustainability issues (Lewis, 2004). The results suggest that if the different business partners do not have a clear understanding of an issue (e.g. conflict minerals), possibilities for misinterpretation and, thus, equivocality are high. As a consequence, sustainability issues with an extensive impact along the supply chain, cannot be improved successfully if equivocality is not sufficiently reduced.

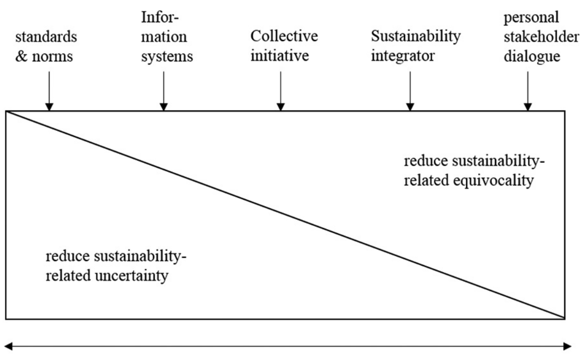
In this respect, standardization of sustainability principles across organization boundaries helps to reduce equivocality and complexity and contributes to efficiency increase across the supply chain (Canzaniello *et al.*, 2017). Hence, to use formalization to address uncertainty in SSM decisions, first equivocality has to be reduced by media and mechanisms fitting the purpose and degree of equivocality and uncertainty.

4.4 Summary

As demonstrated above, various SC challenges regarding SI flows lead to an increase in uncertainty and ambiguity. To counter these tendencies, companies seek to reduce their information needs and/or create mechanisms to coordinate and control SI within and between organizational boundaries. In alignment with recent research (Foerstl *et al.*, 2018), companies seek to deploy IP mechanisms that correspond to their SI needs. In this regard, further investigation is needed to closely assess the assumption that companies use mechanisms to either enhance the IP capacity or reduce the IP needs depending on the degree of sustainability-related uncertainty and equivocality. In a simplified scenario, task, source and supply chain uncertainty and equivocality would be low, thus not requiring further mechanisms and strategies to process SI. However, outsourcing significant steps of the value chain to distant locations and external supply networks have altered the information needs and led to problems relating to uncertainty and equivocality.

As observed in the conducted research, companies are using mechanisms to increase their supply chain's information processing capacity by standardizing procedures, rules and formal information system, which all aim to reduce sustainability-related uncertainty along supply chains. As shown, however, new SI needs may result in an increase in equivocality for the involved parties as SI might be unclear at the beginning. Thus, ambiguous information needs must first be clarified. In this respect, different formats of intra- and inter-organizational lateral relations (related to increasing IP capacity) can serve to address the equivocality of SI.

The observed IP mechanisms and organizational structures established to decrease sustainability-related uncertainty and equivocality along supply chains are not necessarily based on properties that are either present; instead they can be mapped on a continuous scale. As shown, in Figure 3, the authors put forward the idea that certain mechanisms and structural designs are capable of reducing uncertainty or equivocality. Building on Daft and Lengel (1986) seminal work, the mechanisms are presented as a continuum to point out that they may be able to address both sustainability-related uncertainty and equivocality. Extending the idea of intra-organizational mechanisms (e.g. sustainability department or coordinator), they also apply on an inter-organizational level and help to either reduce SI needs or increase IP capacity across corporate boundaries. The two-direction arrow below is a depiction of the time axis and indicates that under specific circumstances a shift between mechanisms can occur once equivocality is reduced.



Source: Adapted from Daft and Lengel (1986)

Figure 3. Role of IP mechanisms and organizational design to reduce sustainability-related uncertainty and equivocality along supply chains

The above concept can be demonstrated by the following example, starting from the right corner. Upcoming sustainability issues are discussed internally or externally in face-to-face meetings to clarify and reach agreement on which SI needs are urgent, relevant, and how they have to be interpreted. This helps to reduce SI-related equivocality. Related to that, departments or coordinators in charge of sustainability management screen upcoming issues, collaborate with internal and external actors to clarify expectations and diffuse thus generated information into the organization. Collective initiatives between industry members and/or other stakeholders help to reduce equivocality and uncertainty. On the one hand, these can help to develop a common agreement as to what sustainability means in certain contexts. On the other hand, collective initiatives can help to harmonize and formalize SI gathered and transferred between relevant supply chain nodes and other parties. Furthermore, information systems can be used to gather and process SI in a formalized way. For example, to help firms track the validity of certified environmental management systems and thus reduce uncertainty. Such sustainability norms indicate a minimum standard in how certified companies manage environmental protection. The above continuum shows that in reality the two information-related challenges of uncertainty and equivocality are related as decisions with high equivocality may require additional data (reducing uncertainty) which then needs to be interpreted (Lavendar *et al.*, 2011).

5. Conclusion and outlook

Companies face numerous challenges due to the increased environmental complexity introduced in the pursuit for an improved understanding of sustainability issues along supply chains. Against this background, this paper sought to shed light on related challenges by focusing on the information flows along supply chains. The theoretical perspective adopted is that of information processing, as it allows an in-depth analysis of coordination and integration processes along the supply chain. Through the information processing lens, the paper investigates three supply chains empirically, each comprising three companies – an OEM, a first-tier supplier, and a second-tier supplier. With the support of a series of interviews to complement publicly available information on the companies, the paper develops and discusses the companies' challenges and approaches to manage SI related issues in the context of SSM.

The findings, first and foremost, explicate why and how different actors in the supply chain approach sustainability-related information issues. The conducted study herein arrives at the conclusion that, depending on the degree of perceived equivocality and uncertainty, companies use and develop individual and collective procedures, standards, and formal sustainability information systems. Whereas a few of these approaches are used to manage information in bilateral relations, others are used to process SI upstream and downstream the supply chain. Second, the analysis highlights importance of IP capacity to improve supply chain sustainability transparency. In the long term, an increased transparency can help to improve supply chain performance. The results indicate that companies have developed and adopted various mechanisms for building such a capacity and have put them to the test. Third, the results indicate that interactions both between intra-organizational actors and among the actors in and outside the supply chain enhance sustainability information processing (Murray *et al.*, 2010; Afreen and Kumar, 2016). Examples of actors outside the supply chain, thereby, include not only commercial actors but also external parties such as NGOs and other multi-stakeholder initiatives.

The contribution boils down to the identified challenges in managing sustainability information needs along several nodes in a supply chain by investigating information uncertainty and ambiguity. In addition, the paper systematically analyses the approaches that companies deploy to address the issues identified herein. By doing so, the paper advances the current understanding of what challenges occur pertaining to corporate sustainability information demands and flows. The insights gained help draft a path to adequately managing these along several nodes in a supply chain, as opposed to being limited to the interactions between OEMs and first-tier suppliers. Furthermore, whereas extant research proposes what sustainability information challenges might occur for a focal company, this paper goes a step further by focusing on the upstream suppliers' perspective beyond the first tier. By doing so, this paper unveils challenges that have remained outside the viewing angle of previous research with regard to IP.

The above findings have several important implications. From a practical perspective, the paper reveals helpful insights into corporate approaches for dealing with extended sustainability information needs, once the upstream supply chain is considered. First, the insights gained may help to thoroughly analyse the company's own and their suppliers' sustainability information demands and the role of sustainability information in the decision-making process. A second key implication is the importance of collaborating with actors along the supply chain to both identify information demands and to jointly develop suitable approaches to fulfil this demand. Third, companies may be better off by not increasing the IP capacity at all costs, as this binds significant resources. Rather the purpose of SI needs, the relevance and urgency, and the available mechanism to reduce the SI needs should be elaborated. Therefore, decision-makers are advised to assess, establish and evaluate the fit between information needs and mechanisms to deal with them in a dynamic environment (cf. Busse *et al.*, 2017; Foerstl *et al.*, 2018). Such a reflection ideally includes the main set of business activities and decisions along the value chain. As this presumes a reduced equivocality related to sustainability issues, decisions on IP mechanisms and organisational structure can help to direct and modify resources according to the degree of SI-related uncertainty and equivocality. In this sense, dynamic capabilities to sense sustainability issues and to seize opportunities could help companies to process SI (Wu *et al.*, 2012).

This research is subject to several limitations. First, the focus on the automotive industry might limit the ability to generally apply the conclusions, although the food, chemical, or textile sector have also been documented to collaborate on different levels to process SI and manage sustainability risks along supply chains (*Sancha et al.*, 2015). The automotive industry is a highly competitive and cost-driven sector with recent scandals related to environmental issues but also related to human right abuses in their globalised raw material supply chains. However, the power of OEMs in both buyer–supplier relationships and in lobbying is usually high, thus driving industry standards and market behaviour (Beske *et al.*, 2008). Whereas OEMs operate on B2C markets, consumers and NGOs approach first and second tier suppliers to a lesser extent, resulting so far in less proactive stakeholder interactions. Second, the study's sample involves companies with headquarters in Germany and Austria. This has been suggested to have an influence on the attitude towards uncertainty and equivocality in organizations (Lewis, 2004). Despite the trend that companies evolve towards similar sustainability challenges over time, context such as industry and country have an influence on SSM practices (Carbone *et al.*, 2012). For example, environmental and social regulation is high in comparison to other regions. This may affect the understanding of certain sustainability issues but also the corporate behaviour in finding solutions with regard to addressing SI needs.

Further research should seek to deepen the results presented by looking at regions outside European companies and even further upstream – hypothetically including the topmost supply chain actors – yet a challenge considering the global dispersity. This could help actors at the bottom of the supply chain to better integrate sustainability information needs and in turn be able to manage sustainability issues both more effectively and more efficiently. Furthermore, research on the role of contingencies might reveal under what circumstances the identified approaches of information processing show high efficacy. Last but not least, as non-financial sustainability-related information plays a significant role in sustainability reporting, future research should investigate this intersection and investigate the influence of reporting needs on SI processing.

References

Afreen, S. and Kumar, S. (2016), "Between a rock and a hard place: the dynamics of stakeholder interactions influencing corporate sustainability practices", *Sustainability Accounting, Management and Policy Journal*, Vol. 7 No. 3, pp. 350-375.

Akhavan, R.M. and Beckmann, M. (2017), "A configuration of sustainable sourcing and supply management strategies", *Journal of Purchasing and Supply Management*, Vol. 23 No. 2, pp. 137-151.

Arvidsson, S. and Johansson, J. (2019), "Sense-making and sense-giving: reaching through the smokescreen of sustainability disclosure in the stock market", *Challenges in Managing Sustainable Business*, Palgrave Macmillan, Cham, pp. 77-109.

Benner, M.J. and Tushman, M.L. (2015), "Reflections on the 2013 decade award exploitation, exploration, and process management: the productivity dilemma revisited ten years later", *Academy of Management Review*, Vol. 40 No. 4, pp. 497-514.

Bennett, M.D., Schaltegger, S. and Zvezdov, D. (2013), *Exploring Corporate Practices in Management Accounting for Sustainability*, ICAEW, London.

Beske, P., Koplin, J. and Seuring, S. (2008), "The use of environmental and social standards by German first-tier suppliers of the Volkswagen AG", *Corporate Social Responsibility and Environmental Management*, Vol. 15 No. 2, pp. 63-75.

Bode, C., Wagner, S.M., Petersen, K.J. and Ellram, L.M. (2011), "Understanding responses to supply chain disruptions: insights from information processing and resource dependence perspectives", *Academy of Management Journal*, Vol. 54 No. 4, pp. 833-856.

Busse, C., Meinlschmidt, J. and Foerstl, K. (2017), "Managing information processing needs in global supply chains: a prerequisite to sustainable supply chain management", *Journal of Supply Chain Management*, Vol. 53 No. 1, pp. 87-113.

Canzaniello, A., Hartmann, E. and Fifka, M.S. (2017), "Intra-industry strategic alliances for managing sustainability-related supplier risks: motivation and outcome", *International Journal of Physical Distribution and Logistics Management*, Vol. 47 No. 5, pp. 387-409.

Carbone, V., Moatti, V. and Vinzi, V.E. (2012), "Mapping corporate responsibility and sustainable supply chains: an exploratory perspective", *Business Strategy and the Environment*, Vol. 21 No. 7, pp. 475-494.

Carter, C.R. and Rogers, D.S. (2008), "A framework of sustainable supply chain management: moving toward new theory", *International Journal of Physical Distribution and Logistics Management*, Vol. 38 No. 5, pp. 360-387.

Crespin-Mazet, F. and Dontenwill, E. (2012), "Sustainable procurement: building legitimacy in the supply network", *Journal of Purchasing and Supply Management*, Vol. 18 No. 4, pp. 207-217.

Daft, R.L. and Lengel, R.H. (1986), "Organizational information requirements, media richness and structural design", *Management Science*, Vol. 32 No. 5, pp. 554-571.

Daft, R.L. and Macintosh, N.B. (1981), "A tentative exploration into the amount and equivocality of information processing in organizational work units", *Administrative Science Quarterly*, Vol. 26 No. 2, pp. 207-224.

Donada, C., Nogatchewsky, G. and Pezet, A. (2016), "Understanding the relational dynamic capability-building process", *Strategic Organization*, Vol. 14 No. 2, pp. 93-117.

Downey, H.K. and Slocum, J.W. (1975), "Uncertainty: measures, research, and sources of variation", *Academy of Management journal*, Vol. 18 No. 3, pp. 562-578.

Eppler, M.J. and Mengis, J. (2004), "The concept of information overload: a review of literature from organization science, accounting, marketing, MIS, and related disciplines", *The Information Society*, Vol. 20 No. 5, pp. 325-344.

Fisher, G. and Aguinis, H. (2017), "Using theory elaboration to make theoretical advancements", *Organizational Research Methods*, Vol. 20 No. 3, pp. 438-464.

Foerstl, K., Azadegan, A., Leppelt, T. and Hartmann, E. (2015), "Drivers of supplier sustainability: moving beyond compliance to commitment", *Journal of Supply Chain Management*, Vol. 51 No. 1, pp. 67-92.

Foerstl, K., Meinlschmidt, J. and Busse, C. (2018), "It's a match! Choosing information processing mechanisms to address sustainability-related uncertainty in sustainable supply management", *Journal of Purchasing and Supply Management*, Vol. 24 No. 3, pp. 204-217.

Galbraith, J.R. (1974), "Organization design: an information processing view", *Interfaces*, Vol. 4 No. 3, pp. 28-36.

Gattiker, T.F. (2007), "Enterprise resource planning (ERP) systems and the manufacturing–marketing interface: an information-processing theory view", *International Journal of Production Research*, Vol. 45 No. 13, pp. 2895-2917.

Gualandris, J., Klassen, R.D., Vachon, S. and Kalchschmidt, M. (2015), "Sustainable evaluation and verification in supply chains: aligning and leveraging accountability to stakeholders", *Journal of Operations Management*, Vol. 38 No. 1, pp. 1-13.

Harms, D., Hansen, E.G. and Schaltegger, S. (2013), "Strategies in sustainable supply chain management: an empirical investigation of large german companies", *Corporate Social Responsibility and Environmental Management*, Vol. 20 No. 4, pp. 205-218.

Huber, G. (1990), "A theory of the effects of advanced information technologies on organizational design, intelligence, and decision making", *Academy of Management Review*, Vol. 15 No. 1, pp. 47-71.

Ketokivi, M. and Choi, T. (2014), "Renaissance of case research as a scientific method", *Journal of Operations Management*, Vol. 32 No. 5, pp. 232-240.

Khanna, M. and Anton, W.R.Q. (2002), "Corporate environmental management: regulatory and market-based incentives", *Land Economics*, Vol. 78 No. 4, pp. 539-558.

Koplin, J., Seuring, S. and Mesterharm, M. (2007), "Incorporating sustainability into supply management in the automotive industry – the case of the Volkswagen AG", *Journal of Cleaner Production*, Vol. 15 Nos 11/12, pp. 1053-1062.

Lewis, G.J. (2004), "Uncertainty and equivocality in the commercial and natural environments: the implications for organizational design", *Corporate Social Responsibility and Environmental Management*, Vol. 11 No. 3, pp. 167-177.

Li, S. and Lin, B. (2006), "Accessing information sharing and information quality in supply chain management", *Decision Support Systems*, Vol. 42 No. 3, pp. 1641-1656.

Linton, J.D., Klassen, R.D. and Jayaraman, V. (2007), "Sustainable supply chains: an introduction", *Journal of Operations Management*, Vol. 25 No. 6, pp. 1075-1082.

Lee, K.H. (2011), "Motivations, barriers, and incentives for adopting environmental management (cost) accounting and related guidelines: a study of the Republic of Korea", *Corporate Social Responsibility and Environmental Management*, Vol. 18 No. 1, pp. 39-49.

Marshall, M.N. (1996), "Sampling for qualitative research", *Family Practice*, Vol. 13 No. 6, pp. 522-526.

Mason-Jones, R. and Towill, D.R. (1997), "Information enrichment: designing the supply chain for competitive advantage, supply chain management", *Supply Chain Management: An International Journal*, Vol. 2 No. 4, pp. 137-148.

Mena, C., Humphries, A. and Choi, T.Y. (2013), "Toward a theory of multi-tier supply chain management", *Journal of Supply Chain Management*, Vol. 49 No. 2, pp. 58-77.

Miemczyk, J., Johnsen, T.E. and Macquet, M. (2012), "Sustainable purchasing and supply management: a structured literature review of definitions and measures at the dyad, chain and network levels", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 478-496.

Miles, M.B., Huberman, A.M. and Saldana, J. (2013), *Qualitative Data Analysis*, Sage, New York, NY.

Mura, M., Longo, M., Micheli, P. and Bolzani, D. (2018), "The evolution of sustainability measurement research", *International Journal of Management Reviews*, Vol. 20 No. 3, pp. 661-695.

Murray, A., Haynes, K. and Hudson, L.J. (2010), "Collaborating to achieve corporate social responsibility and sustainability? Possibilities and problems", *Sustainability Accounting, Management and Policy Journal*, Vol. 1 No. 2, pp. 161-177.

Radner, R. (1993), "The organization of decentralized information processing", *Econometrica*, Vol. 61 No. 5, pp. 1109-1146.

Rothman, N.B., Pratt, M.G., Rees, L. and Vogus, T.J. (2017), "Understanding the dual nature of ambivalence: why and when ambivalence leads to good and bad outcomes", *Academy of Management Annals*, Vol. 11 No. 1, pp. 33-72.

Sancha, C., Longoni, A. and Giménez, C. (2015), "Sustainable supplier development practices: drivers and enablers in a global context", *Journal of Purchasing and Supply Management*, Vol. 21 No. 2, pp. 95-102.

Sarkis, J. (2012), "A boundaries and flows perspective of green supply chain management", *Supply Chain Management: An International Journal*, Vol. 17 No. 2, pp. 202-216.

Sauer, P.C. and Seuring, S. (2017), "Sustainable supply chain management for minerals", *Journal of Cleaner Production*, Vol. 151, pp. 235-249.

Schaltegger, S., Burritt, R., Zvezdov, D., Hörisch, J. and Tingey-Holyoak, J. (2015), "Management roles and sustainability information: exploring corporate practices", *Australian Accounting Review*, Vol. 25 No. 4, pp. 328-345.

Seuring, S. and Müller, M. (2008), "From a literature review to a conceptual framework for sustainable supply chain management", *Journal of Cleaner Production*, Vol. 16 No. 15, pp. 1699-1710.

Sezen, B. (2008), "Relative effects of design, integration and information sharing on supply chain performance", *Supply Chain Management: An International Journal*, Vol. 13 No. 3, pp. 233-240.

Sharfman, M.P., Shaft, T.M. and Anex, R.P. Jr (2009), "The road to cooperative supply-chain environmental management: trust and uncertainty among pro-active firms", *Business Strategy and the Environment*, Vol. 18 No. 1, pp. 1-13.

Sharfman, M.P., Wolf, G., Chase, R.B. and Tansik, D.A. (1988), "Antecedents of organizational slack", *Academy of Management Review*, Vol. 13 No. 4, pp. 601-614.

Silva, S. and Schaltegger, S. (2019), "Social assessment and management of conflict minerals: a systematic literature review", *Sustainability Accounting, Management and Policy Journal*, Vol. 10 No. 1, pp. 157-182. Issue

Simmonds, D., Tadesse, A. and Murthy, U. (2018), "ERP System Implementation and Sustainability Performance Rating and Reputation".

Spickett-Jones, G. and Kitchen, P.J. (2003), "Information processing: a critical literature review and future research directions", *International Journal of Market Research*, Vol. 45 No. 1, pp. 1-20.

Storto, C.L. (2008), "Simulating information ambiguity during new product development: a forecasting model using system dynamic", *International Journal of Modelling, Identification and Control*, Vol. 3 No. 1, pp. 97-110.

Tushman, M.L. and Nadler, D.A. (1978), "Information processing as an integrating concept in organizatonal design", *The Academy of Management Review*, Vol. 3 No. 3, pp. 613-624.

Van Marrewijk, M. and Werre, M. (2003), "Multiple levels of corporate sustainability", *Journal of Business Ethics*, Vol. 44 No. 2, pp. 107-119. Nos

Vilko, J., Ritala, P. and Edelmann, J. (2014), "On uncertainty in supply chain risk management", *The International Journal of Logistics Management*, Vol. 25 No. 1, pp. 3-19.

Weick, K. (1979), *The Social Psychology of Organizing*, McGraw-Hill Humanities, Columbus, OH.

Wolf, J. (2011), "Sustainable supply chain management integration: a qualitative analysis of the German manufacturing industry", *Journal of Business Ethics*, Vol. 102 No. 2, pp. 221-235.

Wu, Q., He, Q., Duan, Y. and O'Regan, N. (2012), "Implementing dynamic capabilities for corporate strategic change toward sustainability", *Strategic Change*, Vol. 21 Nos 5/6, pp. 231-247.

Yin, R.K. (2017), *Case Study Research and Applications: Design and Methods*, Sage publications.

Zelt, S., Schmiedel, T. and Vom Brocke, J. (2018), "Understanding the nature of processes: an information-processing perspective", *Business Process Management Journal*, Vol. 24 No. 1, pp. 67-88.

Zimmer, K., Fröhling, M. and Schultmann, F. (2016), "Sustainable supplier management – a review of models supporting sustainable supplier selection, monitoring and development", *International Journal of Production Research*, Vol. 54 No. 5, pp. 1412-1442.

Further reading

Okongwu, U., Morimoto, R. and Lauras, M. (2013), "The maturity of supply chain sustainability disclosure from a continuous improvement perspective", *International Journal of Productivity and Performance Management*, Vol. 62 No. 8, pp. 827-855.

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