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Review

The complementing role of sustainability standards in managing international and multi-tiered mineral supply chains

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ABSTRACT

Supply chains (SCs) often entail suppliers beyond the focal firm's visible horizon and thus outside its awareness and management. This article conceptualizes how standards can complement the management of complex SCs to identify and manage previously unknown suppliers.

Combining institutional theory and multi-tier SC management (SCM), standards and SCs are conceptualized as meta-institutional fields that can complement each other to enlarge the reach of the focal firm, reduce SC uncertainty, and ensure legitimate SC operations. This conceptualization is empirically supported with 1) a pre-study of eight interviews with large firms in the automotive industry and 2) a structured content-analysis based document analysis of twenty sustainability standards for mineral resources.

The findings identify a standard's ownership, its supplier coverage, and the overlap of its requirements with institutionalized SC values, structures, and practices as critical enablers for establishing supplier compliance in complex and previously unmanaged settings, such as the upstream parts of international and multi-tiered mineral SCs. Based on these findings, focal firms can use standards to enhance the reach and power towards distant suppliers. The reviewed standards could extend their supplier coverage and focus sustainability at large to create synergies for their downstream customers.

The study thus contributes a novel conceptualization of the complementing role of standards in SCs and especially beyond the visible horizon of the focal firm, refines the constructs for a standard's characterization in SCM, and provides first industry-specific empirical support for the relevance of the complementing role and how standards currently fill it.

1. Introduction

Absent or lacking management of suppliers has been found to result in supply chain (SC) uncertainties regarding the stability and quality of supply and changing demand requirements and volumes (Chen and Paulraj, 2004; Kauppi, 2013).

Simultaneously, SC and sustainability managers of large and globally active companies complain about lacking knowledge about the distant parts of their SCs (Schöggl et al., 2016) resulting in unmanageable and only hardly predictable uncertainties while other managers claim to have full visibility of their raw material suppliers, even in complex SCs. Mineral SCs for example entail up to 20 tiers (see also Sheffi, 2018), a complexity within which SC management (SCM) theory and praxis hardly provide any means to establish visibility, not to mention an effective management of the most distant suppliers (Hofmann et al., 2018; Sauer and Seuring, 2019).

To this end, sustainable supply chain management (SSCM) scholars have proposed to complement the focal firm's (FF) supplier management by integrating "nontraditional members", such as non-governmental organizations (NGOs), trade groups, or voluntary standards (Agyemang et al., 2018; Pagell and Wu, 2009; Tachizawa and Wong, 2014; van den Brink et al., 2019). Adding to that, this paper proposes a "complementing role" of these non-traditional members, that is helping the FF to first identify previously unknown distant SC members and subsequently ensure their compliance and thus achieving reduced supply uncertainty (Chen and Paulraj, 2004; Lo, 2013). This *complementing role* recently gained traction, as cases of misconduct by distant suppliers in international SCs, such as the Rana Plaza incident or the use of conflict minerals in consumer products, have revealed critical working and environmental conditions hidden deep in global SCs (Hofmann et al., 2018; Kelling et al., 2020; Muduli et al., 2013; Wilhelm et al., 2016). Moreover, these critical conditions in the upstream SC have

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been found to lower the performance of the entire SC in terms of sustainability (Schmidt et al., 2017) and raise SC uncertainty (Sauer and Seuring, 2018).

To examine the *complementing role* of standards in managing extended and international SCs, this study investigates the empirical field of sustainability in mineral SCs. The mineral supply to downstream industries is an extreme case of SC complexity and sustainability impacts (Hofmann et al., 2018; Sheffi, 2018) making it a valuable object of investigation. Specifically, the supply of mineral resources, further referred to as the "mineral SC", features a high number of tiers and a lack of transparency (Young, 2018; van den Brink et al., 2019). From a sustainability perspective, mineral SCs cause severe social impacts, including human rights violation and adverse working conditions, and substantial environmental impacts (Gorman and Dzombak, 2018; Hofmann et al., 2018; Young, 2018; Sauer and Seuring, 2019). The adverse ecological effects of mining can be high, since mining produces significantly more waste than the 17.7 Billion tons of economic minerals (Owen et al., 2020; Reichl and Schatz, 2020). These adverse effects range from affecting bio-diversity and land fertility through the continuous leakage of toxic substances (e.g. Golev et al., 2014) to the abrupt failure of tailing dams that can destroy entire river ecosystems and what happens on average more than once a year (see Owen et al., 2020 for a recent analysis). Simultaneously, natural resources enable income opportunities for unskilled workers and the development of an industrial sector in developing countries, given a sound governance (Kelling et al., 2020; Muduli et al., 2013). Finally, mineral SCs consist of an upstream and downstream network that substantially differ in terms of context and sustainability ambition (Sauer and Seuring, 2017; Young, 2018; van den Brink et al., 2019). The upstream network covers those SC members that many FFs are not aware of and who supply a diverse set of buyers, including the automotive, jewelry, construction, transport, electronics, and packaging industries (e.g., Brix-Asala et al., 2018; Hofmann et al., 2018).

In effect, current studies show the contribution of standards within an existing network, for example, their positive effect on legitimacy attributions to a SC (e.g., Müller et al., 2009), risk mitigation, and enhanced sustainability performance (Beske and Seuring, 2014; Simpson et al., 2012). But their value in identifying SC partners has been neglected so far although it offers a valuable contribution to the lack of research on the identification and management of suppliers beyond the visible horizon, i.e., those suppliers that the FF initially is unaware of (Carter et al., 2015; Sheffi, 2018). These suppliers have been found to be key to future theoretical development and practical relevance for both generic and sustainable SCM, a combination from here on abbreviated as (S)SCM (Hofmann et al., 2018; Sauer and Seuring, 2018; Wilhelm et al., 2016; Wu and Jia, 2018).

This study thus addresses the research questions:

1 *How can standards support focal firms in identifying suppliers in multi-tier SCs and especially beyond the FF's visible horizon?*
2 *How can sustainability standards reduce uncertainties and ensure the legitimacy of operations in multi-tier SCs and especially beyond the FF's visible horizon?*

To answer these questions, this study adopts a combined approach using interviews of eight SCM and sustainability managers in combination with a document review of 20 sustainability standards for mineral resources and their SCs.

To achieve this, Section 2 conceptualizes the theoretical foundations of multi-tier SSCM. Section 3 presents the applied methodology and measures taken to ensure the study's quality. Section 4 presents the interview material as well as the descriptive and analytical findings of the document analysis that answer the research questions and Section 5 discusses the study's contributions. Section 6 concludes by outlining the study's limitations and deriving research directions.

2. Literature review and conceptualization

2.1. Multi-tier sustainable supply chain management (MT-SSCM)

Although initial (S)SCM definitions and frameworks included multiple supplier tiers (e.g. Mentzer et al., 2001; Seuring and Müller, 2008), multi-tier sustainable supply chain management (MT-SSCM) has only recently emerged as an extension of SSCM to "any lower tier" (Tachizawa and Wong, 2014, p. 651). In its core, MT-SSCM challenges the abundant availability of information among SC members on the SC's sustainability goals, customer and stakeholder requirements, and supplier compliance (Carter et al., 2015; Sauer and Seuring, 2018, 2019; Wilhelm et al., 2016).

And indeed, SC managers report a lack of knowledge about their upstream SC parts, starting often at tier-2 (see e.g. Schöggl et al. (2016) and Section 4.1). This matches the concept of the visible horizon describing the boundary beyond which a firm does not have any information about its SC and can thus not take conscious action towards it. This visible horizon is subject to cultural and physical distance and the number of tiers between FF and a supplier (Carter et al., 2015). Simultaneously, and amplifying the visible horizon's relevance, the sustainability impact of a supplier has been found to rise the more one moves toward the ultimate supplier (Mena et al., 2013; Sauer and Seuring, 2019; Schmidt et al., 2017).

Beside problems in identifying distant SC members (Schöggl et al., 2016), SCs face uncertainty due to the resulting lack of shared information and goals (Kauppi, 2013). Across the (S)SCM field, two core constructs for inter-organizational uncertainty are used: supply uncertainty (supplier does not meet requirements) and demand uncertainty (volume and quality requirements change) (Chen and Paulraj, 2004; Lo, 2013; Kauppi, 2013). These uncertainty constructs have been found to negatively affect SC performance (Chen and Paulraj, 2004) and SC sustainability (Lo, 2013; Yawar and Kauppi, 2018).

Based on the abovementioned theoretical foundations of MT-SSCM, Fig. 1 displays the core idiosyncrasies of MT-SSCM as a basis for the document analysis, as suggested by Durach et al. (2017).

From top to bottom, this study takes an ultimate SC perspective from the ultimate supplier to the ultimate customer (Mentzer et al., 2001) focusing the FF and the actions it can take to manage sub-suppliers with the support of standards. Following Tachizawa & Wong (2014), all MT-SSCM approaches can be used if the FF is aware of the supplier (right of the visible horizon). Beyond the visible horizon, however, only the "using third parties" or the "don't bother" approach in MT-SSCM remain viable since the FF's knowledge of the supplier is low and the distance between FF and supplier is high (see also Schöggl et al., 2016). Alternatively, the cascaded approach by Sauer & Seuring (2019) can be applied, implying contact with a second, more powerful firm upstream of the original FF, the so-called "upstream FF".

This study thus proposes a *complementing role* of third parties in multi-tier SCs and aims to investigate their usefulness for first mapping and second managing the extended SC based on institutional theory, whose intersection with MT-SSCM is presented next.

2.2. Institutional theory in multi-tier sustainable supply chain management

Institutional theory provides a fruitful lens for investigating the adoption of values, structures, and practices as a response to external pressure (Terlaak, 2007). Its use in SSCM is rising (Kauppi, 2013; Touboulic and Walker, 2015), but investigations on the SC level are still underdeveloped (Busse et al., 2016; Wu and Jia, 2018).

There are two central constructs in institutional theory: institutions and the institutional field.

Institutions represent "cognitive, normative, and regulative structures and activities that provide stability and meaning to social behavior" (Scott, 1999, p. 33) and build the basis for attributing

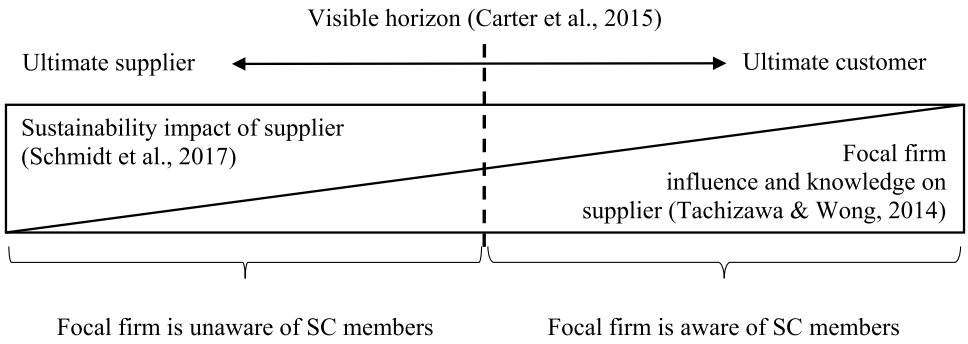

Fig. 1. Core idiosyncrasies of multi-tier sustainable supply chain management.

legitimacy, i.e., the perception that a company's actions as "desirable, proper, or appropriate within a socially constructed system of norms, values, beliefs, and definitions" (Suchman, 1995, p. 574). The institutional field is the unit of analysis in institutional theory since it is the arena in which the institutional processes work (Wooten and Hoffman, 2013; Wu and Jia, 2018). It delimits institutional analysis by defining (a) the relevant social actors, (b) the pressure they exert on each other, and (c) the institutions guiding this pressure (Wooten and Hoffman, 2013).

This concept of an institutional field has been mainly used to frame the environment of a single organizational or national context (Kostova et al., 2008). This is problematic for its application in multi-tier SCs, business networks and multi- or international contexts, as they face "multiple, fragmented, nested, or often conflicting institutional environments" (Kostova et al., 2008, p. 998).

The present study thus combines the suggestion that an organization is not part of only one institutional field but of many in which it is embedded (Kostova et al., 2008; Wooten and Hoffman, 2013) with the proposition that a field does not exist ex ante, but is only established once the actors start to "take note of each other and … referencing each other" (Wooten and Hoffman, 2013, p. 138). It thus conceptualizes a multi-tier SC as a meta-institutional field as proposed by Sauer & Seuring (2018). Building on Kostova et al. (2008), a meta-institutional field spans multiple national and organizational institutional fields and is broad in its coverage of actors but narrow in institutionalized values and practices. This so-called "SC field" spans the FF, its customers, suppliers, and sub-suppliers within the visible horizon of the FF and is guided by the FF's institutionalized economical and ethical values, structures, and practices. It overlaps with multiple other (national and organizational) fields that can build up competing demands on (sub-)suppliers, customers, and the FF. Moreover, the SC field can acquire new actors by means of interaction, which is hindered by the visible horizon of the FF (Sauer and Seuring, 2018; Wooten and Hoffman, 2013).

This conceptualization underlines that the visible horizon of the FF limits the SC field and especially its coverage of actors. Consequently, FFs cannot pressure any actor beyond their visible horizon, thus limiting SCM efforts to the known SC tiers often leaving the majority of tiers out of scope. To address this critical problem, the next section conceptualizes how a standard can *complement* the management of a multi-tier SC by identifying actors beyond the visible horizon and influencing their behavior.

2.3. Using standards to complement (S)SCM in complex settings

Scientific literature labels third party standards as certified management schemes (Terlaak, 2007), voluntary certification schemes (Tröster and Hiete, 2018; Chkanikova and Sroufe, 2020), or voluntary standards (Bartley, 2007; Tachizawa and Wong, 2014). From an institutional perspective, such standards define the regulative or norm-like institutions that provide stability and meaning to social behavior (Bartley, 2007; Scott, 1999) by defining a set of legitimate, that is, desirable, proper, or appropriate actions and requirements for these action (Suchman, 1995). To be legitimate, these requirements need to be set, implemented, and governed by a diverse and inclusive group that integrates all concerned stakeholders (Müller et al., 2009; Tröster and Hiete, 2018; Young, 2018; Sauer and Hiete, 2020).

Additionally, standards deliver two benefits to adopting SCs. First, standards often grant certification to adopting organizations (Bartley, 2007; Müller et al., 2009; Tröster and Hiete, 2018) signaling sustainability performance (Simpson et al., 2012; Terlaak, 2007). Consequently, firms and SCs gain legitimacy by adhering to standards and obtain economic benefits like price premiums and increased customer loyalty (Müller et al., 2009; Simpson et al., 2012; Tröster and Hiete, 2018). Second, supplier compliance is enforced with the standard's requirements (Bartley, 2007; Terlaak, 2007), which reduces supply uncertainty and enhances the provision of information about the SC to both the supplier and the FF (Seuring and Müller, 2008) reducing demand uncertainty (Sauer and Seuring, 2018).

A standard brings together social actors across industries, which define and implement the legitimate practices for these industries (Chkanikova and Sroufe, 2020; Simpson et al., 2012; Terlaak, 2007; Tröster and Hiete, 2018). Standards thus span multiple national and organizational institutional fields and represent a meta-institutional field that is broad in its coverage of actors but narrow in institutionalized values and practices (Kostova et al., 2008).

Building on the conceptualization of both SCs and standards as institutional fields and the idiosyncrasies of MT-SSCM in Fig. 1, especially the visible horizon, Fig. 2 depicts an ideal combination of the two fields into a more comprehensive SC field over time, i.e., from t_0 in the upper part of Fig. 2 to t_1 in the lower part.

The meta-institutional field enables the theorization of how a standard can *complement* the management of a SC based on a) the creation of an institutional field encompassing ideally all SC members and b) shaping the institution that guides the values, structures, and practices within the institutional field.

Enlarging the SC field is enabled by the standard's information, events, or decision-making bodies. These encompass different SC tiers

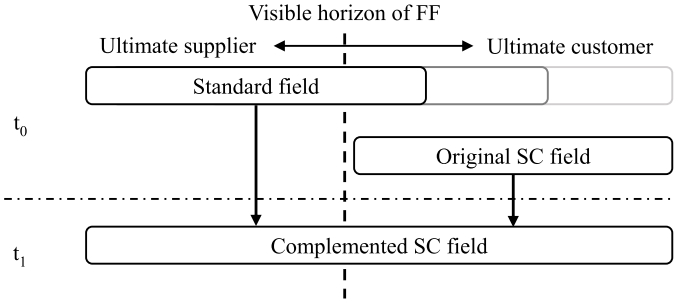

Fig. 2. How standards and SCs can complement each other as meta-institutional fields.

depending on the focus of the standard. While mineral standards likely encompass more suppliers at the very upstream end, standards for fair production will cover mid-tier suppliers. This potential difference or overlap is indicated in Fig. 2 by the overlapping boxes of the "Standard field". The mentioned standard field can serve as a starting point for the FF and suppliers (of which the FF is initially unaware) to "take note of each other and … referencing each other" (Wooten and Hoffman, 2013, p. 138), thus establishing interaction with actors beyond the FF's original visible horizon that was not possible at t_0.

As a result of the *complementation* at t_1, a standard should ideally include all SC stages crucial for the SC's sustainability and the legitimacy of the operations (Müller et al., 2009; Tröster and Hiete, 2018; Young, 2018). This especially includes the raw material suppliers (Mena et al., 2013; Hofmann et al., 2018; Sauer and Seuring, 2019) and the FF with its stakeholders, as this enhances the market power represented by the standard and thus its coercive power (Tate et al., 2011). This is captured in the two concepts (from here on written in *italics* for better recognizability) of the standard's *SC integration*, that is, the "integration of all participants along the supply chain" and *inclusivity*, being the "wide integration of all stakeholders concerned" (Müller et al., 2009, p. 512). Since the original definition does not specify the scope of the SC addressed, these two characteristics of a standard are refined to comprehend an extended or ultimate SC scope (Mentzer et al., 2001) and described and referenced in Table 1. Within the SC, only the physical SC (Carter et al., 2015), i.e., only the product-related SC partners and their stakeholders are concerned, not the ones suppling machinery or auxiliary materials and services. Additionally, Table 1 represents the first part of the coding scheme for the document analysis.

Thus, *inclusivity* is supplemented by the notion of *standard ownership* (Tröster and Hiete, 2018) and *SC integration* is re-labelled as *SC coverage* to avoid confusion with other integration concepts in (S)SCM. Second, *SC coverage* is split into three subconstructs that are inspired by the sustainability and SCM challenges in mineral SCs.

These subconstructs encompass standards' material and geographical coverage, since the environmental and social challenges associated with a raw material depend on the material's production requirements and the institutional characteristics of its production environment. There are substantial differences in the provision of (a) different materials such as agricultural goods, crude oil, or different minerals (Haufler, 2009; Hiete et al., 2019), and (b) the provision of the same material in different environments and locations (OECD, 2016). These issues can be structured against the supplier tiers that a standard monitors, i.e., the third subconstruct of supplier coverage (van den Brink et al., 2019; Young, 2018), to enhance the understanding of the required management actions, their drivers, and barriers like the visible horizon (see Fig. 1).

Splitting *SC coverage* enables an enhanced construct validity and scope (Fisher and Aguinis, 2017). While the proposed subconstructs are almost trivial for dyadic SCs, the arguments just given underline their criticality in complex international and multi-tier SCs affected by the idiosyncrasies outlined in Fig. 1.

The second implication for a *complemented* SC field is related to the institution guiding the institutional field. A standard can only *complement* the SC field if its values, structures, and practices (i.e., the institutions) match the institutions of the SC field. For evaluating this match in mineral SCs, the investigation is further informed by the SSCM for minerals framework by Sauer & Seuring (2017). This framework defines 23 practices in six categories for the realization of the SSCM in mineral SCs. It is used to systematically classify the standards' requirements and processes and investigate their *complementing role* in the management of the SC members that the FF originally was unaware of. Sauer and Seuring's (2017) framework is outlined in Table 2 and represents the second part of the coding scheme required for the systematic review of the material (Durach et al., 2017; Fink, 2010; Seuring and Gold, 2012).

The document review outlined below analyzes how the codes outlined in Tables 1 and 2 match the standards' characteristics and requirements.

Table 1
– Coding scheme for SC coverage and inclusivity/ownership.

Characteristics of a standard	Description	References
Inclusivity/ standard ownership	Wide integration of all stakeholders concerned in the governance and management of a standard to gain legitimacy with them.	Müller et al. (2009); Tröster & Hiete (2018); Young (2018)
SC coverage: (a) Material coverage (b) Geographical coverage (c) Supplier coverage	Integration of all partners along the SC relative to a product and an agent. For complex products and their SCs, the subconstructs (a) to (c) enable a more fine-grained evaluation of a standard's coverage of critical materials, regions, and SC segments or industries.	Carter et al. (2015); Sauer & Seuring (2017, 2019); Haufler (2009); Hofmann et al. (2018); Müller et al. (2009); Tachizawa & Wong (2014); van den Brink et al. (2019); Young (2018)

3. Methodology

The applied two-step study combines first an interview-based identification of challenges in multi-tier SCM that pointed to standards as potential solutions with second a document analysis-based identification of the standards' full potential. This unconventional approach is owed to the complexity of multi-tier (S)SCM (Tachizawa and Wong, 2014; Wilhelm et al., 2016) and the complexity of the field of sustainability standards for minerals, that easily overwhelms even sourcing experts (e.g. Hiete et al., 2019; Young, 2018). The challenge in this study is the interest in a truly multi-tier SCM approach that aims at understanding the challenges of downstream SC actors in tracing and managing upstream suppliers that often remain beyond their visible horizon.

To achieve this, the interview-based pre-study encompassed eight interviews conducted in the automotive industry including one globally active original equipment manufacturer (OEM) and seven of its first-tier suppliers. The interviews were explorative and focused an inductive identification of the challenges faced in the upstream SC of the interview partners. The main open questions aimed at the identification of the most relevant raw materials, the reach of the tracing and management of material streams (in terms of supplier tiers) of the individual firms, the extend of SC visibility in terms of supplier tiers and information categories, the complexity of the SC of the interviewed firms as well as the application of SC management and SC visibility solutions. Finally, a variety of potential responses to the challenges were discussed. The interview partners encompassed seven different component and raw material suppliers and one OEM, which are all based in Europe and large firms according to the definition of the European Union. Table 3 summarizes the main data regarding the interviews that were conducted in the second half of 2019. The interviews have been conducted online with three sustainability and five SC managers in English and German and lasted between 32 and 73 min (mean: 55 min). The discussions were recorded, transcribed, doublechecked by the interviewees for validation and content analyzed following state of the art guidelines (Mayring, 2010).

The interviews revealed a widespread lack of multi-tier SC visibility and thus MT-SSCM in the automotive industry and only few incidences of solving these by means of standards. It was thus decided to use this primary evidence for identifying the challenges, while the solution was systematically investigated in the second step, that is a comprehensive analysis of standards.

This second steps represents a systematic content-analysis based document analysis (Seuring and Gold, 2012) considering also related quality criteria for reviews in general (Fink, 2010) and reviews in (S)

Table 2
- Coding scheme for SSCM for minerals categories and practices, as adapted from Sauer & Seuring (2017) with updated references.

Categories and practices	Description	References
Government interventions 1) Direct regulation 2) Interactive regulation 3) Facilitating self-regulation 4) Government as consumer	**Governments** intervene in SC operations by imposing legally binding **direct regulations, interacting** with and financing social society actors, and providing information to **facilitate self-regulation**. They can also aim to **consume** more sustainable products and services.	Agyemang et al. (2018); Bartley (2007); Haufler (2009); Hofmann et al. (2018); Muduli et al. (2013); Rentizelas et al. (2020); Young (2018)
Orientation 5) Dedication to TBL 6) Dedication to SCM	**Orientation** centers on the strategic decisions of SC members to adopt triple bottom line (**TBL**) and **SCM** practices to realize a competitive advantage.	Beske & Seuring (2014); Guarnieri & Trojan (2019); Pagell & Wu (2009); Müller et al. (2009); Hofmann et al. (2018)
Continuity 7) SC partner development 8) Long-term relationships 9) SC partner selection	Continuity draws on the SC structure and focuses on building **long-term relationships** with **selected SC partners**. Subsequent **development of** weak **partners** enhances overall SC performance.	Beske & Seuring (2014); Brix-Asala et al. (2021); Chen & Paulraj (2004); Guarnieri & Trojan (2019); Yawar & Kauppi (2018);
Collaboration 10) Enhanced communication 11) Technological integration 12) Logistical integration 13) Joint development	Operational practices, such as **enhanced communication** and **joint development**, strengthen the **collaboration** among SC members, which is further facilitated by integrating **logistical** and **technological** structures.	Beske & Seuring (2014); Chen & Paulraj (2004); Sauer & Seuring (2019): Yawar & Kauppi (2018)
Risk management 14) Standards and certification 15) Selective monitoring 16) Pressure groups 17) Primary supply stability 18) Governance gaps	**Pressure groups** targeting unsustainable suppliers are major SC **risks**, which can be mitigated by **monitoring** suppliers and relying on **standards and certification**. Mineral SCs actors have to complement the often weak governance contexts they span. It is further important to **stabilize primary mineral supplies**, which have recently been very volatile and represent a supply risk.	Beske & Seuring (2014); Haufler (2009); Hofmann et al. (2018); Sauer & Seuring (2019); van den Brink et al. (2019)
Pro-activity management 19) Stakeholder management 20) Learning 21) Innovation 22) Environmental pro activity 23) Linkage development	**Developing linkages** at the mine aims at sharing revenues with local **stakeholders. Managing stakeholders** enables **learning** effects, which stimulate SC **innovation. Environmental pro-activity** represents a further means to diversify from competitors and gain competitive advantages in mineral SCs.	Beske & Seuring (2014); Brix-Asala et al. (2018); Hofmann et al. (2018); Müller et al. (2009); Sauer & Seuring (2019);

SCM in particular (Carter and Washispack, 2018; Durach et al., 2017; (Seuring et al., 2021)).

Seuring & Gold (2012) defined four steps of such reviews: (1) material collection, (2) descriptive analysis, (3) category selection, and (4) material evaluation, which are adopted in this study and outlined below.

Step (1) material collection includes the definition of research questions and search parameters for the literature (Seuring and Gold, 2012). As a result, 20 sustainability standards for mineral resources (marked with squared brackets in the references) were identified by combining an online search and searching the scientific and the gray literature on sustainability in mineral SCs. Due to the heterogeneous nature of the standards, the sample was built by merging and updating the samples of the prior studies listed in the Appendix. The aim was to identify the currently established and operational standards in order to produce a valid representation of the field. A number of new standards are under development, but since their survival until implementation is not warranted (Young et al., 2014) they were excluded.

Table 3
– Summary of interviews.

Firm code	Firm size	Interviewees	Location of headquarters
OEM	Large	Sustainability manager	Europe
Supplier A	Large	Supply chain manager	North America
Supplier B	Large	Supply chain manager	Europe
Supplier C	Large	Supply chain manager	Europe
Supplier D	Large	Sustainability manager	North America
Supplier E	Large	Supply chain manager	Europe
Supplier F	Large	Sustainability manager	Europe
Supplier G	Large	Supply chain manager	Europe

The core documents of the standards comprised 1263 pages of text obtained from standards' websites. This comprehensive collection of sustainability standards for mineral resources enabled an evaluation of the standards in their totality, as called for by Haufler (2009), and complemented the existing reviews of multiple standards listed in the Appendix. To date, the analysis of a sample of gray literature is uncommon in (S)SCM research, but enables a move beyond the "safe topics" and can advance our field both from a theoretical and practical perspective to generate more tangible implications (Carter and Washispack, 2018; Bubicz et al., 2019).

Step (2) descriptive analysis records the formal characteristics of the analyzed material. Following Table 1, these focus on the *standard ownership* and the standards' *SC coverage*. These descriptive categories yielded 145 coded text passages outlining the standards' structural limits.

Step (3) category selection provides the codes for the analysis of the material, which is guided by the conceptualization in Section 2 following state-of-the-art guidelines (Durach et al., 2017; Carter and Washispack, 2018; Seuring et al., 2020). The analysis of the standards is mainly deductive and based on concepts of *SC coverage* and *standard ownership* by Müller et al. (2009) and the SSCM for minerals framework by Sauer & Seuring (2017).

Step (4) material evaluation classifies the material against the selected categories and codes. The results present the state-of-the-art in the analyzed material and outlines the strengths and weaknesses of the material related to the literature-based framework and concepts used for coding (Seuring and Gold, 2012). Ultimately, 1163 text passages were coded and analyzed to generate the findings of the material evaluation presented in Section 4.3.

Generally, content analysis allows for qualitative and quantitative analysis of the results (Mayring, 2010). However, the low number of standards in the sample impeded quantitative statistical methods and required qualitative approaches and reasoning. This was mainly conducted via cross-tabulations to enable the detection of interlinked categories across the material. Sample quotes are presented in the Supporting Information to underline the manifestation of the analyzed categories in the standards. The content analysis of both the interviews and standards was supported by the software MAXQDA that allows to store the transcripts, to manually assign codes to text passages, to trace as well as manually summarize the coded text, and cross tabulate the results.

Finally, validity was ensured by deductively using categories from well-established literature to define a coding and review scheme (Mayring, 2010; Fink, 2010; Seuring et al., 2020). The assignment of codes to single text passages is made transparent by using the pre-defined coding scheme (Tables 1 and 2) and sample quotes from the reviewed material (Supporting Information). The tables were validated

during a "discursive alignment of interpretation" (Seuring and Gold, 2012) with a "knowledgeable person" (Fink, 2010) in SSCM and mineral SCs to ensure the validity and reliability of the results (Fink, 2010). That person's knowledge is underlined by more than 20 years of academic experience in (S)SCM and having conducted multiple empirical research projects on commodity SCs including minerals. The alignment encompassed detailed discussions on how to refine the coding scheme and its application to the reviewed material (supported by discussing quotes from the material) since these original codes have been defined for other fields than minerals (Table 1) or other review material than gray literature (Table 2). Follwing Durach et al. (2017), the validated coding scheme guided the coding, which was conducted by one person requiring to focus on intra-coder reliability. This was enhanced by coding a quarter of the interviews and standards twice before coding the remaining material, delivering the results displayed below.

4. Findings: the challenges in tracing and managing multi-tier SCs and the potential of using sustainability standards to complement multi-tier SCM

This section is divided into Section 4.1 presenting the primary evidence on the challenges in multi-tier SCs and the experienced usefulness of standards. Section 4.2 focuses the categories of *SC coverage* (including its sub-categories of *material,* (b) *geographical,* and (c) s*upplier coverage*) and *standard ownership*. This answers research question 1 on how standards complement a FF's identification of suppliers. Section 4.3 explores the values, structures, and practices prescribed by the standards to enable the evaluation of the overlap of standard and SC institutions, thus answering research question 2. The constructs of interest are written in italics to facilitate reading.

4.1. Challenges in identifying and managing partners in multi-tier SCs

The interview-based pre-study on challenges in MT-SSCM reveals a set of supplies for which SC transparency and certification is a reality and others for which OEM and suppliers agree that "basically … we are all not aware of what happens in our upstream SC parts" (OEM). In effect three main factors can be identified for this lack of SC visibility.

First and in line with the OEM, the suppliers underline the complexity of mineral SCs. For example, supplier A describes the SC upstream its tier-1 as a "blackbox", while other suppliers elaborate the complexity of the SC as the main challenge for retrieving information. Supplier H describes this complexity to entail on the one hand very short material streams of which it has full knowledge, while the same supplier H on the other hand is facing one material stream covering up to 20 supplier tiers until the mine with intermediate tiers lacking integrated information systems and information processing capacity. Moreover, suppliers C and D underline the interconnectedness of upstream material streams that contrast the "perception of a stable supply chain" (supplier C) that would be clearly definable. Instead, raw materials that were sourced in bulk form different sub-suppliers are mixed in production processes across the SC tiers. Such challenges due to high SC complexity are well known in SSCM literature and has been found in agricultural, food, clothing, footwear and electronics industries (e.g. Brix-Asala et al., 2018; Mena et al., 2013; Wilhelm et al., 2016a,b).

Second, the interviews underline the influence of the material of interest and the use of standards. Supplier C reports that for complex products containing conflict minerals, a group of materials that has reached a relatively high traceability (Young, 2018), there are cases in which material from "all major smelting facilities globally ends up in your product" (supplier C). In 2015 the number of smelters was estimated to over 400 globally, which is however by far less complex than monitoring the more than 10,000 informal and small-scale mines supplying them only from the Democratic Republic of Congo (DRC) (Young, 2018). Suppliers C, E, and G support this and underline that they apply some of the reviewed standards for conflict minerals (see Section 4.2 and 4.3) and know which of the 400 smelters are in their SC, while even at the same suppliers the visibility for other materials ends again after their tier-1. Beyond conflict minerals, supplier E has transparency up to the mine in cases in which the ASI certification (ASI, 2017a) is used, while supplier G sources its aluminum at the London Metal Exchange and reports to have no information on its origin and production conditions. The same effect of lacking information is reported for the involvement of traders in SCs that regularly refer to confidentiality concerns and fear to be excluded from the chain by means of direct sourcing if their sub-suppliers are revealed (supplier A, D and F). Such a use of standards is an established topic in SSCM and has extensively been investigated for example in the food and forest sector (e.g. Chkanikova and Sroufe, 2020; Müller et al., 2009). Contrastingly, the role of different materials or product classes within one industry is largely neglected and this study is one of the first to identify it in the minerals related challenges of automotive SCs.

Third, the interviewees report difficulties in obtaining sustainability information due to institutional differences, since some suppliers do not collect related information because it is deemed to be worthless in business. As reasons, supplier G explicitly identifies differences in "culture, … country-specific regulation, government [and] policy". This is again only contrasted if there are global regulations in play that limit access to major markets like the USA in case of the Dodd-Frank Act (supplier E). This act regulates the reporting of conflict minerals in products of US stock market listed firms and led to an involvement of almost a 100% of all tantalum suppliers in the CFSP as early as 2014 (Young, 2018). Such institutional influences in multi-tier SCs have only recently started to be investigated (e.g. Busse et al., 2016; Sauer and Seuring, 2018). Nevertheless, the interviews underline their relevance for research and practice.

In summary, the interviews re-enforce previous literature suggesting that the positioning of the visible horizon, that is central to multi-tier SCM (see also Figs. 1 and 2), can be linked to a) SC complexity (see also Section 2). Moreover, it becomes evident that b) the material of interest as well as the use of related standards such as the ASI to *complement* the FF's SCM and that c) the cognitive and regulative structures, i.e., institutions, influence the availability of multi-tier supplier transparency and thus the positioning of the visible horizon. The interviews identify that the institutional fields that FFs are able to create without a standard often do not entail the entire SC up to the raw material suppliers, as depicted in the upper part of Fig. 2. Moreover, the FFs often cannot impose their practices, structures and values, i.e., the preferred SC institutions, beyond tier-1 or tier-2 suppliers depending on the FF's visible horizon. Three of the seven suppliers state to use standards and have SC visibility. Suppliers E and G are involved in SCs of conflict minerals and aluminum. While supplier G supports only the conflict mineral SC with a standard and has no visibility in the other, supplier E applies standards in both SCs and reports high visibility in both of them. In effect, standards can be seen as key to drive the SC as an institutional field and the related institutions beyond the visible horizon, as theorized in the conceptualization in Section 2.3.

Nevertheless, the interviews provide evidence limited to single standards and to single *complementing* functions of them. To enable a comprehensive investigation of the available standards and their *complementing role*, the document analysis is presented next.

4.2. Descriptive analysis: sc coverage and standard ownership

First, Table 4 depicts the *inclusivity* of a standard in its decision-making bodies, also referred to as *standard ownership* (Müller et al., 2009; Tröster and Hiete, 2018; Young, 2018). From the reviewed standards 80% involve the industry and 50% represent multi-stakeholder systems. Considering the *geographical coverage* that hardly focuses single continents, the standard's international and self-regulating character becomes obvious.

Regarding the *material coverage*, a focus on the valuable metals like

Table 4
–Results of the descriptive analysis of the reviewed standards ($n = 20$).

	KP (2003)	ICMM (2008)	CTC (2011)	CFSI (2012a, 2012b, 2013a, 2013b, 2013c, 2014)	WGC (2012)	Bettercoal (2013)	Fairtrade (2013)	GRI (2013)	RJC (2013)	ARM (2014)	RCM (2014)	iTSCi (2014)	LBMA (2015)	DDI (2016)	EITI (2016)	Fair Stone (2016)	ICMI (2016)	IRMA (2016)	Xertifix e. V. (2016)	ASI (2017a, 2017b)	SUM
Standard ownership																					
State			x								x										2
Industry		x		x		x	x					x	x								6
NGOs							x			x											2
Industry - NGOs								x	x								x	x		x	5
State - Industry - NGOs	x													x	x	x			x		5
Material coverage																					
Mineral resources in general		x						x							x			x			4
Coal						x															1
Natural stones																x			x		2
Bauxite/ Aluminium																				x	1
3Ts (Tin, Tantalum, Tungsten)			x	x							x	x									4
Gold			x	x		x		x		x	x		x				x				9
Silber							x			x							x				3
PGEs (Platinum Group Elements)							x		x	x											3
Diamonds	x								x					x							3
Geographical focus																					
no focus	x	x		x		x	x		x	x			x	x	x		x	x			12
Europe																					0
Oceania							x			x											2
Asia							x			x						x			x		4
Latin America							x			x						x					3
North Amerika																					0
Africa			x				x			x	x	x				x					6
Supplier coverage																					
Extraction only		x				x		x							x			x			5
Extraction to export	x		x								x			x			x				5
Extraction to smelter				x								x	x								3
Entire SC						x	x		x	x						x			x	x	7

the 3Ts (global annual production 401,047 t/a), Gold (3367,607 t/a), Silver (27,698,787 t/a), PGEs (435,545 t/a), and Diamonds (29 t/a) is evident with 12 of 20 standards focusing them. Contrastingly, the mass metals bauxite/aluminum (334,962,385 t/a), coal (6824,114,436 Mt/a), and natural stones are focused by four standards and four more standards are generic (all production data by Reichl & Schatz (2020)). This supports previous studies, which found strong coercive pressure on downstream buyers to prove the legitimacy of their mineral suppliers (e.g. Hofmann et al., 2018).

The *geographical coverage* underlines the distribution of sustainability hotspots of mineral SCs in the global south and developing countries. Strikingly, no standard focuses Europe or North America, but seven standards focus on the remaining continents. Considering *supplier coverage* as a measure for which and how many tiers the reviewed standards cover, none of these seven standards focuses on mineral extraction only, but the standards underline the need for a multi-tier *supplier coverage* as proposed by Müller et al. (2009). Moreover the centrality of SC cooperation for resolving sustainability challenges in the often international mineral SC is underlined (Hofmann et al., 2018; Sauer and Seuring, 2017, 2019; Young, 2018).

Table 4 shows four groups of standards significant to *supplier coverage*. Two groups focus on extraction only or extraction to export, which is relevant for conflict minerals or diamonds. These are often mined and traded in conflict-affected areas, and their sourcing represents a reputational risk for the SC that needs to be reported (Haufler, 2009; Hofmann et al., 2018). Moreover, this extraction to export scope underlines the value of conceptualizing the SC as a meta-institutional field since the actual SC spans multiple national fields that are substantially different from an institutional perspective. A more material stream oriented logic applies to conflict minerals when certifying the smelter, that has also been found in the interviews in the automotive SC. The smelter represents an ideal bottleneck for monitoring global metal ore streams, as the number of smelters is substantially lower than the number of exporters (Young et al., 2014; Young, 2018). Notably, only the remaining seven standards establish a comprehensive supplier coverage, yet they are very specific regarding the minerals they address and focusing fair labor conditions. Out of these seven, only the industry-specific standards ASI (2017a, 2017b) and Bettercoal (2013) focus all TBL dimension.

In summary, none of the reviewed standards combine the theoretical best-case of full *SC coverage* (including generic geographical and mineral coverage) and full *inclusivity of / ownership by* a diverse stakeholder group in the decision-making bodies. This emphasizes the complexity of the minerals sector (Young et al., 2014; Young, 2018), whose "heterogeneity, scarcity, and risks […] are much more complex than many realize" (Sauer and Seuring, 2019, p. 8) and in which one standard "may not provide an effective model for regulating other 'conflict commodities' because of the[ir] unique character" (Haufler, 2009, p. 403). This underlines the negative impact of SC complexity on SSCM as well as the relevance of investigating it further (Wilhelm et al., 2016). This incompatibility among *SC coverage* and *inclusivity/ownership* remains a field for future research. Despite this, the standards cover the sustainability hotspots in mineral SCs and some reach out to downstream buyers. Nevertheless, a standard's potential for *complementing* MT-SSCM is also driven by their overlap of prescribed values, practices, and structures, which is evaluated next.

4.3. Material evaluation: sscm for minerals practices prescribed by the standards

Table 5 shows which standard prescribes the use of which SSCM for minerals practices that define the strategic values, SC structure and SSCM processes in a sustainable SC of mineral resources (Sauer and Seuring, 2017).

4.3.1. Government interventions

Noticeably, all standards reference government interventions, especially *direct regulation* by defining the respective national legislation and the acquisition of local mining or export licenses as minimum requirements. Furthermore, eleven standards define minimum ages of laborers and maximum working hours (IRMA, 2016), corruption and discrimination measures (ASI, 2017b), or rely on systems such as the OECD Due Diligence Guidance (iTSCi, 2014) and ILO Conventions (ASI, 2017b; Fair Stone, 2016) to *complement* national regulations. These requirements and national legislation thus become part of the certification and incline minimum requirements toward more Western sustainability perceptions. Contrastingly, the remaining multi-stakeholder practices in the government interventions category are largely bypassed.

The standards underline that the international nature of mineral SCs leads to substantial gaps in state governance of sustainability in the sector (Hofmann et al., 2018; Sauer and Seuring, 2017). These issues have also been outlined as challenging for the automotive SC in Section 4.1. This requires in some countries a complementation by private actors, i.e., the standards or SCs, to ensure legitimate operations and underlines the synergies that standards and SCM can generate in this industry (see also Young, 2018).

4.3.2. Orientation

According to the initial definition of this category by Beske and Seuring (2014) and the refinement by Sauer and Seuring (2017), this category has a pure strategic or organizational policy focus evaluating the values that drive the investigated organization. In effect, the orientation category needs to be distinguished from the following categories that investigate actual practices in the organizations' operations that can but do not have to be backed by a dedication to SCM or the TBL. The reviewed standards hardly address the orientation category, and only ICMM (2008) and ASI (2017a) explicitly push the *dedication to SCM* that helps to institutionalize cooperation and SCM in the chain. Similarly, there is a lack of TBL dedication that is found in four standards only (ASI, 2017a; Bettercoal, 2013; RJC, 2013; ICMM, 2008), which nevertheless have a clear social focus on workers' rights, health and safety requirements, minimum wages, minimum workers' ages, and maximum working hours.

Combining both practices, ASI (2017a) and ICMM (2008) emerge as best-cases. Despite their similarities, ASI (2017a) covers the entire SC and is one of the most recent standards, while ICMM (2008) was among the frontrunners in the sector exclusively dedicated to extraction operations.

4.3.3. Continuity

Both orientation and government interventions drive the creation of continuity in the SC. Only four of the 20 standards address *long-term relations*. However, they propose to "establish, where practicable, long-term relationships with suppliers as opposed to short-term or one-off contracts in order to build leverage over suppliers" (OECD 2016, p.40), which perfectly fits (S)SCM principles (Beske and Seuring, 2014; Chen and Paulraj, 2004). Surprisingly, only one of the standards referring to *long-term relations* covers the entire SC (Fairtrade, 2013). However, *SC partner selection* is represented in all but two standards and mainly links to a chain of custody, defined as an "assessment of corporate processes and production conditions at every company with financial ownership of the respective product" (Hofmann et al., 2018, p. 121; see van den Brink et al., 2019 for an overview of related approaches) covering, for example, the entire SC "from certified conflict-free mines in the DRC, all the way to final end-product in the USA or other markets" (Young, 2018, p. 1437). This practice is prevalent for conflict minerals with reporting requirements on material sources. Moreover, some standards require the termination of relations with non-compliant suppliers to ensure fully certified SCs. *SC partner development* practices used by the standards refer to corrective action plans, training, prepayments, and progressively increasing performance goals.

Table 5
– Coding results of the SSCM for minerals categories and practices ($n = 20$).

	Xertifix	WGC	LBMA	RJC	ICMM	Fairtrade	CTC	Fairmined	CFSI	Bettercoal	ASI	RCM	ICMI	iTSCi	IRMA	Fair Stone	DDI	KP	EITI	GRI	SUM
1. Government interventions (focus: compliance to government practices)																					
Direct regulation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
Interactive regulation					x								x								2
Facilitating self-regulation												x						x			2
Government as consumer								x											x		2
2. Orientation (focus: firm strategy)																					
Dedication to TBL				x	x					x	x										4
Dedication to SCM					x						x			x							3
3. Continuity (focus: firm practices)																					
Long-term relationships						x		x						x	x						4
SC partner selection	x	x	x	x	x	x	x	x	x	x	x	x	X	x		x	x	x	x		18
SC partner development	x	x	x	x	x	x	x	x	x	x	x	x	X	x		x			x		16
4. Collaboration (focus: firm practices)																					
Technological integration												x		x		x					3
Logistical integration												x		x				x			3
Enhanced communication	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	19
Joint development														x		x					2
5. Risk management (focus: firm practices)																					
Standards and certification			x			x			x	x	x			x					x		7
Selective monitoring	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
Pressure groups		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x			16
Governance gaps		x		x	x	x	x	x		x				x			x				9
Primary supply stability																					0
6. Pro-activity management (focus: firm practices)																					
Stakeholder management	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	19
Learning						x				x	x				x			x	x		6
Innovation					x					x	x				x						4
Environmental pro activity					x						x		x		x	x	x			x	7
Linkage development		x	x	x	x	x	x	x		x		x		x	x		x		x	x	14
SUM	6	9	8	10	14	12	9	11	8	13	13	11	8	15	10	10	8	9	10	6	200

Ultimately, the standards' *supplier selection* and *development* practices can level out national differences in international SCs. The standards can enhance supplier sustainability or support supplier selection decisions, thus reducing supply uncertainty. In turn, they define internationally legitimate practices and corrective actions beyond the termination of contracts that reduce the suppliers' demand uncertainty. Still, these effects could be strengthened by emphasizing *long-term relations* that enable SSCM success (Beske and Seuring, 2014) since buyer - (sub-) supplier relations are often limited by large cultural and physical distances in international SCs in general (Carter et al., 2015) and mineral SCs in particular.

4.3.4. Collaboration

Collaboration is driven by *enhanced communication*, which is established in all standards but one (DDI, 2016). The standards describe it as "Coordination between industry members who share suppliers", "Cooperation between upstream and downstream companies", and "Building partnerships with international and civil society organizations" (all quotations: OECD, 2016, p. 14), and sharing information via chain of custody systems. This reduces supply and demand uncertainty by providing information within the SC and across national fields. Contrastingly, the category's remaining practices are largely bypassed, although *integration* and *joint development* add value to the relationship and thus reduce the likelihood of its termination and supplier misconduct (Simpson et al., 2012). Only four standards define online tools for sharing information falling under *technological integration. Logistical integration* is associated to the chain of custody but refers to the handling of certified materials. Nevertheless, more *integration* could drive the operational efficiency and reduce both supply and demand uncertainty by implementing similar processes and structures in the SC.

4.3.5. Risk management

All standards apply the *selective monitoring* of suppliers by defining auditing requirements that are central to third party standards (Müller et al., 2009; Terlaak, 2007) and thus unsurprising. Although the conflict minerals standards do not cover the entire SC, they are "specifically designed to assist downstream customers with their compliance to Section 1502 of the Dodd-Frank Act" (CFSI, 2012b, p. 21). Also interesting is the handling of *pressure groups*, in which state and customer are both mentioned by six standards and NGOs only by three. Seven standards focus on *standards and certificates* by requiring the definition and enforcement of codes of conduct (e.g. ASI, 2017b) in either their own operations or also the ones of business partners by including the code of conduct into contracts (e.g. Fairtrade 2013, iTSCi, 2014). This might seem surprising, but the standards only define the issues to address and practices to do so. However, the standards often do not define exact thresholds to be adhered to in these practices but leave this to the individual firms and SCs so that they can adjust to the specificities of their mines, facilities, and the related context. This again reduces uncertainty about suppliers' behavior and used materials. *Governance gaps* are closely associated to lacking state actors' enforcement capabilities, which are thus taken over by private actors (Hofmann et al., 2018; Kelling et al., 2020; Terlaak, 2007; Muduli et al., 2013); however, distant FFs might not be powerful enough or may lack awareness of and influence over actors (Sauer and Seuring, 2019). In such cases, this responsibility can be delegated to third parties that combine the power of all buyers they represent (Tachizawa and Wong, 2014; Tate et al., 2011; Agyemang et al., 2018). The only practice not addressed is the *primary supply stability*, a concern of downstream SC partners (Sauer and Seuring, 2017), while the reviewed standards take an upstream perspective in which this is implicitly included in all considerations.

4.3.6. Pro-activity management

Stakeholder management practices encompassing the inclusion of stakeholders into the standards' governance bodies and supporting local stakeholders is mentioned by 19 standards. It mainly covers grievance mechanisms, pro-actively informing stakeholders, considering indigenous people and planning for a sustainable mine closure. 14 standards cover the *linkage development* practice focusing enhanced local infrastructure, governance capacities and education besides transparent tax payments. This helps to reduce supply and demand uncertainty by enhancing supplier sustainability. Only seven standards cover *environmental pro-activity* meaning ecologically beneficial practices, which can be strengthened to complement the social focus and achieve TBL performance. Contrastingly, *innovation* and *learning* practices are lacking, which, however, are more directed to inter-organizational cooperation (Beske and Seuring, 2014) that lies outside the scope of a sustainability standard and is only touched by six and four standards respectively.

The findings provide empirical evidence on how the standards can be used to realize synergies with the management of international and multi-tiered SCs. This answers the research questions and contributes to our understanding of standards in MT-SSCM. This contribution is discussed in detail in the following section.

5. Discussion

5.1. Theoretical contributions to (S)SCM

This study is one of the first studies to provide a theoretical conceptualization of multi-tier or extended SCs and standards as meta-institutional fields together with an empirical support of how they can *complement* each other. As outlined in the research questions this *complementation* serves a two-step process of a) identifying previously unidentifiable SC members by analyzing the institutional field a standard creates and b) managing these suppliers by relying on the enforcement of legitimate structures, strategies and values, i.e., institutions embraced by the standard. This conceptualization enhances our understanding of multi-tier supply chains and their management and contributes to theory elaboration in SCM and SSCM in two main ways:

First, it refines the conceptualization of institutional fields in general, that has been criticized for being too simplistic for the complexity today's global business (Kostova et al., 2008; Wooten and Hoffman, 2013). This is achieved by moving beyond the currently mostly absent or simplistic definitions of a SC as the sum of suppliers, customers and the focal firm (Sauer and Seuring, 2018; Wu and Jia, 2018) that disregard the challenges that arise from cultural, physical, and SC distance, i.e., the number of tiers to be managed (Carter et al., 2015) as well as differing characteristics of material streams. In effect, the proposed conceptualization allows (S)SCM researchers and practitioners to understand what is hindering them from moving beyond the visible horizon into the "blind spot" of current SCM theory and praxis (Carter et al., 2015) and identifies the *complementing role* of standards for realizing this.

Second, this study grounds the use of standards as an efficient approach for enhancing the reach of sustainable multi-tier SCM (as proposed by Tachizawa & Wong (2014)) into parts of the SC the FF originally was not having any information (Schöggl et al., 2016), thus impeding any supplier management. This is achieved by defining and embracing the idiosyncrasies of MT-SSCM, such as the absent or at least lacking visibility of upstream suppliers to the FF, but to upstream standards, this study drives our understanding of the field, a need suggested by Durach et al. (2017). By building on these idiosyncrasies, the study at hand refines the evaluation of a standard's *SC coverage* and *inclusivity/ownership*. This theory elaboration improves the adequacy of SSCM theory regarding the *complementing role* of standards (Fisher and Aguinis, 2017), since the previous concept of *SC coverage* did not include the materials and regions covered by a standard. However, the results reveal that the reviewed standards limit their applicability to regions like the Democratic Republic of Congo that is a hotspot in mining related human rights violations (CTC, 2011; Hofmann et al., 2018). In line with Bubicz et al. (2019), this focus beyond the developed countries enriches

the social component of SSCM (see also Rentizelas et al., 2020). The self-limitation of the standards moreover enables a closer match of the certification requirements, i.e., the operationalization of the underlying institution, to the specificities of the context, i.e., the institutional field. This underlines the value of the approach taken in this study that focusses these two core elements of institutional theory. Nevertheless, the analysis could not find comprehensive *SC coverage* and *inclusivity/ownership* in their theoretically optimal combination. This raises the question of their mutual compatibility as a future research direction. However, the observed *SC coverage* of the standards supports prior propositions about the importance of covering central SC stages (Müller et al., 2009; Tröster and Hiete, 2018; Young, 2018), such as the most powerful buyers that might sit at the downstream end of the chain, in order to motivate suppliers to adopt the standard (Tate et al., 2011; Chkanikova and Sroufe, 2020) and ensure consistent legitimacy attributions across the entire SC (Busse et al., 2016).

5.2. Implications for managing international and multi-tiered supply chains

This study has provided evidence of the *complementing role* of standards to identify previously hidden SC members and using this knowledge and the standards to mitigate supply risks related to sustainability as well as reducing the demand uncertainty in the context of the minerals sector. The findings underline that the standards are particularly strong in enhancing communication among standard members, which is a key feature of the standard as a meta-institutional field and a critical enabler of success in (S)SCM (Beske and Seuring, 2014; Carter et al., 2015) and even more in complex and vulnerable multi-tier SCs (Sauer and Seuring, 2019; Tachizawa and Wong, 2014; Wilhelm et al., 2016).

Combining the standards' strengths in driving communication with their focus on selecting and developing suppliers, this study provides evidence that the standards can help to enlarge and shape the SC as an institutional field. They can especially build a basis for identifying field actors who are new and valuable to the SC and institutionalizing the FF's values and practices at both sides of the visible horizon. This adds to the suggestions of including NGOs, competitors, and trade groups into the SC (Pagell and Wu, 2009) and delegating management or monitoring responsibilities to them (Tachizawa and Wong, 2014; Wilhelm et al., 2016).

The results thus explicitly add the reduction of SC uncertainty and the postponement of the visible horizon further upstream to the current perception of standards as a relatively cost-effective means of risk mitigation (Beske and Seuring, 2014). The study moreover suggests that in contrast to the agricultural, forestry, fishery or retailing industry, which dominate the current academic discussion on certification (Tröster and Hiete, 2018; Chkanikova and Sroufe, 2020), the visible horizon as a driver of uncertainty is especially relevant in the minerals sector, which is found to have only recently developed reliable certification and tracing systems. This supports the growing trend for comprehensive certification of the sector (Kickler and Franken, 2017) and further answers the call by Kauppi (2013) for considering SC uncertainties that build the link to institutional theory that also aims to reduce uncertainty.

Finally, the findings show a growing body of standards that cover the entire SC (see Table 4) and that SCM considerations are generally gaining traction in the sector, which is traditionally decoupled from downstream industries (Hofmann et al., 2018; Sauer and Seuring, 2017). This trend enhances the *complementing role* of the standards for MT-SSCM for passively mitigating risks and pro-actively driving sustainability, as Beske & Seuring (2014) suggested. The standards can thus reduce uncertainty in complex multi-tier SCs and drive the formation of a uniform and institutionalized set of sustainability requirements along them, as called for by Busse et al. (2016) and Wu & Jia (2018).

Despite the focus of this study on the FF, the reduction of uncertainty should not be understood as a one-way road to the benefit of FFs and downstream actors. It should rather be understood as a shared responsibility in multi-tier SCs focusing on supply and demand uncertainty simultaneously. The review results underline that the standards offer a tool for establishing visibility as well as compliance and for generating price premiums and establishing profit-sharing schemes that relief the price pressure on suppliers that is typical for commodity SCs (Sauer and Seuring, 2017; Young, 2018). Beyond the standards, Hofmann et al. (2018) showed that a compliance-oriented implementation of SC Due Diligence for minerals enhances the financial performance of SC partners irrespective of SC position and size. Relating this to the conceptualization and especially Fig. 1 on the idiosyncrasies of multi-tier SSCM, FFs' SC managers have the opportunity to counter the sustainability hotspots at their upstream suppliers. These hotspots have been created by decades of cost pressure combined with lacking visibility. The standards offer viable tools for pro-active SSCM beyond the original visible horizon including risk and benefit sharing, supplier development and stakeholder engagement in which the standards excel (see Table 5).

5.3. Implications for research and practice on sustainability standards

Some findings support mainstream institutional research on standards, such as the complementation of national regulation (Bartley, 2007; Terlaak, 2007). Nevertheless, the standards can complement national regulations that might not live up to western sustainability perceptions. This is especially valuable, as these perceptions are critical to the legitimacy attribution of the FF's stakeholders (Busse et al., 2016).

Moreover, this study adds to understandings of how standards can not only add value for the industry sectors from which they emerge but also the customers or suppliers of these sectors. This applicability across industry sectors has two major implications. First, it enlarges the basis for evaluating the relevant legitimacy-granting subjects (Suchman, 1995) from the stakeholders of the organization which conducts the (non-)legitimate practices to the stakeholders of the organization that finances this conduct by buying related products (see also Chkanikova and Sroufe, 2020). Although, NGOs have held FFs responsible for their suppliers for many years, this difference of legitimacy attributions across the SC has been neglected in SSCM (Busse et al., 2016). Still, the findings provide evidence that the standards fall short in driving the integration of up- and downstream SC actors, which is a major barrier to more sustainability in the sector. Additionally, the findings reveal that multiple standards exist for one mineral, which fragments the market and reduces the pressure on single suppliers to adopt a standard (Tate et al., 2011; Hiete et al., 2019). Second, the results of this study bring more detail to the importance of a SC perspective to sustainability standards and enable a better investigation of it by refining the constructs of *inclusivity/ownership* and *SC coverage*. This alteration adds to the validity and scope of the original constructs by Müller et al. (2009), which are now better suited to investigating the SC components critical to sustainability performance.

Moreover, the findings indicate two blind spots of the standards. In particular, the relational aspects of SSCM can be strengthened by emphasizing strategic values besides enhanced *integration* and *long-term relations* among SC partners. Furthermore, there is a lack of ecological concerns in the analyzed standards since Table 5 reveals that not even half of them prescribe environmentally pro-active practices. Closing this gap could enhance the *complementing role* of the standards for SSCM, as this would enable the standards to certify TBL performance as called for by SSCM scholars (Beske and Seuring, 2014; Schöggl et al., 2016; Guarnieri and Trojan, 2019) and Western regulators (Hofmann et al., 2018).

5.4. Implications for regulating and governing multi-tier mineral supply chains

The findings of the study underline a high specialization of the standards on valuable minerals, which are in the focus of public

attention and that are familiar to the end-customer. In stark contrast to this, only few standards are generic or focus mass minerals which account for the bulk of mineral extraction (Reichl and Schatz, 2020) and the related social and environmental impacts (e.g. Owen et al., 2020). Moreover, the state is involved in a total of seven of the 20 reviewed standards and there is an evident reaction of standards to regulation of minerals' origin and sustainability (Young, 2018; Sauer and Hiete, 2020). In effect, the available standards and the conceptualization offered in this study underline that there is a widely applicable body of standards that provide ample opportunity for SCs and firms to take more responsibility for their mineral SCs. This implies for national and supra-national policy makers that such responsibility in mineral SCs can increasingly be demanded, especially from large and multi-national firms that often already practice SC Due Diligence for minerals like Gold or the 3Ts (e.g. Young, 2018; van den Brink et al., 2019). Finally, the findings also support at least for the field of minerals some recent SC related regulatory actions like the laws for SC responsibility in Germany or against modern slavery in the United Kingdom.

6. Conclusions, limitations and research directions

FFs and buyers in global SCs have recently realized the impact of raw materials such as mineral resources for their products' sustainability and are actively reaching out to the upstream SC that is however hidden behind their visible horizon. This study thus sheds light on the *complementing role* of standards for the establishment of more sustainability along the extended SC. Its findings can guide SC and standard managers by providing evidence of which SSCM practices are already applied by the standards and how standards can be developed further to enhance their *complementing role* for the needs of the downstream buyers who, at least indirectly, drive the mineral market (Young, 2018).

However, the study has four major limitations that need to be acknowledged but also lead to way for future studies in the issue. First, the interviews conducted to identify the challenges related to the visible horizon in multi-tier SCs are specific to the automotive industry and a single automotive SC. Competing SCs or other industries might not feature the same SC complexity, most notably the high number of tiers in the investigated automotive SC thus leading to potentially different results. Second, the evaluation of the SSCM practices is based on a single framework by Sauer and Seuring (2017), limiting the generalizability of the results. Third, the study is single-authored and the coding is, thus, subjectively influenced. Although the study was carefully designed considering validity and reliability concerns in content analysis (Mayring, 2010), other authors might come to different findings. Fourth, large parts of the analyzed material have not been designed from a SC perspective and mainly focus on the upstream SC, limiting the generalizability of the results but ensuring the comparability of the reviewed objects (Durach et al., 2017). Nonetheless, the findings underline the large overlap of the standards with SSCM practices justifying the used conceptualization.

The proposed theoretical conceptualization in Section 2.3 carefully enlarges current theory and offers, thus, a number of research directions. These include a further empirical validation with traditional and non-traditional actors involved in the sectors (Pagell and Wu, 2009), such as interviewing certified mines, traders, FFs, regulators, and stakeholders to investigate their perceptions of the uncertainties and potential alterations of the standards. Involving for-profit and societal actors is rare in SSCM research but promises rich insights (Wu and Jia, 2018). Moreover, the influence of institutional similarities can be evaluated by investigating certified actors in similar contexts, such as mines and FFs in the US or European Union. This suggestion is again biased by a developed country perspective (Bubicz et al., 2019), but entire SCs in developing economies are scarce in the sector. Considering theory, this study used sustainability standards and the mineral sector as an example. Questions remain about what the refined variables look like in sectors other than minerals and in fields other than sustainability. Finally, this study focused on the role of standards in identifying and managing actual suppliers, but the standards also offer ample opportunities for finding and selection new suppliers. Future studies could thus enlarge the conceptualization given in Section 2.3 to include such considerations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.resconrec.2021.105747.

APPENDICES

Appendix – Prior studies on the topic including their focus

Prior studies	Analyzed standards	Study focus
Stark & Levin (2011)	8	• "which Standards most effectively safeguard specified social, environmental, and management issues in the industrial gold mining sector" • "The credibility and effectiveness of the Standards were evaluated through benchmarking, stakeholder consultation, and review of documentary critiques"
Stetter & Zangl (2013)	7	• "identifying the institutional characteristics of successful Global Standards and Certification Schemes" • Intersection to SCM: systematic evaluation of chain of custody systems and of the actors involved in the standard
Young et al. (2014)	4	• "Four initiatives are reviewed to illustrate the status and prospects of metal certification (…). Opportunities and issues for growth of metals certification are considered."
Mori Junior et al. (2015)	15	• Scope: "full range of planned and operational schemes applicable to the mining, minerals and metals industries and their supply chains"

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Prior studies	Analyzed standards	Study focus
Kickler & Franken (2017)	19	• "design characteristics: objectives, focus, process for standards development and operation" • Comparative analysis of "the schemes' various objectives and scopes, their respective supply chain coverage and differences in standard catalogues and requirements" • "details on their characteristics such as standard-setting, type of conformity assessments, auditor status and frequency of assessments, grievance mechanisms and transparency on company performance"
Young (2018)	16	• "enquiry into program governance, program standards, and certification processes" • "The object is to examine the structure and operation of certification of raw materials and explore strengths, weaknesses, and opportunities of certification as a mechanism for responsible sourcing."
van den Brink et al. (2019)	15	• "This study maps the sustainability requirements of such schemes and uses these to categorize them as socially responsible sourcing, sustainable sourcing or green sourcing. It also identifies the extent in the supply chain to which the schemes provide assurance or certification and how far traceability extends."
Sauer & Hiete (2020)	20	"This study thus aims to contribute to answer the following research questions: • To what extent do MSIs represent a social innovation from a governance perspective? • How do voluntary MSIs for responsible mining complement the authority-based governance of sustainability in the mining sector?"

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