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Using Country Sustainability Risk to Inform Sustainable Supply Chain Management: A Design Science Study

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The sustainability of our global supply chains is an essential concern in strategic supply chain management research. Modern information and communication technologies enable stakeholders to punish buying firms for any sustainability-related grievances at their suppliers, even in remote locations. This study investigates how the notion of country sustainability risk can inform sustainable supply chain management, in particular with respect to sustainability risk assessment at the individual supplier level. Drawing on institutional theory, we provide insights surrounding the emergence of environmental, social, and governance-related country-level sustainability risks and show their implications for and application in sustainable supply chain management. The study employs a design science methodology, based on cooperation with a multidivisional German technology firm, to develop a supply chain sustainability risk (SCSR) map as technological solution design. This article contributes to the study of SCSR by reconciling the scholarly SCSR discourse with the buying firms' pursuit of efficiency. Moreover, it elucidates the augmentation of a research agenda through a design science approach. In practical terms, the technological solution design can directly inform managers about SCSR at the country level and serves as a decision basis for the management of individual suppliers.

Keywords: supply chain risk; sustainability; design science; institutional theory; stakeholder

INTRODUCTION

Today, buying firms assess their global suppliers not only in terms of economic criteria such as quality and price, but also with respect to environmental criteria such as emissions and waste and social criteria such as pay and workplace security (Klassen and Vereecke 2012; Lee et al. 2014; Sanders and Wood 2015). They do so because stakeholders observe buying firms closely and may punish them if they regard their suppliers' sustainability-related conditions as illegitimate (Carter and Rogers 2008; Reuter et al. 2010).

On the one hand, the resulting supply chain sustainability risk (SCSR) has gained importance in recent years due to the advances in information and communication technology offered by the Internet and its associated technologies and services (Isenmann et al. 2007; Autry et al. 2013). Through media such as online newspapers or Facebook, stakeholders can easily obtain and share information about negative sustainability-related incidents in supply chains (Bansal 2005). Apple, for instance, was recently criticized for purchasing from cobalt mines in the Congo where adults and even children were found to be working in hazardous conditions (Fortune 2017).

On the other hand, supply chain complexity keeps buying firms from assessing the sustainability of all of their suppliers (Rossiter Hofer and Knemeyer 2009; Bode and Wagner 2015). Buying firms therefore often face information-processing challenges surrounding the sustainability-related conditions in their upstream supply chains (Busse et al. 2017b; Foerstl et al. 2018). Consequently, they are rethinking the SCSR assessment strategies for their complex supply chains (Flint and Golicic 2009; Golicic and Smith 2013). New technologies and software tools can support this effort, responding to the increased need for efficient SCSR assessment (Shevchenko et al. 2016; Wieland et al. 2016). Nevertheless, no comprehensive framework for an efficient SCSR assessment is available (Gimenez and Sierra 2013).

SCSR research has shown *that* country-level risk is an established criterion for selecting a supplier (Canzaniello et al. 2017) and represents the foundation for sustainability-related supplier development (Reuter et al. 2010). However, in the context of sustainability it is not yet clear *how* country-level risk can be measured nor *why* it is important for supplier assessment. Against this background, the purpose of this study was to explore whether publicly available proxy variables at the country level can facilitate supplier-level sustainability risk assessment. Under the premise that sustainability-related country-level data are available and that sustainability-related supplier-level data are not, this article posits the following research question: *How can the assessment of sustainability risks at the supplier level be informed by measures of country-level sustainability risk?* By answering this research question, our study provides a theoretical understanding of sustainability risk at the country level. The country-level sustainability risk measure can be used for managing supply chain complexity in the context of SCSR assessment, thereby reducing the associated costs.

We employ a design science methodology, based on cooperation with a multidivisional German technology firm to facilitate the assessment of SCSR (Van Aken 2004; Tanskanen et al. 2015). In doing so, we strive for "finding balance in strategies that mitigate risks while not wastefully deploying resources," which is one of the "greatest hits" for practitioners (Zinn and Goldsby 2017, 4). The theoretical foundation of our study is institutional theory (Campbell 2007). The remainder of this article is structured into four sections. The next section describes the conceptual background, expressing the need for an efficient

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solution design to assess SCSR. In the second section, we present the design science methodology along with the empirical context and the solution design development process. The third section offers the results, which include the solution design, three use cases on applying it, and a methodological contribution that elucidates how the design science methodology can augment a research agenda, in this case for the efficient assessment of SCSR. We conclude with a summary of the study, its contributions and limitations, and possibilities for future research.

CONCEPTUAL BACKGROUND

Sustainability risk in supply chains

Risk in supply chains can be considered the likelihood of a negative deviation from the expected value of one or more performance goals (e.g., profit or customer satisfaction), leading to negative outcomes for a buying firm (Manuj and Mentzer 2008; Wagner and Bode 2008). Numerous researchers have developed conceptual frameworks on supply chain risk management (e.g., Ritchie and Brindley 2007; Rao and Goldsby 2009; Foerstl et al. 2010). Although the terminology differs among the studies, a supply chain risk management procedure typically consists of four steps: risk identification, risk assessment with regard to likelihood and influence, risk handling, and risk monitoring (Hallikas et al. 2004; Kaufmann et al. 2016). Our study focuses on risk assessment. Without a structured risk assessment, an effective management of supplier sustainability can only be achieved by chance, resulting in potentially harmful financial losses (Foerstl et al. 2010; Wagner et al. 2017).

In the supply chain risk management discourse, SCSR has recently attracted increased research attention (e.g., Foerstl et al. 2010; Hajmohammad and Vachon 2016). SCSR is "a condition or a potentially occurring event [. . .] within a focal firm's supply chain [. . .] that may provoke harmful stakeholder reactions" (Hofmann et al. 2014, 168). It manifests only when stakeholders become aware of one or more negative sustainability-related incidents in the upstream supply chain, assign responsibility to the buying firm, and then punish the buying firm accordingly (Hofmann et al. 2014). For example, customers as stakeholders can exert pressure on buying firms when they stop purchasing their products due to the unsustainable behavior of the buying firms' suppliers (Bregman et al. 2015; Wood 2015). Overall, SCSR can be subcategorized into environmental-, social-, and governance-related (jointly: sustainability-related) issues (Schleper and Busse 2013).

The largest share of a company's sustainability risks falls outside of its direct operational control in manufacturing, packaging, and transportation (Giannakis and Papadopoulos 2016). Therefore, companies should develop an early warning instrument with regard to sustainability risks by building detailed knowledge about sustainability issues within their supply chains (Koplin et al. 2007). Information technologies facilitate the development of suitable instruments as they already have proven in the past (Boone et al. 2012). However, the development of an early warning instrument with the help of information technology is difficult, since buying firms are never fully informed about the sustainability conditions at all supplier sites because of knowledge deficits, in addition to time and cost constraints (Christopher and Lee 2004; Sanders and Wood 2015).

Almost all buying firms purchase products or services from a large and globally distributed network of suppliers (Choi and Hong 2002; Sanders et al. 2016). Consequently, supply chain complexity is a key managerial issue for buying firms (Rossiter Hofer and Knemeyer 2009; Bode and Wagner 2015). Researchers make a distinction among horizontal (number of suppliers), vertical (number of tiers), and spatial supply chain complexity (physical distance between the buying firm and its suppliers) (Choi et al. 2001; Choi and Hong 2002). Jointly, the three dimensions of supply chain complexity obstruct the task of supplier-level sustainability risk assessment severely. This study reduces the associated task complexity through integrating country-level sustainability measures in the supplier-level assessment process.

There are several ways for buying firms to manage SCSR at the supplier level. The most important ones are supplier codes of conduct (Emmelhainz and Adams 1999), supplier self-disclosures (Reimsbach and Hahn 2015), and supplier audits (Joyce 2006). However, supplier codes of conduct are often insufficient assessment instruments, because suppliers may sign them despite behaving unsustainably. Supplier self-disclosures require a consistent supply base without alteration of suppliers over time and the suppliers' activities can be decoupled from their self-disclosures, meaning for instance that suppliers behave unsustainable despite claiming to be sustainable in their self-disclosure (Meyer and Rowan 1977; Jiang 2009). Supplier audits are very costly, making it prohibitive for them to be performed for each and every supplier (Spekman and Davis 2004). The same rationale applies to supplier development activities like trainings or improvement projects which can enhance the sustainability standard of suppliers (Sancha et al. 2015; Busse et al. 2016b), but are inherently costly as well. Against this background, an efficient assessment of SCSR at the country level can alleviate the concerns of the supplier-level sustainability risk assessment mentioned above.

An institutional explanation of sustainability risks in supply chains

Our research focus on the differences in SCSR explained by country-level differences suggests the use of institutional theory (Campbell 2007). Institutional theory is an established theoretical perspective within sustainable supply chain management research (Zhu and Sarkis 2007; Tate et al. 2011; Touboulic and Walker 2015) and has also been applied to SCSR (Busse et al. 2016a). The theory is concerned with the impact of institutions on the conduct of social actors like firms (Scott 1987; Zucker 1987; Powell and DiMaggio 1990). Institutions in this sense consist of "multifaceted, durable social structures, made up of symbolic elements, social activities, and material resources" (Scott 2014, 57). Due to institutional imprinting (Mezias 1990), the country level is a reasonable level of analysis.

Institutions lead to different expectations with regard to the conduct of firms (Meyer and Rowan 1977). Importantly, these expectations vary among countries (e.g., Dobbin 1994; Kostova and Roth 2002). There are three institutional pillars (Scott 2014). First, the regulative pillar is based on differences in rules,

regulations, and laws among countries. Suppliers are more likely to act sustainably if there are strong regulative elements with regard to sustainability, industrial self-regulation that ensures sustainable conduct, and political regulations through which nongovernmental organizations (NGOs) can operate (North 1990; Campbell 2007). In this vein, regulatory uncertainty even increases country-specific differences in sustainability due to differences in regulation enforcement (Mair and Marti 2009). Second, the cultural-cognitive pillar captures "widely held beliefs and taken-for-granted assumptions that provide a framework for everyday routines, as well as the more specialized, explicit and codified knowledge and belief systems promulgated by various professional and scientific bodies" (Scott and Meyer 1994, 81). Suppliers are socially embedded in their country of origin due to their managers, employees, and owners, who have a shared understanding of cultural-cognitive elements. This results in county-specific differences with respect to SCSR. Finally, the normative pillar describes the broader social obligations in a country, such as the working conditions of its employees (Xu and Shenkar 2002). In the same manner, country-specific differences in SCSR occur because of managers, employees, and owners holding the same values with respect to normative elements. To sum up, the three pillars provide evidence that the country-specific SCSR shapes the suppliers operating in this institutional environment.

Global supply chains usually involve numerous institutions and the perception of what represents legitimate conduct differs greatly among the institutional environments (countries) (Busse et al. 2016a). Only when firms comply with the requirements from their institutional environment (country), are they considered as legitimate (Suchman 1995; Busse et al. 2016a). Consequently, firms are influenced both by internal efficiency requirements and by the external institutions in their country (DiMaggio and Powell 1983; Scott 2014).

Country-level analyses have become increasingly popular in sustainability research. For instance, Maignan and Ralston (2002) show that there are differences in firms' public commitment to social sustainability in France, the Netherlands, the United Kingdom, and the United States, Husted (2005) establishes a link between countries' cultural properties and their environmental sustainability, Vachon and Mao (2008) investigate the link between supply chain strength (number and quality of suppliers) and sustainable development at the country level, and Busse et al. (2016a) demonstrate that the institutional distance between the buying firm and the supplier country increases the probability for SCSR.

Existing software solutions for the assessment of sustainability risks in supply chains

Software solutions for SCSR assessment received surprisingly little scholarly attention, despite their obvious relevance to corporate practice in our digitally interconnected world. With the application of such software solutions, supply chain complexity can be better managed by buying firms, leading to a reduced risk of undesirable stakeholder reactions due to negative sustainability-related incidents in the upper supply chain and to lower SCSR assessment costs (Waller et al. 2015). Therefore, we address the topic of efficient software-based SCSR assessment.

Several idiosyncratic software solutions facilitate the assessment of SCSR at the country level (see Table 1). Some software solutions are survey- (e.g., Achilles) or audit-based (e.g., Enablon), while others rely on firm-internal documents (e.g., Ecovadis) or measure criticism from the media (e.g., RepRisk). In this case, the studied German technology firm strove to have a scientifically viable software solution that relies on transparent and publicly available secondary data from renowned international organizations to ensure credibility. The solution should also be free of charge. To be clear, we make no assertion that the solution design developed in this study is superior to extant software solutions, but it is based on rigorous research.

METHODOLOGY

Design science methodology

Even though there has been profound scholarly attention to the sustainability of our global supply chains, most modern supply chains are still unsustainable (Mollenkopf et al. 2010; Pagell and Shevchenko 2014). In this vein, Goldsby and Zinn (2016) recognized that firms face unprecedented challenges that can be solved by academic researchers. With the *Journal of Business Logistics'* Practitioner Panel, Zinn and Goldsby (2017) identify that finding strategies for risk mitigation that do not consume too many resources represents an essential research topic in supply chain management. They conclude that researchers should also study practical challenges to generate interesting results and, consider applied research as an essential field of study for the *Journal of Business Logistics*.

Against this background, this study subscribes to the design science paradigm. It relies on a design science methodology focusing on a multidivisional German technology firm. The benefit of the design science methodology is its aim of enhancing practice (Holmstroem et al. 2009). It provides applicable solutions and, hence, increases the effectiveness of companies (Denyer et al. 2008). Therefore, employing a design science methodology can be particularly worthwhile for researchers who are concerned about the practical relevance of their results (Van Aken 2005). In contrast to design sciences, which are an appropriate means of solving real-world business problems, explanatory sciences revolve around the development of theory (Denyer et al. 2008). Table 2 summarizes the main differences between the prescription-driven design sciences and the description-driven explanatory sciences (Van Aken 2004; Holmstroem et al. 2009).

Our design science study seeks an efficient way to assess SCSR. We develop an SCSR map, specifically an Excel tool that provides an overview of the issue-specific and overall sustainability risk for different purchasing countries of the technology firm under consideration. Since we generate an initial solution design with our SCSR map, the study belongs to the solution incubation phase. We are not refining the SCSR map (i.e., testing it with a broader range of companies). Therefore, this research does not include the solution refinement phase.

Simon (1996) states that "everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (p. 130). In accordance with this view, management itself can be considered a design discipline (Simon 1996). The

Table 1: Existing software solutions for supply chain sustainability risk assessment (see Appendix 1 for exact data sources)

Software solution	Tool description	Data collection
Achilles	Achilles offers a fully managed supplier registration, information, compliance management, and prequalification service It provides supplier information via 40 online communities, covering key industries in more than 130 countries It underpins compliance with legislative and business standards, assessing suppliers' capabilities and financial, legal, health, safety, environmental, and quality risks	Prequalification (supplied products and services, business locations, annual revenues, anticipated contract value, number of employees) If necessary, surveys and audits as next step
ChainPoint	ChainPoint provides auditing and certification and makes it easy to establish new standards, or to use existing ones, and apply them along the supply chain. ChainPoint Analytics show the customer where he stands in achieving his key performance indicators by visualizing information gathered from the supply chain. ChainPoint Storytelling uses smart phone scanning to connect customers to supply chain information It monitors product-related factors at the supplier level (e.g., child labor, deforestation, and CO_2 emissions)	On-the-ground monitors, laboratory technicians, and inspectors provide real-time details Direct connection with information technology systems already in place If necessary, audits and certificates as next step
CSRware	CSRware prepares companies for U.S. federal contracts, antislavery requirements, supply chain performance improvement, and cost reduction by driving corrective actions Different industries are considered	Integrated scorecards/surveys If necessary, self-designed scorecards/surveys with existing or newly defined criteria
Ecovadis	Ecovadis provides reliable corporate social responsibility (CSR) ratings and scorecards, covering 21 CSR indicators, 150 commodities, and 110 countries It is useful for both buyers and suppliers	Online surveys customized to sector, size, and country Supporting documents (e.g., CSR report, annual report, and sustainable procurement strategy)
Enablon	Enablon makes it possible to assess, audit, and validate process efficiency and product compliance internally or throughout the supply chain It enables assessment of suppliers' and contractors' compliance with standard and nonstandard protocols around CSR, labor, environment, conflict minerals, health, and safety The Enablon Publisher is an online solution to design and publish digital reports for sustainability, environment, health, safety, and risk management	Auto-evaluation surveys for suppliers Audits
Intertek	Intertek's supply chain management services measure business risk, capacity, and capabilities, workplace conditions, product quality and safety, security, and environmental sustainability Its portfolio of risk assessment tools and audit solutions includes global supplier management systems, trade goods (online marketplace where responsible buyers and trusted suppliers can get trusted information about their supply chain partners), think green initiatives, supplier qualification programs, workplace conditions assessment, mill qualification program, global security verification, and sandblasting assessment and management (in the garment industry)	Inspections and audits
RepRisk	RepRisk manages environmental, social, governance, and reputational risks in day-to-day business It is useful for banks, insurance providers, asset managers and owners, supply chain and procurement managers, and compliance, investor relations, CSR, and communication teams It provides a global analysis of 34 sectors, 73,011 companies, 18,416 projects, 12,999 NGOs and 9,464 government bodies	Data from the media, stakeholders, and other public sources external to the company

Continued.

Table 1: (Continued)

Software solution	Tool description	Data collection
Thinkstep SoFI	Thinkstep SoFI analyzes the supply chain and identifies hotspots, benchmarks suppliers' performance, provides individual feedback reports, shares best practices throughout the supply chain, tracks improvements with supplier score cards, and manages supplier audits and follow-up actions It can be used for the aspects of environment, health and safety, carbon management, sustainability reporting, energy management, and sustainable supply chain	Automated data capture from ERP systems and meters Global Reporting Initiative and Carbon Disclosure Project surveys 100.000 greenhouse gas factors with automated updates
Verisk Maple Croft	Verisk Maple Croft integrates global risk analytics, expert insights, and user-centric platforms It includes more than 200 risk indices and interactive maps evaluating the key environmental, social, economic, and political risks for all countries down to the subnational level	Surveys and scoring frameworks for analyzing qualitative data

term *design science* is chosen to emphasize the orientation to knowledge-for-design, which should offer solutions for real-world problems in contrast to the operational action and the skills necessary for appropriate action. The latter is the domain of practitioners (Van Aken 2005). A researcher pursuing a design science methodology matches a means to an end. Means-end analysis is based on current states, requested states, and the distinction between the two. The activities that modify the current state into the requested one are also in focus (Peffers et al. 2007). The design science methodology assists in achieving the requested state (Simon 1996; Holmstroem et al. 2009). Either the means and/or the end should be newly developed (Gregor and Jones 2007). In this study, the means is newly generated, since we propose an SCSR map as new technological solution design. Design science research should produce generic and actionable knowledge (Hodgkinson and Healey 2008; Jelinek et al. 2008). This required generality is incorporated into the solution design of our study through the use of publicly available proxy variables.

Van Aken (2004) argues that the mission of academic research in design science is to generate scientific knowledge that contributes to the design of measures or artifacts that are useful for human intentions (Simon 1996). These measures or artifacts can follow "CIMO logic," which describes how, within a certain problem context (C), an intervention (I) triggers generative mechanisms (M) that lead to certain outcomes (O) (Denyer et al. 2008). In this study, (C) refers to the evaluation of a supplier's sustainable business conduct by a renowned buying firm that is scrutinized by its stakeholders. The SCSR map represents a technological intervention (I) whose adoption facilitates the efficient evaluation of SCSR as a generative mechanism with the help of country-level data as a predictor (M). The outcome (O) is that SCSR at the level of the individual supplier can be assessed (i.e., predicted) in an automated manner by means of proxy variables at the country level. The application of the CIMO logic ensures a rigorous and scientific development of the solution design (Hevner et al. 2004).

Design science research has been discussed in and publicized by leading management journals in recent decades (e.g., Van Aken 2004; Romme and Endenburg 2006; Denyer et al. 2008; Holmstroem et al. 2009; Kieser et al. 2015; Van Aken et al. 2016). The approach is also quite established in leading information systems journals (e.g., Abbasi and Chen 2008; Adomavicius et al. 2008; Pries-Heje and Baskerville 2008). Moreover, a growing number of supply chain management studies have adopted the design science methodology in recent years. For example, Finne and Holmstroem (2013) investigated a triadic collaboration for service delivery, Schleper and Busse (2013) developed a standardized supplier code of ethics, Holmstroem and Partanen (2014) explored digital manufacturing-driven transformations of service supply chains for complex products, Tanskanen et al. (2015) analyzed the adoption of on-site shops in construction supply chains, Busse et al. (2017c) studied how buying firms with a poor supply chain visibility can use their stakeholders to detect SCSR, and Groop et al. (2017) enhanced the efficiency of the home care delivery system of a Northern European city.

Empirical context

In this study, we collaborated with a multidivisional German technology firm with a revenue of around four billion Euro, which sources from more than 20,000 suppliers and has an invoice volume of approximately three billion Euros. Originally, the company sought to generate at least 80% of its invoice volume with suppliers who guaranteed certain sustainability standards via self-disclosure forms. However, assessing SCSR in this manner turned out to be inefficient, due to a high variability in the supply base. For instance, the same suppliers who accounted for 80% of the invoice volume in the financial year 2012/2013 accounted for only 54% of the invoice volume in the financial year 2014/2015. Hence, a more efficient SCSR assessment method was required.

In our initial workshops with the technology firm, we established requirements for the development of the SCSR map. First, the proxy variables should be based on publicly available data from internationally renowned organizations to ensure high-quality data and instill trust in the assessment. In this vein, the proxy variables are also accessible by the buying firm itself since they

Table 2: Differences between design sciences and explanatory sciences

	Design sciences		Explanatory sciences	
Focus	Solution focused		Problem focused	
Research question	Solutions for a class of problems		Explanation	
Research phases	1. Solution incubation	2. Solution refinement	3. Explanation I	4. Explanation II
Research objective	Development of initial solution design	Refinement of initial solution design; solving the problem	Development of substantive theory; establishing theoretical relevance	Development of formal theory; strengthening theoretical and statistical generalizability
End product	Solution to a problem		Explanatory theory, prediction	

Source: Adapted from Van Aken (2004) and Holmstroem et al. (2009).

can be found without access restrictions on the websites of the international organizations. Second, the proxy variables should be effective such that they describe the manifestation of the risky sustainability issues as well as possible. This means that the country-level proxy variables should be adequate predictors for the supplier-level sustainability risk. Third, from an efficiency perspective the number of proxy variables should only be as high as necessary but as low as possible to ensure a practical solution. Fourth, the SCSR map is supposed to complement the extant, sustainability-unrelated, risk assessment tools, and processes. For this reason, we did not consider operational supply chain risks.

The scope of the SCSR map was defined such that it covered most of the purchasing in terms of the country of origin. We selected the countries with respect to their purchasing volume in the previous three financial years, their current importance for the technology firm, and their SCSR susceptibility. While the importance of individual suppliers varies substantially over time due to the fluctuations in the supply base with regard to invoice volume, the 17 purchasing countries chosen here are responsible for a large share of the invoice volume over a longer time.

Solution design development process

The supply chain sustainability issues considered here were adopted from a content analysis of supraorganizational supplier codes of conduct (Schleper and Busse 2013). A supply chain sustainability *issue* only becomes *risky* to the extent that it can elicit punishment from stakeholders (Reuter et al. 2012). The understanding of what constitutes illegitimate behavior, however, differs substantially among alternate legitimacy contexts, for example for stakeholders from various countries (Busse et al. 2016a). For instance, a sustainability issue might be perceived as illegitimate by stakeholders in a developed economy (and might therefore become a risky sustainability issue for a buying firm), but as legitimate by stakeholders living in an emerging economy. Empirical research results on stakeholder sensitivity vis-à-vis the most typical SCSR issues contingent on the legitimacy context are not yet available. Therefore, we relied on the perceived riskiness of the different sustainability issues in the German legitimacy context, which we discussed with the firm numerous times in 14 phone conservations (with an average duration of 30 min and involving two participants) and four workshops (one on-site workshop at the technology firm and three telephone workshops for an average duration of 120 min and with five participants on average). All firm participants were knowledgeable purchasing or sustainability managers. The importance of the risky sustainability issues was assessed during the same phone conservations and workshops, based on the expected intensity of stakeholder reactions to a negative sustainability-related incident.

To assess the manifestation of the risky sustainability issues for the countries studied, we considered all relevant international organizations (15 organizations), which provide proxy variables that describe the level of risk associated with individual suppliers. In the end, we adopted secondary data from 10 international organizations: German Investment and Development Corporation, European Commission, International Labor Organization (ILO), International Organization for Standardization (ISO), Organisation for Economic Co-operation and Development (OECD), Transparency International, United Nations (UN), United Nations Children's Fund (UNICEF), World Bank, and World Wide Fund for Nature (WWF). Data from Amnesty International, Business Environmental Performance Initiative, Business Social Compliance Initiative, Supplier Ethical Data Exchange, and the World Health Organization were also considered but not chosen. Across all proxy variables for all considered countries, the average secondary data availability is 86%, which means that the collected data are 14% incomplete for the 17 countries, since for some proxy variables, the value for at least one of the countries is missing.

RESULTS

Solution design

This study considers 15 risky sustainability issues for the analysis. Each of these issues is represented by one to three proxy variables from the secondary data sources. Four risky sustainability issues—disposal and waste reduction, environmentally friendly products and practices, emissions and pollution, and water conservation and reduction—comprise the environmental dimension. The social dimension consists of seven risky sustainability issues, which are nondiscrimination, child labor, freedom of association and collective bargaining, forced labor, workplace safety and health, remuneration, benefits and wages, and working hours. Finally, the governance dimension contains four risky sustainability issues: compliance with local and (inter)national laws and regulations; safe products and services; corruption, extortion,

and bribery; and human rights. Table 3 shows all risky sustainability issues for the environmental, social, and governance dimensions with their associated proxy variables and data sources.

Table 4 shows the exact form and function of the SCSR map spreadsheets. As a basis for the determination of the SCSR, the quantile for each country is calculated by considering the lowest and highest value of the proxy variable among all countries. For example, ranking Austria in the 60% quantile for a proxy variable implies that 60% of all countries have an equal or worse value for this proxy variable. Whenever the data for one or several proxy variables is unavailable, these proxy variables are set to the highest risk. The solution depicts the weighted average values for all risky issues as the country-level overall SCSR. Overall, the approach identifies France as the least risky country and Serbia as the riskiest. Table 5 depicts the exact SCSR for all countries and sustainability issues. With these results, it is possible for managers to save time and SCSR assessment costs by identifying the most relevant risky sustainability issues. The results are reasonable from the perspective of the multidivisional German technology firm, which is implementing the SCSR map in its purchasing operations, suggesting that it is possible to assess SCSR with environmental, social, and governance proxy variables at the country level, in response to our research question.

The following three tables define the environmental (Table 6), social (Table 7), and governance (Table 8) proxy variables, illustrating their measurement, and presenting a rationale supporting their effectiveness. The respective definitions stem from the international organization corresponding to the proxy variable. The measurement column describes the data collection methods used by the international organizations to calculate the proxy variables. Because of the effort associated with the collection of the data, it would not make sense for the buying firm to collect primary data about the proxy variables on its own. The effectiveness column presents the reasons we regard the respective country-level proxy variables as appropriate predictors for the

Table 3: Solution design form

Dimension	Risky sustainability issue	Proxy variable	Data source
Environmental	Disposal and waste reduction	Municipal recycling rate	UN
		Share of total population served by municipal waste collection	UN
	Environmental-friendly products and practices	Share of companies with an environmental management system according to ISO 14001 with regard to total domestic companies	ISO World Bank
	Emissions and pollution	CO_2/million $ GDP	European Commission, World Bank
	Water conservation and reduction	Water scarcity as a ratio of available to consumed water	German Investment and Development Corporation, WWF
Social	Nondiscrimination	Gender wage gap	ILO
	Child labor	Share of children in child labor	UNICEF
	Freedom of association and collective bargaining	Voice and accountability index	World Bank
		Trade union density rate	OECD
		Collective bargaining coverage rate	ILO
	Forced labor	Share of workers in forced labor	ILO
	Workplace safety and health	Rate of nonfatal occupational injuries	ILO
		Rate of fatal occupational injuries	ILO
		Labor inspection rate	ILO
	Remuneration, benefits, wages	Working poverty rate (<$2/day)	ILO
	Working hours	Weekly normal hours limit	ILO
		Distribution of the employed population by hours of work	ILO
Governance	Compliance with local and (inter) national laws and regulations	Rule of law index	World Bank
		Government effectiveness index	World Bank
	Safe products and services	World distribution of ISO 9001 certificates with regard to total domestic companies	ISO, World Bank
	Corruption, extortion, and bribery	Bribe payers index	Transparency International
		Control of corruption index	Transparency International
	Human rights	Ratification share of the 18 International Human Rights Treaties	UN
		Accreditation of national human rights institutions	UN

Table 4: Form and function of the supply chain sustainability risk (SCSR) map spreadsheets

Spreadsheet	Form and function
1	General introduction to the SCSR map: no modification possible
2	User input: the weighting factors for the risky sustainability issues can be modified
3	SCSR for different countries: automatic calculations in order to assess the SCSR, no modification possible
4–7	Environmental SCSR: selected proxy variables with their publicly available data sources and their relevant stored data, modification possible whenever necessary
8–14	Social SCSR: selected proxy variables with their publicly available data sources and their relevant stored data, modification possible whenever necessary
15–18	Governance SCSR: selected proxy variables with their publicly available data sources and their relevant stored data, modification possible whenever necessary

supplier-level sustainability risk. The general rationale is that when the proxy variable at the country level changes (falls or rises), the risk at the supplier level of the country changes (falls or rises) as well. With this simplification, complexity is reduced, thereby fostering SCSR assessment and rendering SCSR more manageable.

To preserve writing space, we illustrate the effectiveness of the proxy variables with two examples each in the environmental, social, and governance dimensions. For the environmental dimension, we chose the proxy variables "share of companies with an ISO 14001 certificate with regard to total domestic companies" and "CO_2/million $ GDP." Table 6 illustrates the remaining proxy variables.

The ISO 14000 family of standards provides practical tools for companies that aim to manage their environmental responsibilities (Babakri et al. 2003). ISO 14001 offers the criteria for an environmental management system and maps out a framework that a company or organization can follow to set up an effective environmental management system (Corbett and Kirsch 2001). In doing so, organizations from every activity or sector can use the standards. Every year ISO conducts a count of certifications to their ISO 14001 standard. There are now more than 300,000 certifications to ISO 14001 within 171 countries. Organizations planning to be certified to the ISO 14001 standard must contact an independent certification body. The application of ISO 14001 can reassure company management, employees, and external stakeholders that the environmental impact of a firm's products is being measured and improved. The proxy variable is effective since it shows how environmentally sustainable companies in a country are operating.

The European Commission calculates the proxy variable CO_2 emissions/million $ gross domestic product (GDP) based on their data from the Emission Database for Global Atmospheric Research, the energy balance statistics of the International Energy Agency, data of the British Petroleum Statistical Review of World Energy, and recent Chinese coal consumption data of the China Statistical Abstract. Country-specific CO_2 emissions total the fossil fuel use and industrial processes (e.g., cement production). In this way, short-cycle biomass burning (e.g., agricultural waste burning) and large-scale biomass burning (e.g., forest fires) are excluded. By relating the country-specific CO_2 emissions to the GDP, we arrive at a measure of sustainability performance that does not depend on a country's economic activity (Budzianowski 2013). Historic time series of energy demand indicate the continuous growth of country-specific CO_2 emissions (Friedlingstein et al. 2014). Nevertheless, suppliers in countries with low CO_2 emissions per million $GDP tend to operate in a more environmentally friendly manner.

Hereafter, we describe the social proxy variables "share of children in child labor" and "frequency rate of occupational injuries." Table 7 shows the other proxy variables for the social dimension.

The ILO defines child labor as work that deprives children of their childhood, potential, and dignity; that is harmful to their physical and mental development; and that interferes with their schooling (see Appendix 2). At its worst, child labor involves children being enslaved, separated from their families, exposed to serious hazards and illnesses, and/or left to fend for themselves. The variable captures workers younger than 15 years; it draws on an increasing amount of data from national-level child labor surveys. Understanding Children's Work, an interagency program on child labor statistics and research by the ILO, UNICEF, and the World Bank provided access to non-ILO data. Child labor is one of the riskiest sustainability issues, eliciting the strongest stakeholder reactions (Park-Poaps and Rees 2010). An estimated 168 million children worldwide are in child labor, accounting for almost 11% of the entire child population (ILO 2017). The higher the rate of child labor in a country, the more likely a supplier from that country is involved.

According to the ILO, an occupational accident is an unexpected occurrence, arising in connection with work which results in one or more workers being injured, killed, or contracting a disease (see Appendix 2). The number of new occupational injuries during a year, divided by the total number of hours worked by workers during the year, multiplied by 1,000,000 defines the occupational injury proxy variable. In this vein, we distinguish between nonfatal and fatal occupational injuries in our SCSR map. The data used varies from country to country but includes mainly compensation claims received from insurance companies, self-insurers, and some government departments. Given that stakeholders are particularly interested in working conditions at supplier sites (Longoni et al. 2013), occupational injuries are one of the most important and easy-to-quantify aspects of working conditions. The lower the frequency of occupational injuries in a country, the lower the probability that unacceptable working conditions prevail at a supplier site within this country.

Below, we present the governance-related proxy variables "government effectiveness index" and "bribe payers index." Table 8 provides the remaining proxy variables.

The World Bank's government effectiveness index captures perceptions of the quality of public services, the quality of the

Table 5: Supply chain sustainability risk for all countries and all sustainability issues (values in %)

	Risky sustainability issue																	
	Environmental					Social								Governance				
Country	Disposal and waste reduction	Environmental-friendly products and practices	Emissions and pollution	Water conservation and reduction	Total	Nondiscrimination	Child labor	Freedom of association and collective bargaining	Forced labor	Workplace safety and health	Remuneration, benefits, wages	Working hours	Total	Compliance with local and (inter) national laws and regulations	Safe products and services	Corruption, extortion, and bribery	Human rights	Total	Total
Austria	88	76	82	69	78	7	100	84	100	55	100	50	75	88	71	38	56	63	72
Brazil	8	53	65	88	59	43	12	8	83	6	24	18	30	20	65	37	50	43	44
Canada	54	6	47	94	41	29	100	67	100	0	100	93	72	86	6	88	65	61	58
Chile	4	47	35	100	50	0	18	41	83	42	29	18	37	55	53	35	91	59	48
China	0	88	18	50	51	0	100	22	67	0	18	50	43	16	88	7	24	34	43
France	75	82	94	38	76	79	100	60	100	88	100	71	88	57	76	64	100	74	80
Germany	100	65	65	13	58	64	100	77	100	15	100	7	72	80	82	87	91	85	72
Hungary	29	94	41	81	69	50	100	26	100	64	100	50	75	49	94	21	76	60	68
India	0	12	12	50	18	21	6	8	67	33	6	7	25	10	18	15	59	25	23
Italy	63	100	76	31	75	0	100	67	100	11	100	50	67	41	100	30	65	59	67
Poland	13	29	29	31	28	86	100	38	100	27	100	21	71	55	35	24	71	46	48
South Africa	0	35	24	19	25	57	100	27	33	21	12	18	43	24	41	36	71	43	37
Serbia	0	18	6	0	9	100	24	12	17	0	35	0	23	20	12	9	85	31	21
Spain	71	41	76	6	48	36	100	63	100	52	100	86	80	49	29	58	100	59	62
Sweden	96	71	94	75	81	93	100	67	100	64	100	50	84	90	47	50	47	59	75
Switzerland	63	59	100	63	72	14	100	66	100	73	100	39	76	98	59	94	29	70	73
United States	79	24	53	56	44	71	100	31	100	36	100	57	74	67	24	66	18	43	54

Table 6: Definition, measurement, and effectiveness of environmental proxy variables

Proxy variable	Definition	Measurement	Effectiveness
Municipal recycling rate	Municipal waste includes waste originating from households, commerce and trade, small businesses, office buildings, and institutions (e.g., schools). It also includes bulky waste (e.g., old furniture) and waste from selected municipal services (e.g., park maintenance) Recycling is defined as reprocessing of waste in a production process that diverts it from the waste stream, except for reuse as fuel	Data on municipal recycling is gathered through surveys of municipalities which are responsible for waste recycling or from transport companies that recycle the waste	The proxy variable covers waste recycled by or on behalf of municipalities Waste recycled by the informal sector, waste generated in areas not covered by the municipal recycling system, or illegally dumped waste is not included Therefore, all waste which is recycled from supplier sites is included. A low value of the proxy variable indicates a low environmental SCSR and, thereby, a low probability that stakeholders complain
Share of total population served by municipal waste collection	Municipal waste collected refers to waste collected by or on behalf of municipalities and municipal waste collected by the private sector It includes mixed waste and fractions collected separately for recovery operations through door-to-door collection and/or through voluntary deposits	Data on municipal waste is gathered through surveys of municipalities, which are responsible for waste collection, or from transport companies that collect waste and transport it to a disposal site	The proxy variable covers waste collected by or on behalf of municipalities Therefore, all waste which is collected from supplier sites is included. A low value of the proxy variable indicates a low environmental SCSR and, thereby, a low probability that stakeholders complain
Share of companies with an ISO 14001 certificate with regard to total domestic companies	The ISO 14000 family of standards provides practical tools for companies which want to manage their environmental responsibilities ISO 14001 sets out the criteria for an environmental management system and maps out a framework that a company or organization can follow to set up an effective environmental management system	Every year ISO performs a questionnaire which counts the certifications to their ISO 14001 standard	Using ISO 14001 can provide assurance to company management, employees, and external stakeholders that the environmental impact is being measured and improved There are more than 300,000 certifications to ISO 14001 in 171 countries which show how environmentally sustainable companies in a country are typically operating
CO_2/million $ GDP	Country-specific CO_2 emissions total of fossil fuel use and industrial processes, excluded are short-cycle biomass burning and large-scale biomass burning Gross domestic product (GDP) is the total value added by all economic sectors	The proxy variable is calculated by the European Commission based on their data from the Emission Database for Global Atmospheric Research, the energy balance statistics of the International Energy Agency, data of the British Petroleum Statistical Review of World Energy, and recent Chinese coal consumption data of the China Statistical Abstract	Historic time series of energy demand indicate a continuous growth of CO_2 emissions, which need to be limited, particularly by limiting the level of energy-intensive activities Therefore, suppliers in countries with low CO_2 emissions per million $ GDP tend to operate in a more environmentally friendly manner

Continued.

Table 6: (Continued)

Proxy variable	Definition	Measurement	Effectiveness
Water scarcity as a ratio of available to consumed water	Water scarcity is defined as the ratio of water footprint to water availability, in which the latter is taken as natural runoff minus environmental flow. It is classified into four levels: 1 Low water scarcity (<100%) 2 Moderate water scarcity (100%–150%) 3 Significant water scarcity (150%–200%) 4 Severe water scarcity (>200%) Water resources are surface water and groundwater	The data is taken from the Water Footprint Network which considers 405 river basins, which together cover 66% of the global land area (excluding Antarctica) and represent 65% of the global population. The land areas not covered include Greenland and the Sahara Desert in North Africa. Also excluded are many smaller pieces of land that do not fall within major river basins	Many stakeholders are critically observing the water consumption of suppliers Therefore, the question arises regarding how much water consumption suppliers are involved Since water scarcity is based on water consumption rather than water withdrawal, it remains an appropriate predictor for the water consumption of suppliers in a country The water consumption pattern is different from the population density pattern, because intensive water consumption in the industry is not related to where most people live and, hence, the proxy variable is a good indicator for environmental SCSR

civil service, and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (see Appendix 2). It relies on 441 individual variables measuring different dimensions of governance. The World Bank takes these variables from 35 sources and 33 organizations. In countries with a low government effectiveness index, policies exist only on paper (Mair and Marti 2009) implying that suppliers may maintain nonacceptable behavior and go unpunished. Consequently, there is a high risk of punishing stakeholder reactions when sourcing from countries with a low government effectiveness index (Busse et al. 2016a).

Continuing globalization leads to business transactions among countries with a range of norms and rules governing bribery (Baughn et al. 2010). The bribe payers index evaluates the likelihood of firms to bribe abroad. Transparency International collects the index based on the views of 3,016 executives from 30 countries who evaluated each of the 28 countries with which they interact. In doing so, it surveyed a minimum of 82 people in each country. The assessment of the ethical behavior of companies from a country correlates strongly with perceptions of foreign bribery from that country. Therefore, we argue that stakeholders view suppliers from countries, which are less likely to engage in foreign bribery as more ethically entrenched.

Three use cases for applying the solution design

It is recommendable for managers to use the convenient SCSR map before applying or relying on other less efficient supplier assessment or development instruments. In the following, we show three use cases on how the SCSR map can inform buying firms about current and potential future suppliers—as one criterion in addition to numerous others, and how it can be used to compare several supplier alternatives.

When using the SCSR map to assess the current supply base, it is possible to presort suppliers for audits and supplier development activities according to environmental, social, and governance issues and by specific proxy variables. In this way, for example, only suppliers from high-risk countries can be chosen for criteria-specific audits and supplier development activities (Reuter et al. 2010). According to the logic of the SCSR map, for instance, current Chinese suppliers should be specifically audited and developed with regard to governance issues such as corruption, extortion, and bribery, if no supplier alternatives from low-risk countries are available.

The SCSR map can also be utilized to assess potential future suppliers. Thus, it is possible to mitigate the problem that suppliers often sign codes of conduct and still behave unsustainably. Just as for assessing a current supplier, potential future suppliers can be rated according to environmental, social, and governance issues, and specific proxy variables by the buying firm. For instance, when considering a less costly supplier from India, the buying firm knows with the help of the SCSR map that it should conduct further assessment, focusing particularly on whether the supplier is socially sustainable with regard to child labor, remuneration, benefits, and wages.

Often there is more than one supplier alternative, leading to the need to assess which supplier is more sustainable. Again, the comparison of the sustainability of the suppliers can be performed according to different proxy variables using the SCSR map. For instance, when a buying firm has the choice between two,

Table 7: Definition, measurement, and effectiveness of social proxy variables

Proxy variable	Definition	Measurement	Effectiveness
Gender wage gap (%)	The gender wage gap is calculated as the difference between average earnings of men and average earnings of women expressed as a percentage of average earnings of men Full-time and part-time workers are covered	The methodology used for the proxy variable is the census method. The objective is to find wage data for all countries and to develop an explicit estimation treatment in the case of nonresponse	Stakeholders complain about suppliers who discriminate against their employees Wage inequality has been growing in many countries and is one of the most important aspects of the quantitative determinable forms of discrimination We assume that in countries where one form of discrimination is present, other forms of discrimination are present as well. Therefore, suppliers in countries with a low gender pay gap are more socially friendly
Share of children in child labor	Child labor is defined as work that deprives children of their childhood, their potential, and their dignity; that is harmful to their physical and mental development; and that interferes with their schooling The proxy variable includes workers younger than 15 years	The proxy variable draws on an increasing amount of data from national-level child labor surveys Understanding Children's Work, an interagency program by the ILO, UNICEF, and the World Bank, provided access to non-ILO data	Child labor is an SCSR which can cause the most punishing stakeholder reactions The estimates indicate that 168 million children worldwide engage in child labor The higher the risk for child labor in a country, the higher the probability that a supplier from this country is involved in child labor
Voice and accountability index	The proxy variable captures perceptions of the extent to which a country's citizens are able to participate in selecting their government as well as freedom of expression, freedom of association, and a free media	The proxy variable relies on 441 individual variables measuring different governance dimensions These are taken from 35 different sources which are produced by 33 different organizations	The media and citizens as stakeholders serve an important role in monitoring those in authority and holding them accountable for their actions Therefore, there is a high risk of punishing stakeholder reactions related to countries with a low voice and accountability index
Trade union density rate	A trade union is defined as a workers' organization constituted for the purpose of furthering and defending the interests of workers The trade union density rate conveys the number of employees who are union members as a percentage of the total number of employees	A survey was completed by the National Statistical Offices and Ministries of Labor Based on this survey, the trade union density rate was calculated for 77 countries In the European Union (EU), Switzerland, and Norway, data from the OECD Labor Force Statistics were also used	The right to form trade unions is the bedrock of sound industrial relations and effective social dialogue The trade union density rate can assist in monitoring progress toward the realization of this right It also provides valuable information on the quality of employee protection at sites in the respective country, portraying the average values for the suppliers
Collective bargaining coverage rate	The collective bargaining coverage rate conveys the number of employees whose conditions of employment are determined by one or more collective agreement(s) as a percentage of the total number of employees	A survey was completed by the National Statistical Offices and Ministries of Labor Based on this survey, the collective bargaining coverage was only calculated for 62 countries	The right of collective bargaining is a fundamental principle at work The collective bargaining coverage rate can contribute by controlling progress toward the implementation of this right

Continued.

Table 7: (Continued)

Proxy variable	Definition	Measurement	Effectiveness
	Collective bargaining coverage rates are adjusted for the fact that some workers do not have the right to bargain collectively over wages (e.g., workers in the public services)		It offers valuable information on the quality of the relationship between employers and employees at supplier sites
Share of workers in forced labor	Forced labor is defined as all work or service which is executed from a person under the menace of any penalty and for which the said person has not offered himself voluntarily The geographical stratification of forced labor is based on a regional classification in six categories: Developed Economies and the EU, Central and South-Eastern Europe (non-EU) and the Commonwealth of Independent States, Asia–Pacific, Latin America and the Caribbean, Middle East, and Africa	The ILO used own reports, media reports (e.g., newspapers), NGO documents, government documents, academic reports, trade union reports, and employers' organization reports to calculate the proxy variable	Forced labor is an SCSR which can cause the most punishing stakeholder reactions While sometimes the means of coercion used by the exploiter(s) can be observable (e.g., armed guards), more often the coercion applied is subtler (e.g., confiscation of identity papers) Forced labor, therefore, presents major challenges in terms of detection, which makes the regional estimation a valid choice The higher the risk for forced labor in a specific region, the higher the probability that a supplier from a country in this region is involved in forced labor
Frequency rate of (non-)fatal occupational injuries	A (non-)fatal occupational injury is resulting from an occupational accident It is calculated as the number of new (non-)fatal occupational injuries during a year divided by the total number of hours worked by workers during the year multiplied by 1,000,000	The data used varies from country to country but includes mainly compensation claims received from insurance companies, self-insurers, and some government departments	Stakeholders are interested in the working conditions at supplier sites. Occupational injuries are especially important aspects of quantitative determinable forms of working conditions The lower the frequency rate of (non-)fatal occupational injuries in a country, the lower the probability that unacceptable working conditions prevail at a supplier site of this country
Labor inspection rate	The proxy variable conveys the average number of labor inspectors per 10,000 employed persons, which provides some indication of the resources available for monitoring and enforcing appropriate work conditions and the corresponding standards	The proxy variable was drawn by the ILO based on own data, national reports on labor inspection, Eurostat, websites of ministries responsible for labor inspection, audits, and technical memorandums on the labor inspection and verification reports	Labor inspectors are public officials who secure the enforcement of the legal provisions relating to conditions of work, supply information to employers and workers concerning the most effective means of complying with the legal provisions, and bring defects or abuses not specifically covered by existing legal provisions to the notice of the authority The higher the labor inspection rate in a country, the lower the probability that a supplier from this country is engaged in socially unacceptable actions

Continued.

Table 7: (Continued)

Proxy variable	Definition	Measurement	Effectiveness
Working poverty rate (<$2/day)	The proxy variable includes workers employed but earning less than $2 per day for full-time employment The workers are unable to earn enough to lift themselves and their families above the poverty threshold	The proxy variable relies on internationally comparable data derived from statistical standards agreed upon by the International Conference of Labor Statisticians	Working poverty is on the rise; 839 million workers in developing countries are still "working poor," which represents one-third of total employment Since standard labor market indicators such as unemployment are insufficient in developing countries, the working poverty rate is a good proxy variable for socially unacceptable working conditions at supplier sites
Share of employed persons working more than 48 hr per week	The proxy variable describes the extent of long working hours of employees, defined as more than 48 hr per week Included are persons above 15 years (16 years in the United States) who are working long hours	Data on the distribution of weekly working hours were collected from national statistics by household-based labor force surveys 60 countries participated in the survey	About 22% of all workers are still working more than 48 hr per week Long hours are not only harmful to economic efficiency but also to the mental welfare of employees Therefore, countries with a high share of workers working long hours represent a high risk for employees at supplier sites to have negative health impacts
Weekly normal hours limit	The proxy variable describes the maximum time which employees are allowed to work per week. There are four categories distinguished: 1 35–40 hr 2 41–48 hr 3 More than 48 hr 4 No universal statutory limit	ILO's Database of Working Time Laws allows to undertake an analysis of laws concerning working time regulations in more than 100 countries In order to fill the knowledge gap for some developing countries, ILO carried out 15 additional country studies through small-scale surveys	Policy goals concerning the weekly normal hours limit are successfully incorporated in some countries Therefore, the weekly normal hours limit is a useful means to ensure that working hours provide employees at supplier sites arrangements that preserve health and safety, are family-friendly, and enhance productivity

according to our SCSR map, overall equally sustainable suppliers from Austria and Germany and focuses specifically on the proxy variable water conservation and reduction, it is favorable for the buying firm to choose the supplier from Austria. However, if it wants to focus more on the proxy variable disposal and waste reduction, it is probably advantageous to cooperate with the German supplier. Therefore, with the SCSR map it is possible for buying firms to avoid the continuous collection of supplier self-disclosures for their often-changing low-risk suppliers.

Augmenting the research agenda on SCSR

The study also provides insights into future research opportunities on SCSR. First, few studies are available on the topic of how supply chain sustainability issues become SCSR (Hartmann and Moeller 2014). In particular, empirical research results on stakeholder sensitivity vis-à-vis the most typical SCSR issues contingent on the legitimacy context are not yet available. In this case, it was only possible to execute a pragmatic judgment together with the firm under consideration (Carter et al. 2015). We regarded a sustainability issue as risky to the extent that it can presumably elicit punishing stakeholder reactions for the multidivisional German technology firm studied here. However, we do not yet know how sensitive stakeholders are (1) vis-à-vis different sustainability-related issues and (2) how this sensitivity depends on the legitimacy context (Busse et al. 2016a). Therefore, our study contributed by adding stakeholder sensitivity with respect to SCSR to the research agenda. Additional research can focus on the exact determinants that influence stakeholders to punish buying firms due to negative sustainability-related incidents in their upper supply chain. Only with this knowledge is it possible for buying firms to assess SCSR in an effective and efficient manner to increase transparency, knowledge, and control.

Second, although the necessity for and benefits of SCSR management have already received substantial research attention (e.g., Foerstl et al. 2010; Hofmann et al. 2014; Bregman et al.

Table 8: Definition, measurement, and effectiveness of governance proxy variables

Proxy variable	Definition	Measurement	Effectiveness
Rule of law index	The proxy variable captures the extent to which agents have confidence in the rules of society, in particular the quality of contract enforcement, property rights, the police, and the courts The likelihood of crime and violence is also included in the proxy variable	The proxy variable relies on a total of 441 individual variables measuring different dimensions of governance These are taken from 35 different sources which are produced by 33 different organizations	The proxy variable measures the success of a country in developing an environment in which fair and predictable rules form the basis for economic and social interactions Therefore, there is a high risk of punishing stakeholder reactions related to countries with a low rule of law index
Government effectiveness index	The proxy variable captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	The proxy variable relies on a total of 441 individual variables measuring different dimensions of governance	In countries with a low government effectiveness index, policies exist on paper but are not enforced Nonacceptable behavior of suppliers remains unpunished and is, therefore, maintained by the suppliers Consequently, there is a high risk of punishing stakeholder reactions in countries with a low government effectiveness index
Share of companies with an ISO 9001 certificate with regard to total domestic companies	ISO 9001 sets out the requirements of a quality management system The seven quality management principles are customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision making, and relationship management	Every year ISO performs a questionnaire which counts the certifications to their ISO 9001 standard Organizations planning to get certified to must contact an independent certification body	ISO 9001 can be used by any organization regardless of its activity or sector It ensures that customers get consistent, high-quality products and services There are more than a million certifications to ISO 9001 in 170 countries, which show how quality-oriented companies in a country are typically operating
Bribe payers index	The proxy variable evaluates the likelihood of firms to bribe abroad	The index is based on the view of 3,016 executives from 30 countries who evaluated each of the 28 countries with which they interact	The assessment of the ethical behavior of companies from a country correlates strongly with perceptions of foreign bribery from that country Therefore, suppliers from countries which are less likely to engage in foreign bribery are seen as strongly ethically entrenched by stakeholders
Control of corruption index	The proxy variable reflects perceptions of the extent to which public power is exercised for private gain It includes petty and grand forms of corruption, as well as "capture" of the country by elites and private interests	The proxy variable relies on a total of 441 individual variables measuring different dimensions of governance These are taken from 35 different sources which are produced by 33 different organizations	In countries with a low control of corruption index, the government does not properly fight against corruption Thus, corruption by suppliers remains unpunished and is, therefore, maintained by them Consequently, there is a high risk of punishing stakeholder reactions in countries with a low control of

Continued.

Table 8: (Continued)

Proxy variable	Definition	Measurement	Effectiveness
			corruption index since the proxy variable is correlated with citizens' self-defined well-being and with service delivery and development outcomes
Ratification share of the 18 International Human Rights Treaties	The proxy variable refers to the consent of a country to be bound by a human rights treaty under international law.There are three possible status: 1 State party: a country expressed its consent 2 Signatory: a country wants to examine the treaty and considers ratifying it 3 No action: a country did not express its consent	The proxy variable is produced by the Office of the High Commissioner for Human Rights based on data obtained from and regularly updated by the United Nations Office of Legal Affairs	When a country ratifies one of the international human rights treaties, it assumes a legal obligation to implement the rights recognized in that treaty Through ratification, countries commit to introduce domestic measures and legislation compatible with their treaty obligations and to submit regular reports on how the rights are implemented Therefore, the higher the ratification share of a country, the more attention is directed to human rights in that country
Accreditation of national human rights institutions	A National Human Rights Institution is an independent administrative body set up by a country to promote and protect human rights Compliance with the Paris Principles is the basis for the accreditation of National Human Rights Institutions There are three possible types of accreditation: 1 Compliance with the Paris Principles 2 Observer Status—Not fully in compliance with the Paris Principles or insufficient information provided to make a determination 3 Noncompliance with the Paris Principles	The proxy variable is based on administrative records of the Sub-Committee on Accreditation Reports of the International Coordinating Committee of National Institutions	The creation and fosterage of National Human Rights Institutions indicate a countries' commitment to promote and protect human rights Compliance with the Paris Principles vests National Human Rights Institutions the power to investigate, report, and publicize human rights through information and education The fundamental functions which National Human Rights Institutions play make them important actors in the improvement of the human rights situation and, therefore, in ensuring better working conditions at supplier sites

Table 9: Possible errors when predicting supplier-level risk through country-level risk

		Country-level risk	
		Low	**High**
Supplier-level risk	**Low**	Correct classification	Type 1 error (False positive finding)
	High	Type 2 error (False negative finding)	Correct classification

2015), there is only scarce research concerning the efficient (i.e., low-cost) handling of these risks (Hajmohammad and Vachon 2016). Given that ensuring the efficiency of SCSR assessment is an essential concern in corporate practice, we developed the complexity-reducing SCSR map. Future studies should also view the benefits and costs associated with SCSR assessment jointly.

CONCLUDING DISCUSSION

Buying firms face substantial information-processing challenges surrounding the various sustainability-related grievances lurking in their complex global supply chains (Busse et al. 2017b; Foerstl et al. 2018). These challenges are aggravated by the fact that information and communication technologies grant the buying firms' stakeholders easy access to information surrounding the sustainability-related misconduct of suppliers, leading them to consider punishments of the more accessible buying firms. At the same time, the different information technologies and software tools can potentially also foster SCSR assessment for the buying firms (Boone et al. 2012), an insight that provided the springboard to this research.

We departed from the assumption that most firms look at sustainability from a rather instrumental perspective, seeing it as a potential driver to their overarching economic performance. Empirical evidence suggests that this view is indeed widespread (Deegan and Shelly 2014). Such a business case cognitive frame (Hahn et al. 2014) implies that buying firms conceive of SCSR as a potential detriment to their own economic performance that should be carefully assessed and subsequently managed (e.g., avoided, mitigated, or accepted). In other words, in absence of a direct self-interest in supply chain sustainability (Busse 2016), an SCSR cognitive frame can be regarded as a contextualization of Hahn et al.'s (2014) business case frame for the supply chain context. Against this background and in light of the usual resource constraints in business practice, we directed our attention not only to the task of SCSR assessment as such, but also to the buying firms' interest in an *efficient* assessment of SCSR (Hajmohammad and Vachon 2016; Zinn and Goldsby 2017). In doing so, we relied on the extant literature about SCSR, institutional theory, and a design science methodology. Our results illuminate which proxy variables can be chosen for assessing social-, environmental-, and governance-related SCSR at the level of the purchasing country. The designed artifact, an SCSR map, employs quantitative data from 10 international organizations, including the ILO, the United Nations, and the World Bank.

Scholarly contributions

This study makes three important scholarly contributions. First and foremost, it offers a theoretical underpinning for the notion of country-level sustainability risk, drawing on institutional theory. It provides cross-level theorizing by showing how to use publicly available country-level proxy variables from international organizations to inform supplier-level sustainability risk assessment. Based on our description of the definition, measurement, and effectiveness of the proxy variables, it is possible for researchers to explain the variance in sustainability performance through specific indicators and, thereby, to gain deeper insights into the breakdown of SCSR. This is especially useful when there is a high number or high variability of suppliers in the supply base, since the SCSR does not have to be assessed for each and every supplier.

Second, our design science study helps reconcile the scholarly SCSR discourse with the buying firms' pursuit of efficiency. The importance of SCSR management has already been extensively studied. However, there is little research on the efficient handling of these risks. More research is warranted to determine how supply chain managers can not only effectively but also efficiently extend their reach in the supply chain. By means of this additional research and the appropriate selection of purchasing countries, it is possible for buying firms to reduce the risk of stakeholder punishment and their own financial losses with respect to SCSR. By identifying which sustainability issues should be considered as risky in cooperation with the multidivisional German technology firm, we began a conversation on the riskiness of the different sustainability issues from a stakeholder perspective.

Third, and in methodological terms, our study elucidates how it is possible to augment a research agenda based on a design science study. During the design science research process, new research questions can easily arise, and the research stream can be calibrated in such a way that it connects more closely with the practical needs underlying the respective study. In this case, we calibrated the research agenda with respect to SCSR such that it aligns the scholarly discourse more closely with the requirements of business practice (Thomas et al. 2011; Pagell and Shevchenko 2014). In other words, our research shows how design science enables researchers to identify relevant problems in business practice. These problems might otherwise remain unresolved, since scholarly literature does not automatically consider all relevant facets of real-world problems (Hambrick 2007). In this vein, we added stakeholder sensitivity with respect to SCSR to the research agenda, and we hope to have calibrated the stream of SCSR research such that it also considers SCSR assessment costs.

Practical contributions

This research offers an efficient tool that buying firm managers can use in assessing a supplier's sustainability risk based on the purchasing country. We worked with a multidivisional German technology firm to develop the solution design and presented three use cases showing how the SCSR map can inform practical supplier-level risk assessment.

Due to the assessment of countries with respect to their SCSR susceptibility, buying firm managers can easily choose procurement countries with low SCSR. With the knowledge of the country-specific SCSR, they can better decide which of their current suppliers should be audited, developed, or even replaced to prevent punishment from stakeholders, which could lead to financial losses.

Additionally, the breakdown of the risky sustainability issues into four environmental, seven social, and four governance risky sustainability issues, which are represented with 24 proxy variables, substantially reduces the complexity. Buying firm managers working with suppliers from several countries can better understand the basis for similarities and differences among countries by comparing the manifestations of the different risky sustainability issues and the values of the specific proxy variables with each other.

Finally, the results for the SCSR susceptibility of the countries are scalable, since the weighting factors for the risky sustainability issues can be modified. Therefore, the SCSR map can inform companies with different risk priorities.

Limitations and future research

The choices we made for this study have certain limitations. Although the results show a valuable estimate for the average of all suppliers in a country, individual suppliers differ in their sustainability performance and, therefore, in their susceptibility to trigger punishing stakeholder reactions. For example, a supplier from one country might have several children working in his factories, whereas another supplier from the same country does not. Moreover, there are regional differences in the sustainability performance of suppliers. Especially in emerging economies, these differences may be substantial (Hoskisson et al. 2000; Boons et al. 2013). Table 9 captures the two possible errors when assessing supplier-level risk through country-level risk, resulting from the above-mentioned variance in individual and regional supplier sustainability. A type 1 error occurs when the supplier-level risk is low but the country-level risk is high (false positive finding). Conversely, a type 2 error arises when the supplier-level risk is high and the country-level risk is low (false negative finding). We acknowledge that the SCSR map does not capture such variance in individual and regional supplier sustainability performance. However, scholars frequently face conflicts between accuracy and simplicity (Thorngate 1976; Weick 1999; Busse et al. 2017a). The purpose of this research was not to measure SCSR as accurately as possible, but rather to offer an efficient, complexity-reducing measurement instrument.

Moreover, different stakeholders do not assign the same importance to different sustainability issues (Gualandris et al. 2015). The perception of illegitimate behavior may vary among contexts, for example for stakeholders from different countries (Busse et al. 2016a). For instance, a consumer from a Western country might be more sensitive to certain sustainability issues than a consumer from a developing country. However, in accordance with the goal of complexity reduction, our study investigates only the aggregate of all stakeholders of the German technology firm, rather than focusing on the variance between stakeholders.

Next, in our dynamic global economy, the effectiveness of the proxy variables and their values might change over time. Although the SCSR map captures only the status quo, the proxy variables and especially their values can be updated with reasonable effort using the same international organizations as data sources.

Last, but possibly most fundamentally, the SCSR map developed in this study is tailored to buying firms with business case or SCSR cognitive frames as potential applicants. While such frames are clearly widespread (Deegan and Shelly 2014), they are not the only possible frames for viewing supply chain sustainability. An alternative paradoxical frame might be more complex and might juxtapose economic, environmental, and social concerns even when the respective performance dimensions are misaligned (Hahn et al. 2014). Firms adopting a paradoxical frame in their sustainable supply chain management might therefore be sincerely interested not just in minimizing SCSR, but in fostering supply chain sustainability performances more broadly. They would hence not prioritize the economic dimension, but be simultaneously interested in environmental, social, and governance performance. Such companies could expand the SCSR map developed in this study into a benefit map,[1] arguing that the emphasis of sustainability is not only on avoiding harm, but also on doing better (Campbell 2007). A benefit map could capture a country's propensity to fund environmental, social, and governance initiatives (e.g., construction of parks and green spaces, support for elderly people, and sustainable construction of public buildings).

Another interesting possibility for future research is the empirical validation of the effectiveness of the SCSR map by companies from different industries (Brockhaus et al. 2013). It can be realized using supplier self-disclosures, audit reports, and the frequency of negative sustainability-related incidents for suppliers from different countries. Moreover, further research should be conducted on stakeholder sensitivity in relation to SCSR (e.g., on how a sustainability issue becomes a risky sustainability issue), including the determinants that motivate stakeholders to punish buying firms for negative sustainability-related incidents in their upper supply chain.

We hope that the proposed SCSR map can efficiently inform buying firms about sustainability risks in their supply chains. This study has contributed toward complexity reduction in the context of SCSR assessment in order to facilitate more widespread scrutiny of SCSR by buying firms.

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[1] We thank an anonymous reviewer for pointing out the idea of a benefit map.

APPENDIX 1
Data sources for existing software solutions

Software solution	Data source
Achilles	http://www.achilles.com/en/for-buyers/supply-chain-risk-and-performance-management
ChainPoint	http://chainpoint.com/de/
CSRware	http://csrware.com/sustainable-supply-chain-2/
Ecovadis	http://www.ecovadis.com/
Enablon	http://enablon.com/solutions/collaborative-supply-chain
Intertek	http://www.intertek.com/business-assurance/supplier-management/
RepRisk	https://www.reprisk.com/
Thinkstep SoFI	http://www.sofi-software.com/international/applications/sustainable-supply-chain/
Verisk Maple Croft	https://www.maplecroft.com/

APPENDIX 2
Data sources for the definition, measurement, and effectiveness of proxy variables

Proxy variable	Data source
Municipal recycling rate	http://unstats.un.org/unsd/environment/wastetreatment.htm
Share of total population served by municipal waste collection	http://unstats.un.org/unsd/environment/wastetreatment.htm
Share of companies with an environmental management system according to ISO 14001	http://www.iso.org/iso/iso14000
CO_2/million $ GDP	http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2013 http://edgar.jrc.ec.europa.eu/news_docs/jrc-2015-trends-in-global-co2-emissions-2015-report-98184.pdf
Water scarcity as a ratio of available to consumed water	http://waterriskfilter.panda.org/en/CountryProfiles#88/profile http://waterfootprint.org/media/downloads/Report53-GlobalBlueWaterScarcity.pdf
Gender wage gap (%)	https://goo.gl/2WKDb4 http://www.ilo.org/wcmsp5/groups/public/—dgreports/—dcomm/—publ/documents/publication/wcms_324678.pdf
Share of children in child labor	http://www.ilo.org/ipec/facts/lang–en/index.htm http://www.ilo.org/wcmsp5/groups/public/—ed_norm/—ipec/documents/publication/wcms_221513.pdf
Voice and accountability index	http://info.worldbank.org/governance/wgi/pdf/va.pdf https://goo.gl/BOMiIx
Trade union density rate	https://goo.gl/wKQX7hhttps://stats.oecd.org/Index.aspx?DataSetCode=UN_DEN http://www.oecd.org/employment/emp/UnionDensity_Sourcesandmethods.pdf
Collective bargaining coverage rate	https://goo.gl/wKQX7h http://laborsta.ilo.org/applv8/data/TUM/TUD%20and%20CBC%20Technical%20Brief.pdf
Share of workers in forced labor	http://www.ilo.org/global/topics/forced-labour/lang–en/index.htm
Frequency rate of nonfatal occupational injuries	https://goo.gl/0en42r http://laborsta.ilo.org/applv8/data/c8e.html
Frequency rate of fatal occupational injuries	https://goo.gl/0en42r http://laborsta.ilo.org/applv8/data/c8e.html

Continued.

APPENDIX 2: (Continued)

Proxy variable	Data source
Labor inspection rate	https://goo.gl/uxJ1Dd http://www.ilo.org/labadmin/info/WCMS_141079/lang–en/index.htm#P10_2028
Working poverty rate (<$2/day)	http://www.ilo.org/wcmsp5/groups/public/—dgreports/—stat/documents/publication/wcms_423670.pdf http://www.ilo.org/wcmsp5/groups/public/—dgreports/—dcomm/documents/publication/wcms_243961.pdf
Share of employed persons working more than 48 hr per week	http://laborsta.ilo.org/ http://laborsta.ilo.org/applv8/data/travaile.html http://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_104895.pdf
Weekly normal hours limit	http://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_104895.pdf
Rule of law index	http://info.worldbank.org/governance/wgi/index.aspx#doc-sources https://papers.ssrn.com/sol3/papers.cfm?abstract_id=188568
Government effectiveness index	http://info.worldbank.org/governance/wgi/index.aspx#doc-sources https://papers.ssrn.com/sol3/papers.cfm?abstract_id=188568
World distribution of ISO 9001 certificates with regard to total domestic companies	http://www.iso.org/iso/home/standards/management-standards/iso_9000.htm http://www.iso.org/iso/pub100080.pdf
Bribe payers index	https://www.transparency.org/research/bpi http://info.worldbank.org/governance/wgi/index.aspx#doc-sources
Control of corruption index	https://www.transparency.org/country/#CHN https://www.oecd.org/dac/governance-peace/publications/FINAL%20Addressing%20corruption%20together.pdf
Ratification share of the 18 International Human Rights Treaties	http://indicators.ohchr.org/Stock/Documents/MetadataRatificationTotal_Dashboard.pdf
Accreditation of national human rights institutions	http://www.ohchr.org/Documents/Issues/HRIndicators/MetadataNHRIAccreditation.pdf

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