Chapter 1
Sustainable Supply Chains: Introduction

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1.1 Sustainable Supply Chains: What's New?

Are supply chains becoming more or less sustainable over time? The answer is not obvious. In the 1960s, we became aware of the dangers inherent in various chemicals including those used in pesticides, specifically DDT. Some would point to Rachel Carson's 1962 book *Silent Spring* as a defining moment in the history of the environmental movement, contributing to the creation of the environmental movement and the Environmental Protection Agency in the USA. In the 1970s, we started to learn that seemingly innocent aerosols in spray cans were eating a hole in the ozone layer, removing a crucial protection against being toasted and eventually burned by the sun. Various regulatory and voluntary actions followed, and depletion of the ozone layer seems to have slowed down recently. In the 1980s, we found out that acid rain was killing our lakes and eating our cities. Various regulatory responses have since helped to reduce emissions of chemicals leading to acidification. During the 1990s, we heard horror stories of how workers in sweatshops in China, Vietnam, and elsewhere were treated. Firms such as Nike initially responded that they did not own the factories, and hence it was not their problem, but by the 2000s, at least some firms (including Nike) had completely changed their tone. Throughout these

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decades, it transpired increasingly clearly that anthropogenic emissions were likely contributing to rising levels of greenhouse gases in the atmosphere, with a variety of effects on sea level and climate. A plethora of regulatory and voluntary responses is underway to mitigate climate change, with decidedly mixed results so far.

But how much of all this is new? Insecticides have been regulated in the USA as far back as 1910, though what is now the UK already passed a rule in about 1236 AD that “forbade the addition of anything to the food supply which was ‘not wholesome’” (Aspelin 2003, Chap. 2: 10–11). The ozone layer was discovered in 1913, and its properties and thickness were already increasingly measured during the subsequent decades (e.g., Solomon 1999). The link between acid rain and atmospheric pollution was established in 1852, with the term “acid rain” appearing in 1872; damaging effects of pollution had been observed even earlier (see, e.g., Cowling 1982). Early anti-sweatshop movements gave rise to the Factory Act in the UK in 1833 (Nardinelli 1980) and more recently to the Fair Labor Standards Act in the USA in 1938 (Samuel 2000).

Climate change is no different. Arrhenius (1896) already reported on the connection between atmospheric carbon dioxide concentrations and global temperature, predicting that a doubling of the CO_2 concentration would lead to a temperature increase of 4.9–6.1 °C (depending on the latitude). This estimate is remarkably close to more recent ones by the IPCC, who report a range of predicted temperature rises between 1.5–4.5 °C (Houghton et al. 1995). Arrhenius was keenly aware of the geological importance of his calculations, writing (p. 267) “I should certainly not have undertaken these tedious calculations if an extraordinary interest had not been connected with them.” His primary motivation, however, was explaining the Ice Age, rather than predicting future global warming.

These timelines have a clear implication for any book on “sustainable supply chains”: scientists of all kinds are undoubtedly already making observations and constructing theories of environmental and social aspects that we are blissfully unaware of today but that will come to haunt us in the decades to come. In other words, there can be no such thing as a “sustainable supply chain,” as we do not and cannot know today what will be critical elements of “sustainability” tomorrow.

Even if we limit ourselves to the environmental and social factors that we are already aware of, a truly “sustainable” supply chain is difficult to envision. This is certainly true when one adopts a strong sustainability perspective, which does not allow manufactured capital to substitute for natural capital. Almost any supply chain, at some level, converts natural capital into manufactured capital, rendering them inherently unsustainable under that perspective. In the weak sustainability view, it is acceptable to deplete natural resources, as long as there is a corresponding increase in manufactured capital. Deforestation is acceptable as long as technological progress delivers substitutes for wood. Increasing water pollution is acceptable as long as decontamination technology advances in parallel. In this perspective, a supply chain could be sustainable if its “net” impact on people and planet is neutral, still a tall order. As Pagell and Wu argue in Chap. 15, sustainability in supply chains should be thought of in terms of trajectories, rather than absolute states.

Our quick historical sketches above underline that such trajectories can never have a well-defined endpoint. Instead, a more sustainable supply chain is one that is better at identifying current and future environmental and social impacts and finding ways to mitigate those. That is the, admittedly very loose, definition we use in this book for "sustainable." We take no position on weak vs. strong sustainability, on whether one should be more concerned about climate change, water availability, or social impacts. We do take the position that for a firm to thrive, it is increasingly imperative that it be aware of economic, environmental, and social dimensions of the entire supply chain it belongs to and that it proactively monitor and manage those.

The arguments so far might point towards the need for a firm to engage with its economic, environmental, and social impacts. But why would it need to do so for the entire supply chain within which it operates? As firms become progressively more tightly coupled in global supply chains, rather than being large vertically integrated monoliths, risks and opportunities associated with activities upstream or downstream will increasingly impinge upon their own well-being. Referring to "risks and opportunities associated with activities upstream or downstream" clearly signifies an equally broad and loose definition of "supply chains": we will not attempt to draw a clear boundary of what we do and do not consider part of a supply chain, but in this book, we do include not just suppliers and customers but also consumers, society, employees, communities, NGO partners, and others who in one way or another participate in the "activities upstream or downstream." For many firms, some of the main risks and opportunities do lie outside their own boundaries, hence necessitating this broader supply chain perspective.

To summarize, this book should not be called "Sustainable Supply Chains," but rather something like "Gradual but Never-Ending Paths Towards Less Unsustainable Global Value Networks."

1.2 Sustainable Supply Chains: What's Really New?

Having argued that in some sense "sustainability" is not new, one might still ask what *is* new? Why assemble this book at this particular point in time?

First, the scientific understanding of many aspects of sustainability is advancing faster than ever before. In the past, many environmental and social issues were largely treated independently from one another, but we are increasingly understanding that climate change interacts heavily with health and poverty. The links between energy, food, and water are sinking in. Climate change threatens biodiversity which in turn endangers continuity of supply of various crops, putting already poor constituencies at further risk, etc.

Second, the political landscape is evolving in parallel. While there is a wide variation in regulation and enforcement across countries, and even across cities or regions within countries, the global trend is undeniably towards more and more comprehensive environmental and social regulation.

Third, the landscape within which business operates is undergoing similar evolution. Firms no longer treat environmental concerns as single-issue one-off distractions, but are increasingly taking a comprehensive approach to managing their full spectrum of environmental and social (as well as economic) impacts. That is triggered in part by the evolution in scientific understanding and political agendas, but presumably most of all by the maturing realization that, done judiciously, a proactive approach to sustainability can go hand in hand with increased profitability (more on which below). This is the result of market forces, the changing regulatory environment, employee engagement, investor action, and more.

Finally, and perhaps most importantly in terms of this book, we have noticed a recent surge in the number of courses on "sustainable supply chain management" or related topics, but a relative lack of corresponding teaching materials. While sustainability has been widely studied at the level of company strategy and extensive pedagogical materials exist at that more strategic level, there is still a relative lack of materials on sustainability with a supply chain management perspective.

Taken together, we hope that these observations jointly indicate that the time is ripe for a book of this nature. At the same time, these observations point to some principles that we adopted in assembling this book, outlined in the next section.

1.3 Principles Underlying This Book

Having established that neither "sustainability" nor "supply chains" are necessarily new in themselves, we made a number of deliberate choices in designing this book, each of which we discuss in more detail below.

1. There are economic reasons for firms to adopt a proactive approach to sustainability (but not every sustainability initiative is necessarily profitable).
2. Merely measuring environmental and social impacts is often already enough to bring about improvements in performance.
3. Supply chain operations are key to boosting sustainability performance.
4. Sustainability is not a state, but (at best) a direction.
5. Sustainability involves engaging with a range of stakeholders, not limited to the traditional supply chain partners.

1.3.1 Economic Drivers of Sustainability

There is clearly a strong ethical dimension to sustainability. However, in this book we emphasize the economic side. Many studies seek to determine whether firms that are more sustainable are also more profitable. That question, as stated, is probably unanswerable, as "more sustainable" can mean too many different things, and even for any specific dimension of sustainability the answer will depend on too many conditions, such as geography, industry, market conditions, timing, and more. There are some meta-analyses of this literature that generally do point towards a positive link between sustainability and profitability; see for instance Orlitzky et al. (2003) for a meta-analysis of the link between corporate social performance and financial outcomes and Horváthová (2010) for the link between financial and environmental performance. This link need not always be direct; for instance, in Chap. 19, Scholten and Fynes (2017) discuss how sustainability can lead to greater resilience. Moreover, the fact that the weight of the evidence tilts towards a positive link does not mean that every sustainability initiative will be profitable by every metric. For instance, in Chap. 14, Jacobs et al. (2017) report that the US stock market responded negatively to firms' announcements of GHG and especially non-GHG emissions reductions, though they also point out that those emissions reductions may have other indirect benefits not immediately captured by the stock market reaction. Their findings should not be taken as implying that sustainability is not profitable; they do highlight that practitioners should not naively assume that every sustainability-related initiative will be immediately profitable or rewarded by the stock market.

This discussion might suggest that becoming more sustainable is optional. Sometimes, it is not: firms are facing increasing pressure to become more sustainable and to take their supply chains with them. That pressure comes from customers, both from individual consumers (especially in developed countries) and from organizations in the B2B context. Regulations continue to target larger segments of the supply chain and on more dimensions. Governments are moving more and more to a cradle-to-grave (or even cradle-to-cradle) perspective in designing regulation, which makes the supply chain the inevitable unit of analysis. In addition, non-governmental organizations (NGOs) find various ways to encourage or pressure firms to adopt more sustainable behavior, whether related to labor practices, eliminating various ingredients in food, reducing emissions, or otherwise. Add to this pressure from investors, banks, insurance companies, employees, and more, and it is clear that sustainability is often an imperative more than a luxury.

1.3.2 What You Measure Is What You Get

There are good reasons to believe that the mere act of measuring something triggers ways to improve it. The fact that Walmart, of all firms, was able to find ways to reduce both GHG emissions and costs by installing auxiliary power units in their trucks once they started taking a close look at their carbon footprint is a prime example of this. That is one reason why this book contains several chapters on measurement. Moreover, measurement is not at all straightforward and inherently requires a supply chain perspective. A firm seeking to reduce its "own" emissions faces two big challenges. First, it is practically impossible to unambiguously measure or even closely estimate a firm's responsibility for the emissions associated with a final product or service. A typical product goes through numerous manufacturing and transportation activities, often jointly operated by a number of companies in a supply chain. Second, the direct emissions that a firm might abate typically constitute a small part of the supply chain emissions. Matthews et al. (2008) report that across all industries, companies' direct emissions average only 14 % of their supply chain emissions *prior to* use and disposal. Therefore, sustainability measurement should take a supply chain perspective, rather than limiting itself to the firm's own emissions and impacts.

In Chap. 2, Guinée and Heijungs (2017) provide an introduction to life cycle assessment, which can be thought of as the overarching framework for measurement of environmental (and perhaps in future also social) impacts. Of all the environmental impacts, those related to climate change currently receive the most attention. Therefore, Chap. 3, by Boukherroub et al. (2017), focuses on measurement of carbon footprints specifically. Water is increasingly recognized as another key resource that is under threat, due to overuse, climate change, and pollution. Although the term "water footprint" insinuates a parallel with "carbon footprint," the measurement issues are in fact quite different, among others due to water not being time and space invariant the way that GHG emissions are. Hoekstra (2017) delves deeper into this in Chap. 4. There are numerous other raw materials that can be sources of concern, as outlined by Blass et al. (2017) in Chap. 5. Finally, Bateman et al. (2017) link these various measurement paradigms to reporting and disclosure programs in Chap. 6.

This series of chapters highlights that measurement, although highly valuable, is often not trivial. Challenges include the multiple dimensions of impacts that need to be consolidated, the appropriate acknowledgment of how impacts differ across space and time, the challenge of setting appropriate boundaries, how to deal with variation and uncertainty, and more. Many of these questions are the topic of ongoing research and unresolved. Nevertheless, we believe that the most frequent sustainability-related tasks which students will find themselves confronted with revolve around measurement.

1.3.3 Supply Chain Operations Are Key to Sustainability

One could argue that there are two broad domains within which one can strive for more sustainable outcomes. One is consumer behavior: this can be getting consumers to launder their clothes at lower temperatures and less frequently, or to consume less goods and services in the first place. That is largely outside the scope of this book. The other domain is the supply chain leading up to the consumer. Here, we contend, genuine improvements in sustainability outcomes ultimately require changes in the supply chain's operations, broadly defined. Operations form the core of every organization, whether in manufacturing, service, or nonprofit industries. In the past few decades, firms have experienced increasing globalization and a shifting focus to competition among networks of firms. Due to these trends, the field of supply chain management has become an increasingly central domain within operations. This can refer to greener logistics (Chap. 7 by Blanco and Sheffi 2017), inventory management (Chap. 8 by Marklund and Berling 2017), or facility location (Chap. 9 by Velázquez-Martínez and Fransoo 2017). The specific challenges and opportunities vary by industry, as Bloemhof and Soysal (2017, Chap. 18) discuss in the context of the food supply chain. Operations can involve adopting greener technologies (Ovchinnikov 2017, Chap. 12), rethinking product design (Luttropp 2017, Chap. 13), or developing closed-loop supply chains (Abbey and Guide 2017, Chap. 17).

Although inevitably these topics are discussed in separate chapters, one of the challenges in practice is that they are all interrelated. For example, a product or component design that serves the same functionality with less material use will not just help the manufacturer due to a cut down in the material costs, but it will also decrease all transport and storage related requirements downstream in the supply chain and hence also the related costs and environmental burden (such as emissions due to transport) in the supply chain. Similarly, developing technologies that increase fuel efficiency of vehicles or use renewable energy sources benefits also supply chain actors through decreased fuel usage.

Sometimes these operational changes are driven by changes in business model, by shifting the emphasis from products to services, as outlined in Bellos and Ferguson (2017, Chap. 16). In other instances, they result from regulation. Huang and Atasu (2017, Chap. 10) point out that even well-intended regulations can have adverse consequences, as the devil is often in the detail; an immediate consequence is that regulators also need a deeper understanding of the operations of the firms they are trying to regulate and that firms need a more nuanced understanding of the exact effect certain regulations will have on their supply chains.

1.3.4 Sustainability as a Direction, Not a State

As noted above, a supply chain is unlikely to ever be "sustainable" (even by the weak definition). It is nevertheless a worthwhile goal to constantly strive for, as some firms are aggressively doing. Dole's operating subsidiary Standard Fruit de Costa Rica will develop a carbon-neutral supply chain for bananas and pineapples from Costa Rica to North America and Europe[1] in keeping with Costa Rica's goal to become the first carbon-neutral country by 2030. Finsbury Green in Australia sells carbon-neutral paper under its FreshZero brand, offsetting all supply chain emissions. Tesco aims to be a zero-carbon business by 2050. Brazil's Natura Cosméticos offsets not only its own emissions but those of its entire supply chain, which is all the more noteworthy given that the supply chain accounts for 95 % of those emissions. As of 2015, Apple does not allow suppliers to use bonded labor. Other examples abound. In order to determine whether a firm or supply chain is making progress towards that goal, one has to have the right measures in place, hence our focus on measurement at the beginning of this book.

[1] http://www.doleorganic.com/index.php?option=com_content&view=article&id=158, last accessed October 1, 2015

Recognizing that sustainability is a path, not a state, it is helpful to analyze the stages that firms go through on that path. Pagell and Wu (2017, Chap. 15) outline three main trajectories that firms can follow and point out that choices firms make today determine the options available to them in future. This notion of path dependency, while well known in itself, is often neglected in the literature on sustainable supply chains. As a firm embarks on a path towards becoming more sustainable, that also changes the way they interact with their suppliers, as van Weele and van Tubergen (2017, Chap. 11) illustrate in more detail.

1.3.5 Sustainability Involves Wider Range of Stakeholders

An inescapable consequence of the rising expectations firms face related to sustainability is the expanding set of stakeholders they have to interact with and the more complex ways in which they have to interact with each of them. Keeping shareholders happy has long been a prime objective, but that now requires far more extensive reporting than ever before. This trend is further encouraged by an emerging set of NGOs who are, depending on one's perspective, either representing investors by asking these wide-ranging questions, or using investors to exert pressure on firms to expand their reporting. Customers, employees, and regulators are expecting more from firms. At the same time, firms are expected to be aware of environmental and social issues faced by communities around the world that are (positively or negatively) affected by their supply chains, whether directly or through local regulators and NGOs. Lee and Rammohan (2017, Chap. 20) explain the importance of sensing and responding to social and environmental problems in global supply chains. Sodhi and Tang (2017, Chap. 21) ask what social responsibility firms bear and argue that firms can and should take the utilities of a wide range of stakeholders into account when making decisions. Sometimes firms choose to partner proactively with NGOs to address environmental or social problems in their supply chains; Balaisyte et al. (2017, Chap. 22) discuss factors that contribute to the success of such partnerships.

1.4 The Future of Sustainable Supply Chains

We started this chapter by arguing that, in many ways, the themes currently being discussed under the heading "sustainability" are not new. Therefore, one easy prediction about what the future holds for sustainable supply chains is "more of the same." At the same time, it is certain that the future will bring new challenges and opportunities, some of which may already be visible today even if not yet recognized as major issues. Here, we first elaborate on what "more of the same" will look like and then speculate about what else may be around the corner.

1.4.1 More of the Same

We are convinced that "sustainability" will continue to become a larger part of the conversation between supply chain partners worldwide. These conversations will be increasingly wide ranging, moving from focusing on a single issue (such as carbon, child labor, or fire safety) to a more systematic multidimensional view. The emphasis may shift over time from one set of issues to another, depending on (unpredictable) world events, but we would be surprised if the overall emphasis on sustainability did not increase.

As a result of this, and of the constant expansion of resources dedicated to measuring and reporting sustainability performance, this will become an increasingly quantitative and standardized affair, ever more tightly integrated within firms' decision processes. This will enable firms to make more analytical, proactive, and long-term decisions related to sustainability, rather than (often) having to respond to "the issue of the day." Accounting as an organized profession emerged in the nineteenth century, and hence financial accounting has a head start of at least 100 years over sustainability accounting; one could use the advances that have occurred in financial accounting since the 1900s as a guideline for predicting what might happen with sustainability accounting and reporting over the coming 100 years. Despite those advances in financial accounting, the profession still faces challenges that are relevant for operations and supply chains.

One is that the data that are generated for financial accounting purposes are often unsuitable for operational decision-making, but nevertheless widely used for precisely that as there is no other easy substitute available. One can anticipate the same happening with sustainability-related information: data on social impacts that is collected for the firm's annual sustainability report may not be suitable to support day-to-day decisions on how to operate a supply chain, but unfortunately it is likely that the errors that currently exist in how financial accounting information is used will be replicated in sustainability accounting.

A second challenge is that financial accounting data are still subject to various degrees of manipulation, ranging from mild and innocent to outright fraud. As sustainability reporting gains importance, the stakes become higher, and hence the likelihood of biases and actual fraud increases. The fact that sustainability-related information may be even harder to audit than financial information further exacerbates this.

1.4.2 What's Around the Corner

Climate change may be the most-discussed environmental (and social) issue facing the world today. However, some might argue that availability of freshwater may overtake climate change as the dominant topic, either because society tires of climate change or because it genuinely becomes a more imminent threat. Even if, as seems very unlikely today, renewable energy grows fast enough to prevent dangerous climate change, will we discover negative unintended consequences of photovoltaic panels, solar farms, and wind turbines? Some are already known, and as adoption becomes more widespread, others will inevitable crop up.

As our historical analogies at the beginning of this chapter point out, there are undoubtedly chemicals being used today, or even new materials being introduced today, that, at some point in future, will turn out to have been mistakes. The continued opposition to genetically modified organisms (GMOs), especially in Europe, suggest that many fear they will fall into this category. Nanomaterials have great promise, but their properties are far from fully understood.

Improving working and living conditions for employees and local communities in faraway countries upstream in a global supply chain seems very noble (and should be encouraged). Is there a risk that firms, in doing so, contribute to creating a population that is more educated and less despondent, more prone to travel or migrate around the globe, and therefore less accepting of local governments, democratic or otherwise? Will firms that find ways to reduce poverty end up contributing to increasing inequality and hence fomenting social problems that do not currently exist?

None of these questions have easy answers. The fact that there may be unintended negative consequences of well-intended actions today does not mean that we should not take those well-intended actions, quite the contrary. But it does mean that we should constantly be vigilant, looking for what new issues may emerge, recognizing that more sustainable supply chains can be a force for good but that they will never be truly sustainable. We hope that this book will contribute to educating future supply chain managers and business leaders about many of the issues they will face today and tomorrow and equip them with the tools and frameworks that will help them on this journey.

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