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An Investigation of the Sustainability Agenda – or Lack of Same - in Supply Chain Transformation Programs

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Abstract

The motivation for manufacturing companies to engage in environmental sustainability efforts is intensifying with the wide recognition of climate crisis, re-enforced by regulatory requirements and political consumers. Yet emissions increase and global waste levels continue to grow, and with them the need to re-use or re-cycle, combust or deposit waste. Employing a paradox methodology, this multi-case study investigates how supply chain strategies can contribute to the development of more sustainable manufacturing and supply chain systems. We explore in a multi-case study, how sustainability has been part of the strategic agenda in supply chain transformation programs, and how trade-offs, win-wins or synergies are perceived by key decision-makers. The research suggests multiple approaches to relieve inherent tensions and contradictions in sustainable supply chain management. The paper proposes implications for strategy-makers and identifies directions for further research in manufacturing and supply chain strategy formulation processes, where sustainability is part of the equation. It is proposed that supply chain managers can achieve sustainability in a win-win approach by directing their attention to transparency and agility in pursuit of efficiency and sufficiency and deploy a two-sided symbolic-rational approach to strategy formation.

Keywords
Multi-case study, Sustainable Supply Chain Management (SSCM), Strategy Formulation, and Paradox Theory.

1. Introduction

The United Nations' 2015 Sustainable Development Goals emphasize the need for responsible consumption and production, urging organizations to adopt practices that foster long-term environmental and social sustainability. Still, sustainability efforts are often not implemented on a voluntary basis (Karutz 2018) and supply chain managers often view sustainability initiatives as potentially conflicting with resilience efforts, leading to hesitation in fully integrating sustainable practices (Cotta et al. 2023, Karutz et al. 2018). Research has demonstrated that *when a numerical assessment of the performance is present, the impact on costs was almost always positive* (Negri et al. 2024, p.104), while Samah et al. (2022) conclude that despite the attention and increase in research on the concept of sustainable supply chain management (SSCM), it is still a contested concept, with ambiguity in the literature, where some studies show that implementation of sustainable supply chain practices can provide win-win situations, while others cast doubt on this positive relation. In stark contrast to the regulatory pressure and the findings of Karutz et al. (2018), voluntariness is emphasized in the definition of sustainable supply chain management (Ahi and Searcy 2013). Thus, this research operates within multiple tensions; that of seemingly contradictory operational objectives relating back to the concept of the triple-bottom-line (Elkington 1994) and sustainability versus resilience, supplemented with a dispute on the presence of potential synergies, and a contradictory assumption of voluntariness in a largely regulated domain.

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This research explores how supply chain leaders navigate those tensions. The research takes a paradox perspective, assuming that there is a *persistent contradiction between interdependent elements* (Schad et al. 2016, Smith and Lewis 2011). The paradox theory suggests that the extent to which the relationship between sets of organizational practices manifests contradictory or synergistic aspects is partially a function of how organizational actors experience and approach the challenges generated by the tension (Miron-Spektor et al. 2018). A variety of approaches exist for embracing tensions, including balance or finding an equilibrium point between opposites, reframing or developing them into a new whole, transcending them through shifting their boundaries, and connecting them through a dynamic interplay between poles (Putnam et al. 2016). Recent research findings indicate that the success of sustainability transformation will depend on an organizational ability to recognize, accept and navigate paradoxical tensions in the supply chain (Cichosz et al. 2025).

This leads us to the following research question:

How can supply chain leaders approach tensions related to supply chain sustainability, navigating interdependent operational objectives in a domain driven by regulatory politics side-by-side a quest for good.

The research responds to recent calls for exploring the extent to which perceptions about complementarities and conflicts relate to downstream, internal, and upstream practices and how their juxtaposition is perceived and enacted by relevant organizational actors (Cotta et al. 2023), and how organizations learn form past experiences, refine their digital sustainability strategies and navigate the changing landscape of supply chain sustainability (Patrucco et al. 2025). It is found particularly important to generate more empirical insights on how the characteristics of sustainable and resilient supply chain management relate to enabling elements such as transparency and diversity (Karutz et al. 2018). Diversity here refers to regional, supplier, customer and product diversity, each of which has been found to lead to higher levels of sustainability (Karutz et al. 2018).

1.1 Objectives

The overarching objective of this study is to contribute to knowledge in the domain of manufacturing and supply chain strategy processes, where sustainability is part of the equation. More specifically, the research aims to:

- Identify different ways of navigating tensions associated with sustainable supply chain management
- Derive propositions relating to strategy formation in manufacturing and supply chain management
- Establish a directional agenda for further research

In the discussion of implications for strategy formation, we will relate to the modes of strategy formation as suggested by Hart (1992), who established an integrative framework for strategy-making processes, describing the style and roles of top management and organizational actors in command, symbolic, rational, transactive and generative modes of strategy formation. The framework can be further related to strategic phases of learning, reviewing, aligning and redirecting (Nielsen-Englyst 2003), recognizing the dynamics of strategic management. We shall return to this topic in the discussion. In the next section, a literature review focused on sustainable supply chain management in a manufacturing context is presented, followed by a methodology section, before the paper proceeds to present data collection, cross-case analysis and a summary of findings. Finally, implications for strategic supply chain management are discussed, and the study is concluded.

2. Literature Review – Sustainable Supply Chain and Manufacturing Systems

The literature review is purposed to summarize how supply chain management may contribute to increase environmental sustainability, and to establish the theoretical basis for the research.

2.1 Industry 4.0 and supply chain enablers of sustainability

There is a general belief that Industry 4.0 technologies have a strong potential for sustainable value creation (Jamwal et al. 2021, Ching et al. 2022, Liu et al. 2023, Kamble 2023, Mithas et al. 2022). The enabling technologies are largely digital, including digital twin technologies, internet of things, cloud computing, big data analytics, blockchain, artificial intelligence, machine learning, and more. They are seen to contribute to sustainability by driving resource efficiency, focusing on manufacturing processes, minimizing resource utilization and utilizing sustainable resources (Jamwal et al. 2021). Flexible and reconfigurable manufacturing systems, additive manufacturing and postponement strategies are also highlighted as enablers for sustainable development (Prataviera et al. 2024, Jamwal et al. 2021),

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and research further suggests that the positive impact of industry 4.0 capabilities on sustainability is accelerated by digital business transformation and organizational ambidexterity, as established by Belhadi et al. (2022), who argue that *partners in the supply chain should recognize and reconcile divergences and tensions between exploration and exploitation through great agility and connectivity provided by industry 4.0 capabilities*.

Supply chain process integration is found to be a (the) stepping stone toward sustainable manufacturing under the Industry 4.0 scenario (Ching et al 2022), as transparency, flexibility and traceability in connected global manufacturing value chains enable collaboration. Independently of technology, the value of transparency is emphasized also by Karutz et al. (2018), proposing that transparency facilitates collaboration and coordination efforts, stakeholder engagement and flexibility/agility, and can therefore be a driver for both sustainability and resilience.

2.2 Sustainable supply chain management practices

Sustainable supply chain management (SSCM) emerges as a concept around year 2008 (Stindt 2017). Research and practice evolved rapidly in the following years, and sustainable supply chain practices are reviewed and summarized by Stindt (2017), who builds a framework for supporting the development of sustainable supply chain strategies. Similarly, Samah et al. (2022) conducted a thorough literature review on sustainable supply chain management and revealed six sustainable (environment) supply chain practices. The categories from Samah et al. (2022) are used in this study, cross-checked with the Stindt (2017) study for completeness, and supplemented by a few more sources:

(1) *Internal Environmental Management* refers to processes, strategies and procedures supporting environmental goals within the organization, typically implementation of management systems and standards. The role of management systems is emphasised also by Seuring and Müller (2008), finding that monitoring, evaluation, reporting and sanctions are often alluded to as supporting factors for implementing sustainable supply chains.

(2) *Green Procurement* refers to the purchase of sustainable goods and services and reflects the importance of working with suppliers. There is a strong regulatory element including practices around supplier evaluation schemes and declarations (Stindt 2017), while there is also a performance dimension, seeking to improve the overall supply chain performance (Seuring and Müller 2008). Configurations and governance mechanisms are key elements for sustainable supply chain management in global supply chains (Koberg and Longoni 2019).

(3) *Green Design* refers to the actions taken during product development to minimize the environmental impact of the product throughout its lifecycle, including design for resource efficiency. Sustainable product design includes design for material efficiency, design for sustainable production, design for sustainable usage, and design for recovery (Stindt 2017).

(4) *Green Packaging* refers to use of packaging that has the lowest impact on the environment

(5) *Green Distribution* considers the use of transportation means that have the least negative impact from suppliers to customers. Optimal delivery is also referred to here, hinting to planning practices. Stindt (2017) highlights sustainable supply chain design as a separate concept, and further emphasises sustainable warehousing and inventory management, considering optimization of order quantities and order frequency as well as energy demands for temperature control.

(6) *Reverse Logistics* concerns all activities that aim to take back or return products for the purpose of re-use, recycling, repair, remanufacturing, refurbishment or disposal. Supply chains may influence each other, for example as waste products from one industrial process can serve as input to another, as a manufacturing material or source of energy (MacCarthy and Ivanov 2022). Stindt (2017) refers to this as industrial symbiosis.

Jamwal et al. (2021) pointed to a lack of studies on planning and scheduling, which can contribute to achieving manufacturing sustainability. Indeed, planning is only hinted at in the sustainable supply chain practices listed above. Digital twin technologies are discussed in the Industry 4.0 context, and is perhaps the most substantial contribution to the planning and decision-making aspects, making it possible to receive real-time information from the physical world for simulation analysis (He and Bai 2021). Sindhwani et al. (2022) considers AI-based management systems, advanced simulation, IoT-enabled systems and Big Data, but not in having impact on waste prevention, which is perceived as an enabler in itself, where recycling and reuse of materials contribute to industry sustainability.

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To recap, the literature review shows that the topic of sustainable supply chain management has been largely researched, to the extent that it has gotten its own abbreviation (SSCM) and has been the subject of several extensive literature reviews, complementing each other in mapping out supply chain practices, technologies, configurations and governance mechanisms. Industry 4.0 technologies play a key role and digital transformation, ambidextrous leadership and process integration are identified as mediating factors. In addition to the tensions described in the introduction, one more tension has been identified, namely that between exploration and exploitation.

3. Methods

The research is a multi-case study, with the purpose of detecting a variety of ways of working and opening a possibility for identifying patterns and relationships between variables. The multi-case study encompasses complementary data from supply chain transformations covering a variety of industries, to increase the likelihood for variety in ways of working and avoid bias towards a single industry. All companies are multi-national, successful companies, with a long track-record in manufacturing and supply chain management.

The research seeks for meaning in the interpretation and logical analysis of observations. The research offers a reflective pragmatism with ambition to *furnish alternatives, open vistas for action and expand the realm of the possible* (Cooperrider 2013). Perceived successful cases are chosen as per an appreciative inquiry approach, where research seeks to learn from good experience, while not claiming best practice. The approach is interpretive and is conducted through direct observation in a natural setting (Meredith 1998). The setting consisted of two summits over a six-month period, where supply chain practitioners at manager, group director and vice president levels in multi-national companies have shared insights in their supply chain transformation programs. The researcher observed and inquired into the extent to which sustainability was part of the agenda. The data collection and interpretation are confined by the researcher's perceptual framework as supply chain specialist. As preparation for data collection, the researcher conducted a literature review and used an observation guide for sharpening of attention. For sake of triangulation, some observations were cross-checked with company websites.

The analysis is using a paradox lens. This is found suitable due to the many tensions that supply chain managers are faced with in relation to sustainability. It is a lens used oftentimes within supply chain management, recognizing that as organizational environments become more global, dynamic, and competitive, contradictory demands intensify. (Smith and Lewis 2011). There are two core characteristics of paradox that helps us sharpen the lens, namely contradiction and interdependence (Schad et al. 2016).

The cases are coded in multiple dimensions:

(1) Targeted effect indicators, adapted from the Danish Academy of Technical Sciences (ATV 2022). The categories are (a) Resource utilisation and-productivity, (b) Water and energy consumption, (c) Waste production and (d) CO2 emissions.
(2) Sustainable supply chain practices, as derived from the literature review, listed above *(1-6)*
(3) Key program levers, derived also from the literature review: (a) Digital technologies, (b) Manufacturing equipment, (c) Diversity (in suppliers, products/configurations, and regions), and (d) Leadership ambidexterity
(4) The approach to relieve tension, adopted from Putnam et al. (2016): (a) Either-or approaches (defensive, selection and separation), (b) Both-and approaches (incl. compromising, oscillation), and (c) More-than approaches (incl. reframing and challenging normal boundaries). In the context of this study, these approaches will be referred to as *trade-off, win-win, or synergy.*

In the data interpretation, special attention is given to abnormalities or vacancies of representation; for example, if some sustainable practices of effect indicators are not represented in the cases. The case sample is large enough to allow for some statistical analysis (Meredith 1998), or at least for considering patterns and frequency.

4. Data Collection and Case Overview

A total of ten cases were collected, as summarized in Table 1 below. The cases represent five industry categories, namely personal care, food products, beverages, machinery, and pharmaceutical. They are manufacturing companies of various sizes, with discrete manufacturing and a relatively high degree of vertical integration. In the following, the cases are introduced individually.

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Table 1. Case overview

Case	Industry	Size (empl.)	Informants	Agenda
A	Personal care products	85.000	Global Supply Chain Director Europe	Agility in Operations
B	Food Products, Personal Care	30.000	VP Global Planning, Group SC IBP Director	Redefining Resilience
C	Food products	100.000	Global Operations Transformation Director	AI Based Forecasting Journey
D	Food products	2.000	Global Head of Brands, Sustainability and Innovation	Make it Unique
E	Food Products	275.000	Supply chain manager Europe	Inventory Reduction Program
F	Beverages	40.000	IT Director, Supply Chain	Transparency for Operational Excellence
G	Machinery	20.000	Chief engineer, Product Data Management	Driving Sustainable Innovation
H	Pharmaceutical	4.000	Director, Global Logistics and Distribution	Rethinking modes of Transport for a Sustainable Future
I	Food products	1.500	Head of Sustainability Excellence	Restore Nature
J	Personal care products	6.500	Senior Director Planning EMEA	Responsible Sourcing

Company A
Under the headline of agility, this company operating in the personal care industry focused on elevating end-customer satisfaction by *re-inventing planning for a responsive and resilient supply chain*. The program was customer centric, including advanced technologies for social listening and proactive communication, seamless data transmission and untouched orders. There was a high focus on navigating the landscape of regulations, which were seen to increase the supply chain complexity. The global supply chain director for the Euopean market argued that *inclusive and sustainable go together with other recipes for success*, and envisioned the deployment of a *sustainable, cost-effective and agile fulfillment network.*

Company B
Company B is a bio-chemical manufacturer with worldwide presence and industrial customers within food products and personal care. This company showcased their implementation of an advanced planning system, with an objective for planning to *become a real competitive advantage* and redefining resilience through end-to-end-planning. With an aim to *deliver a superior experience for our customers while using efficiently our resources,* sustainability was not initially on the agenda. However, the strategic focus on sustainability was increasing in the company and the vice president for global planning elaborated that *now, with the new strategic focus, we investigate how this new system can help in sustainability, though lowering inventories.*

Company C
Artificial intelligence (AI) was at the core of this program, aiming to transform planning by implementing multi-category planning, visibility, scenario planning, and integrated business planning (IBP). The program focused on *assessing waste at each stage in the end-to-end supply chain, engaging with stakeholders, suppliers and external partners with our collective aim to reduce food waste*. Each production site was tracked by a reporting system and had financial and environmental targets to optimize processes and reduce waste. The Global Operations Transformation Director explained how they *unlocked data analytics to accelerate transformation on scalable and sustainable solutions,* and had already demonstrated *35% waste reduction achieved together with internal efficiency and forecast accuracy.* Faster forecast proposal generation was a key capability, enabling multiple scenario evaluations and *sharper decision-making and resource allocation*.

Company D
This case was presented by a provider of highly flexible manufacturing equipment, having enabled Company D to redesign their supply chain, offering highly customized products delivered directly to end-consumers. Further, direct shipments were made in high-mix from manufacturing to retailers, without any intermediate break-bulk operations. Digital ordering from a website frontend was highlighted as a key enabler, communicating MRP requirements to the manufacturing equipment and packaging site operations. Sustainability was seen as a positive side-effect to improving supply chain agility and resilience, as *the new setup reduced waste and CO2 emissions*. This was further highlighted in relation to positively influencing brand equity.

Company E
Much like Company D, Company E leveraged flexible manufacturing equipment. They established regional distribution centers with label-on-demand equipment, meaning they *moved the decoupling point downstream, closer to the customer, and thereby reducing waste*. While the primary target was inventory reduction, the European supply chain manager explained that they had achieved waste reduction through postponed variant creation.

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Company F
The case of Company F was presented by the IT director for supply chain, who displayed a clear sustainability focus, stating for example that *making informed decisions help us improve water and energy usage, and we improve efficiency too*. The program included use of sensors and monitoring systems, as well as Internet of Things (IoT) technologies and sustainability features in the enterprise system platform (SAP). The overall transformation objective was operational excellence, and sustainability was seen as an integral part of this. Company F operates in the beverage industry and aside from the IT-agenda, the company focused also on packaging, recycling, and on reuse and collection of bottles. Further, there was a focus on use of sustainable plastics (vs. virgin plastics).

Table 2. Case summary

	A	B	C	D	E	F	G	H	I	J	
Targeted effect indicators											Indicators
Resource utilization	X	X	X			X			X	X	Improve efficiency, cost-focus, reduce process-waste
Water- and energy consumption		X				X			X		Reduce consumption, footprint (land, warehouses, factories, data centres)
Waste production		X	X	X	X						Reduce overproduction, waste, scrap, obsolescence.
Co2 emissions	X			X		X	X	X	X	X	Reduce emissions, pollution, use of chemicals
Sustainable SC practices											
Internal Environmental Management						X	X				Management systems, product data management, monitor and report
Green Distribution	X			X	X		X	X			Transport modes, distribution system, order systems, direct shipment
Green Design / Eco-design	X									X	Lifecycle perspective, design for sustainability in all phases
Green Procurement	X		X			X	X		X	X	Supplier collaboration, supplier assessment, avoid virgin materials
Green Packaging	X					X				X	Minimize packing materials, choice of packaging materials
Reverse Logistics						X	X				Return, re-use, remanufacturing, input to other supply chain
Key program levers											
Digital technologies	X	X	X	X		X	X				Digitize, IoT, APS-systems, transparency, connectedness, sensing
Manufacturing equipment	X			X	X				X		Focus on agility, flexible equipment,
Diversity in suppliers, regions, products	X						X			X	Focus on network, supply chain complexity/diversity, optionality
Leadership ambidexterity		X	X			X			X		Explore and exploit, innovation focus, organisational focus
Approach to relieve tensions											
Trade-off (Either-or)	X						X			X	Selection, defensive, regulatory driver, involuntary
Win-Win (Both-and)	X	X	X	X	X	X		X	X		Compromise, balancing, or no conflict
Synergy (More-than)				X					X		Reframing, synergy, brand value, opportunity-seeking

Company G
Sustainability was at the core of this case, where the agenda was *driving sustainable innovation: The convergence of digitalization and sustainability*. The chief engineer for product data management highlighted a lifecycle perspective as he showcased recycling of end-of-life products, and continued to explain how sustainability data enable this project-based company to *offer customers green products considering supply chain configuration*. It was demonstrated how data at the vendor, site and material level was utilized to aggregate emission impact of a project product configuration, thus facilitating a transparent optimization or trade-off decision. Further, the company would forecast emissions based on distance and transport modes in advanced planning system scenario simulations.

Company H
This case directly targeted emission reduction, referred to as *scope 3 requirements*. The Director of Global Logistics and Distribution elaborated how *increasing use of slow vessels and use of military containers enabled a shift from air to vessel transport*. Military containers are designed to transport essential supplies such as food and medical supplies, as was needed in this case. The director further explained, that *it is an investment in leadtime - meaning cash tied up in inventories - to lower cost and emissions*. He stated explicitly that in his perception *cost reduction and sustainability can go hand in hand*.

Company I
This case focused on raw material sourcing, and on the agricultural practices in the supply chain. The Head of Sustainability Excellence explained how *increasing crop production and reversing global warming were once*

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considered incompatible, but we now have solutions to do both. The program focused on scaling regenerative agriculture, rolling out new technologies. *We link sustainability with efficiency and business; it is good business to be sustainable, in the long view*. For example, he stated, *it is both efficient and sustainable if farmers use less pesticides or less land.*

Company J
In the last case, sustainability efforts were seen to be driven by regulatory requirements. As stated by the Senior Director for Planning, EMEA, *the sustainability efforts are driven by regulatory needs, and we are trying to be agile at the same time*. Operating in personal care products, the company was subject to massive regulations related to ingredients, and the company overall drives an agenda for *responsible sourcing*. One key focus was on packaging materials, where *plastics ending up in the oceans* was perceived to negatively impact brand image.

This completes the case introductions and data collection. The cases are summarized in Table 2, showing overall that all effect indicators, sustainable supply chain practices, and types of program levers have been identified, along with different ways of navigating or relieving tensions related to sustainable supply chain management.

5. Results and Discussion

In the following the cross-case analysis is presented followed by a short summary and discussion, suggestions for improvement and validation of findings.

5.1 Cross-case analysis

As mentioned already, all cases include a sustainability agenda, and we are seeing a broad set of levers and motivations in the agendas. Most companies showed an ability to balance sustainability with other operational objectives including resilience and cost efficiency, or found that objectives could be met with no inherent conflict, which has been characterized as win-win approaches, see Figure 1. The use of digital technologies was also predominant, see Figure 1, but always in combination with another lever. Several cases introduced advanced planning systems, while the use of sensors, social listening, monitoring and control systems was also represented. Digital twin and blockchain technologies were not mentioned, whereas seamless data integration, data analytics and data management emerged as key themes.

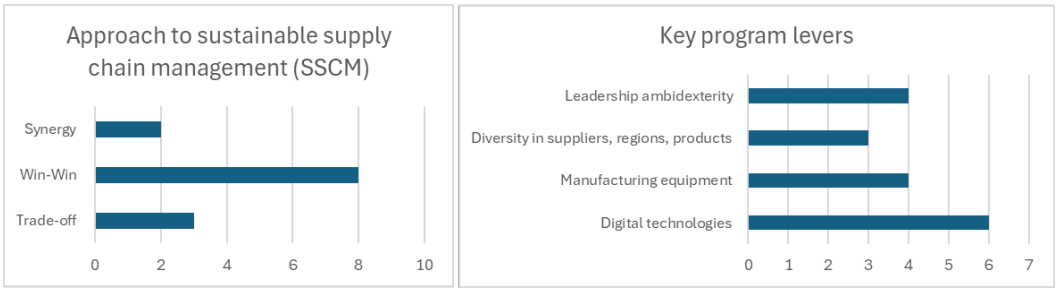

Figure 1. Approaches and key program levers across case companies

Most cases had attention to emission levels and resource utilization, whereas focus on waste, water and energy was less predominant, see Figure 2. Some companies focused solely on emissions, while, on the other hand, resource utilization never stood alone. In several cases, it is expressed that resource utilization can be achieved *together* with sustainability, indicating that resource utilization is not recognized as sustainable per se.

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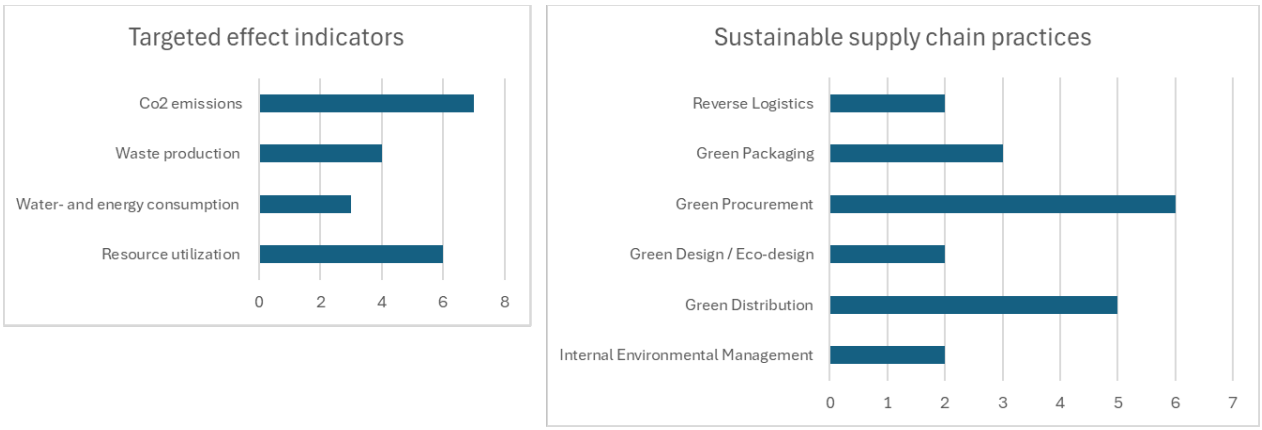

Figure 2. Sustainability focus in supply chain agendas across case companies

In terms of supply chain practices, green procurement and green distribution had the highest representation, (Figure 2). Green procurement ranged from supplier collaboration and development to responsible sourcing and use of non-virgin materials, while green distribution was mainly related to ordering systems, postponement and direct distribution, and a single case where there was a change of transport mode. The low attention to reverse logistics is interpreted to indicate that the primary focus of supply chain management is (still) to generate value from bringing products forward to customers, and not from the value of revers flows or circular business models. The agendas in internal environmental management were not related to management systems, but to product data management, monitoring and reporting, thus establishing transparency and enabling decision-making.

Taking a deeper look at the cases, a few patterns appear, see Table 3.

Table 3. Patterns across dimensions

	G	J	A	H	B	C	D	I	E	F	B	C	E	D	H	I	F	A	J	G	C	B	I	F	A	J	G	D	E	H	F	B	I	C	J	A	G	D	E	H
Targeted effect indicators																											4														
Resource utilization		x	x		x	x		x		x	x	x				x	x	x	x		x	x	x	x	x	x					x	x	x	x	x	x				
Water / energy consumption					x			x		x	x					x	x					x	x	x							x	x	x	(x)						
Waste production					x	x	x		x		x	x	x	x							x	x						x	x				x		x				x	x	
Co2 emissions	x	x	x	x			x	x		x				x	x	x	x	x	x				x	x	x	x	x	x		x			x		x	x	x	x		x
Sustainable SC practices													2						3																5						
Internal Env. Management	x									x							x			x				x			x				x					x				
Green Distribution	x		x	x				x		x				x	x	x			x	x						x		x	x	x	x					x	x	x	x	x
Green Design / Eco-design		x	x															x	x							x	x								x	x				
Green Procurement	x	x	x			x		x		x		x			x	x	x	x	x	x	x		x	x	x	x	x				x		x	x	x	x	x			
Green Packaging		x	x							x							x	x	x					x	x	x					x					x	x			
Reverse Logistics	x									x							x			x				x			x				x						x			
Key program levers				1																																				
Digital technologies	x		x		x	x	x			x	x	x		x			x	x		x	x	x		x	x		x	x			x	x		x		x	x	x		
Manufacturing equipment			x					x	x	x			x	x		x		x					x		x			x	x				x			x		x	x	
Diversity	x	x	x															x							x	x	x								x	x	x			
Leadership ambidexterity					x	x		x		x	x	x				x	x				x	x	x	x							x	x	x	x						
Approach to relieve tensions																																								
Trade-off	x	x	x															x	x						x	x	x								x	x	x			
Win-Win			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x			x	x	x	x	x	x		x		x	x	x
Synergy								x	x					x		x							x					x						x				x		

First (1), taking an outset in the approach to relieve tensions, it becomes evident that companies with a trade-off approach lean on diversity and green design, which we do not see in companies displaying a win-win approach. Trade-off oriented companies are largely driven by regulatory requirements, and while a relation to brand image and

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customer value offering is recognized, the position is reactive. These companies expressed concerns related to *trying* to be agile, and supply chain appeared to be in a victim position, suffering from regulations and supply chain complexity.

Second (2) none of the companies with attention to waste production have green design, green packaging or reverse logistics on their agenda. They explore use of digital technologies and flexible manufacturing equipment to avoid overproduction, inventories and associated waste, and set this direction independently of the sustainable practices. Inventory creates waste through obsolescence and perishability, which is unwelcome from a sustainability perspective (Cotta 2023), but also from a cost perspective, meaning that companies focusing on inventories and waste reduction easily display a win-win approach, where supply chain contributes to sustainability without compromising financial objectives. Somewhat surprisingly, a contradiction of interest between sustainability and resilience was not identified, also not when lowering inventories, as seen in company B.

Third (3), we observe a relative strong co-occurrence of focus on CO2 emissions and green procurement. Companies pursuing this agenda display different approaches, it is a common agenda, and some companies manage to avoid compromise or even gain synergies. The synergies are however found in terms of brand value, and not operational supply chain objectives. Fourth (4), with a big overlap to CO2 emissions, resource utilization also co-incide with green procurement. Further, companies with attention to resource utilization appear to frequently display some level of leadership ambidexterity and tend to use digital levers.

Finally (5), when water- and energy consumption is on the agenda, it goes together with resource efficiency and leadership ambidexterity, in a win-win approach leveraging a range of technologies but *not* leaning on green distribution, green design or diversity in suppliers, regions, or products. This thus emerges as a relatively independent proactive approach to drive sustainability without compromising operational objectives.

5.2 Summary of findings

This study found that a *win-win* approach to sustainable supply chain management was predominant, as opposed to trade-off or synergy approaches. Companies with focus on waste reduction displayed a win-win approach where supply chain contributes to sustainability without compromising other operational objectives, and with low dependency to sustainable supply chain practices. Similarly, water- and energy consumption was found to be on the agenda together with resource efficiency and leadership ambidexterity, in a win-win approach leveraging a range of technologies and *not* leaning on green distribution, green design or diversity in suppliers, regions, or products. On the other hand, companies with a trade-off approach leaned on diversity in products and suppliers and on green design. Green procurement combined with a CO2 emission focus is found to be a common agenda regardless of approach, while reverse logistics was not a dominating theme.

Resource utilization was not perceived as sustainable in itself, and was found to be typically combined with a green procurement agenda and showcasing ambidextrous leadership and new technologies. There was a frequent use of digital technologies, but always in combination with another lever. Industry 4.0 was not mentioned in any of the cases, but seamless data integration, data analytics and data management emerged as key themes. The definition and use of sustainable product and process data emerged as a topic, while digital twin and blockchain technologies that could support this (MacCarthy and Ivanov 2022, Patrucco et al. 2025) were not mentioned.

5.3 Reflection and Propositions

This study has revealed some possible ways of navigating the paradoxes of sustainable supply chain management. While exploring tensions between voluntary and regulatory motivations, interdependent and contradictory operational objectives, it was found possible and common to release tensions in a win-win approach. This resonates with the finding by Negri et al. (2024), that (when measured) there is oftentimes a positive performance impact. The study indicates that paradoxes may be relieved when companies increase transparency and agility in operations and devote attention to reduction of waste, energy and water. This can be expanded conceptually to pursuing efficiency and sufficiency approaches (Schaltegger and Burritt 2014), where efficiency approaches drive down emissions, material and energy intensity per product unit, and sufficiency approaches include waste reduction, less consumption, and substitution of products with services. A third approach is elaborated by Schaltegger and Burritt (2014), namely that of consistency, focusing on product design and elimination of unsustainable materials. While this route should not be abandoned, this research indicates that it is more likely to require trade-offs.

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Proposition 1: Supply chain managers can achieve sustainability in a win-win approach by directing their attention to transparency and agility in pursuit of efficiency and sufficiency

The research has showcased how top-down management can play a key role in redefining objectives in a mission-driven way, where supply chain leaders respond to the challenge set by top management by reviewing and redirecting ongoing initiatives. This reflects a symbolic mode of strategy formation (Hart 1992, Nielsen-Englyst 2003). It was also found that monitoring and reporting systems played a key role in driving sustainable decision-making, which is a more transactional mode. Belhadi et al. (2022) indicated that *high sustainable performance is achieved by companies regardless of the mediating effect of digital business transformation and the moderating effect of circular business models if they, nonetheless, show higher ambidexterity in their organizations* (p.704). Further to this, our research suggests a dynamic two-sided approach to sustainable supply chain strategy formation, where symbolic leadership is combined with a rational approach characterized by extensive data processing.

Proposition 2: Navigating the tensions of sustainable supply chain management, managers will benefit from a two-sided symbolic-rational approach to strategy formation

Resource utilization appears not to be perceived as sustainable per se. When it has been included as a separate effect indicator in this study, it is based on the position that the consumption of resources (materials) should be reduced, in absolute terms and relative to value-creation (ATV 2022, Schaltegger and Burritt 2014). This agenda is not recognized in the cases. Material intensity of a product is suggested as a performance measure of a complete supply chain alongside the carbon footprint and the energy intensity of a product (Schaltegger and Burritt 2014), yet in the cases of this study, there appears to be a primary focus on carbon footprint, secondarily on energy (and water) consumption, and little if any attention to material consumption.

5.4 Proposed Improvements

The research at hand would benefit from a deeper investigation of the identified patterns, to reveal mental models, rationales and potential cause-and-effect relationships, potentially linked to operational objectives or contextual contingencies. In-depth interviews with strategy-makers might further elaborate the understanding of strategic approaches and their suitability at different stages of sustainability journeys, anticipating that path dependencies exist, as suggested by Karutz et al. (2018).

5.5 Validation

The identified patterns may be validated in a quantitative survey approach, including a performance element considering sustainability metrics (Schaltegger and Burritt 2014) and strategy formulation success criteria including whether a general level of agreement and motivation has been achieved, with confidence that the company will be more successful as a result of realizing specified plans (Acur and Englyst 2006).

6. Conclusions and directions for further research

This research builds on an assumption of paradox in sustainable supply chain management, and a need for organizational ability to recognize, accept and navigate paradoxical tensions in the supply chain (Cichosz et al. 2025). We have recognized and explored tensions between operational objectives, between voluntary action and regulatory forces, and between leadership modes in a domain characterized by a lack of clarity of potential synergies, and proposed how supply chain leaders and strategy-makers may navigate in this landscape. Multiple routes have been outlined, and their dependencies to different practices and levers discussed. It is proposed that supply chain managers can achieve sustainability in a win-win approach by directing their attention to transparency and agility in pursuit of efficiency and sufficiency, and that when navigating the tensions of sustainable supply chain management, managers will benefit from a two-sided symbolic-rational approach to strategy formation, where data and monitoring systems play a key role. The use of sustainable product and process data along the supply chain emerged as a key theme, supplementing other sustainable practices, where green procurement is dominating.

The study was open to potentially identify a lack of sustainability agendas, but this was not the case. Sustainability was often high on the agenda, and always a theme. The variety of supply chain programs suggests an opportunity for further research to identify and explore best practices and contingencies, path dependencies or success factors, as a next step in learning how to navigate the landscape or waters of sustainable supply chain management.

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References

Acur, N. and Englyst, L., Assessment of strategy formulation: How to ensure quality in process and outcome, *International Journal of Operations and Production Management*, vol. 26, no.1, pp. 69–91, 2006.

Ahi, P., and Searcy, C., A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production*, vol. 52, pp. 329–341, 2013.

Belhadi, A., Kamble, S., Gunasekaran, A., and Mani, V., Analyzing the mediating role of organizational ambidexterity and digital business transformation on industry 4.0 capabilities and sustainable supply chain performance. *Supply Chain Management: An International Journal*, vol. 27, no. 6, pp. 696–711, 2022.

Ching, N. , Ghobakhloo, M., Iranmanesh, M., Maroufkhani, P., and Asadi, S., Industry 4.0 applications for sustainable manufacturing: A systematic literature review and a roadmap to sustainable development, *Journal of Cleaner Production*, vol. 334, Article 130133. 2022

Cichosz, M., Aluchna, M., Sońta-Drączkowska, E., and Knemeyer, A., Navigating paradoxical tensions in pursuit of sustainable supply chain management: review and guidance for future inquiry. *The International Journal of Logistics Management*, vol. 36, no.7, pp. 99–136, 2025.

Cooperrider, D., A Contemporary Commentary on Appreciative Inquiry in Organizational Life, in Cooperrider, D., Zandee, D., Godwin, L., Avital, M., and Boland, B. (Eds.), *Organizational Generativity: The Appreciative Inquiry Summit and a Scholarship of Transformation,* Vol. 4, pp. 3–67, 2013.

Cotta, D., Klink, L., Alten, T., and Al Madhoon, B. How do supply chain managers perceive the relationship between resilience and sustainability practices? An exploratory study. *Business Strategy and the Environment*, vol. 32, no. 6, pp. 3737–3751, 2023.

Elkington, J., Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California Management Review*, vol. 36, no. 2, pp. 90-100, 1994

Hart, S., An Integrative Framework for Strategy-Making Processes. *The Academy of Management Review*, vol. 17, no. 2, pp. 327–351, 1992.

He, B., & Bai, K., Digital twin-based sustainable intelligent manufacturing: a review, *Advances in Manufacturing*, vol. 9, no.1, pp. 1–21, 2021.

Jamwal, A., Agrawal, R., Sharma, M., and Giallanza, A., Industry 4.0 Technologies for Manufacturing Sustainability: A Systematic Review and Future Research Directions. *Applied Science-Basel*, vol. 11, no 12, Article 5725, 2021.

Kamble, S., & Gunasekaran, A. Analysing the role of Industry 4.0 technologies and circular economy practices in improving sustainable performance in Indian manufacturing organisations. *Production Planning and Control*, vol. 34, no. 10, pp. 887–901, 2023.

Karutz, R., Riedner, L., Vega, L., Stumpf, L., and Damert, M., Compromise or complement? Exploring the interactions between sustainable and resilient supply chain management. *International Journal of Supply Chain and Operations Resilience*, vol. 3, no. 2, pp. 117–142, 2018.

Koberg, E., and Longoni, A., A systematic review of sustainable supply chain management in global supply chains, *Journal of Cleaner Production*, vol. 207, pp. 1084–1098, 2019.

Liu, L., Song, W., and Liu, Y., Leveraging digital capabilities toward a circular economy: Reinforcing sustainable supply chain management with Industry 4.0 technologies. *Computers & Industrial Engineering*, vol. 178, Article 109113, 2023.

MacCarthy, B., & Ivanov, D., The Digital Supply Chain (1 ed.). Elsevier, 2022.

Meredith, J., Building operations management theory through case and field research, *Journal of Operations Management*, vol. 16, no. 4, pp. 441–454, 1998.

Miron-Spektor, E., Ingram, A., Keller, J., Smith, W., & Lewis, M., Microfoundations of organizational paradox: The problem is how we think about the problem, *Academy of management Journal*, vol. 61, no. 1, pp. 26–45, 2018.

Mithas, S., Chen, Z., Saldanha, T., & Silveira, A., How will artificial intelligence and Industry 4.0 emerging technologies transform operations management?, *Production and Operations Management*, vol. 31, no. 12, pp. 4475–4487, 2022.

Nielsen-Englyst, L. Operations strategy formation - a continuous process. *Integrated Manufacturing Systems*, vol. 14, no. 8, pp. 677–685, 2003.

Patrucco, A., Seuring, S., Fosso Wamba, S., Kaliyan, M., and Appolloni, A., Guest editorial: The missing link between supply chain technologies and sustainability issues: advancing theory and practice*, International Journal of Physical Distribution & Logistics Management*, vol. 55, no. 3, pp. 177–195, 2025.

Prataviera, L. B., Jazairy, A., and Abushaikha, I. Navigating the intersection between postponement strategies and additive manufacturing: insights and research agenda. *International Journal of Production Research*, 2024

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Putnam, L., Fairhurst, G., and Banghart, S., Contradictions, Dialectics, and Paradoxes in Organizations: A Constitutive Approach, *Academy of Management Annals*, vol. 10, no. 1, pp. 65–171, 2016

Samah, M., Salah, O., and Imane, I., A Literature Review on Sustainable Supply chain Management and its Impact on Sustainable Performance, *2022 14th International Colloquium of Logistics and Supply Chain Management*, 2022.

Schad, J., Lewis, M., Raisch, S, and Smith, W., Paradox Research in Management Science: Looking Back to Move Forward, *The Academy of Management Annals*, vol. 10, no. 1, pp. 5–64, 2016.

Schaltegger, S., and Burritt, R., Measuring and managing sustainability performance of supply chains. *Supply Chain Management: An International Journal*, vol. 19, no. 3, 2014.

Seuring, S., and Müller, M. From a literature review to a conceptual framework for sustainable supply chain management, *Journal of Cleaner Production*, vol. 16, no. 15, pp. 1699–1710, 2008

Sindhwani, R., Afridi, S., Kumar, A., Banaitis, A., Luthra, S., and Singh, P., Can industry 5.0 revolutionize the wave of resilience and social value creation? A multi-criteria framework to analyze enablers, Technology in Society, vol. 68, Article 101887, 2022

Smith, W. and Lewis, M., Toward a Theory of paradox: A dynamic equilibrium model of organizing, *Academy of Management Review*, vol. 36, no 2, pp. 381–403, 2011.

Stindt, D., A generic planning approach for sustainable supply chain management - How to integrate concepts and methods to address the issues of sustainability? *Journal of Cleaner Production*, vol. 153, no. 1, pp. 146–163, 2017.

ATV, A Baseline 2022 - Den bæredygtige omstilling af dansk produktionsindustri, Available: https://atv.dk/udgivelser-viden/fremtidens-baeredygtige-produktion-baseline-2022, Accessed April 24th, 2025.

Biography

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