UNIVERSITY OF TURKU

ABSTRACT

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Title	Distribution of environmental and social sustainability in supply chains: Analysis of green and social bullwhip effects		
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Abstract

Stakeholder demands for environmentally and socially sustainable operations are at an all-time high as the repercussions of global crises, such as climate change, are becoming clearer when business is conducted "as usual". By better understanding the distribution of sustainability in supply chains, stakeholders could apply pressure on the least sustainable tiers of the chain.

Green bullwhip effect refers to the transformation of external stakeholder pressure to environmental requirements within a supply chain. Stakeholders exert pressure on the most visible company in the downstream wherefrom each tier in the chain renders the requirements content- and implementation schedule-wise more stringent for the next-in-line to create a safety buffer or in anticipation of future demands. Environmental requirements, as a result, are tightest at the upstream of the supply chain. Green bullwhip effect has been studied to some extent, whereas possible social bullwhip effect has been scarcely explored. Instead of environmental requirements, in the case of social bullwhip effect, demands for social reforms are analogously magnified throughout the supply chain. These two phenomena could shed light on sustainability patterns in supply chains.

Using environmental, social and corporate governance (ESG) data from 290 European companies involved in manufacturing supply chains, analysis of variance was applied to test for statistically significant differences between the group means, groups referring to different supply chain positions and industries. Each company was given a supply chain position and an industry attribute to test the distribution of sustainability between tiers, and between industries. Results support the existence of both green and social bullwhip effect to some extent. Industry was discovered to have no effect on sustainability. Results imply that stakeholders should turn their attention towards wholesale and retail activities, as they perform the worst in comparison to other tiers in a supply chain, namely end product manufacturers and raw material suppliers/component manufacturers.

Key words	green bullwhip effect, social bullwhip effect, sustainability, stakeholder pressure
Further information	

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Tiivistelmä

Sidosryhmät vaativat yrityksiltä ympäristöllisesti ja sosiaalisesti kestäviä liiketoimintatapoja enemmän kuin koskaan aikaisemmin tilanteessa, jossa maailmanlaajuisten kriisien kuten ilmastonmuutoksen vaikutukset näkyvät entistä selvemmin, kun liiketoimintaa jatketaan ”entiseen malliin”. Ymmärtämällä paremmin kestävyyden jakautumista toimitusketjuissa sidosryhmät osaisivat kohdistaa paineistamistoimensa toimitusketjujen vähiten kestäviä tasoja kohtaan.

Vihreä piiskavaikutus tarkoittaa ulkoisen sidosryhmäpaineen muuntamista ympäristövaatimuksiksi toimitusketjun sisällä. Sidosryhmät painostavat toimitusketjun näkyvintä yritystä alavirralla, jolta ympäristöllisesti kestävään liiketoimintaan tähtäävät vaatimukset kulkevat tasolta toiselle jokaisen tason kiristäessä joko vaatimusten sisältöä tai toteutusaikataulua. Tämä kiristys on seurausta toimijoiden halusta varmistaa oma toimintansa luomalla varmuuspuskuri tai varautua uusiin vaatimuksiin kiristämällä vaatimuksia entisestään. Lopputuloksena nämä vaatimukset ovat tiukimmat toimitusketjun ylävirralla. Vihreätä piiskavaikutusta on tutkittu jonkun verran, kun taas sosiaalista piiskavaikutusta ei käytännössä lainkaan. Sosiaalisessa piiskavaikutuksessa ympäristövaatimusten sijasta vaaditaan sosiaalisia uudistuksia, joita tiukennetaan ympäristövaatimusten tavalla läpi toimitusketjun.

Varianssianalyysiä käytettiin tutkimusmenetelmänä tilastollisesti merkittävien erojen havaitsemiseksi ympäristöllistä ja sosiaalista suorituskykyä mittaavien keskiarvojen välillä. Jokaiselle otoksen 290 eurooppalaiselle yritykselle määriteltiin ryhmäattribuutti toimitusketjusijainnin ja toimialan mukaan. Tulokset tukevat vihreän ja sosiaalisen piiskavaikutuksen olemassaoloa varauksin. Toimialalla ei havaittu olevan vaikutusta kestävyyteen. Tulosten mukaan sidosryhmien tulisi kohdistaa paineistamistoimia tukku- ja vähittäismyyjiä kohtaan näiden valmistavia tasoja heikoimman ympäristöllisen ja sosiaalisen kestävyyden vuoksi.

Asiasanat	vihreä piiskavaikutus, sosiaalinen piiskavaikutus, kestävyys, sidosryhmäpaine
Muita tietoja	

UNIVERSITY
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Economics

DISTRIBUTION OF ENVIRONMENTAL AND SOCIAL SUSTAINABILITY IN SUPPLY CHAINS

Analysis of green and social bullwhip effects

Master´s Thesis
in Operations and Supply
Chain Management

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The originality of this thesis has been checked in accordance with the University of Turku quality assurance system using the Turnitin OriginalityCheck service.

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List of abbreviations

ANOVA	Analysis of variance
BSC	Balanced Scorecard
CSPMS	Corporate sustainability performance measurement system
CSR	Corporate social responsibility
DJSI	Dow Jones Sustainability Indices
ESG	Environmental, social and corporate governance
GBE	Green bullwhip effect
GEMI	Global Environmental Management Initiative
GHG	Greenhouse gas
GRI	Global Reporting Initiative
GSCM	Green supply chain management
IPCC	Intergovernmental Panel on Climate Change
KPI	Key performance indicator
LCSCM	Low carbon supply chain management
MSCI	Morgan Stanley Capital International
NGO	Non-governmental organisation
SBE	Social bullwhip effect
SCM	Supply chain management
SCP	Supply chain position
SM	Sustainable manufacturing
SPMS	Strategic performance measurement system
TBL	Triple bottom line
TR	Thomson Reuters
TRBC	Thomson Reuters Business Classification

1 INTRODUCTION

1.1 Background and motivation for the research

Practices aiming at conducting business in a more environmentally and socially sustainable manner are currently unprecedentedly popular, and sustainability has been recognised as a megatrend (Mittelstaedt et al. 2014). Although the emergence of sustainable-minded business paradigm cannot be pinpointed to one specific moment in history, one concept can be viewed to have acted as a catalyst for such development. This concept was *triple bottom line* popularised by Elkington in 1994. Elkington introduced two new dimensions alongside the traditional economic approach for monitoring company performance, environmental and social. (Elkington 2018.) What ensued was a growing interest to study sustainable practices and to measure sustainability by different means in the academic field.

Triple bottom line (TBL) incorporated all three elements of the "people, planet, profit" triangle into one accounting paradigm in contrast to the traditional "single bottom line" monitoring only financial performance of a company (Elkington 2004). The concept in practice developed into *green supply chain management* (GSCM) and *sustainable supply chain management* (SSCM), providing concrete tools for companies to embrace new ideals not solely revolving around turning a profit. GSCM refers to the integration of environmental management to business activities. GSCM is implemented through different practices which can be internal or external—internal ones have an effect in-house, such as eco-design, while external practices target external stakeholders, e.g. requiring suppliers to provide an environmental certification. (Srivastava 2007; Zhu et al. 2012.) Definition of SSCM often overlaps with the one of GSCM, but traditionally SSCM has also incorporated the social dimension to business management. SSCM practices with a social approach are, for example, participating in ventures within the local community of supplier to improve living and working conditions. (Seuring & Müller 2008; Klassen & Vereecke 2012.)

By implementing such modern sustainability practices, companies could e.g. reduce their resource use, motivate employees to work more efficiently and gain access to certain expertise of suppliers and customers in a supply chain and key resources offered by stakeholders. Ultimately, competitive advantage is created, and new customer groups are attracted, especially ethical consumers. (Wolf 2014.) Ethical products is an increasingly important market which cannot be entirely neglected by manufacturing supply chains due to its expanding size. According to Bezençon and Blili (2010, 1305) market of ethical products where "consumers buy intangibility, justice and perhaps conscience, is challeng-

ing the common theories of consumer rationality". Ethical products are described to possess one or more environmental and/or social principles which can affect the purchasing decision of the consumer. (Berry & McEachern 2005; Bezençon & Blili 2010; Ethical Consumer 2018.) Demand for sustainability, however, did not originate from consumer stakeholders alone.

The severity of climate change is a generally acknowledged fact and its consequences are becoming increasingly dire in terms of human casualties and monetary damages. In the field of supply chain management (SCM), the accelerating pace of climate change and its disastrous consequences in form of increasingly devastating weather phenomena have also been acknowledged. (Chen & Wang 2016.) As a manifestation of this realisation, low carbon supply chain management (LCSCM) is gaining momentum in both academic and industrial realms alongside GSCM and SSCM. Whereas GSCM is a very broad concept, LCSCM adopts a more specific perspective. Aiming at the abatement of CO_2, CO_2 equivalent or greenhouse gas (GHG) emissions in supply chains operations, concept of LCSCM also incorporates carbon footprint accounting and monitoring. (Zhou et al. 2016; Das & Jharkharia 2018.)

Stakeholders, led by legislators, non-governmental organisations (NGO) and consumers, are, in growing numbers acting to combat climate change with treaties and regulation with an aim to reduce emissions (Meixell & Luoma 2015). One of the most prominent examples of such a treaty is the Paris agreement striving to limit the global temperature rise well below 2°C above pre-industrial levels and further pursue efforts to limit the rise to 1.5°C (UNFCC 2018). The recent Special Report on Global Warming of 1.5°C by Intergovernmental Panel on Climate Change (IPCC) verified the true graveness of the current situation and the future of unprecedented climate disasters unless GHG emissions are swiftly and considerably cut (IPCC 2018). Tightening regulation has forced companies to engage in GSCM and SSCM practices with growing fervour. Stakeholders are using pressure as a means to impose regulation on companies, demanding for environmental and social reforms in value-creating activities. (DiMaggio & Powell 1983; Lee et al. 2014; Seles et al. 2016.)

In terms of stakeholder pressure, the most visible company in the supply chain experiences the most pressure. This company is oftentimes located relatively close to the end consumer in the downstream of the supply chain and possesses considerable negotiation power over other companies, its suppliers, in the supply chain. (Chiu & Sharfman 2011; Wolf 2014; Seles et al. 2016; Schmidt et al. 2017.) Nestlé is a prominent example of such a company. Through their well-known and recognisable brands, these companies most often experience the entirety of stakeholder pressure, even if the controversy was caused by a supplier at the upstream of the supply chain—a phenomenon known as the chain

liability effect (Hartmann & Moeller 2014; Wilhelm et al. 2016). To understand the transformation of stakeholder pressure into requirements for environmental and social reforms in supply chains, we must first comprehend *bullwhip effect*.

Bullwhip effect refers to ineffective allocation of resources in a supply chain caused by distorted demand data. In academic literature the concept of bullwhip effect has been widely addressed by Lee et al. (1997a; 1997b). As each tier in a supply chain attempts to respond rationally to demand higher than normal, managers in charge of different value-creating activities along a supply chain tend to create a safety buffer for themselves by ordering beyond the actual need. This practice sends an erroneous signal of increased demand to the next-in-line, and demand information is further distorted by each tier in the supply chain. When the demand eventually returns to, or sinks even below, previous levels, stocks of products start to inevitably accumulate along the supply chain, tying up working capital in the process. (Lee et al. 1997a; 1997b.) The legendary Beer Game is also based on this phenomenon (Dizikes 2013).

The external, coercive pressure imposed on companies governing their supply chains by stakeholders has been observed to trigger an extension of the traditional bullwhip effect (DiMaggio & Powell 1983; Lee et al. 2014; Seles et al. 2016). Analogously to demand information moving through a supply chain exposed to the bullwhip effect, stakeholder pressure also moves through a supply chain. Instead of the bullwhip effect, its extensions, *green* and *social bullwhip effect*, influence stakeholder pressure in a supply chain. In contrast to the bullwhip effect, these extensions have been examined to a lesser extent in academic literature.

Green bullwhip effect refers to the process where the company governing the supply chain transforms environmental pressures received from stakeholders into more stringent environmental requirements and relays them to the preceding tier in the supply chain. First-tier supplier assesses the requirement and like the company before it, seeks to build a safety buffer by tightening the requirements for its own supplier. Environmental requirements continue to become more stringent in terms of content or implementation deadlines as they move towards the upstream companies. As a result, the first company in the supply chain, manufacturer of raw materials or components, faces the most stringent environmental requirements. (Lee et al. 2014; Seles et al. 2016.)

The existence of possible social bullwhip effect has been scarcely explored. Social bullwhip effect, in reference to its green counterpart, would be triggered by stakeholder pressure concerning social issues and would then be rendered into increasingly stringent requirements along the supply chain. The aim of this thesis is to fill the research gap on the distribution of sustainability within a manufacturing supply chain and explore the concept of social bullwhip effect. Distribution of sustainability refers to the pattern sustainability displays in a supply chain—whether sustainability distributes evenly, if it ac-

cumulates to a specific *supply chain position*, increases towards the upstream or distributes completely differently than the ways described before. By better understanding the nature of environmental and social sustainability distribution, it would be possible to make supply chains transparent to a greater extent and turn the attention of stakeholders to the least sustainable parts of a supply chain. Discovering the possible effect the industry of a company has on sustainability could also aid the stakeholders to better comprehend the possible interdependence relationship between types of certain business activities and sustainability, and thus point out industries more prone to sustainability misconduct.

1.2 Research questions & structure of the thesis

Distribution of sustainability in supply chain between supply chain positions is studied in this research. Sustainability is assessed from two perspectives, environmental and social. In addition, the interdependence between sustainability and industries of the sample companies will be studied. For this research, quantitative environmental, social and corporate governance (ESG) data available from sample companies is utilised and analysis of variance is applied to examine how environmental and social sustainability distribute along a supply chain. Sample is collected from European large manufacturing, wholesale and retail companies involved in manufacturing supply chains. All sample companies are part of the STOXX® Europe 600 index. Sample companies are divided into three supply chain positions: *manufacturer 1* whose value-creating activities comprise extraction of raw materials and production of components; *manufacturer 2* assembling end products; and *vendor*, whose business activities constitute of wholesale and retail activities.

Research questions are as follows:

- How does environmental and social sustainability distribute in manufacturing supply chains between supply chain positions?
- How does the industry of a company affect environmental and social sustainability?

Using these research questions, this thesis also investigates the possible existence of social bullwhip effect in addition to seeking additional evidence to the existence of the green bullwhip effect.

This thesis consists of seven chapters. Chapters 2–4 serve as a literature review and provide theoretical background on the researched phenomena, whereas Chapter 5 presents the hypotheses formulated based on the research questions above. Chapter 6 introduces the scientific methodology, data used and methods of data analysis. Chapter 7 presents the results of the empirical research conducted and Chapter 8 connects the results to the academic literature and previous research. Chapter 8 also discusses the theoretical and practical implications of the results and suggests further research topics.

2 DEMAND FOR ENVIRONMENTAL AND SOCIAL SUSTAINABILITY IN BUSINESS

2.1 Dawn of modern sustainability concept: triple bottom line

The concept of triple bottom line (TBL) was coined and later popularised by Elkington in 1994 (Elkington 2018). Elkington's vision was to create a sustainability framework examining the impact of corporate value-creating activities across three dimensions—economic, environmental and social. TBL was the manifestation of "people, planet, profit" triangle, striving to treat economic, environmental and social measures as equally important. Using TBL, environmental consideration and actualisation of social justice in value-creating activities were intended to be monitored by using audits and reports, just like economic performance. (Elkington 1999.)

Elkington has previously presented concepts highlighting the environmental aspect in conducting business; environmental excellence in 1984 and green consumer in 1986, but TBL was the first concept spearheaded by Elkington to incorporate the social element alongside environmental and economic dimensions (Elkington 2004). Prior to this, logistics and supply chain management literature had principally contemplated issues concerning environment, actualisation of human rights and safety at workplace as well as maximising efficiency in production processes as separate, independent phenomena (Carter & Jennings 2002; Carter & Rogers 2008). Savitz and Weber (2006) hailed sustainability as the new fundamental principle of smart management. According to Wu and Pagell (2011), TBL leads to sustainability in the long term and exposes decision makers of organisations implementing TBL to fewer strategic trade-offs between environmental, social and economic performance than decision makers representing organisations not having adopted TBL in their value-creating activities.

Emergence of TBL has inspired a wide range of different sustainability reporting measures, e.g. Global Reporting Initiative (GRI) in 1997, Dow Jones Sustainability Indices (DJSI) in 1999 and social return on investment—a methodology converting the environmental and social value of an investment into monetary terms—which has been discussed in academic literature already in 2000 (Millar & Hall 2013; GRI 2018; RobecoSAM 2018). In addition, various other environmental, social and corporate governance (ESG) measures including the one used in this research, Thomson Reuters ESG scoring, have their origins in TBL (Thomson Reuters 2018).

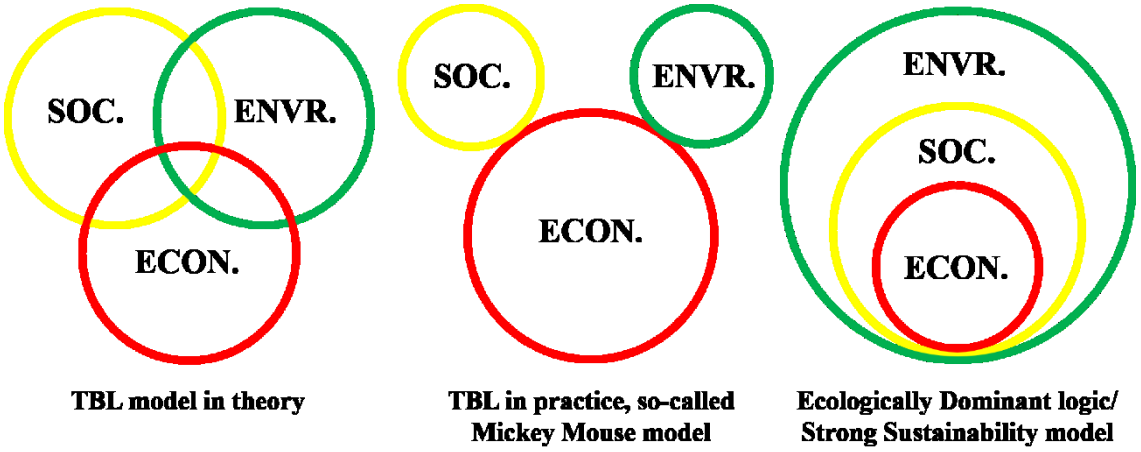
2.2 Criticism of triple bottom line

Like many concepts before, TBL has not been without criticism either. MacDonald and Norman (2007) commented on the adoption of TBL by hundreds of organisations— websites and documents containing enthusiastic announcements of TBL in use and endorsements for the concept—stating that the implementation in most cases was done without any critical scrutiny. Claiming the concept of TBL to have noteworthy shortcomings, MacDonald and Norman (2007) view the use of an accounting paradigm to evaluate a company and the ethical dimensions of the said company as a fundamentally unfit method for the task—how can environmental or social performance be condensed into single bottom line? The plethora of measures reported in various units cannot be treated in the same manner financial information is treated in terms of commensurability. MacDonald and Norman (2007) went on and compared financial bottom line to a so-called social bottom line using the following example: how could the secretary answer to the question of the managing director, has the social bottom line of the company increased or decreased from last year. In the case of financial bottom line, this question could be answered. However, with social bottom line in question, no unambiguous answer could be provided. (Norman & MacDonald 2004; MacDonald & Norman 2007.)

Milne and Gray (2013) animadvert upon TBL for distorting the definition of what are considered sufficient corporate actions to sustain the planet's ecology. Milne and Gray (2013) claim that TBL and GRI in fact bolster unsustainable business practices by presenting those as an adequate standard. Mixing the incomplete TBL reporting with true sustainability further exacerbates the situation as managers falsely believe that the companies they represent conduct business in an environmentally, and ecologically, sustainable manner (Milne & Gray 2013). Bansal and Song (2017) argue that the recent integration of economy, society and environment by scholars has shifted the paradigm from how to sustain systems to how companies can sustain systems, thereby elevating companies as the ultimate stakeholder. Consequently, economic interests of a company can become a starting point in research and sustaining these interests a goal in practice as trade-offs are made between the three domains, economy, society and environment. Managers would implement social and environmental sustainability practices only if such practices would be aligned with the strategic interests of the company or have profit expectations (Bansal & Song 2017). As some of the planet's natural resources are depleting at an alarming rate, Pagell and Shevchenko (2014) urge future SCM research to examine environmental and social performance of supply chains at the very least as equally important or preferably more crucial than the ability to generate profit.

Montabon et al. (2016), in turn, questioned the prevailing TBL doctrine. The ultimate driver for implementing environmentally and socially sustainable practices in TBL is the economic gain. Instead of this mindset, the question "how can a supply chain become

sustainable" must be asked—harm reduction does not lead to true sustainability. As an alternative to, or as an improvement of TBL, Montabon et al. (2016) propose the concept of ecologically dominant logic. Whereas the traditional logic currently in place in the corporate world emphasises the economic aspect of business, ecologically dominant logic would nest social and economic issues inside environmental issues and economic issues within social issues. This change of perspective first satisfies environmental needs followed the fulfilment of social needs and only then turns to fulfilling customer demands in contrast to the short-term profit-seeking practice with an aim only to mitigate negative long-term environmental and social outcomes. As environment is the "great enabler", providing societies with a living environment and a chance to conduct business in the first place, environment is incontestably the ultimate constraint in the equation for generating profit. (Montabon et al. 2016.) Comparison of different sustainability concepts is provided in Figure 1.



Note Used abbreviations: econ. = economic; envr. = environmental; soc. = social

Figure 1 Comparison of TBL how it was intended by Elkington, how TBL is often implemented in practice and the ecologically dominant logic leading to true sustainability (adapted from Elkington 1999; Adams 2006; Adams et al. 2009; Montabon 2016; Mulia et al. 2016)

Ecologically dominant logic is not the first concept to place environment ahead of society and economic gain, yet it is one of the first to do so in the field of SCM. As early as 1991, Henderson introduced the layer cake model where Mother nature forms the foundation for upper layers which are the society—the love economy, including e.g. volunteering work, parenting, community structures—and public and private sector, the gross national product monetised half of the cake. Above all this rests the market economy with its cash transactions. The layer cake model is displayed in Figure 2. (Henderson 1991.)

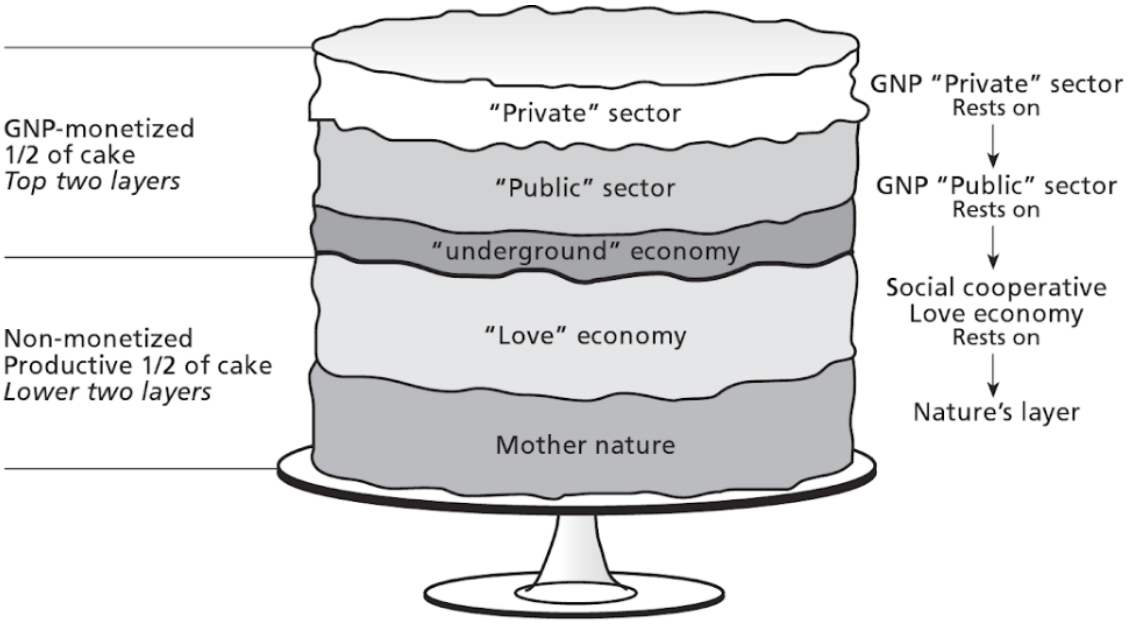


Figure 2 Layer cake model distinguishing the interdependence between environmental, social and economic dimension (adapted from Henderson 1991; Cato 2008)

The impact of sustainability reporting on truly changing corporate behaviour has been questioned. Some scholars and organisations, e.g. Christian Aid (2004), Gray (2006), Murray et al. (2017), claim that corporate responsibility reporting acts as a mere smokescreen and the status quo, unsustainable operations, prevails behind the façade of reporting. In June 2018, "the father" of TBL himself issued a recall on the concept. Elkington purports that TBL has been mostly adopted as an accounting tool, not as a holistic way of conducting business. According to Elkington, TBL, once a revolutionary idea, has been diluted by the excessive amount of sustainability reporting. This view is shared by Tim Mohin, GRI's Chief Executive. Both individuals demand for harmonisation among various reporting standards, Mohin, in an interview given to Ethical Corporation, calling for more effective data applications instead of traditional company-produced marketing reports, which attract little mainstream investment community attention (Slavin 2018). Mohin insists that data should be more concise, always up-to-date and data should be exploited to forecast upcoming trends and events. Both Elkington and Mohin agree that TBL-based ESG data is needed more than ever before, but the data must still be in an instantly accessible, clear and applicable form for different purposes. (Elkington 2018; Slavin 2018.)

2.3 Notions on sustainability in the academic realm

Due to human-induced climate change finally becoming a generally recognised fact, at the latest after the signing of the Paris agreement, heeding the environment is of ever-increasing importance to conducting business. Environmental considerations have already been incorporated into the daily operations of many companies. (UNFCC 2018.) In the field of SCM, doctrines aiming to establish green supply chains are gaining foothold among management practices as means to comply with constantly tightening environmental legislation and to create competitive advantage (Rajeev et al. 2017; Taborga et al. 2018). Green supply chains strive to integrate the environmental aspect into all the operations conducted in the chain from product design to end-of-life management of the product (Srivastava 2007).

Competitive advantage can also appear as product or service differentiation, and thus is not only restricted to process-based cost reductions and efficiency improvements (Laari et al. 2017). Climate change is to be blamed for both increased frequency and magnitude of extreme weather phenomena in the recent years and this observation has had its repercussions on SCM practices as well (Mal et al. 2017; Herring et al. 2018). IPCC's special report on the devastating effects of global temperature average increasing by more than 1.5°C above pre-industrial levels has given further impetus to conduct business in a more environmentally friendly manner, and many legislating bodies have expressed their concern for the situation globally and spoken for severely tightening environmental regulation in many sectors of society (IPCC 2018; Willuhn 2018).

However, Van der Leeuw et al. (2012, 118) state that academia is poorly positioned in addressing sustainability issues and "suffers from anachronistic pedagogy, inertia, and disciplinary insularity and isolation". Bursztyn and Drummond (2014) assert that non-academic research institutions are more flexible than universities in responding to problem-oriented demands. Interdisciplinary research and training programmes in the field of sustainability are still in the nascent stage in universities in comparison to the situation in non-academic research institutions. This hinders the realisation of synergies between different faculties through multidisciplinary research teams and exchange of knowledge in universities. Universities are being pushed to differentiate their study modules and specialise at the cost of encompassing perspective. Non-academic research institutions benefit from a more pragmatic, problem-oriented approach in research in contrast to the somewhat fixed department and faculty structure of universities. More adaptive and responsive multidisciplinary task forces may be deployed and shuffled into new teams in a much more agile fashion than research teams of the academic world. (Bursztyn & Drummond 2014.)

Another factor impeding the attempts of academia to address sustainability issues is the use of terminology. Sustainability and responsibility are oftentimes used as synonyms

in an inconsistent and ambiguous fashion. These two concepts have displayed convergence only during the last two decades, albeit having evolved from different paradigms. Responsibility originally focused on social issues and sustainability examined environmental concerns. (Bansal & Song 2017.) Bansal and Song (2017) argue that the semantic blurring between sustainability and responsibility has resulted in the stagnation of both fields of research, omitting vast, potential areas of study which could generate further knowledge of the relationship between business and society. Outside the academic realm, notable actors have also fostered the ambiguity of terminology, one prominent example being United Nations Global Compact defining their mission—"by committing to sustainability, business can take shared responsibility for achieving a better world" (United Nations Global Compact 2018).

In parallel to Bansal and Song (2017), Van der Leeuw et al. (2012) assert that academia is circumventing urgent and severe issues e.g. climate change, loss of biodiversity and poverty as the discussion is ridden with a plethora of interpretations of sustainability. These interpretations are coupled with own methodological choices, goals and frameworks of each interpretation causing fragmentation of the discourse, resulting in the use of rhetoric in a mismatch with real-world sustainability transitions. (Van der Leeuw et al. 2012.) While out of touch with reality, academia ought to seek and establish partnerships with actors from industry, NGO field and other stakeholders of the society. This rapprochement would initiate a transition towards a sustainability solution orientation as proposed by Van der Leeuw et al. (2012) and Yarime et al. (2012), drawing parallels to the proposals made by Bursztyn and Drummond (2014) to develop interdisciplinary research and training programmes in the field of sustainability and deepen the interaction with non-academic research institutions.

2.4 Under pressure—a stakeholder perspective on sustainability

DiMaggio and Powell (1983) introduced three mechanisms which act as drivers of institutional isomorphism. Institutional isomorphism can be defined, in a straightforward manner, as a process where organisations operating in the same organisational field start to eventually resemble one another as rational actors representing those organisations strive for improvements. This homogenisation process is triggered by three mechanisms: coercive, mimetic and normative pressure. Mimetic pressure results in organisations mimicking each other's responses to uncertainty, whereas normative pressure drives members of an occupation to unite their forces in a process called professionalisation. Coercive isomorphism, however, is manifested in an organisation when other organisations, also known as stakeholders in this context, exert formal or informal pressures on the examined organisation. (DiMaggio & Powell 1983.) Such pressure can be perceived

in a positive or negative fashion—"as force, as persuasion, or as invitations to join in collusion" (DiMaggio & Powell 1983, 150). Organisations, which depend on stakeholder organisations e.g. manufacturers dependent on their customers, are exposed to certain requirements. In terms of sustainability, manufacturers have a strong imperative to reduce emissions of their value-creating activities as their customers in the downstream of the supply chain, on their behalf, are being exposed to pressure as a result of the emission control policies introduced by their government or by some other legislative body. Emission performance of suppliers might also play a key role due to the legislative pressure when the customer company in the downstream shortlists potential manufacturers. (Hu et al. 2015; Jabbour et al. 2015; Kuo et al. 2015.) The surrounding society may also impose cultural expectations on the company, for example, local community might require a foreign company to operate according to ethical business practices customary to the country in question. (DiMaggio & Powell 1983.)

One of the most prominent stakeholder groups are consumers (Seles et al. 2016). Possessing purchasing power, being the end user of the proliferation of manufactured goods produced and the ultimate mainstay of the whole capitalist system, consumers with their decisions dictate the survival and prosperity of companies in manufacturing supply chains. Not simply being limited to the decision to buy or not, consumers can also rally others behind the cause of boycotting certain brands. One of the growing consumer movements, and subsequently also one growing market, is ethical consumerism. (Berry & McEachern 2005; Bezençon & Blili 2010; Ethical Consumer 2018.) Ethical consumerism is defined as "the intentional purchase of products considered to be made with minimal harm to humans, animals and the natural environment" by Burke et al. (2014, 2237) who adapted their definition from Auger et al. (2003), Bray et al. (2011) and Papaoikonomou et al. (2012).

Ethical consumerism has displayed growing importance financially and in terms of consumer attitudes and concerns during the last decade. Consumers are increasingly concerned about environmental and social facets of production processes, and the number of consumers willing to pay a premium for products produced by socially responsible companies is on the rise. In United Kingdom, ethical spending in 2005–2011 increased by one third to a total market value of GBP 47.2 billion. By 2017, the total market value had increased by over three quarters from the figure of 2011 to GBP 83.3 billion, a growth driven primarily by increased environmental concern. Additionally, during 2017 almost the half of (49 %) of consumers under 24 years of age avoided a product or service based on its negative environmental impact according to a report by Ethical Consumer. (Bonini & Oppenheim 2008; Ethical Consumer 2012; 2018; Nielsen 2013; Burke et al. 2014.) Consumers engaging in conscious consumption, not merely purchasing ethical products but also reducing consumption overall, are also more prone to political engagement, acting as active citizens and making individualised decisions opposed to collective ones.

Such consumers have the possibility to exert further influence on manufacturing supply chains through fostering social change. (Willis & Schor 2012.) Oftentimes, ethical consumerism is viewed exclusively as a Western phenomenon displayed in post-industrial societies, but signs of similar trends and preferences have been observed to emerge also in developing economies (Balasubramanian & Soman 2018). For instance, China has based its economic planning on the concept of circular economy in three of its Five-Year Plans 2006–2020, signalling of a salient change in mindset towards consideration for the environment (Zhang et al. 2008; Central Compilation & Translation Press 2016; Murray et al. 2017).

Alongside environmental aspect gaining momentum in conducting business, social sustainability is also becoming an integral part of modern business practices. Failing to comply with current standards of social sustainability imposed on the supply chain leads to widely reported media controversies, which spread rapidly in the era of easily accessible social media. For example, technology giant Apple has often been accused of, in some cases inhumane, working conditions and inadequate safety measures of its suppliers, which led e.g. to the explosion at the site of Apple's main supplier Foxconn in China 2011 killing four and injuring 18 workers and prompting a boycott campaign against Apple in 2012 (Duhigg & Barboza 2012; Harris 2012). World's largest food and beverage company Nestlé, in turn, has faced heavy criticism due to its unsustainable and unethical business practices (Tennant 2015; White 2017; Fullerton 2018). Component suppliers of Samsung in Malaysia have been, in a similar vein, exposed for e.g. confiscating the passports of their labour force, thus forcing them to live in constant fear of deportation. Same suppliers have also been paying considerably smaller wages than initially promised, rendering some of the workers effectively modern slaves working to pay back just the loan they took to settle the initial the recruitment fee. (Pattison 2018.)

Other repercussions from violating social sustainability standards than media backlash can be e.g. having to pay considerable compensations for damages and the loss of investors and/or customers (Yawar & Seuring 2017). Prominent cases regarding indemnity include California State Court ordering agrochemical and agricultural biotechnology corporation Monsanto to pay a former groundskeeper USD 289 million as the company's weedkiller product caused the groundskeeper to develop cancer. The sum was later lowered to USD 78.5 million. (Levin & Greenfield 2018; Wamsley 2018.) In May 2019, Monsanto has been obliged to pay more than USD 2 billion in damages to a California couple due to cancer discovered in both wife and husband. The cancer was caused or contributed by herbicide glyphosate used by Monsanto in some of its products. (Blankstein & Kaplan 2019.)

In addition to direct demand for environmental and social sustainability, corporate social responsibility (CSR) practices have also been studied to have a considerable influence

on consumer perceptions of brand equity (Kang & Namkung 2018). United Nations Industrial Development Organization defines CSR as "a management concept whereby companies integrate social and environmental concerns in their business operations and interactions with stakeholders". The term encompasses economic, social and environmental performance—social performance can be measured in e.g. the state of working conditions, realisation of human rights at the workplace and the quality of governance policy. (UNIDO 2018.)

Consumers are not the sole stakeholder group pressurising companies to conduct business in an environmentally and socially sustainable manner. Other stakeholder groups such as legislators and NGOs face a troublesome task of monitoring the realisation of sustainability from the start to the end of the process in growingly complex manufacturing supply chains (Cannella et al. 2018). Through their own direct and indirect monitoring and pressurising activities, the stakeholders—competitors, communities, NGOs, governments and customers—initiate the implementation of green supply chain management (GSCM) and sustainable supply chain management (SSCM) practices by exerting influence on the most visible company in the supply chain with considerable negotiation power over its suppliers—a company governing the supply chain (Seles et al. 2016; Schmidt et al. 2017). Comprehensive definitions for GSCM and SSCM will be provided in Chapters 3.1 and 3.2, but for the sake of clarity, a short definition is provided already here. GSCM aims at "greening" supply chains and SSCM incorporates social reforms alongside with green initiatives in supply chains (Srivastava 2007; Seuring & Müller 2008).

Regarding SSCM, Meixell and Luoma (2015) discovered that stakeholder pressure may result in three different outcomes for a company, and for a supply chain at large. Firstly, stakeholder pressure may raise awareness of sustainability within a company. Pressure may also lead to the company setting sustainability goals and, ultimately, result in the implementation of SSCM practices. Secondly, stakeholder type also affects where the pressure is felt—media pressure most often affects purchasing decisions and shareholders, in turn, influence logistics decisions. Finally, stakeholder type also effects the dimension of sustainability targeted: social sustainability is predominantly enforced by employees and NGOs, whereas environmental sustainability is affected by external stakeholders e.g. governmental bodies and end consumers. (Meixell & Luoma 2015.)

Wolf (2014) dissected the relationship between SSCM, stakeholder pressure and corporate sustainability performance, being among the first to assert that supply chains, and thus companies, could benefit from implementing SSCM beyond reduction of stakeholder pressure. Wolf (2014) discovered that SSCM can grant companies access to key resources, enhance their reputation as a "good citizen" and develop unique resources and capabilities, challenging the view that external stakeholder pressure is the sole driver for SSCM. Stakeholders were observed to engage in two strategies regarding key resources, withhold and usage strategies. In the example of Nestlé and its palm oil supplier Sinar

Mas, Nestlé first applied the withhold strategy, but later switched to usage strategy. Greenpeace exerted pressure over Nestlé to end the supply of unsustainably extracted palm oil by Sinar Mas, where Greenpeace succeeded. Nestlé later re-established the supply relationship with Sinar Mas with the condition that the said supplier upgrades its operations to meet the standards of sustainable palm oil production certificate issuer. (Wolf 2014.)

Stakeholders have been proven to punish the company governing the supply chain most severely even for the non-compliance of its suppliers. Stakeholders, however, have trouble reaching any other supply chain positions in the chain beyond the companies most visible to the public at the downstream of the supply chain. As supply chains oftentimes possess little transparency and are complex in design, the sustainability of operations along the line is hard to assess (Cannella et al. 2018). In other words, global brands may receive negative publicity due to lower-tier suppliers not adhering to sustainability standards. This phenomenon is known as the chain liability effect. Concluded by Hartmann and Moeller (2014), in the case of an environmental degradation incident, consumers might comprehend how arduous and complex of a task enforcing sustainability throughout the entire supply chain imposed on the company governing the supply is, but nonetheless still resort to blame the governing company for the dereliction of standards committed by its suppliers for the sake of convenience. (Hartmann & Moeller 2014; Wilhelm et al. 2016; Villena & Gioia 2018.)

3 ENVIRONMENTAL AND SOCIAL SUSTAINABILITY MANAGEMENT & MEASUREMENT

3.1 Green Supply Chain Management

TBL has inspired two often intertwining concepts, green supply chain management (GSCM) and sustainable supply chain management (SSCM). Payman and Searcy (2013) studied the differences between these two definitions, which are frequently used interchangeably even by scholars. In general, GSCM has intrinsically emphasised the environmental dimension of SCM operations, whereas SSCM takes a more holistic approach including all three elements of TBL sustainability, "people, planet, profit". Srivastava (2007) has been one of the pioneers in the field of GSCM conducting a literature review of various GSCM definitions. His interpretation of GSCM incorporates a life cycle approach into the definition as he describes GSCM as "integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life" (Srivastava 2007, 54).

Zhu et al. (2012) divide GSCM practices into internal and external ones—previous encompass practices implemented in-house such as eco-design and environmental management, whereas latter includes transactions with suppliers and customers. Concrete examples of internal GSCM practices are pollution prevention programmes in internal processes, special training for workers on environmental issues, and collection and sale of scrap and used materials. External GSCM practices include e.g. requiring suppliers to have an ISO 14001 (environmental management system) certification and co-operation with customers for green packaging and for reverse logistics agreements. (Zhu et al. 2012.) Schmidt et al. (2017) base their categorisation of GSCM practices on several academic publications and divide practices into green design, green internal management, green logistics, green purchasing and green manufacturing.

One of the latest trends affecting the field of GSCM is the transition towards circular economy, one prominent example of this being China. Circular economy is defined as "an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximise ecosystem functioning and human well-being" (Murray et al. 2017, 377). As opposed to the construct of linear economy, where natural resources are converted into waste by means of production, circular economy seeks to manage the flux of resources in cycles. Aiming for no net effect on the environment, circular economy strives for restoring damage inflicted on the environment in resource extraction phase and minimising waste generation throughout the life cycle of a product based on the principle of three Rs: reduce, reuse and recycle.

When resources stay in the cycle for longer, waste output is delayed, and both rate of replacement and need for resources decrease. (Murray et al. 2017.) Much like certain early GSCM practices before they matured, the concept of circular economy has been recognised as a means for achieving competitive advantage (Genovese et al. 2017; Ellen MacArthur Foundation 2019). Genovese et al. (2017) identify clear advantages from integrating circular economy principles in GSCM practices, especially production-related, from an environmental point of view.

Another concept analogous to GSCM is low carbon supply chain management (LCSCM). The number of journal articles addressing carbon emission issues in supply chain management has increased sharply from 2010 onwards, albeit research on carbon emissions issues in SCM is still a fledgling field of research. Das and Jharkharia (2018), in their comprehensive literature review on LCSCM, suggest the Kyoto Protocol, which placed legislative pressure on organisations for abating emissions in 2005, as a possible reason for the emerging LCSCM trend. The definition of LCSCM according to Das and Jharkharia (2018, 399) is "a strategy that integrates CO_2 or CO_2 equivalent or GHG emissions either as a constraint or as an objective in supply chain design and planning".

In comparison to green or sustainable supply chain management, LCSCM represents a more specific approach to involve environmental concerns in supply chain activities from a pollution point of view as the concept revolves around carbon emission reduction. Such reduction can be achieved by e.g. selecting suppliers, managing transportations and designing networks with emission abatement as a driver. Furthermore, LCSCM also highlights the need for carbon footprint accounting and conceptualisation in SCM and acknowledges the need for trade-offs between economic and environmental objectives across different supply chain functions. (Zhou et al. 2016; Das & Jharkharia 2018.)

3.2 Sustainable Supply Chain Management

During the last decades, SSCM has transitioned from the marginal into the research mainstream. SSCM definitions have comprehensively been mapped by Seuring and Müller (2008) and they propose two different strategies—one focusing on suppliers in terms of risk and performance while the other one takes a product-based stance. As stated by Seuring and Müller (2008, 1700), the definition of SSCM is "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements". Considering this definition, SSCM can be regarded as an extension of GSCM introducing the social aspect, and thus sharing the threefold division framework with TBL (Pagell & Shevchenko 2014).

Nonetheless, comprehensive mapping effort has not succeeded in ending the treatment of SSCM as s separate entity of SCM. Pagell and Shevchenko (2014) claim that five salient issues prevent the discovery of new practices and procedures to create truly sustainable supply chains. Preponderance of studies in both fields, GSCM and SSCM, have been dictated by the question "does it pay to be green" which places the focus on economic performance of a company, neglecting the development of harm elimination. Regarding stakeholder prioritisation, managers and shareholders are predominantly viewed as the most important stakeholders in a supply chain, effectively elevating the fulfilment of monetary goals above all else. (Hart & Ahuja 1996; Ambec & Lanoie 2008; Carter & Rogers 2008.)

The development of SSCM research has also been hindered by concentration on familiar practices. Explorative SSCM practice studies are few in number as the majority of studies are limited to merely examining how existing practices can transform unsustainable supply chains to less unsustainable, thus setting the standard as damage mitigation instead of elimination. Pagell and Shevchenko (2014) also name unfit empirical tools and ill-suited measures as impediments for reaching truly sustainable supply chains. Academia has lagged behind the development of industry and empirical tools are currently formulated to answer "what" questions, rather than "how" questions, and have a historical emphasis. Such tools thus have a built-in propensity to neglect radically innovating supply chains. Measures serving as indicators of supply chain impacts are largely based on secondary data as managerial perceptions on environmental and social issues are often subjective. Measures utilising secondary data generally fail to capture impacts of entire supply chains. (Pagell & Shevchenko 2014.)

The social dimension of supply chain management has been overshadowed by the proliferation of GSCM practices (Yawar & Seuring 2017). Klassen and Vereecke (2012, 103) determine social issues in supply chains as "product or process related aspects of operations that affect human safety, welfare and community development". Yawar and Seuring (2017) use the term responsible supply chain actions when referring to practices solving social issues in supply chains. They divide such practices to communication, compliance and supplier development strategies. The objective of communication strategies is to e.g. address stakeholder concerns and commit customers by presenting sustainable operations in communication. Typical practices include sustainability reporting and product labelling which conveys product characteristics in a transparent fashion. Instruments of compliance strategies include codes of conducts, standards, and auditing and monitoring measures. Two previous ones aim to solve social issues occurring in supply chains, whereas the latter two, auditing and monitoring, track the implementation of practices required to meet standards, and measure the impact of sustainability practice adaptation on supplier performance. The most popular practice for resolving social issues is the im-

plementation of codes of conduct and standards (Van Tulder et al. 2009). Supplier development strategies in practice comprise collaborations, training, investments into assets, and financial and technical support (Krause et al. 2007). As companies governing supply chains are oftentimes held accountable for social sustainability of the whole chain, the social performance of suppliers is of importance to both internal and external stakeholders (Yawar & Seuring 2017).

One concrete example of social sustainability practices, and more specifically of codes of conduct and standards, is SA8000 social certification. SA8000 is measuring social performance through eight criteria, which include abstaining from child labour and enforcing freedom of association. The implementation of SA8000 along the supply chain is audited and monitored by regular revisions. (Klassen & Vereecke 2012; Social Accountability International 2018.) Other types of examples are joint social development projects in collaboration with stakeholders from local communities, for instance, building a school and funding research and education aimed at improving women's healthcare (Klassen & Vereecke 2012).

3.3 From financial performance measurement to sustainability performance measurement

When it comes to monitoring economic sustainability, various metrics and measures exist for assessing different aspects of economic performance of a company. Key performance indicators (KPI) and ratios measuring profitability, liquidity, solvency, efficiency of asset use and market value of a company appear numerous and diverse. (Investopedia 2019.) As the primary objective of a company is to generate profit, these measures have traditionally received the most attention in business management (Rajnoha et al. 2016). In numerical sense and in terms of maturity, ratios measuring sustainability have been lagging behind financial ratios in development (Fowler & Hope 2007). Also, the obscurity and lack of distinction among concepts and the subjective nature of sustainability assessment—which level of performance is perceived as good or acceptable—have hindered the development of instruments for measuring sustainability in supply chains (Pagell & Shevchenko 2014; Bansal & Song 2017; Yawar & Seuring 2017).

One plausible reason explaining the gap between the measure types available, alongside focus on mere financial performance in the past, is the very nature of environmental and social sustainability performance. Performance in these two fields is hard to detect or express upon implementation of the practice, as the effects can often be recognised only after a delay. The preponderance of research has focused on how does improving the environmental and social dimensions of operations impact financial performance. (Pagell & Shevchenko 2014; Friede et al. 2015; Laari et al. 2016; Lee et al. 2016.) Another factor

contributing to the enhanced emphasis on environmental and social sustainability measuring is stakeholder pressure as last two decades have witnessed a transformation from focusing on shareholder values to addressing the concerns of a wider stakeholder group (Rajnoha et al. 2016).

Demand for diverse sustainability measures and indices is stronger than ever before as e.g. increasingly many consumers want to make ethical choices and companies are required to conduct business in an ethical and sustainable manner by many stakeholder groups (Hancock 2017; Ethical Consumer 2018; Russell 2018). Pressure to comply with demands comes from legislative stakeholders, NGOs and consumers alike. In recent years, the development of ratios measuring environmental and social sustainability performance has been accelerating and the general attitude has been shifting from monitoring primarily financial measures to strategic performance measurement involving all three components of TBL. (Speziale & Klovienė 2014; Izadikhah & Farzipoor Saen 2016; Rajnoha et al. 2016.) Performance measurement systems consist of a set of both financial and non-financial measures which collect, process and analyse quantified data and ultimately produce information to support the top brass of a company in decision-making (Rajnoha et al. 2016). Such systems expand the scope beyond the realm of financial performance measurement by involving non-financial indicators.

Strategic performance measurement systems (SPMS) are a derivative of performance measurement systems, adding different perspectives to the examination of performance of a company. When these perspectives—financial concerns, customer demands, internal processes and long-term innovation—are combined, managers are presented with means to translate company strategy into effective and sound performance measures, KPIs. SPMSs possess the potential to recognise causal relationships between the operations and strategy of a company with an aim to create a framework, where to formulate and implement strategies. (Chenhall 2005.) SPMSs can also be viewed as a strategy implementation tool as through the KPIs, SPMSs contribute to the achievement of strategic goals through a set of mechanisms. These mechanisms comprise enhanced understanding of links between different policy priorities, sound communication between objectives and activities and lastly, allocation of resources and tasks in an efficient manner. (Dossi & Patelli 2010; Rajnoha et al. 2016.) A typical example of a SPMS is the Balanced Scorecard (BSC), a system of balanced objectives and indicators developed by Kaplan and Norton (1993).

BSC is defined by Figge et al. (2002, 279) as "a tool to identify the 15–25 strategically most relevant aspects and to link them causally and hierarchically towards the long-term success measured by the financial perspective". BSC methodology is largely based on stakeholder theory, presenting cause-effect relationships between operational and non-business activities and long-term corporate strategy. Identifying these links, according to Figge et al. (2002), leads to the prioritisation of activities based on their strategic importance. Transformation from shareholder values to addressing concerns of a wider

stakeholder audience, through the adaption of sustainable-oriented BSCs, has resulted in stakeholders examining the impact of value-creating activities on environment and society more rigorously than previously. (Rajnoha et al. 2016.)

Searcy (2012) mapped the evolution of corporate sustainability performance measurement systems (CSPMS), their implementation and use exhaustively in his review study. In comparison to other performance measurement systems, CSPMSs are characterised by the need to measure the ability of a system to adapt to change over an extended period of time (Milman & Short 2008). A longer time span is required as the impacts of environmental and social practices surface gradually as opposed to practices aiming to improve financial bottom line resulting in sudden yields (Laari et al. 2016; Lee et al. 2016). Another difference to performance measures is the intrinsic focus of a CSPMS on environmental and social dimensions of operations (Searcy 2012). CSPMS is defined by Searcy (2012, 240) as "a system of indicators that provides a corporation with information needed to help in the short and long-term management, controlling, planning, and performance of the economic, environmental, and social activities undertaken by the corporation"—a system implementing TBL.

One of the CSPMS was developed as a direct upgrade of the BSC, to advance the measurement of environmental and social impact of corporate operations. Figge et al. (2002) introduced the Sustainability Balanced Scorecard to overcome the shortcomings of the original BSC, which was ill-suited to comprehensively measure sustainability. The process of developing a Sustainability BSC is threefold and includes the integration of environmental and social management into business management, ensuring that the created scorecard is business unit specific and unique in design, meets the specific characteristics and requirements of the strategy and complies with the environmental and social aspects of the business. Finally, environmental and social aspects of a business, which are strategically relevant, are to be integrated. (Figge et al. 2002.)

3.4 Means of measuring sustainability

TBL has been used not only as a business management concept, but also as a tool to measure sustainability, alongside Sustainability BSC. Slaper and Hall (2011), however, have pointed out that no uniform standard on how to calculate TBL is in place nor is there a universal agreement on the measures comprising the three categories of TBL. Sloan (2010) identifies sets of management tools to assist companies in making sustainable decisions and methods for reporting sustainability. These tools contain e.g. life cycle assessment used to evaluate the impact of a product on the environment from design to disposal, global efficiency ratio, environmentally conscious manufacturing programmes and the

previously introduced Sustainability BSC (Sloan 2010). Global efficiency ratio, developed by Barbiroli and Raggi in 2003, is a numeric index determining the impact of environmental innovations on a specific process (Barbiroli & Raggi 2003). Sarkis (1999), in turn, has innovated conscious manufacturing programmes where in the first phase of the programme, factors affecting the selection of a manufacturing alternative are given relative weights through an analytical network process. In the second phase, data envelopment analysis ranks the manufacturing alternatives (Sarkis 1999).

Measures used to analyse, and report sustainability are most often based on TBL concept (Sloan 2010). GRI provides standards for economic, environmental and social performance reporting. Such standards instruct how to collect, analyse and report sustainability information in a standardised form. (GRI 2018.) Another initiative focused on sustainability is the Global Environmental Management Initiative (GEMI). Unlike GRI, GEMI does not concentrate on developing and disseminating standards, but rather provides tools and consultancy for organisations to foster environmental sustainability and health and safety at workplace, thus striving for reduced burden on the planet and safer working environments. (Sloan 2010; GEMI 2019.)

Sustainability indices and measures generating numerical values are attempting to provide more objective data on sustainability than standard-based self-reporting initiatives. Roberts Enterprise Development Fund developed social return on investment in 2000 as a response to the growing pressure exerted on non-profit social enterprises to exhibit the social value created by the enterprises in monetary terms (Low 2006). Social return on investment results from dividing the net present value of benefits with the net present value of investments (Millar & Hall 2013). Prominent indices incorporating all elements of the "people, planet, profit" triangle include e.g. DJSI, Morgan Stanley Capital International (MSCI) ESG Ratings and Thomson Reuters ESG Scores. These indices take certain measures, focusing on environmental, social and corporate governance performance, and use these measures to calculate relative scores for individual companies, industries and regions to render sustainability benchmarking, based on relatively objective data generated by a standardised process, possible. (RobecoSAM 2018; Thomson Reuters 2018; MSCI 2019.)

Nine different indices with a specific geographical focus, e.g. DJSI Europe, DJSI Asia Pacific and DJSI Korea, comprise the DJSI family. Dow Jones index families themselves are six in total with each having a different emphasis. S&P Fossil Fuel Free index family for instance tracks the performance of companies not in the possession of fossil fuel reserves and places additional weight on carbon emissions in performance evaluation. Through the annual Corporate Sustainability Assessment, companies across 60 industries are compared based on a questionnaire consisting of 80–100 cross-industry and industry-specific questions. These results are then processed, and companies receive a score on a

range 0–100, where 100 is the best score, and a percentile ranking on 20 financially relevant sustainability criteria, as a result. (RobecoSAM 2018; 2019.)

MSCI ESG Ratings and Thomson Reuters ESG Scores are more similar in design in contrast to the self-evaluation methodology approach used by to DJSI. Analysts at MSCI gather macro datasets generated by academical and governmental actors and NGOs, for example, datasets of Transparency International and World Bank. Company disclosures, e.g. sustainability reports, and the media are also among utilised data sources. Data is in the next phase processed through the lens of 37 key issues selected annually for each industry, and ultimately an ESG Letter Rating is issued for individual companies to be used for benchmarking purposes. (MSCI 2019.) In the case of Thomson Reuters, ESG Score is calculated in a very similar fashion to the rating of specific sustainability measures used by MSCI, which are refined into comparable scores for over 7,000 companies. Thomson Reuters ESG methodology is comprehensively described in Chapter 6.2 (Thomson Reuters 2018.)

4 BULLWHIP EFFECT AND ITS EXTENSIONS

4.1 Bullwhip effect encountered, recognised & popularised

The position of a company in the supply chain has been asserted to have a considerable effect on stakeholder pressure and salience experienced by the company. Companies are exposed to varying degrees of pressure in the supply chain based on the position of the company. The inclination of stakeholders to apply pressure grows when the targeted company is visible to the public. (Siegel 2009; Wynstra et al. 2010; Lo 2013; Schmidt et al. 2017.) In this thesis, the definition of supply chain position (SCP) by Schmidt et al. (2017), who derived their definition from Wynstra et al. (2010) and Lo (2013), is used when referring to the business units and/or companies engaged in different value-creation activities in the supply chain. Schmidt et al. (2017, 7) define SCP as the "the structural position of a firm's value creation activities within the overarching supply chain",

Bullwhip effect in the field of SCM refers to inefficiencies stemming from demand forecasting—each SCP strives to react rationally to changes in demand in their own environment which creates demand variance to the upstream of the supply chain. Bullwhip effect in action is the easiest to comprehend through an illustration. For some reason, demand for a certain product starts to suddenly proliferate—reasons for the surge in demand, depending on the product in question—vary. In the case of, for example beer, a successful marketing campaign, hot weather, shortages of competing and substituting products and a plethora of other events could alone or combined result in a surge in demand. Data of soaring demand is then fed into the system through a retailer or SCP in contact with the end consumer. Lack of communication between SCPs in the chain magnifies the variance of demand data as, for instance, manufacturers are not fully aware of the new advertisement campaign initiated by the retailer. Batch order sizes vary more radically the further SCP is located in the upstream as managers along the supply chain attempt to respond to the growing demand by increasing their order size and create a safety buffer for themselves. The motion of this variance of demand resembles that of a bullwhip when cracked. (Lee et al. 1997a; 1997b.)

When the demand eventually returns to its previous levels, or below these levels, and the peak is over, demand data travelling through the supply chain is lagging behind the real market situation, and managers in the upstream SCPs receive information of decreasing demand levels with a significant delay. All this time, production of the product affected by demand fluctuations has been increased, and when the demand stabilises, stocks of the product start to appear along the chain. In a worse-case scenario, these stocks do not only tie up capital—which could be used more efficiently—but stocks of products might also soon become unsaleable, especially when grocery items are in question. SCPs

in the supply chain engage in forecast updating i.e. companies project consumer demand pattern based on observations. In practice, this means that companies interpret larger orders as a sign of larger demand, prompting them to increase output in advance. (Lee et al. 1997a; 1997b.)

Bullwhip effect was first reported by Jay Wright Forrester in 1961 when he was discussing with the management of General Electric, an American conglomerate. The management reported notable swings in production output, inventory sizes and profits. Forrester modelled the supply chain and realised that the closed structure of the supply chain amplified demand variations into constant cyclic swings. Observation made by Forrester gained prominence only 36 years later. (Forrester 1961; Lane & Sterman 2011.) In 1997, Lee, Padmanabhan and Whang from Stanford University developed Forrester's observation further by identifying four main causes for the bullwhip effect and ways to protect operations from these causes in their journal article. The main causes presented were demand forecast updating, order batching, price fluctuation, and rationing and shortage gaming. (Lee et al. 1997a; 1997b.)

Order batching in short refers to the practice of postponing the placement of an order till a certain threshold, e.g. full truckload of the ordered item, has been exceeded due to, for example, the limited capacity of a supplier to produce and ship deliveries and better pricing terms offered by suppliers for larger deliveries. Price fluctuation is caused by forward buying agreements made between manufacturers and wholesalers/retailers. Through these agreements, manufacturers ensure filled order books and wholesalers/retailers are presented with lucrative price offerings. Finally, rationing and shortage gaming is a result of manufacturer limiting a supply of a product, and when this product is in short supply, customers exaggerate their real needs and order more. When demand levels of the product in short supply ultimately start to decline, customers previously ordering beyond their actual need begin to place fewer orders and cancellations start to appear. (Lee et al. 1997a; 1997b.) To combat these phenomena, Lee et al. (1997a; 1997b) propose avoiding multiple demand forecast updates, i.e. downstream and upstream actors of a supply chain utilise the same raw data, resupplying more frequently to avoid unusually large orders when demand surges, that manufacturers should establish uniform wholesale pricing policies to reduce the incentive for retailers to forward buy, and that suppliers should allocate products in proportion to past sales when a shortage hits. (Lee et al. 1997a; 1997b.)

Four years later Lee popularised the bullwhip effect using the notorious green-coloured cars case of Volvo from the 1990s as an illustration. Volvo had produced more green-coloured cars than there was demand for. Sales and marketing team then started substantial promotions and made special offers. These efforts bore fruit, while production department was not aware of the promotional activities—production department interpreted the sales figures as a shift in customer preferences and started to assemble even more green-coloured cars. (The Economist 2002.) Bullwhip effect can be summarised as

the growing volatility and inaccuracy of demand data from the downstream to the upstream, aggravated by the sub-optimisation of each actor along the supply chain, resulting in misallocation of resources.

4.2 Green take on the bullwhip effect

Recently, bullwhip effect has been applied to GSCM. Klumpp (2011) was among the first, if not the first, to use the term green bullwhip effect (GBE) in academic literature. In his simulation, he postulates that the use of green logistics instruments—electric driven trucks, reduction of empty tours (trucks), slow-steaming ships, use of biofuel in planes and carbon dioxide emissions trading by airlines—predominantly have a negative effect on the flexibility and volatility of a supply chain (Klumpp 2011). While Klumpp applies a proactive aspect in his research and interpret GBE on his behalf to be mostly a negative phenomenon, Lee et al. (2014) approach GBE as a reactive phenomenon with also positive repercussions.

Lee, not to be confused with previously introduced Hau L. Lee also fascinated by the bullwhip effect, and his colleagues defined GBE as the tightening of environmental requirements from the downstream to the upstream in a supply chain. Stakeholders pressurising the company governing the supply chain in the downstream for environmental sustainability very often leads to GBE. Company feeling the pressure seeks to create a safety buffer for itself by tightening the deadline for implementation of compliance measures and relays the requirement to its first-tier supplier. Safety buffer is added in case the supplier somehow fails to meet the requirements on time. In anticipation of future environmental requirements from the stakeholders, company governing the supply chain may also render the content of the requirement more stringent than original demands in order to save effort in later. First-level supplier follows suit and tightens yet again the requirements for its own supplier, either regarding implementation schedule, content or both. Environmental regulations faced by SCP closest to the end consumer and by position furthest in the upstream are of very different nature as environmental demands tighten from succeeding to preceding tier in a similar manner order batch sizes vary in the case of traditional bullwhip effect (Lee et al. 2014).

However, unlike the bullwhip effect, GBE can be better avoided and prepared for, provided that all SCPs co-operate to implement the requirements according to a predetermined schedule. This is often not the case due to human nature and the need of an individual actor to optimise its operations which leads to sub-optimisation on the magnitude of the entire supply chain. (Green et al. 2000; Lee et al. 2014.) Companies experiencing environmental pressures respond by implementing GSCM practices. These pressures are

imposed by various stakeholder groups. Laari et al. (2016) identify pressure from customer stakeholders as particularly effective in triggering the implementation of internal GSCM practices, and thus also as a strong driver for GBE.

Lee et al. (2014) also compare bullwhip effect with its green extension and observe that the previous is a demand-based phenomenon, whereas the latter is more random in nature and an event-driven phenomenon. Another difference is the source of the phenomenon. Bullwhip effect is a systematic, built-in phenomenon in supply chains. In bullwhip effect, every actor tries to mitigate and respond to the volatility of demand, whereas the company being targeted by stakeholders in the downstream can intentionally trigger GBE by implementing GSCM practices. Also, GBE does not only cause negative effect—a toxic compound used during production of a product might be phased out prior to regulative deadline due to managers creating safety buffers for themselves in the supply chain. Another positive effect can be local spillover effects, results of co-operation between customer and supplier SCPs as the customers, labour force and community benefit from the supplier being a pioneer company and conducting its operations above the level of environmental regulations. (Lee et al. 2014; Seles et al. 2016.)

However, varying opinions on the distribution of sustainability in supply chains have been voiced in the academic discourse. Wilhelm et al. (2016) explored the double agency role of the first-tier supplier. Due to its double agency role, first-tier supplier was postulated to act as a primary agent, fulfilling the sustainability requirements of the preceding tier in the supply chain, customer, in its own operations and secondarily, to propagate these sustainability requirements onwards to lower-tier suppliers (Wilhelm et al. 2016). According to the study by Wilhelm et al. (2016), the ultimate gatekeeper in ensuring the distribution of environmental sustainability in the supply chain is the first-tier supplier, not the company governing the supply chain. Schmidt et al. (2017) examined *supply chain position paradox*, which will be presented in Chapter 4.4. Commenting on the observations made by Lee et al. (2014), Schmidt et al. (2017) propose that upstream suppliers may be forced to overinvest into GSCM practices and may oppose the implementation of new GSCM practices.

4.3 Social bullwhip effect—does it exist?

In the past, environmentally sustainable, or green, dimension has dominated the academic discussion on sustainable operations. Although TBL concept encompasses also the social aspect of sustainability, the focus of research has been more on the environmental aspect of value-creating activities. (Klassen & Vereecke 2012; Payman & Searcy 2013; Lee et al. 2014.) Klassen and Vereecke (2012), in their study concerning social issues in supply chains, draw parallels between environmental and social supply chain capabilities. In

other words, environmental and social sustainability in supply chains have some similarities, albeit environmental issues have been more widely researched in the academic field. Lee et al. (2014) also relate environmental and social dimensions of sustainability, proposing the examination of similarities and differences between environmental and social issues in supply chains as a future research topic. A similar proposal to apply social aspect to supply chain position paradox observed in the case of GSCM was also made by Schmidt et al. (2017). What is already established, however, is that external stakeholder pressure acts as a driver for enforcing both environmental and social sustainability in supply chains (Eriksson & Svensson 2015). Lee (2011) observes that the nature and strength of combined external stakeholder and institutional pressures, e.g. policy, cultural norms and routines, shape the CSR strategy of an organisation. Suggestions to study the social dimension of a phenomenon previously observed from an environmental point of view and stakeholder pressure affecting both dimensions of sustainability provide additional justification to examine green and social bullwhip effect (SBE) as phenomena sharing similar characteristics.

Asgary and Li (2016) conceived the concept of bullwhip effect due to unethical operations and, by doing this, expanded the scope of traditional bullwhip effect to include the social dimension of conducting business. Like the case with traditional bullwhip effect, unethical operations may engage consumers in forecast updating—however, not with demand data but with the reputation of a company. First misconduct can be neglected with little impact, but repeated offences could lead to rapid decline in consumer loyalty, which in term has a dramatic effect on the financial bottom line of a company. (Asgary & Li 2016.)

Different from the concept of bullwhip effect due to unethical operations, SBE in this thesis is defined as the tightening of social requirements both schedule- and content-wise as the social demands propagate among SCPs from downstream to upstream in a supply chain. Managers at each SCP aim to optimise their activities which leads to tighter demands for the next-in-line, in parallel to how requirements are transformed in the case of GBE. GBE can also be more prone to occur within supply chains of certain industries, whereas SBE is more potential to appear in other industries. For example, environmental concerns often prevail in the automotive industry while apparel industry is more characterised by social issues. Another difference is that environmental violations are usually easier to detect and measure than social ones—emissions affect the global ecosystem, regardless of the release location, whereas a 12-hour shift might be illegal in one country and legal in another. (Wilhelm et al. 2016.)

Very little research studying the existence of SBE in supply chains has been conducted, and the term itself has been scarcely used in academic literature. However, as environmental and social sustainability share characteristics, and although SBE has been researched to a lesser extent, it does not necessarily mean SBE would not exist. What does

exist, is a research gap in academic literature. Such gap has also been identified by Wang and Disney (2016) who call for further research to complement traditional and green bullwhip effect by other forms or extensions of the phenomena, and especially from the sustainability point of view.

A concrete example of social sustainability pressure from stakeholders—in this case, from legislators—that could set off SBE, is the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act), verified by the Obama regime in July 2010 (Dodd-Frank Wall Street Reform and Consumer Protection Act 2010). This act has recently addressed the issues concerning the so-called conflict minerals which are mainly being extracted in the Democratic Republic of Congo. The extraction and trading process of conflict minerals in the Democratic Republic of Congo is partially controlled by armed groups, which commit atrocities against basic human rights. (Global Witness 2014.) Initiatives analogous to the Dodd-Frank Act require supply chains to be cleared of minerals with dubious origins, thus acting as potential impetus to trigger SBE. Companies like LG governing the supply chain have issued sustainability policies or joined sustainability schemes to eradicate conflict minerals from their supply chains, and by doing this, potentially set off SBE. (LG 2013; Hofmann et al. 2018.)

4.4 Supply chain position paradox

In their research, Schmidt et al. (2017) apply the concept of SCP to study the relationship between implementation and effects of GSCM practices. The outcome was that although every SCP in the supply chain does benefit from GSCM practices, the benefit gained diminishes the closer SCP is located to the end consumer. The study also highlights that the closer an SCP is to the end consumer, the more GSCM practices the company in that SCP performs. Schmidt et. al. (2017) named this phenomenon supply chain position paradox. What explains the diminishing marginal utility of GSCM practices, when the proximity of SCP to the end consumer increases, is the maturity of the GSCM practices implemented. Companies governing supply chains and companies in general located in the downstream have been under stakeholder pressure and public scrutiny from early on which has led them to already have "reaped the low-hanging fruits" by implementing GSCM practices with direct efficiency and market performance yields in an early adopter position (Delmas & Montiel 2009: Siegel 2009). Same companies implement more mature GSCM practices which affect processes rather than result in immediate outcomes. Improvements in process performance actualise with a delay, and thus cannot be showcased with the same tempo as the earlier GSCM yields of less mature practices. (Darnall & Edwards 2006; Busch & Hoffmann 2011; Schmidt et al. 2017.)

However, to overcome the burden of being in the ungrateful SCP close to the end consumers and most visible to stakeholders, companies in this position should take a more proactive stance towards involvement of stakeholders in operations according to Schmidt et al. (2017). Although consumer stakeholders pose requirements for high levels of environmental sustainability for original equipment manufacturer (OEM) and retailer operations, this does not always materialise into purchasing decisions. Stakeholders instead should be more involved in the operations of the entire supply chain. (Aragón-Correa & Sharma 2003; Buysse & Verbeke 2003; Ateş et al. 2012; Schmidt et al. 2017.) Some stakeholders possess certain expertise which can be utilised to formulate more considerate sustainability objectives, and which can aid in implementing GSCM practices throughout the supply chain (Manetti & Toccafondi 2012; Gualandris et al. 2015). To enhance the involvement of stakeholders in operations along the entire supply chain, stakeholders with expertise are to be recognised and treated as valuable members of the value-creating ecosystem—not as an external party (Schmidt et al. 2017).

In previous research, it has been stated that many of the lower-tier suppliers administer issues of environmental and social sustainability passively, thus posing the largest and most probable risk of sustainability misconduct in the supply chain (Plambeck 2012; Villena & Gioia 2018). The passiveness in addressing sustainability issues can also be explained by the lower level of scrutiny stakeholders are imposing on these lower-tier, less visible companies (Chiu & Sharfman 2011; Schmidt et al. 2017).

5 HYPOTHESES DEVELOPMENT

Previous research on the distribution of environmental and social sustainability between SCPs and between different industries has been scarce. GBE has been studied most notably by Klumpp (2011; 2019), Lee et al. (2014), Klumpp et al. (2016) and Seles et al. (2016)— very little research on SBE has been conducted. Pioneering studies by Lee et al. (2014) and Seles et al. (2016) support the existence of GBE and consider the possible positive effects of GBE e.g. more sustainably aware and greener supply chains. Klumpp (2011) and Klumpp et al. (2016), in contrast, interpret GBE as a predominantly negative phenomenon having a deteriorating impact on supply chain flexibility and volatility in form of excess flexibility costs. Klumpp (2019) also expanded his interpretation of GBE to sustainable lifestyles. Study by Villena and Gioia (2018), in turn, concluded that lower-tier suppliers in the upstream of supply chains are most likely to treat environmental and social issues passively and are the most probable to cause misconduct. Villena and Gioia (2018), however, included supply chains stretching beyond European borders into emerging economies within their sample, thus gaining better insight on the operations of lower-tier suppliers. For this research, the examination of environmental and social sustainability distribution in supply chains is combined with the study on both GBE and SBE.

In this thesis, it is postulated a priori that GBE exists as proven by Lee et al. (2014) and Seles et al. (2016) in their case research and statements made by Klumpp (2011; 2019) and Klumpp et al. (2016) are critically contemplated. Lee et al. (2014) examined three different supply chain cases with the scope of three SCPs—OEM and the first two tiers of suppliers—in electronics and fashion apparel industries. They concluded that environmental requirements, which are converted into GSCM practices, tighten along the supply chain from the downstream towards the upstream, and at the upstream, yield spill-over benefits for local customers, workers and communities. Data was collected through interviewing managers at case companies and by utilising archival material, capturing longitudinal information unavailable to the public, and published organisational documents. (Lee et al. 2014.)

Seles et al. (2016), on their behalf, while referring to research by Lee et al. (2014), focus on institutional and stakeholder theory in terms of pressure exertion on manufacturing supply chains. Seles et al. (2016) studied the distribution of environmental requirements and GSCM practices in a Brazilian automotive battery supply chain. Extending the scope to four SCPs compared to the study by Lee et al. (2014), Seles et al. (2016) examined a supply chain consisting of OEM “Alpha” (manufacturer of automotive batteries), Alpha’s customer (a heavy vehicle manufacturer), Alpha’s main supplier of plastic components, and CETESB, a governmental body responsible for controlling, inspecting, monitoring and licensing pollution-generating activities. CETESB exerts pressure on Alpha’s customer and thus triggers GBE. Primary data was gathered through interviews and direct

observations made at the studied organisation—organisational documents, reports, manuals, procedures, website information—served as a source of secondary data. Environmental pressures were found to propagate along a supply chain from SCP to SCP, from downstream towards upstream. The end customer, heavy vehicle manufacturer in the case study, received environmental pressure from the governmental body CETESB, which set GBE in motion. Environmental requirements then got tightened both in content and/or in terms of implementation deadlines from SCP to SCP as each actor in the chain relayed pressure forward to the next-in-line, magnifying GBE with each transition of pressure. (Seles et al. 2016.)

Hypotheses H1a and H2a are formulated based on the results by both Lee et al. (2014) and Seles et al. (2016). Hypotheses for the assessment of environmental and social sustainability distribution between SCPs are:

- **H1a.** Environmental sustainability distributes between SCPs according to green bullwhip effect—statistically significant differences exist between environmental sustainability scores of SCPs.
- **H1b.** Social sustainability distributes between SCPs according to proposed social bullwhip effect—statistically significant differences exist between social sustainability scores of SCPs.

Research on how industry affects sustainability has been chiefly conducted as case studies. For example, food, fashion and biofuel industries have been a subject of multiple sustainability studies. In case of food industry, for example Yakovleva et al. (2012) compared environmental, social and economic sustainability of different food industry supply chains, Beske et al. (2014) studied SSCM practices and dynamic capabilities in food industry and Grimm et al. (2014) examined environmentally and socially critical factors for lower-tier supplier management in food supply chains. Sustainability in biofuels industry, in turn, has been explored by e.g. Walter et al. (2011), Gaurav et al. (2017) and Cardoso et al. (2019), whereas sustainability of fashion industry has been the research topic of, for example, Caniato et al. (2012), Shen (2014) and Turker and Altunas (2014). Comparisons of sustainability between industries, however, have been scarce in the academic field. Commonly, such comparisons are limited to only a few industries, e.g. oil and gas and tyre manufacturing industries by Mani et al. (2015), catalytic converter and platinum jewellery industries by du Plessis and Bam (2018), manufacturing, agriculture, services and chemical industries by Singh et al. (2016). Such researches are oftentimes case studies, as well.

Concept of sustainable manufacturing (SM) according to Moldavska and Velo (2012) is becoming increasingly mature. Nonetheless, Moldavska and Velo (2012) conclude that inconsistencies in the interpretation of SM issues result in lack of unified terminology and vocabulary, and that a unified understanding of SM concept has not yet been reached. These observations resemble ones made by Van der Leeuw et al. (2012), Bursztyn and

Drummond (2014) and Bansal and Song (2017) regarding the field of sustainability sciences not having reached maturity. The small number of studies on the effect of industry on sustainability, let alone benchmarking manufacturing industries, might be, to some extent, explained by the immaturity of associated research fields, which calls for exploration of the correlation between environmental and social sustainability and industry.

Hypotheses for the assessment of environmental and social sustainability distribution between industries are:

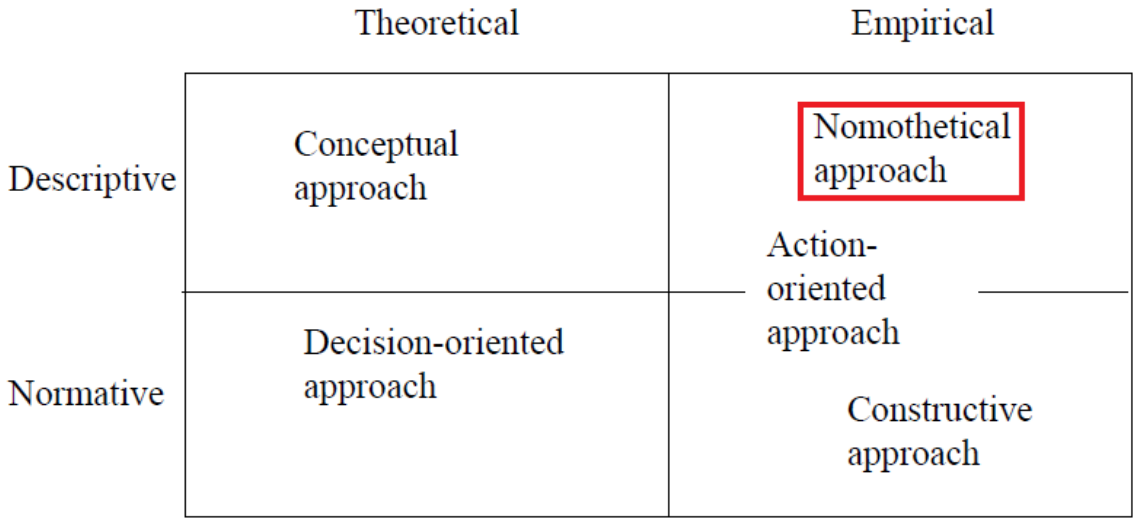
- **H2a.** Industry affects environmental sustainability—statistically significant differences exist between environmental sustainability scores of different industries.
- **H2b.** Industry affects social sustainability—statistically significant differences exist between social sustainability scores of different industries.

If the hypotheses are supported according to the results of this thesis, further evidence on the existence of GBE and arguments for the existence of SBE are provided. Industry affecting environmental and social sustainability would also be affirmed.

6 METHODOLOGY

6.1 Methodological approach

This research can be easily positioned in the framework developed by Neilimo and Näsi (1980) and later supplemented by Kasanen et al. (1993). Business research methodologies framework examines the theoretical-practical trade-off and the aim of the research—is the research striving to introduce a phenomenon in "as-is" state or is the aim of the research to improve the situation at hand, say, suggest a process improvement (Vafidis 2007). On a visualisation of this framework, nomothetical approach in the intersection point between descriptive and empirical research is the most fitting approach for the research conducted in this thesis, illustrated in Figure 3.

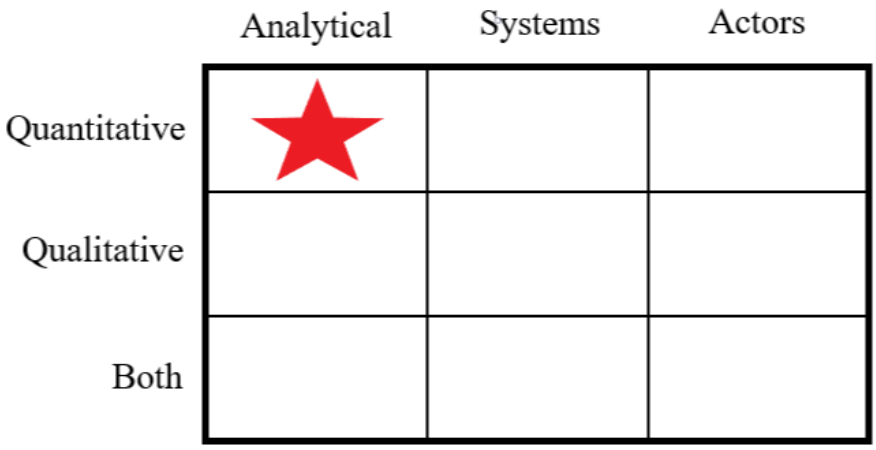


Note Research approach chosen for this thesis highlighted in red

Figure 3 Business research methodologies of the Neilimo and Näsi framework supplemented by Kasanen et al. (adapted from Neilimo and Näsi 1980; Kasanen et al. 1993; Vafidis 2007)

Nomothetical research approach is characterised by the prevalence of positivism—knowledge is generated by making immediate, empirical observations and applying a stringent scientific method on these observations. According to positivism, knowledge is objective in nature, irrelevant of the observer—when conducting nomothetical research, statistical analysis is oftentimes chosen to serve as the method of analysis. (Neilimo & Näsi 1980; Kasanen et al. 1993; Vafidis 2007.) Testing hypotheses on self-collected data in order to better understand the distribution of sustainability within supply chains is nomothetical research at its purest.

The ninefold framework by Arbnor and Bjerke (1997) combines the method of generating knowledge (objective-subjective) with the method of analysis used. According to this framework, an analytical approach (statistical company data from a database) applies to the research conducted in this thesis as analysis of variance was chosen as the method of analysis. Arbnor and Bjerke framework is illustrated in Figure 4.



Note Research approach and main method chosen for this thesis illustrated with a red star

Figure 4 Visualisation of research approaches and main methods in the Arbnor, Bjerke and Vafidis framework (adapted from Arbnor & Bjerke 1997; Vafidis 2007)

Whereas the model developed by Neilimo and Näsi (1980) is more oriented towards assessing the methodological approach and the scope of both practical and theoretical dimensions emphasised by the research, the framework of Arbnor and Bjerke (1997) examines the research perspective. These perspectives are the subjective one aiming at conducting verstehen-type research and the objective one with the intention to explain the research phenomenon. Arbnor and Bjerke (1997) divide main research methods into three categories: analytical, systems and actors approach. Analytical approach is the most positivist one, and thus does not need, nor desire for, subjective human interference in the knowledge production process. Characteristic for this approach is interest in causal relations and that the research object can be split into parts and studied independently of each other—this approach is also the most fitting to describe the research approach of this thesis. Systems approach does not allow the independent examination of parts of a system. Maintaining positivist traits, this approach may also include hermeneutic type of research. Actors approach is a highly subjective research method where research cannot be accessed objectively. Without interpretations of individuals, there is no research when this approach is applied. (Arbnor & Bjerke 1997; Vafidis 2007.)

6.2 Data source

For this research, ESG data provided by Thomson Reuters (TR) has been utilised. Eikon was chosen as the data source due to ease of accessibility, as University of Turku has a license for the database, and due to the size of the database. Eikon database offers ESG scores of over 7,000 companies. To better understand the hierarchy and the structure of ESG scoring by TR, and illustration of ESG scores, pillars and categories is demonstrated in Figure 5 to support the description of the ESG scoring process at TR.

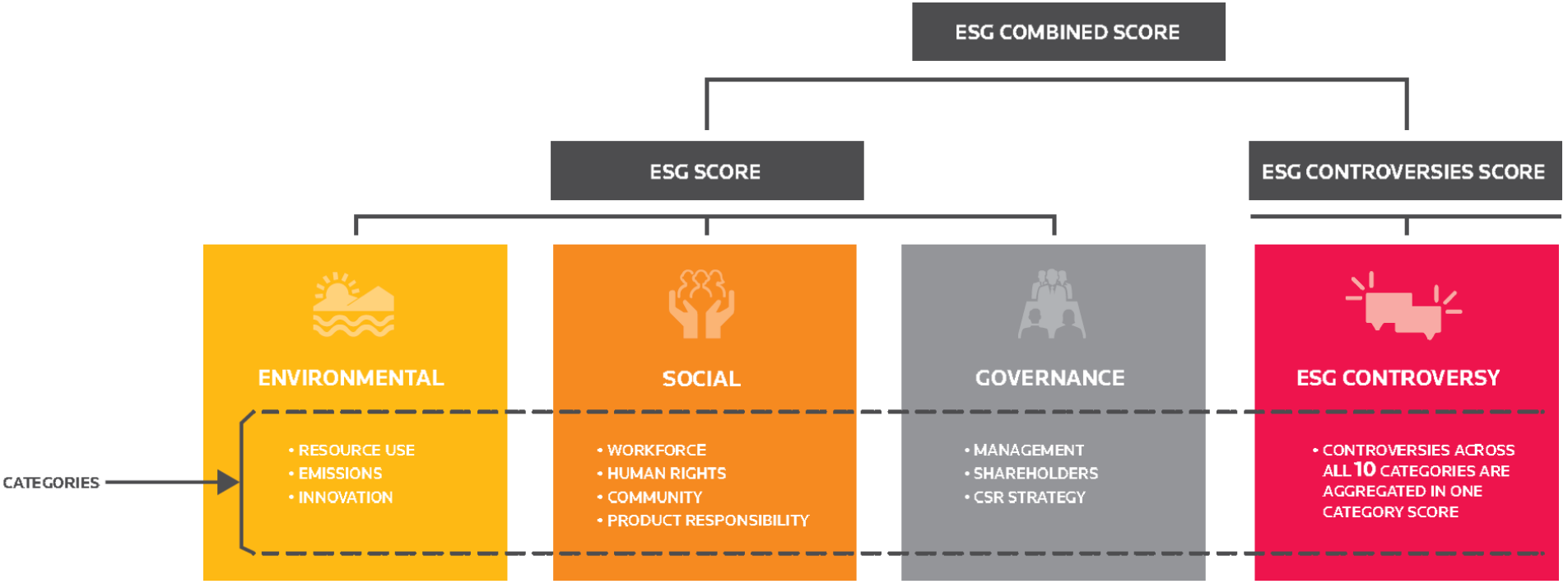


Figure 5 Thomson Reuters ESG scoring (adapted from Thomson Reuters 2018)

150 content research analysts working at TR collect data from six different sources: websites of companies, annual reports, CSR reports, stock exchange filings in addition to NGO websites and news sources. The ESG data extraction process at TR utilises both algorithmic and human methods and the data is refreshed every fortnight, while the majority of ESG data reported is updated in parallel with companies' own ESG publication once a year. Data is collected through 178 measures which form 10 categories and which, on their behalf, form three pillars. These measures can be in form of a question answered with "true" or "false"—"does the company have a policy to improve its energy efficiency?"—or in a form quantitative indicator—"percentage of employees with disabilities or special needs". The entire list of environmental and social measures applied in this research is illustrated in Appendices 1 and 2. An ESG score can be calculated for a company by utilising the three pillars, environmental, social and governance. TR ESG scoring places an additional emphasis on any notable controversies the company has endured during its accounting year. By applying ESG score and controversies score, a final ESG combined score can be calculated. (Thomson Reuters 2018.)

For this research, focus will be on two pillar scores, environmental and social. Controversies scores have been omitted from the data sample as some of the measures used to calculate controversies scores are already used for calculating environmental and social pillar scores. Practice of including controversies scores would imply the duplication of some data in the analysis as well as an addition of a score based on a slightly different methodology than that of environmental and social scores. In a similar vein, corporate governance pillar and its measures have been excluded from this research as these measures evaluate intra-company-related performance and harmonising these measures with social measures would have been an arduous and convoluted process adding little value to this research. Even though governance measures include several social sustainability measures e.g. sustainability compensation incentives, board gender diversity in percentages and CSR sustainability reporting, only a fragment of these 101 measures are purely social sustainability related. Substituting measures for the omitted governance ones can be found among social measures.

In order to achieve a sufficient geographical, industrial and company size diversification among the sample companies, a suitable index was chosen. STOXX® Europe 600 (STOXX 600) constitutes of small, medium and large capitalisation companies from 17 European nations ranging widely in terms of industrial activity (STOXX 2018).

6.3 Data collection & sampling

TR has categorised Eikon companies according to Thomson Reuters Business Classification (TRBC) which stands comparison with the classification used for STOXX 600, Industry Classification Benchmark of FTSE Russell. Unlike TRBC, Industry Classification Benchmark classification follows the hierarchy industry-supersector-sector-subsector, whereas TRBC categorises companies in a more detailed manner, economic sector-business sector-industry group-industry-activity. (FTSE Russell 2018; TRBC 2018.)

Before extraction of ESG data, a sample of companies conducting industrial activities fitting into a manufacturing supply chain framework—operations of the company consist of value chain activities transforming physical resources into a physical product with a demand—was chosen. Some industries were identified with relative ease to be ill-fitting for the sample, e.g. banking services, insurance, software and IT services as no physical product is involved in their core business activities, others due to the lack of any transformation of a physical product (transportation services).

However, there were also ambiguous and less distinct industries which did not have one single field of operations, e.g. construction and engineering, environmental services and equipment, industrial conglomerates. The operations of some companies did not unconditionally fit into their assigned industry and had to be examined individually—e.g. the industry of dormakaba Holding AG on Eikon is reported to be communications and networking, while the company provides physical products e.g. entrance system solutions, door hardware and mechanical key systems (dormakaba 2018). Due to the complex nature of value-creating operations of certain companies, e.g. conglomerates, a criterion was set that over 50 % of the company's revenue must be generated from manufacturing or operations related to manufacturing in the supply chain, such as retail of physical products.

The company sample consists of 290 companies, of which desired ESG data—environmental and social pillar scores—were available from reporting year 2017. Same year was used for all companies to harmonise the data. Lorentz et al. (2016a) developed a fourfold value/supply chain model which elaborates the activities of each SCP and simplifies often complex supply chains on a theoretical level. For this research, the number of SCPs was dropped to three—manufacturer 1 (M1), manufacturer 2 (M2) and vendor (V). SCPs and sample sizes are illustrated in Figure 6. The initial division comprised four SCPs, but wholesaler and retailer SCPs had to be merged into vendor SCP as the number of wholesaler companies with desired ESG data available from 2017 was very small, only 15 companies, in the end. In previous research, Schmidt et al. (2017) also treated distributors and retailers as a single SCP.

Figure 6 Division of SCPs utilised in this research, sample size in parentheses (adapted from Lorentz et al. 2016a)

Value-creating activities of companies identified as manufacturer 1 include e.g. basic resource extraction like mining minerals, production of industrial gases and semiconductors manufacturing. If an SCP of a company is manufacturer 2, the said company produces end products such as vehicles, apparel and pharmaceuticals. Vendor position combines two supply chain activities, wholesaling and retailing. All activities of the three SCPs are related to the transformation of physical resources into a more valuable physical product which has a demand, i.e. service supply chains in industries such as bank and insurance sector and healthcare services have been omitted from this research.

Eikon was searched for all European wholesale and retail companies with ESG data available from 2017, and 28 companies outside of STOXX 600 index were added to the sample in order to increase the data mass. In addition to division to SCPs, companies were also divided between five industries, a division adapted from Lorentz et al. (2016b), with the sample size in parentheses:

- process industry—food and drink, wood, paper, chemical and pharma (113 companies)
- light industry—textile and apparel, rubber and plastic, mineral products and furniture (77 companies)
- metal refining and metal products (16 companies)
- machines, appliances and transport equipment (59 companies)
- computers and electronics (25 companies).

Division to industries was performed based on revenue—industry was chosen to match the activity generating the largest revenue within the company. Industry-based division was done to allow comparisons between the environmental and social sustainability scores of different industries. The sample did not evenly distribute between the industries as process and light industries were dominant ones in sample sizes. Complete sample company list, their SCP, TRBC-classified activity and industry have been illustrated in Appendices 3, 4 and 5.

6.4 Data analysis

To determine if statistically significant differences exist between the ESG data of different SCPs and industries, one-way analysis of variance (ANOVA) was chosen as the statistical model. F-test and Welch's test were consequently chosen as suitable methods of statistical analysis as by comparing group means and stating if statistically significant differences exist or not, hypotheses are supported or rejected. If either test demonstrates p-values higher than the significance level of 0.05—chance of error is 5 %—the chance of error increases excessively, and thus the tested hypothesis must be rejected. (Hair et al. 2010.)

In this research, two sets of means were calculated based on ESG data. Group means based on each SCP and industry, illustrated in Tables Table 4Table 5, were calculated for three environmental categories, four social categories, and environment and social pillar aggregating their respectable categories. Aggregated environmental and social sustainability category and pillar scores of sample companies were defined as the dependent variable and SCP and industry as the independent variable. Group means were then compared to detect statistically significant differences to either support or reject the hypotheses.

6.5 Validity and reliability of the research

Two properties ensure that research has been conducted in a legitimate manner, according to the standards of the scientific community. These two properties are validity and reliability. The first one evaluates the appropriateness of the chosen instrument for measuring the researched phenomenon, i.e. instrument measures what it sets out to measure. Reliability, in turn, determines if an instrument can be consistently interpreted in different situations—in other words, how well the measurement yields trustworthy results instead of random ones.

In this quantitative research, levels of environmental and social sustainability of different companies were of interest. By using ESG scores reflecting environmental and social sustainability of a company, the distribution of both dimensions of sustainability between SCPs and certain industries can be assessed. Using ESG data generated by a large, distinguished financial data provider, the market share of Thomson Reuters was 22.5 % in 2017, is one way to ensure that applied data is reliable (Murphy 2018). TR also proclaims to have one of the largest ESG content collection operations in the world with 150 content research analysts (Thomson Reuters 2018). The selection of data ranking companies based on environmental and social criteria matches superbly with the aim of

this research to explore the distribution of environmental and social sustainability between SCPs and industries. As Thomson Reuters has been publishing ESG data since 2002 and continues to widen their coverage of different industries and regions by adding new companies through different indices, TR also has vast experience in providing sustainability data overall (Thomson Reuters 2018).

Reliability of this research is relatively high as TR updates ESG data constantly and by obtaining the updated company list from the newest version of the STOXX 600 index, this research can be replicated to the highest degree. ESG data by TR has also been utilised in multiple previous studies by e.g. Cheng et al. (2014), Sassen et al. (2016) and Garcia et al. (2017).

7 RESULTS

7.1 Assumptions of ANOVA tests

Hypotheses were defined to explore the distribution of environmental and social sustainability in manufacturing supply chains. Hypotheses were derived from research questions and were based on the division of sample companies into SCPs and industries. H1a and H1b support the claim that statistically significant differences in environmental and social sustainability distribution between SCPs exist, while hypotheses H2a and H2b claim the same for industries. In this thesis, the existence of green and social bullwhip effect were also studied, of which the latter's existence has been scarcely studied in the academic realm. The existence of GBE posits essentially on the observations made by Lee et al. (2014) and Seles et al. (2016). The research conducted in this thesis extends the scope of SCPs examined to include wholesale and retail activities in comparison to studies by Lee et al. (2014) and Seles et al. (2016). The results were anticipated to support the existence of both green and social bullwhip effect. This would imply that companies in the upstream would rank, on average, higher in terms of environmental and social pillar and category scores than the companies located in the downstream closer to the end customer.

In order to conduct one-way ANOVA tests to examine, if statistically significant differences exist between the group means of SCPs and industries, certain assumptions need to be made. Variables need to be independent and identically distributed, data must be normally distributed, i.e. dependent variable is normally distributed in the population, and variables are homoscedastic, in other words, the variances of values are the same in each sub-population. First assumption concerning independent observations can be made as all category and pillar scores are representing 290 individual companies. Second assumption of normally distributed data in each population can be tested by examining the skewness and kurtosis of each population which are here named groups, categories and pillars. (Hair et al. 2010.)

Skewness measures the symmetry of data in a population, in this research comparing it to normal distribution. Skewness can obtain both negative and positive values—positively skewed distribution is composed of relatively few large values and tails to the right, whereas negatively skewed distribution contains few small values and tails to the left. Kurtosis examines either the flatness or the peakedness of a distribution compared to normal distribution. The higher the value of kurtosis, the more peaked the distribution is, while a negative value indicates a rather flat distribution. (Hair et al. 2010.) The results of skewness and kurtosis tests for each population are presented in Table 1.

Table 1 Testing the normal distribution assumption of data between groups

Categories & pillars	N	Minimum	Maximum	Mean	Std. deviation	Skewness		Kurtosis	
						Statistic	Std. error	Statistic	Std. error
ENVIRONMENT	290	13.4	99.4	70.9	17.5	−0.816	0.143	0.627	0.285
Resource Use	290	11.7	99.8	76.4	19.5	−1.044	0.143	0.863	0.285
Emissions	290	1.39	99.8	72.6	22.2	−1.044	0.143	0.577	0.285
Innovations	290	0.29	99.8	63.6	26.6	−0.463	0.143	−0.979	0.285
SOCIAL	290	11.1	98.8	70.4	17.1	−0.855	0.143	0.837	0.285
Workforce	290	10.6	99.8	73.4	19.6	−0.806	0.143	0.030	0.285
Human Rights	290	15.8	99.6	77.8	22.5	−1.261	0.143	0.638	0.285
Community	290	0.68	99.8	62.1	28.4	−0.371	0.143	−1.075	0.285
Product Responsibility	290	1.39	99.8	68.3	25.8	−0.818	0.143	−0.272	0.285

The skewness and kurtosis values of groups varied in the case of skewness [−1.261, −0.371] and kurtosis on the range [−1.075, –0.863]. This indicates that groups tend to contain few small values and tail to the left, whereas the distributions of groups, on average, are more peaked in appearance than flat, although two clearly flat distributed groups can be observed. The acceptable value range to make the normal assumption required for ANOVA is up for debate. For this research, the range of acceptable values for both skewness and kurtosis to support normal distribution assumption is [−2, 2] (George and Mallery 2010). Data fulfils the normal distribution assumption and, ultimately, needs to be tested for homoscedasticity. Levene's test examines whether population has the same variance in each group or not. Levene's tests results for SCP comparison are visualised in Table 2 and for industries in Table 3.

Table 2 Testing the assumption of homoscedasticity with Levene's test, comparisons between SCPs

Categories & pillars	Levene statistic	df1	df2	Significance (p)
ENVIRONMENT	7.193	2	287	0.001
Resource Use	4.587	2	287	0.011
Emissions	5.923	2	287	0.003
Innovations	5.980	2	287	0.003
SOCIAL	**1.294**	**2**	**287**	**0.276**
Workforce	**0.567**	**2**	**287**	**0.568**
Human Rights	5.310	2	287	0.005
Community	**0.654**	**2**	**287**	**0.521**
Product Responsibility	11.28	2	287	0.000

Note Groups, where variances are equal, are bolded

The assumption of homoscedasticity can be made with social pillar, workforce and community categories based on Levene's test in the case of SCP comparison. If the significance value of a group exceeds the threshold of 0.05, variances are equal and thus the assumption of homoscedasticity can be made. However, for the environment pillar and rest of the categories where variances are not equal, Welch's test needs to be made instead of f-test to compare the group means.

Table 3 Testing the assumption of homoscedasticity with Levene's test, comparisons between industries

Categories & pillars	Levene statistic	df1	df2	Significance (p)
ENVIRONMENT	**1.341**	**4**	**285**	**0.255**
Resource Use	**1.115**	**4**	**285**	**0.350**
Emissions	**0.445**	**4**	**285**	**0.776**
Innovations	2.933	4	285	0.021
SOCIAL	**1.825**	**4**	**285**	**0.124**
Workforce	**0.518**	**4**	**285**	**0.723**
Human Rights	**2.297**	**4**	**285**	**0.059**
Community	3.314	4	285	0.011
Product Responsibility	**1.037**	**4**	**285**	**0.388**

Note Groups, where variances are equal, are bolded

In the case of assumption of homoscedasticity between industry groups, all significance values of groups exceed the threshold excluding innovations and community categories which need to be examined with Welch's test instead of the f-test.

7.2 Results of hypotheses testing

According to previous studies on GBE by Lee et al. (2014) and Seles et al. (2016), the company governing the supply chain located at the downstream of the chain shifts the pressures, in form of environmental requirements imposed by stakeholders, onwards in the supply chain to the preceding SCP, the tier next-in-line. Environmental requirements become more stringent with each shift towards upstream, as each company at every SCP attempts to optimise their own operations, simultaneously failing to optimise the entire supply chain. SBE acts the same. Instead of environmental requirements, demands for social reforms, e.g. conducting ethical trade and combatting bribery, corruption and fraud, are shifted towards upstream. Requirements for social reforms become more stringent along the way, implementation schedule- and/or content-wise.

Hypotheses H1a and H1b were supported to a certain degree by the results of ANOVA tests when SCPs were compared. As the p-values remained under the significance level of 0.05 in eight group mean comparisons, two pillars and six categories, statistically significant differences were discovered. Hypothesis H1b could not be supported regarding the workforce category—for this category, statistically significant differences do not exist between SCP scores, and thus comparison based on this category does not support the existence of SBE. Ergo, this category is excluded from the following analysis. Results of the ANOVA tests are illustrated in Table 4 and Table 5.

Table 4 Results of ANOVA tests, distribution of environmental and social sustainability between SCPs

Categories & pillars	Group means				F-statistic	Significance (p)
	M1	M2	V	Total		
Test: F-test ANOVA						
SOCIAL	**72.5**	**73.7**	**61.2**	**70.4**	**13.38**	**0.000**
Workforce	72.7	75.9	70.9	73.4	1.487	0.228
Community	**68.3**	**66.9**	**42.7**	**62.1**	**22.43**	**0.000**
Test: Welch's ANOVA						
ENVIRONMENT	**72.7**	**73.0**	**64.2**	**70.9**	**4.370**	**0.014**
Resource Use	**77.1**	**80.7**	**68.4**	**76.4**	**6.477**	**0.002**
Emissions	**71.7**	**77.3**	**66.7**	**72.6**	**4.496**	**0.013**
Innovation	**69.3**	**60.6**	**57.3**	**63.6**	**5.562**	**0.005**
Human Rights	**81.0**	**80.5**	**67.4**	**77.8**	**7.316**	**0.001**
Product Responsibility	**71.3**	**72.3**	**56.3**	**68.3**	**6.846**	**0.001**

Note SCP abbreviations used are as follows:

M1 Manufacturer 1 (raw materials and components)

M2 Manufacturer 2 (end products)

V Vendor (wholesale and retail)

Group mean comparisons supporting the hypotheses about the existence of scientifically significant differences in sustainability distribution between SCPs bolded

Table 5 Results of ANOVA tests, distribution of environmental and social sustainability between industries

Categories & pillars	Group means					Total	F-statistic	Significance (p)
	P	L	Me	Ma	C			
Test: F-test ANOVA								
ENVIRONMENT	69.6	71.9	71.3	71.4	72.1	70.9	0.255	0.907
Resource Use	76.4	77.9	77.5	73.8	77.7	76.4	0.426	0.790
Emissions	71.4	74.2	80.7	70.7	71.8	72.6	0.826	0.509
SOCIAL	72.1	69.6	72.8	67.6	70.1	70.4	0.799	0.527
Workforce	74.5	74.4	76.7	69.1	73.6	73.4	0.980	0.419
Human Rights	78.4	78.6	84.4	74.6	75.6	77.8	0.755	0.556
Product Responsibility	72.2	65.7	60.4	66.9	66.9	68.3	1.275	0.280
Test: Welch's ANOVA								
Innovation	60.9	63.4	54.9	69.8	66.7	63.6	1.804	0.138
Community	63.7	58.4	69.2	61.5	62.8	62.1	0.707	0.590

Note Industry abbreviations used are as follows:

P Process industry

L Light industry

Me Metal refining and metal productions

Ma Appliances, machines and transport equipment

C Computers and electronics

When comparing group means of five different industries, ANOVA test results indicate no statistically significant differences between any of the group means as chance of error is systematically over the allowed threshold of 5 %—p-values in two pillar and seven categories comparison exceed the threshold value of 0.05 of significance level substantially. It must be thus established that industry does not affect the distribution of environmental and social sustainability according to this research.

7.3 Results of post hoc tests

The post hoc tests used were Tamhane's T2 and Tukey HSD. Post hoc tests are always trade-offs between controlling type I error or type II error. When a test is aiming to control type I error, i.e. a deduction is made that two means are statistically significantly inequal, the test is called conservative. When a test possesses statistical power, it is suited for controlling type II error—a situation where a deduction is made that two means are not statistically significantly inequal. Both tests, Tamhane and Tukey, are conservative. (Field 2018.) Tamhane was used in comparisons where group variances were equal according to Levene's test, whereas Tukey HSD was chosen when variances were not equal. Results of post hoc tests are presented in Tables Table 6, Table 7, Table 8Table 9.

Table 6 Post hoc test p-values for group mean comparisons between SCPs

Categories & pillars	Manufacturers compared	Vendor compared with	
		M1	M2
Post hoc test: Tamhane			
ENVIRONMENT	0.998	**0.020**	**0.018**
Resource Use	0.323	**0.032**	**0.001**
Emissions	0.112	0.484	**0.021**
Innovation	**0.040**	**0.014**	0.843
SOCIAL	0.908	**0.000**	**0.000**
Human Rights	0.996	**0.001**	**0.003**
Product Responsibility	0.985	**0.003**	**0.002**
Post hoc test: Tukey HSD			
Workforce	0.428	0.819	0.233
Community	0.913	**0.000**	**0.000**

Note Values bolded are less than the significance level of 0.05, meaning that statistically significant differences in means between the compared SCPs exist in the given category/pillar

The results of post hoc tests between environmental and social sustainability of group means of SCPs reveal that statistically significant differences exist between the manufacturer 1 and manufacturer 2 SCPs in the innovation category—this was the only group where a statistically significant difference was observed between the manufacturers. When both manufacturer SCPs are compared with the vendor SCP, statistically significant differences are detected in almost every category and pillar. As a matter of fact, only when group means are compared between manufacturer 1 and vendor in the emissions category and between manufacturer 2 and vendor SCPs in the innovation category, no statistically significant differences were detected. Between workforce category group means, as previously established with f-test, no statistically significantly differences exist.

Table 7 Post hoc test p-values for group mean comparisons, process and light industries

Categories & pillars	Compared with process industry				Compared with light industry			
	L	Me	Ma	C	P	Me	Ma	C
Post hoc test: Tamhane								
Innovation	0.999	0.993	0.245	0.987	0.999	0.933	0.755	1.000
Community	0.911	0.995	1.000	1.000	0.911	0.764	1.000	0.999
Post hoc test: Tukey HSD								
ENVIRONMENT	0.903	0.996	0.969	0.971	0.903	1.000	1.000	1.000
Resource Use	0.983	0.999	0.923	0.998	0.983	1.000	0.734	1.000
Emissions	0.918	0.521	1.000	1.000	0.918	0.822	0.894	0.990
SOCIAL	0.858	1.000	0.472	0.984	0.858	0.961	0.962	1.000
Workforce	1.000	0.994	0.415	1.000	1.000	0.993	0.512	1.000
Human Rights	1.000	0.854	0.828	0.980	1.000	0.881	0.838	0.977
Product Responsibility	0.433	0.431	0.700	0.888	0.433	0.946	0.999	1.000

Note Industry abbreviations used are as follows:

P Process industry

L Light industry

Me Metal refining and metal productions

Ma Appliances, machines and transport equipment

C Computers and electronics

Table 8 Post hoc test p-values for group mean comparisons, metal refining and metal products and machines, appliances and transport equipment industries

Categories & pillars	Compared with metal refining and metal products				Compared with machines, appliances and transport equipment			
	P	L	Ma	C	P	L	Me	C
Post hoc test: Tamhane								
Innovation	0.993	0.933	0.371	0.846	0.245	0.755	0.371	1.000
Community	0.995	0.764	0.970	0.996	1.000	1.000	0.970	1.000
Post hoc test: Tukey HSD								
WENVIRONMENT	0.996	1.000	1.000	1.000	0.969	1.000	1.000	1.000
Resource Use	0.999	1.000	0.961	1.000	0.923	0.734	0.961	0.916
Emissions	0.521	0.822	0.499	0.719	1.000	0.894	0.499	1.000
SOCIAL	1.000	0.961	0.820	0.988	0.472	0.962	0.820	0.973
Workforce	0.994	0.993	0.641	0.989	0.415	0.512	0.641	0.865
Human Rights	0.854	0.881	0.529	0.736	0.828	0.838	0.529	1.000
Product Responsibility	0.431	0.946	0.902	0.934	0.700	0.999	0.902	1.000

Note Industry abbreviations used are as follows:

P Process industry

L Light industry

Me Metal refining and metal productions

Ma Appliances, machines and transport equipment

C Computers and electronics

Table 9 Post hoc test p-values for group mean comparisons, computers and electronics industry

Categories & pillars	Compared with computers and electronics			
	P	L	Ma	Me
Post hoc test: Tamhane				
Innovation	0.987	1.000	0.846	1.000
Community	1.000	0.999	0.996	1.000
Post hoc test: Tukey HSD				
ENVIRONMENT	0.971	1.000	1.000	1.000
Resource Use	0.998	1.000	1.000	0.916
Emissions	1.000	0.990	0.719	1.000
SOCIAL	0.984	1.000	0.988	0.973
Workforce	1.000	1.000	0.989	0.865
Human Rights	0.980	0.977	0.736	1.000
Product Responsibility	0.888	1.000	0.934	1.000

Note Industry abbreviations used in the appendix:

P Process industry
L Light industry
Me Metal refining and metal productions
Ma Appliances, machines and transport equipment
C Computers and electronics

In comparison between industries, no statistically significant differences were detected between any of the industries in any category or pillar as demonstrated in Tables Table 7,Table 8 andTable 9.

In all eight comparisons, where statistically significant differences were present, the vendor position received the lowest scores. The scores range 0–100 where 100 is the best possible score. Score differences are illustrated in Table 10. The average score gap between both manufacturing SCPs in comparison to the vendor SCP, is discernible, which initially affirms the existence of both green and social bullwhip effect to a certain degree. The average score differences between vendor and manufacturer 2 were 12.6 and 12.4 between vendor and manufacturer 1, both in favour of the manufacturing SCPs.

Table 10 Score differences between SCPs, workforce category excluded

Categories & pillars	Manufacturer 2 vs. vendor	Manufacturer 1 vs. vendor	Manufacturer 1 vs. manufacturer 2
ENVIRONMENT	8.78	8.42	−0.36
Resource Use	12.3	8.67	−3.64
Emissions	10.5	4.97	−5.58
Innovation	3.32	11.9	8.62
SOCIAL	12.5	11.3	−1.26
Human Rights	13.0	13.6	0.57
Community	24.2	25.6	1.45
Product Responsibility	16.0	15.04	−0.96
Average	**12.6**	**12.4**	**−0.15**

Note The score subtraction was made from SCP mentioned first in the column. For example, vendor's average score in the environment pillar was 64.24 and corresponding score of manufacturer 2 was 73.02, so the subtraction equals 8.78

However, according to both green and social bullwhip effect, ESG scores should noticeably improve when moving towards upstream in the supply chain. This was not the case as differences in scores were, in both environmental and social pillar and in half of the examined categories with workforce category excluded, higher in favour of manufacturer 2—an SCP preceding manufacturer 1 SCP in the supply chain. Compared with the score differences between vendor and both manufacturer SCPs, the difference between the manufacturer SCPs is over ten times smaller. What can be concluded from these observations is that the existence of green and social bullwhip effect is not affirmed by the score comparison between the manufacturing SCPs. This observation can be explained to an extent by the similarity of activities conducted by both manufacturing SCPs—some sample companies were engaging in component and end product manufacturing simultaneously. The case with comparing manufacturing and vendor activities, including wholesale and retail, is a drastically different one as a more distinct demarcation can be made between the activities.

8 CONCLUSIONS & DISCUSSION

8.1 Discussion of the results

The objective of this thesis was to explore the effect that SCP and industry have on the distribution of environmental and social sustainability in manufacturing supply chains. As a theoretically essential element, the extensions of traditional bullwhip effect, green and social bullwhip effect, were introduced in this thesis. Much like their "parent phenomenon" bullwhip effect, green and social bullwhip effect are triggered by coercive pressure exerted by stakeholder group/s on the company governing the supply chain. This company is oftentimes physically closest to the end consumer, most visible to the stakeholders. In the case of GBE, coercive pressure materialises into environmental requirements. The company governing the supply chain in the downstream relays these requirements, more stringent than upon receiving, to the preceding SCP in the supply chain, in this case to its supplier, to create a safety buffer. The requirements move upstream in the supply chain becoming more stringent regarding content or implication deadlines of compliance measures. SBE is a parallel phenomenon where, instead of environmental requirements, demands for social reforms flow towards upstream and are transformed in the process.

Klumpp (2011) was among the first in academic literature to study the concept of GBE. Further investigations on GBE were done most profoundly by Lee et al. (2014) and Seles et al. (2016). Findings made by Lee et al. (2014) and Seles et al. (2016) support the existence of GBE. SBE, however, has been scarcely studied in academic literature, rendering this thesis one of the first academic publications to do so. Environmental and social sustainability issues in supply chains are often conjoined, when sustainability issues are discussed beyond the environmental realm, as these two phenomena bear comparison with one another. (Lee 2011; Klassen & Vereecke 2012; Lee et al. 2014; Eriksson & Svensson 2015; Schmidt et al. 2017.) Triple bottom line concept popularised by Elkington in mid-1990s coupled environmental and social dimensions of business together, at least on a theoretical level, and was a contributing factor in the convergence of environmental and social sustainability research (Elkington 1999).

Another concept related to environmental sustainability in supply chains alongside GBE is supply chain position paradox introduced by Schmidt et al. (2017). According to this concept, implemented GSCM practices generate the highest yields when implemented the furthest from the end consumer in the upstream of the supply chain and yields lower as the proximity to end consumer increases. The number of implemented GSCM practices also peaks at SCP closest to the end consumer. Villena and Gioia (2018) add

that lower-tier suppliers in the upstream tend to administer environmental and social sustainability issues passively, presenting the largest and most probable source of environmental and social misconduct in the supply chain. Supporting observations were earlier made by Plambeck (2012).

The research conducted in this thesis provides partial support to the existence of both green and social bullwhip effect but did not accomplish to affirm the presence of such phenomena unequivocally in manufacturing supply chains. In the pioneering studies on GBE by Lee et al. (2014) and Seles et al. (2016), research conducted was case study with the division of SCPs consisting, in the case of Lee et al. (2014), of three tiers, OEM, first-tier supplier and second-tier supplier. In the case study by Seles et al. (2016) four tiers, i.e. automotive battery manufacturer "Alpha", Alpha's customer, (heavy vehicle manufacturer), Alpha's supplier (plastic component supplier) and CETESB (governmental body), were chosen for examination. In this research, wholesale and retail actors were merged and introduced as the vendor SCP. A very similar division was used by Schmidt et al. (2017)—raw material supplier, component supplier, OEM and distributors/retailers.

For this research, ESG data was acquired from 290 European manufacturing companies diverging in size, industrial activity and nationality. ESG data was refined to include scores measuring environmental and social sustainability. The sample companies were assigned an SCP and an industry attribute. SCPs used were manufacturer 1 at the upstream of the supply chain, extracting basic resources and manufacturing components, manufacturer 2, producing end products and vendor SCP, which consists of companies specialised in wholesale and retail activities. Following Lorentz et al. (2016b), industry categorisation chosen for this research was as follows: process industry, light industry, metal refining and metal products, machines, appliances and transport equipment and computers and electronics. Group means were calculated for each SCP and industry and these means were then tested with one-way ANOVA tests to discover, if statistically significant differences between the group means exist.

Results of the f-tests and Welch's tests revealed statistically significant differences in eight out of nine groups when SCP was used as the independent variable and environmental and social sustainability category and pillar scores of ESG data as the dependent variable. In f- and Welch's tests, the only category where statistically significant differences were not present was workforce. In post hoc tests, statistically significant differences were detected only in the innovation category when manufacturer SCPs were compared. In further post hoc tests between manufacturer and vendor SCPs, only categories, wherein statistically significant differences were not present between SCPs, were emissions, manufacturer 1 and vendor, and innovation, manufacturer 2 and vendor.

In consonance with green and social bullwhip effect theory, environmental and social sustainability scores improved when moved upstream in the supply chain—from vendor to manufacturer 2, the score gap was perceptible. However, environmental and social

scores did not increase when moved from end product manufacturing to basic resource extraction and component manufacturing, in five out of eight comparisons including environmental and social pillar scores. Score gaps were also not nearly as evident as they were between vendor and manufacturing SCPs.

The narrow gap between environmental and social sustainability scores of manufacturing SCPs can be explained to a certain degree by the similar, and occasionally overlapping, industrial activities. The demarcation between manufacturing and wholesale/retail activities is much more distinct than one between manufacturing SCPs. Naturally, component and end product manufacturing, both being manufacturing activities, have more common denominators together, are more homogenous and resemble each other more than manufacturing and sales activities carried out by wholesalers and retailers, but other factors for the similarity of manufacturer SCPs also exist. Studies by Hingley (2005) and Bykadorov et al. (2016) argue that retailer SCP oftentimes has considerable negotiation power over the manufacturing SCPs. This may render manufacturers more willing to horizontally integrate with other manufacturers for enhanced negotiation power. Manufacturers are also bound by intrinsically different kind of legislation than retailers, and manufacturing activities generally are more heavily legislated than retailing activities, consigning the regulative burden on manufacturers. Manufacturing activities consist of practices physically transforming a product; in this process, risk of environmental and social misconduct oftentimes far exceeds similar risk of wholesale and retailing activities. In manufacturing process, damage can be inflicted on environment and on workforce in the form of, e.g. hazardous chemicals spill and work safety violations due to inhumane working conditions in contrast to wholesale and retail activities where accidents may occur, for example, when controlling the retail inventory using a forklift. (Miller 2017; Villena & Gioia 2018; European Commission 2018a; 2018b; 2019.)

When industry was chosen as independent variable instead of SCP, and environmental and social sustainability category and pillar scores of ESG data remained as dependent variable, no statistically significant differences were detected between group means. According to the results of this research, industry seems to have no significant effect on the environmental and social sustainability of a supply chain. Contributing factors for no statistically significant differences existing between group means could be that industry groups are not homogenous enough but are rather based on somewhat loose division into five industries. In a similar vein, another perception on the effect of industry on sustainability is the scarcity of previous research on the phenomenon. The lack of existing research might be explained with a possible notion in place in the academic field that no connection exists between industry and sustainability, rendering efforts to demonstrate the interdependence between industry and environmental and social sustainability futile. Results of hypotheses testing are summarised in Table 11.

Table 11 Summary of hypotheses testing

Hypothesis	Result
H1a: Environmental sustainability distributes between SCPs according to green bullwhip effect— statistically significant differences exist between environmental sustainability scores of SCPs	Supported to some extent
H1b: Social sustainability distributes between SCPs according to proposed social bullwhip effect— statistically significant differences exist between social sustainability scores of SCPs	Supported to some extent
H2a: Industry affects environmental sustainability— statistically significant differences exist between environmental sustainability scores of different industries	Rejected
H2b: Industry affects social sustainability— statistically significant differences exist between social sustainability scores of different industries	Rejected

Results of this research do not either directly support or oppose supply chain position paradox, observed by Schmidt et al. (2017), This paradox asserts that the closer a company is to the end consumer, the higher its GSCM practice levels, and simultaneously the closer the company is to the end consumer in the supply chain, the less performance gains it experiences from implementing such practices. The lower environmental and social sustainability scores obtained by vendor SCPs in comparison to the manufacturers in the upstream, could indicate diminishing GSCM yields closer to the end consumer, but this cannot not be firmly proclaimed. The results, however, do conflict with observations made by Villena and Gioia (2018) to some extent: as opposed to claims that upstream supply chain positions are the largest and most probable source of environmental and social sustainability misconduct, manufacturer SCPs scored better than the upstream vendor SCP closest to the end consumer. However, the sample of 22 non-European lower-tier suppliers used by Villena and Gioia (2018) was radically different than the all-European sample used for this research. Lower-tier suppliers, which were relatively unknown private companies, had their headquarters and factories located in the United States, China, Taiwan and Mexico apart from one location in Hong Kong. The differences in environmental and social sustainability cultures between the countries comprising the two samples, both post-industrial and emerging economies of Villena & Gioia (2018) versus post-industrial European economies of this research, might explain the conflict between the results of said two studies.

In comparison to previous prominent research on GBE by Lee et al. (2014) and Seles et al. (2016), this research was not a case study, thus providing data from a vastly larger

number of sample companies enhancing the applicability and generalisation of results. When compared to research conducted by Schmidt et al. (2017), where data for sample was obtained through a self-evaluation survey sent to informants representing companies conducting business in the German-speaking world, data for this research was collected by professional analysts specialising in ESG data refinement.

8.2 Managerial implications

The results of this research have provided additional proof to the notion that environmental and social sustainability do improve when moved from the retail and wholesale activities in the downstream towards the manufacturers in the upstream of the supply chain. However, among the manufacturers, improvement is not as radical as when transition is made from the retail and wholesale activities to manufacturing activities. Scope of SCPs or tiers in this research was limited to three and all sample companies were European, meaning that this research did not reach lower-tier suppliers far in the upstream. The suppliers furthest in the upstream are, in the globalised economy, usually located beyond European borders, on other continents in emerging economies. Suppliers furthest in the upstream seem to face the most stringent environmental and social requirements as managers at each preceding SCP aim to create a safety buffer for their own operations. This safety buffer is created by tightening the implementation schedules for compliance measures or by tightening the content of requirements in anticipation of future, more stringent regulation or stakeholder pressure to operate even more sustainably. (Lee et al. 2014; Seles et al. 2016; Villena & Gioia 2018.)

The situation for suppliers, due to GBE, is dependent on their strategic importance to customer company, usually a company governing the supply chain, located in the downstream. Lee et al. (2014) observe four different responses taken by managers of customer companies towards their suppliers in terms of environmental requirements: replace, negotiate, accommodate or collaborate. Suppliers displaying little strategic importance, mostly offering commodities, parts which could be fairly easily substituted or duplicated and components in ample supply, were replaced, if they did not meet the requirements imposed or refused to implement the changes required. These suppliers face the most stringent requirements and thus the biggest pressure. Suppliers possessing more negotiation power than ones confronted with the replace response were either negotiated with or accommodation of requirements occurred. The level of stringency in environmental requirements was alleviated when sustainability progress was assured to continue in operations of supplier. Customer companies using the accommodation response did not possess enough negotiation power over suppliers and had to make concessions with more critical suppliers. Collaboration response was reserved for most critical suppliers. This

response translates into active involvement in developing supplier capabilities through monetary investments and intense exchange of technological expertise and information. (Lee et al. 2014.) The results of this thesis from ANOVA tests, f- and Welch's tests, point to an analogous situation in the case of the SBE—requirements for social reforms are more stringent the further the observed SCP is in the upstream.

Ultimately green and social bullwhip effect raise awareness in supply chains about sustainability, accelerate the implementation of GSCM practices and social reforms, but nonetheless expose suppliers furthest in the upstream of the supply chain to most stringent environmental and social requirements in the whole chain. This may either lead to replacement of a supplier or to negotiations or collaboration with a supplier. In the case of collaboration, supplier may receive monetary support in form of investments in e.g. training of the personnel, modernisation of production facilities and technological support through sharing of information and expertise. Seles et al. (2016) propose co-operation between SCPs as a method to mitigate difficulties in responding to environmental pressure. In a similar vein, Manetti and Toccafondi (2012) and Gualandris et al. (2015) highlight the importance of certain stakeholders in implementing GSCM practices throughout the supply chain. Some stakeholders possess certain expertise which can help in the formation of more considerate sustainability objectives, adding incentive for co-operation.

The results of this thesis are somewhat in contradiction with results of study by Villena and Gioia (2018). Villena and Gioia (2018) claim that sustainability misconduct is most probable to occur in far upstream of the supply chain, whereas results of this thesis imply that least sustainable links in the supply chain are wholesalers and retailers in the downstream. Regulatory stakeholders should, thus, reconsider the regulation of wholesale and retail activities in contrast to the heavy legislative burden laid currently on manufacturers, albeit manufacturing activities can be riskier from an environmental and social point of view. In other words, stakeholders should turn their attention to activities occurring at the very downstream of a supply chain. It should, however, be noted that the scope of research conducted in this thesis is limited to large European-based firms and hence the lower-tier suppliers were not investigated. GBE or SBE is oftentimes triggered by stakeholders influencing the company governing the supply chain in the downstream. However, a question could be posed that does the practice of stakeholders skipping wholesale/retail tier preceding the governing company in the supply chain, i.e. exempting wholesalers and retailers from pressure, aid in rendering supply chains more sustainable? This, coupled with results of this thesis, would imply that in the current reality, wholesale and retail activities are, as perceived by stakeholders, effectively excluded from the scrutiny concerning sustainability in favour of companies governing supply chains.

8.3 Limitations and future research

Much like with previous studies, notable examples being Lee et al. (2014) and Seles et al. (2016), the most profound limitation of this research was the limited number of SCPs or tiers in supply chains observed. Due to the limited number of suitable sample companies, wholesale and retail SCPs had to be merged into single vendor SCP. The division of sample companies between two manufacturing SCPs was also an arduous task, as many companies performed activities which had major characteristics belonging to both manufacturing SCPs. Similar issue occurred in case study by Wilhelm et al. (2016) as the distinction between the first- and second-tier suppliers of a tea production supply chain became blurred due to overlapping activities of suppliers. The differences in used samples between the original GBE studies by Lee et al. (2014) and Seles et al. (2016) and this research mentioned must be pointed out, as well. Previous two studies delved in individual supply chains consisting, in the case of Lee et al. (2014), of second-tier and first-tier suppliers and OEMs, and in the case of Seles et al. (2016), of automotive battery manufacturer, its customer, the supplier of a battery manufacturer, and a governmental body. The sample of this research, however, included wholesale and retail activities as well, much like the study by Schmidt et al. (2017). This extension of supply chain tiers to wholesale and retail activities must be taken into consideration when comparing the results of this research on GBE and SBE as the approach was different than one taken by Lee et al. (2014) and Seles et al. (2016).

The somewhat artificial split between two manufacturer SCPs may have been a contributing factor to why the results did not unequivocally support the existence of green and social bullwhip effect at the upstream of manufacturing supply chains. Thus, increase in the number of examined SCPs/tiers would generate more accurate information as the division of value-creating activities would not overlap as much as they did with the threefold model used in this research. According to Plambeck (2012) and Villena and Gioia (2018), the greatest risk of environmental or social misconduct lies furthest in the upstream—lower-tier suppliers. Villena and Gioia (2018) assert that passiveness demonstrated by lower-tier suppliers is caused by a smaller risk of punishment or penalisation in the upstream, where actors are largely hidden from the direct pressure of stakeholders.

The sample used in this research did not reach all the way to the upstream as aggregated and precise data collection from lower-tier suppliers is problematic. In addition to the increase in the number of SCPs in the supply chain for more accurate examination, the division of sample companies to industries could have been more even. Industry with the smallest sample size, metal refining and metal products, consisted only of 16 companies, whereas the largest industry sample size, 113 companies, was that of process industry. Larger sample sizes, or more even ones, could have improved the representativity of

the sample. For future research, increase in the number of SCPs/tiers and sample sizes of industries would be desirable.

A criticism towards the data itself is the source—Thomson Reuters's ESG scoring process, on the measure level, is not very transparent. This lack of transparency prevents the assessment of reliability and objectivity of the scoring process, thus forcing the data to be used as given. The inclusion of controversies scores, which magnify the negative effect of any larger media backlash, would not have most likely altered the results in any dramatic way. Controversies scores were omitted when determining the environmental and social sustainability of sample companies due to the complexity of commensurability of environmental and social pillars with controversies score and low transparency of the scoring process. However, ESG data by Thomson Reuters has been used also in previous studies by, e.g. Chang et al. (2014), Sassen et al. (2016) and Garcia et al. (2017).

For future research, involvement of further tiers of upstream suppliers, similarly to Seles et al. (2016), is proposed to formulate a more holistic image and understand environmental and social sustainability distribution in supply chains better. Especially lower-tier suppliers residing in the very upstream of supply chains should be thoroughly examined. In order to truly target the companies possessing the strongest negotiation power and, hence ones governing the supply chains and the most potential to trigger green and bullwhip effect, large end product manufacturers as well as companies governing the supply chain should be further studied, as well. (Schmidt et al 2017.) Companies like Apple and Nestlé govern their own supply chains and as sustainability violations surface, consumers and stakeholder groups tend to target the largest, most visible companies rather than decide to boycott certain retailers, much smaller in terms of revenue and market capitalisation (Schmidt et al. 2017; Touryalai & Stoller 2018; Ethical Consumer 2019). However, if enough retailers start to boycott large end product manufacturers, this eventually has an impact on manufacturing companies, as well.

Another facet for future research would be to investigate the social dimension of bullwhip effect and social sustainability issues in supply chains further as the research field has been incontrovertibly dominated by exploration of environmental issues and green considerations in supply chains.

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APPENDIX 1 ESG ENVIRONMENTAL MEASURES LIST

Environmental pillar (97 measures in total)
Resource Use category (31)
Resource Reduction Policy
Policy Water Efficiency
Policy Energy Efficiency
Policy Sustainable Packaging
Policy Environmental Supply Chain
Resource Reduction Targets
Targets Water Efficiency
Targets Energy Efficiency
Environment Management Team
Environment Management Training
Environmental Materials Sourcing
Toxic Chemicals Reduction
Total Energy Use/Million in Revenue (USD)
Renewable Energy Use Ratio
Energy Use Total
Energy Purchased Direct
Energy Produced Direct
Electricity Purchased
Electricity Produced
Renewable Energy Purchased
Renewable Energy Produced
Renewable Energy Use
Green Buildings
Total Water Use/Million in Revenue (USD)
Water Withdrawal Total
Fresh Water Withdrawal Total
Environmental Supply Chain Management
Environmental Supply Chain Monitoring
Env Supply Chain Partnership Termination
Land Environmental Impact Reduction
Environmental Controversies

Environmental pillar (97 measures in total)
Emissions category (41)
Policy Emissions
Targets Emissions
Biodiversity Impact Reduction
Total CO2 Emissions/Million in Revenue (USD)
CO2 Equivalent Emissions Total
CO2 Equivalent Emissions Direct, Scope 1
CO2 Equivalent Emissions Direct, Scope 2
CO2 Equivalent Emissions Direct, Scope 3
Carbon Offsets/Credits
Estimated CO2 Equivalents Emission Total
CO2 Estimation Method
Emissions Trading
Climate Change Commercial Risks Opportunities
No_x and So_x Emissions Reduction
No_x Emissions
So_x Emissions
VOC or Particulate Matter Emissions Reduction
VOC Emissions Reduction
Particulate Matter Emissions Reduction
VOC Emissions
Total Waste/Million in Revenue (USD)
Waste Recycled To Total Waste
Total Hazardous Waste/Million in Revenue (USD)
Waste Total
Non-Hazardous Waste
Waste Recycled Total
Waste Recycling Ratio
Hazardous Waste
Waste Reduction Initiatives
e-Waste Reduction
Total Water Pollutant Emissions/ Million in Revenue (USD)
Water Discharged
Water Pollutant Emissions
ISO 14000 or EMS
EMS Certified Percent
Environmental Restoration Initiatives
Staff Transportation Impact Reduction
Environmental Expenditures Investments
Environmental Expenditures
Environmental Investments Initiatives
Environmental Partnerships

Environmental pillar (97 measures in total)
Innovations category (25)
Environmental Products
Eco-Design Products
Total Environmental R&D (USD)/ Million in Revenue (USD)
Noise Reduction
Fleet Fuel Consumption
Hybrid Vehicles
Fleet CO2 Emissions
Environmental Assets Under Management
Equator Principles
Environmental Project Financing
Nuclear
Labelled Wood
Organic Products Initiatives
Product Impact Minimisation
Take-back and Recycling Initiatives
Product Environmental Responsible Use
GMO Products
Agrochemical Products
Agrochemical 5 % Revenue
Animal Testing
Animal Testing Cosmetics
Animal Testing Reduction
Renewable/Clean Energy Products
Water Technologies
Sustainable Building Products

APPENDIX 2 ESG SOCIAL MEASURES LIST

Social pillar (105 measures in total)
Workforce category (47)
Health & Safety Policy
Policy Employee Health & Safety
Policy Supply Chain Health & Safety
Training and Development Policy
Policy Skills Training
Policy Career Development
Policy Diversity and Opportunity
Targets Diversity and Opportunity
Employees Health & Safety Team
Health & Safety Training
Supply Chain Health & Safety Training
Employees Health & Safety OHSAS 18001
Employee Satisfaction
Salary Gap
Salaries and Wages From CSR Reporting
Net Employment Creation
Number of Employees from CSR Reporting
Trade Union Representation
Turnover of Employees
Announced Layoffs To Total Employees
Announced Layoffs
Strikes
Women Employees
Women Managers
Flexible Working Hours
Day Care Services
Employees With Disabilities
Injuries to Million Hours
Total Injury Rate Total
Total Injury Rate Employees
Accidents Total
Employee Accidents
Employee Fatalities
Lost Days/Million Working Days
Lost Time Injury Rate Total
Lost Time Injury Rate Employees
Lost Working Days
Employee Lost Working Days
HIV-AIDS Programme

Social pillar (105 measures in total)
Workforce category (47)
Average Training Hours
Training Hours Total
Training Costs Total
Training Costs Per Employee
Internal Promotion
Management Training
Supplier ESG Training
Wages Working Condition Controversies
Social pillar (105 measures in total)
Human Rights category (9)
Human Rights Policy
Policy Freedom of Association
Policy Child Labour
Policy Forced Labour
Policy Human Rights
Fundamental Human Rights ILO UN
Human Rights Contractor
Ethical Trading Initiative ETI
Human Rights Breaches Contractor
Community category (21)
Policy Fair Competition
Policy Bribery and Corruption
Policy Business Ethics
Policy Community Involvement
Improvement Tools Business Ethics
OECD Guidelines for Multinational Enterprises
Extractive Industries Transparency Initiative
Total Donations/Million in Revenue (USD)
Donations Total
Political Contributions
Lobbying Contribution Amount
Employee Engagement Voluntary Work
Corporate Responsibility Awards
Product Sales at Discount to Emerging Markets
Diseases of the Developing World
Bribery, Corruption and Fraud Controversies
Crisis Management Systems
Anti-Competition Controversies
Critical Country 1
Critical Country 2
Critical Country 3

Social pillar (105 measures in total)
Product Responsibility category (28)
Policy Customer Health & Safety
Policy Data Privacy
Policy Responsible Marketing
Policy Fair Trade
Product Responsibility Monitoring
Quality Management Systems
ISO 9000
Six Sigma and Quality Management Systems
QMS Certified Percent
Customer Satisfaction
Product Access Low Price
Healthy Food or Products
Embryonic Stem Cell Research
Retailing Responsibility
Alcohol
Gambling
Tobacco
Armaments
Pornography
Contraceptives
Obesity Risk
Cluster Bombs
Anti-Personal Landmines
Consumer Complaints Controversies
Product Quality Controversies
Responsible Marketing Controversies
Product Delays
Product Recall

APPENDIX 3 SAMPLE COMPANIES, MANUFACTURER 1 SCP

Company	Thomson Reuters Business Classification Activity	Industry
A2A	Renewable Utilities	P
Aalberts Industries	Industrial Machinery & Equipment (NEC)	Ma
AB SKF	Industrial Machinery & Equipment (NEC)	Ma
ABB	Heavy Electrical Equipment (NEC)	Ma
Aggreko	Business Support Services (NEC)	Ma
Air Liquide	Commodity Chemicals (NEC)	P
Aker BP	Oil & Gas Exploration and Production (NEC)	P
AkzoNobel	Paints & Coatings	P
Alfa Laval	Industrial Machinery & Equipment (NEC)	Ma
Alstom	Heavy Machinery & Vehicles (NEC)	Ma
ams AG	Semiconductors (NEC)	C
Anglo American	Diversified Mining	Me
Antofagasta	Copper Ore Mining	Me
ArcelorMittal	Iron & Steel (NEC)	Me
Arkema	Commodity Chemicals (NEC)	P
ASML Holdiing	Semiconductor Equipment & Testing (NEC)	C
Atlas Copco A	Industrial Machinery & Equipment (NEC)	Ma
BASF	Diversified Chemicals	P
BE Semiconductor	Semiconductor Machinery Manufacturing	C
BHP Billiton	Diversified Mining	Me
BillerudKorsnäs	Paper Packaging (NEC)	L
Boliden	Specialty Mining & Metals (NEC)	Me
BP	Oil & Gas Refining and Marketing (NEC)	P
CEZ	Electric Utilities (NEC)	P
Chr. Hansen Holding	Food Ingredients	P
Clariant	Specialty Chemicals (NEC)	P
Continental	Auto, Truck & Motorcycle Parts (NEC)	Ma
Covestro	Plastics	L
CRH	Construction Materials (NEC)	L
Croda International	Specialty Chemicals (NEC)	P
DS Smith	Paper Packaging (NEC)	L
EDF	Multiline Utilities	P
Ems-Chemie Holding	Commodity Chemicals (NEC)	P
Endesa	Electric Utilities (NEC)	P
ENGIE	Multiline Utilities	P
Eni	Integrated Oil & Gas	P
Equinor	Integrated Oil & Gas	P
Evonik Industries	Diversified Chemicals	P
EVRAZ	Iron, Steel Mills & Foundries	Me
Faurecia	Auto, Truck & Motorcycle Parts (NEC)	Ma

Company	Thomson Reuters Business Classification Activity	Industry
Fortum	Electric Utilities (NEC)	P
Fresnillo	Diversified Mining	Me
FUCHS PETROLUB SE	Commodity Chemicals (NEC)	P
Galp Energia	Oil & Gas Refining and Marketing (NEC)	P
Geberit	Plumbing Fixtures & Fittings	L
Georg Fischer	Industrial Machinery & Equipment (NEC)	Ma
Givaudan	Commodity Chemicals (NEC)	P
Glencore Plc	Coal (NEC)	P
Halma	Electrical Components & Equipment (NEC)	C
HeidelbergCement	Construction Materials (NEC)	L
Henkel AG & Co. KGaA	Adhesives	P
Hexagon B	Electronic Equipment & Parts (NEC)	C
HEXPOL AB	Advanced Polymers	P
Iberdrola	Electric Utilities (NEC)	P
Imerys	Diversified Chemicals	P
IMI plc	Industrial Machinery & Equipment (NEC)	Ma
Infineon Technologies	Semiconductors (NEC)	C
K + S	Agricultural Chemicals (NEC)	P
KAZ Minerals PLC	Diversified Mining	Me
Koninklijke DSM NV	Diversified Chemicals	P
LafargeHolcim	Cement & Concrete Manufacturing	L
LANXESS	Diversified Chemicals	P
Legrand	Electrical Components & Equipment (NEC)	C
Linde AG	Industrial Gases	P
Lonza	Biotechnology & Medical Research (NEC)	P
Lundin Petroleum	Oil & Gas Exploration and Production (NEC)	P
Meggit PLC	Aircraft Parts Manufacturing	Ma
Michelin	Tires & Rubber Products (NEC)	L
Mondi	Paper Packaging (NEC)	L
MTU Aero Engines	Aircraft Parts Manufacturing	Ma
Neste	Oil & Gas Refining and Marketing (NEC)	P
NIBE Industrier AB	Heating, Ventilation & Air Conditioning Systems	L
Nokian Renkaat	Tires & Rubber Products (NEC)	L
Norsk Hydro	Aluminum (NEC)	Me
Novozymes	Commodity Chemicals (NEC)	P
OC Oerlikon	Industrial Machinery & Equipment (NEC)	Ma
OMV	Oil & Gas Refining and Marketing (NEC)	P
OSRAM Licht AG	Lighting Equipment	L
Pirelli & C. S.p.A.	Tire & Tube Manufacturers	L
Plastic Omnium	Automotive Body Parts	Ma
Polymetal International	Diversified Mining	Me
Prysmian	Wires & Cables	C

Company	Thomson Reuters Business Classification Activity	Industry
Randgold Resources	Gold (NEC)	Me
Repsol	Oil & Gas Refining and Marketing (NEC)	P
Rexel	Electrical Components & Equipment (NEC)	C
Rheinmetall	Engine & Powertrain Systems	Ma
Rio Tinto	Diversified Mining	Me
Rockwool International A/S	Construction Supplies	L
Rotork	Fluid Power Cylinder & Actuators	Ma
Royal Dutch Shell plc	Integrated Oil & Gas	P
RPC Group Plc	Plastic Containers & Packaging	L
Safran	Aircraft Parts Manufacturing	Ma
Saint-Gobain	Construction Supplies & Fixtures (NEC)	L
Sandvik	Industrial Machinery & Equipment (NEC)	Ma
Schaeffler AG	Auto, Truck & Motorcycle Parts (NEC)	Ma
Schindler	Elevator & Conveying Equipment	Ma
Schneider Electric	Electrical Components & Equipment (NEC)	C
Sika	Specialty Chemicals (NEC)	P
Siltronic AG	Semiconductors (NEC)	C
Smurfit Kappa Group	Paper Packaging (NEC)	L
Solvay	Commodity Chemicals (NEC)	P
Spectris	Electrical Components & Equipment (NEC)	C
Spirax-Sarco Engineering plc	Industrial Machinery & Equipment (NEC)	Ma
STMicroelectronics	Semiconductors (NEC)	C
Stora Enso Oyj	Paper Products (NEC)	L
Svenska Cellulosa (SCA) AB	Paper Products (NEC)	L
Symrise	Specialty Chemicals (NEC)	P
Tate & Lyle	Food Ingredients	P
Tenaris	Oil Related Equipment	L
ThyssenKrupp	Iron & Steel (NEC)	Me
Total	Integrated Oil & Gas	P
Trelleborg AB	Specialty Chemicals (NEC)	P
Tullow Oil	Oil & Gas Exploration and Production (NEC)	P
Umicore	Waste Management, Disposal & Recycling Services	P
UPM-Kymmene	Paper Products (NEC)	P
Valeo	Auto, Truck & Motorcycle Parts (NEC)	Ma
VAT Group AG	Industrial Valve Manufacturing	L
Victrex	Specialty Chemicals (NEC)	P
Wienerberger	Construction Materials (NEC)	L
Viscofan	Non-Paper Containers & Packaging (NEC)	L
Voestalpine	Iron & Steel (NEC)	Me
Wärtsila	Industrial Conglomerates	Ma
Yara International ASA	Agricultural Chemicals (NEC)	P

Company	Thomson Reuters Business Classification Activity	Industry
UPM-Kymmene	Paper Products (NEC)	P
Valeo	Auto, Truck & Motorcycle Parts (NEC)	Ma
VAT Group AG	Industrial Valve Manufacturing	L
Victrex	Specialty Chemicals (NEC)	P
Wienerberger	Construction Materials (NEC)	L
Viscofan	Non-Paper Containers & Packaging (NEC)	L
Voestalpine	Iron & Steel (NEC)	Me
Wärtsila	Industrial Conglomerates	Ma
Yara International ASA	Agricultural Chemicals (NEC)	P

Note Industry abbreviations used in the appendix:

P Process industry

L Light industry

Me Metal refining and metal productions

Ma Appliances, machines and transport equipment

C Computers and electronics

APPENDIX 4 SAMPLE COMPANIES, MANUFACTURER 2 SCP

Company	Thomson Reuters Busines Classification Activity	Industry
Adidas	Sports & Outdoor Footwear	L
Airbus	Commercial Aircraft Manufacturing	Ma
Ambu	Medical Equipment, Supplies & Distribution (NEC)	C
Amer Sports	Sporting & Outdoor Goods	L
Andritz	Industrial Machinery & Equipment (NEC)	Ma
Anheuser-Busch InBev	Brewers (NEC)	P
Assa Abloy	Construction Supplies & Fixtures (NEC)	L
Associated British Foods	Food Processing (NEC)	P
BAE Systems	Aerospace & Defense (NEC)	Ma
Barry Callebaut	Chocolate & Confectionery	P
Bayer	Pharmaceuticals (NEC)	P
Beiersdorf	Personal Products (NEC)	L
BIC	Business Support Supplies (NEC)	L
BMW	Auto & Truck Manufacturers (NEC)	Ma
British American Tobacco	Tobacco (NEC)	P
Britvic	Non-Alcoholic Beverages (NEC)	P
BTG PLC	Pharmaceuticals (NEC)	P
Bucher Industries	Heavy Machinery & Vehicles (NEC)	Ma
Carlsberg A/S	Brewers (NEC)	P
Christian Dior SE	Apparel & Accessories (NEC)	L
CNH Industrial N.V.	Heavy Machinery & Vehicles (NEC)	Ma
Cobham plc	Aerospace & Defense (NEC)	Ma
Coca-Cola Hbc	Non-Alcoholic Beverages (NEC)	P
Compagnie Financière Richemont SA	Jewelry	Me
ConvaTec	Proprietary & Advanced Pharmaceuticals	P
Daimler	Auto & Truck Manufacturers (NEC)	Ma
Danone	Food Processing (NEC)	P
Dassault Aviation	Commercial Aircraft Manufacturing	Ma
Davide Campari-Milano S.p.A.	Distillers & Wineries (NEC)	P
Dechra Pharmaceuticals	Veterinary Drugs	P
Diageo	Distillers & Wineries (NEC)	P
dormakaba Holding AG	Security & Surveillance	C
Dúrr AG	Industrial Machinery & Equipment (NEC)	Ma
Electrolux AB	Appliances, Tools & Housewares (NEC)	L
Epiroc AB	Heavy Machinery & Vehicles (NEC)	Ma
F. Hoffmann-La Roche AG	Pharmaceuticals (NEC)	P
Ferrari N.V.	Automobiles & Multi Utility Vehicles	Ma
Fiat Chrysler Automobiles	Automobiles & Multi Utility Vehicles	Ma

Company	Thomson Reuters Business Classification Activity	Industry
Fresenius Medical Care AG	Healthcare Facilities & Services (NEC)	P
GEA Group	Industrial Machinery & Equipment (NEC)	Ma
Getinge AB	Medical Equipment	L
Glanbia Plc	Dairy Products	P
GN Store Nord	Advanced Medical Equipment & Technology (NEC)	C
Grifols	Biopharmaceuticals	P
Groupe SEB	Appliances, Tools & Housewares (NEC)	Ma
H & M Hennes & Mauritz AB	Apparel & Accessories (NEC)	L
H. Lundbeck A/S	Pharmaceuticals (NEC)	P
Heineken N.V.	Brewers (NEC)	P
Howden Joinery Group plc	Home Furnishings (NEC)	L
Hugo Boss AG	Apparel & Accessories (NEC)	L
Huhtamäki Oyj	Paper Packaging (NEC)	L
Husqvarna AB	Appliances, Tools & Housewares (NEC)	L
Imperial Brands	Tobacco (NEC)	P
Indivior	Proprietary & Advanced Pharmaceuticals	P
Ipsen	Pharmaceuticals (NEC)	P
Johnson Matthey	Specialty Chemicals (NEC)	P
Kerry Group	Fruit & Vegetable Processing	P
Kingspan Group	Flooring & Interior Tile Manufacturers	L
KION Group	Heavy Machinery & Vehicles (NEC)	Ma
KONE Oyj	Elevator & Conveying Equipment	Ma
Konecranes	Heavy Machinery & Vehicles (NEC)	Ma
Leonardo S.p.A.	Aerospace & Defense (NEC)	Ma
Lindt & Sprüngli	Chocolate & Confectionery	P
Logitech International S.A.	Computer Hardware (NEC)	C
L'Oreal S.A.	Cosmetics & Perfumes	L
LVMH Moët Hennessy Louis Vuitton SE	Apparel & Accessories (NEC)	L
Marine Harvest	Food Processing (NEC)	P
Merck KGaA	Proprietary & Advanced Pharmaceuticals	P
Metso Oyj	Industrial Machinery & Equipment (NEC)	Ma
Nestlé	Food Processing (NEC)	P
Novartis	Pharmaceuticals (NEC)	P
Novo Nordisk	Pharmaceuticals (NEC)	P
Orion	Pharmaceuticals (NEC)	P
Orkla	Food Processing (NEC)	P
Pandora	Jewelry	Me
Pernod Ricard	Distillers & Wineries (NEC)	P
Peugeot	Auto & Truck Manufacturers (NEC)	Ma
Philips	Advanced Medical Equipment & Technology (NEC)	L

Company	Thomson Reuters Business Classification Activity	Industry
Porsche Automobil Holding SE	Auto & Truck Manufacturers (NEC)	Ma
Reckitt Benckiser	Personal Products (NEC)	L
Recordati	Pharmaceuticals (NEC)	P
Remy Cointreau	Distillers & Wineries (NEC)	P
Renault	Auto & Truck Manufacturers (NEC)	Ma
Rolls-Royce Holdings	Aerospace & Defense (NEC)	Ma
Saab AB	Aerospace & Defense (NEC)	Ma
Shire	Pharmaceuticals (NEC)	P
Siemens AB	Industrial Conglomerates	C
Siemens Gamesa	Wind Systems & Equipment	Ma
Signify	Lighting Fixtures	L
Smiths Group	Industrial Conglomerates	L
Sonova Holding AG	Medical Prosthetics	C
Straumann	Medical Prosthetics	C
Swatch Group	Watches	L
Swedish Match	Tobacco (NEC)	P
Tecan Group AG	Scientific & Precision Equipment	C
Thales Group	Satellite Design & Manufacture	C
UCB S.A.	Pharmaceuticals (NEC)	P
Unilever N.V.	Personal Products (NEC)	L
Unilever plc	Personal Products (NEC)	L
Vestas Wind Systems A/S	Wind Systems & Equipment	Ma
Volkswagen AG	Auto & Truck Manufacturers (NEC)	Ma
Volvo AB	Heavy Trucks	Ma

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APPENDIX 5 SAMPLE COMPANIES, VENDOR SCP

Company	Thomson Reuters Business Classification Activity	Industry
Ahold Delhaize	Food Retail & Distribution (NEC)	P
ASOS plc	Apparel & Accessories Retailers (NEC)	L
Axfood AB	Supermarkets & Convenience Stores	P
B&M European Value Retail S.A.	Discount Stores (NEC)	P
Bergman & Beving AB	Industrial Machinery & Equipment Wholesale	Ma
Brenntag AG	Diversified Chemicals	P
Bunzl plc	Diversified Industrial Goods Wholesalers	L
Burberry Group PLC	Apparel & Accessories Retailers (NEC)	L
Card Factory plc	Gift, Novelty & Souvenir Stores	L
CCC S.A.	Footwear Retailers	L
CECONOMY AG	Computer & Electronics Retailers (NEC)	C
Clas Ohlson AB	Home Improvement Products & Services Retailers (NEC)	L
Coloplast A/S	Medical Equipment Wholesale	L
Debenhams Plc	Department Stores (NEC)	L
D'Ieteren SA	Auto Vehicles, Parts & Service Retailers (NEC)	Ma
Dino Polska S.A.	Supermarkets & Convenience Stores	P
Diploma plc	Industrial Machinery & Equipment Wholesale	Ma
Dixons Carphone plc	Computer & Electronics Retailers (NEC)	C
Dufry AG	Miscellaneous Specialty Retailers (NEC)	L
Dunelm Group plc	Home Furnishings Retailers (NEC)	L
Electrocomponents plc	Electric Equipment Wholesale	C
Etablissementen Franz Colruyt NV	Food Retail & Distribution (NEC)	P
Eurocash S.A.	Food Retail & Distribution (NEC)	P
Ferguson plc	Construction Supplies & Fixtures Wholesale	L
Fielmann AG	Optical Goods Stores	L
Findel plc	Internet & Mail Order Department Stores	L
Galenica AG	Retail - Drugs without Grocery	P
Grafton Group plc	Construction Material Wholesale	L
GrandVision N.V.	Optical Goods Stores	L
Hermes International SCA	Handbags & Luggage	L
Ica Gruppen AB	Supermarkets & Convenience Stores	P
IMCD	Specialty Chemicals Wholesale	P
Inchcape plc	Auto Vehicles, Parts & Service Retailers (NEC)	Ma

Company	Thomson Reuters Business Classification Activity	Industry
Industria de Diseño Textil S.A.	Apparel & Accessories Retailers (NEC)	L
J Sainsbury plc	Supermarkets & Convenience Stores	P
JD Sports Fashion Plc	Sports & Outdoors Retailers	L
Jerónimo Martins	Food Retail & Distribution (NEC)	P
Jumbo S.A.	Miscellaneous Specialty Retailers (NEC)	L
Kering	Apparel & Accessories Retailers (NEC)	L
Kesko	Supermarkets & Convenience Stores	P
Kingfisher plc	Home Improvement Products & Services Retailers (NEC)	L
Lookers plc	New Car Dealers	Ma
Luxottica Group	Optical Goods Stores	L
Magnit PAO	Food Retail & Distribution (NEC)	P
Marks & Spencer Group plc	Miscellaneous Specialty Retailers (NEC)	P
McKesson Europe AG	Drug Retailers (NEC)	P
Mekonomen AB	Automotive Parts & Accessories Retailers	Ma
Metro AG	Food Retail & Distribution (NEC)	P
Moncler	Apparel & Accessories (NEC)	L
N Brown Group plc	Apparel & Accessories Retailers (NEC)	L
Next PLC	Miscellaneous Specialty Retailers (NEC)	L
Ocado	Internet & Mail Order Discount Stores	P
Pets at Home Group Plc	Pet & Pet Supplies Retailers	P
Rubis	Petroleum Product Wholesale	P
SIG plc	Construction Supplies & Fixtures Wholesale	L
Sports Direct International plc	Sporting Goods Stores	L
Superdry PLC	Apparel & Accessories Retailers (NEC)	L
Ted Baker PLC	Apparel & Accessories Retailers (NEC)	L
Tesco plc	Food Retail & Distribution (NEC)	P
Travis Perkins plc	Builder Merchants	L
Valora Holding AG	Miscellaneous Specialty Retailers (NEC)	P
WHSmith plc	Book & Magazine Retailers	P
Vifor Pharma	Pharmaceuticals (NEC)	P
Wm Morrison Supermarkets plc	Food Retail & Distribution (NEC)	P
Zalando	Apparel & Accessories Retailers (NEC)	L

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