Supply Chain Structures
Promoting Development of Sustainable Supply Chains

The Case of Surplus Food Recovery

CAROLINE SUNDGREN
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Key words: supply chain structure, supply chain, food waste

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PREFACE

The journey of a PhD can never be accomplished alone. First of all, my deepest thank you goes to my thesis supervisor Árni Halldórsson. I have felt privileged to have you as a mentor and learn from your research skills. Thank you especially for being forward looking, for your positivity, and for never criticizing unfinished work. Without your guidance, and comments on various drafts of the dissertation and papers, I would not be here today. I am also very grateful to my degree supervisor David Grant for all your professional support at the later stages of the PhD process and always helping bring the process forward. A big thanks also goes to my former degree supervisor Gyöngyi Kovács for the support in the beginning of the process and for encouraging me to take on this project.

I wish to thank the pre-examiners, Professor Jakob Rehme and Dr. Anne Touboulic for insightful comments, which significantly helped improve the quality of the final manuscript. Thank you also to Anna Aminoff and to Qifeng Yan for careful reading and constructive feedback when acting as opponents at the manuscript seminar.

I also had the opportunity to do a research visit at Politecnico di Milano, and my sincerest thank you goes to Professor Federico Caniato for enabling this visit and helping me to gain insight into surplus food redistribution in Italy.

One of the most enjoyable parts of the PhD process have been my wonderful colleagues and fellow PhD students. A special thanks to my first office mate, Hannu, and to Marie-Lou, Sanchi and Maria for the many fascinating lunch and afterwork discussions. Thank you also to Minchul, Isabella, Linda, Wonde, Sabari, Eija, Greta, Virva, Robert, Anna, Félicia, Russell, and many others. Special thanks also to faculty and personnel at the subject of Supply Chain Management and Social Responsibility for the support. Especially, Nikodemus Solitander, Wojciech Piotrowicz, Diego Vega, Amin Maghsoudi, Hanne Dumur-Laanila and Kristjana Adalgeirsdottir. Equal thanks goes to the faculty members in the Department of Marketing, and for colleagues at Politecnico di Milano and Chalmers who helped me feel welcome. Thank you also to the Hanken doctoral school, and especially to Anu Helkkula for constantly reminding us PhD students of the positive endeavor a PhD journey is.

The financial support from various funding institutions have allowed me to work uninterrupted on this project, and participate in conferences and research visits, which I am extremely grateful for. This project was financed by the Society of Swedish Literature in Finland from Bröderna Lars och Ernst Krogius research fund, the Paulo Foundation, Marcus Wallenbergs Stiftelse för Företagsekonomisk Forskning, Liikesivistysrahasto, Otto A. Malm’s Donationsfond and Stiftelsen Svenska Handelshögskolan.

I also wish to show my greatest gratitude to the organisation and company representatives who have given of their time to discuss the topic of my thesis. Your contribution is invaluable.

A special thanks to my academic friends. Man (Flora), I value our friendship and have learned much from you. Jessica and Toulou, I am extremely glad our paths have crossed during this journey. Thank you also to my friends outside of academia, Hilla, Alina, Veronica, Lina, Ami, Pernilla, Janina and Cessi, and several others. Talking, laughing, and spending time with you have made this journey so much nicer to undertake.
My deepest gratitude goes to my parents, Lenita and Stefan, for your love and for always supporting me. You have provided me with the best possible foundation in life. Dad, I highly appreciate your honest insights about academic life. Finally, Jukka, thank you for being there day in and day out during this five-year long journey to listen, discuss, and, when needed, read drafts, and cook. Thank you for all your love, I think we did this together.

Caroline Sundgren

Helsinki, May 2021
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1 INTRODUCTION

1.1 Background

Despite considerable increased academic and business attention over the past several decades on sustainability issues, the challenges are far from resolved. Climate change is one of the largest threats facing humanity, challenging socio-economic achievements and worsening the condition of an already ravaged planet. Unprecedented changes are required to stay within planetary boundaries (Steffen et al., 2015). For instance, anthropogenic carbon emissions must peak in 2020, in order to limit global warming well below 2°C, and then be halved every decade thereafter to reach net-zero emissions by 2050 (Rockström et al., 2017).

The food industry is particularly resource intensive, requiring 21.3 billion tons per year (PACE, 2020). The food sector emits 18 Gt CO2 equivalent per year, amounting to 34 per cent of global anthropogenic greenhouse gas emissions (Crippa et al., 2021). Supply chain activities (such as, retail, transport, waste management etc.) contributes directly to 29 per cent of these emissions, while the largest contribution comes from agriculture and land use (ibid.). Despite this, approximately 17 per cent of food produced is wasted annually in the supply chain (UNEP, 2021). This food has already contributed to global emissions from the agricultural to retail phase of the supply chain. It is widely recognized that wasted food has a significant, negative environmental impact and has moral implications (Muriana, 2017). To tackle the food waste problem, the EU Directive 2018/851 set a target to reduce per-capita food waste by 30 percent by 2025 and 50 percent by 2030. The European Commission proposed legally binding targets to reduce food waste across EU by the end of 2023 and a revision of the best before and use by date markings by the end of 2022, as part of the Farm to Fork Strategy under the European Green Deal (EC, 2020). In Finland, the campaign Älska en smula was recently launched by the Ministry of Agriculture and Forestry, under the initiative of President of the Republic, Sauli Niinistö, to encourage Finnish citizens to reduce food waste and sort out their bio-waste.

Until recently, food waste was seen as unmanageable and an inevitable externality of the food supply chain (Muriana, 2017), underlining a lack of ownership of the problem. However, surplus food is a multi-actor problem (such as, who in the chain gets most shelf life), and solutions must look broader than just optimizing the behavior of one actor. This is supported by Mena et al. (2014), who argue that a holistic supply chain perspective can reduce supply chain waste. Despite this, only a few empirical studies have addressed the inter-organizational inefficiencies contributing to food waste (Ciulli et al., 2019; Gadde and Amani, 2016; Liljestrand, 2017; Mena et al., 2014; Muriana, 2017; Rijpkemaa et al., 2014), most of which focused on causes of food waste. On the other hand, data has shown that there is potential to recover surplus food at all stages of the supply chain. A report from Canada found that 32 percent of wasted food, is surplus that could be rescued to support local communities (Nikke et al., 2019). The potential for surplus food recovery is greatest, at the processing and manufacturing stages of the supply chain (4.82 million tons), followed by the consumer stage (2.38 million tons) (Nikke et al., 2019). A study from Italy shows that 181,400 tons of surplus food (0.4 percent of sales) is recoverable in the manufacturing and retail sectors (Garrone et al., 2014a). However, relatively few scholars (Aschemann-Witzel et al., 2017; Ciulli et al., 2019; Liljestrand, 2017) have studied surplus food solutions.
To tackle the complex global problems of carbon emissions and food waste, we need to understand the mechanisms behind these events. Firms in the food supply chain are at the heart of the problem, by creating food waste as a by-product of their operations. Like the bullwhip effect (Lee et al., 1997) where demand distortions arise as a result of optimization behaviors by actors in the supply chain, the underlying causes can be found at a different supply chain level, best captured through the supply chain’s structure. The assumption is that food supply chains have a certain structure, which, under certain conditions, will produce externalities such as surplus food, food waste and carbon emissions. Looking at supply chain structures, they consist of both material and non-material structural elements (Aastrup and Halldórsson, 2008). The material elements are, for example, the physical flows, information flows and financial flows while the non-material elements are the social agents in the structure with their own choices and intentions (ibid.). Such structures can be both designed and managed to reduce their externalities.

On the one hand, forward supply chains are sequential and their operations and the transportation activity generate carbon emissions and waste. Therefore is improving supply chain efficiency important to reduce their environmental impact. The literature about sustainable supply chain management (SSCM) is vast, but much of it focuses on minimizing harm by adopting well-known practices from supply chain management (SCM), such as lean management. For reaching truly sustainable supply chains, novel practices and processes must also be developed (Pagell and Shevchenko, 2014). On the other hand, supply chains can enable the flow of by-products to new owners by coordination and new structures. However, as described earlier, knowledge about effective supply chains enabling surplus food recovery is limited. Relevant in this regard are circular supply chains (CSC) defined as “the coordinated forward and reverse supply chains via purposeful business ecosystem integration for value creation from products/services, by-products and useful waste flows through prolonged life cycles that improve the economic, social and environmental sustainability of organizations” (Batista et al., 2018, p. 446).

Matopoulos et al. (2015) call for more research on the nature of supply chain relationships and appropriate configurations to improve resource efficiency in the food supply chain. Furthermore, Knight et al. (2015) explain that new supply chains need to be established to support sustainability transitions. Therefore, is it crucial to understand how supply chain structures can promote surplus food recovery, and whether such structures have broader implications for developing sustainable supply chains. The definition of supply chain structure adopted here is: A constellation of actors that are linked together, enabling the flow of materials, services, finances and information to other actors in the constellation. Thus, this thesis focuses on the concept of the supply chain structure as an enabler of sustainability to elaborate on the unanswered calls. It follows a phenomenon-driven approach (Schwarz and Stensaker, 2014) and starts from the practical problem of surplus food generation across the supply chain. This thesis takes into account the complexity of this phenomenon and makes use of social network theory (SNT) to understand the patterns of interaction between actors within structures, both in the essays and in this summary section. SNT has the potential to shed light on the development of sustainable supply chains, but has infrequently been applied in SSCM literature (Touboulcic and Walker, 2015a). This thesis primarily contributes to sustainable and circular supply chain literature. Eventually, this summary section brings the essays together and discusses their combined insights.
1.2 Purpose and research questions

As outlined above, it is necessary to transition toward supply chains that are both more sustainable, and that can enhance sustainability. Transformational change faces many barriers, many of which are commercial or managerial, rather than technological. Sustainability transitions force supply chain actors to operate under great uncertainty (and face supply- and demand-side uncertainties), which may block or slow transitions (Knight et al., 2015). The forthcoming sections of this thesis investigates in detail some building blocks to enable transitioning into sustainable supply chains.

This thesis’ purpose is to enhance our understanding of how supply chain structures can promote surplus food recovery and implications for developing sustainable supply chains.

Traditional supply chain literature views the structural dimensions of a supply chain as both horizontal and vertical (Lambert and Cooper, 2000). The horizontal structure refers to length of the supply chain while the vertical structure refers to the number of suppliers/customers represented within each tier (ibid.). However, supply chain structures should be more broadly conceptualized to deal with sustainability. Parallels can be drawn to organizational structures such as in Mintzberg (1991), who refers to a configuration as a consistent and highly integrated form of organization, which is very effective. He identifies seven types of organizational configurations: Entrepreneurial, machine, professional, adhocracy, diversified, ideological and political. Configurations tend to go through cycles in which they change form, but the organization remains the same (Mintzberg, 1991). To further investigate supply chains’ structural elements, Question (1) asks:

**RQ (1):** Which elements of supply chain structures can be modified to enhance the development of sustainable supply chains?

Building upon RQ (1), the second research question explores in more detail how sustainability transitions can occur. Pagell and Wu (2009) suggest that more sustainable supply chains tend to either reconceptualize who forms part of the supply chain or move toward closed-loop chains. Traditionally, the supply chain forms around one focal actor, while others remain outside the chain’s visible boundary (Carter et al., 2015). In addition to the actors involved, actors outside the focal chain, such as intermediaries, may play different roles, leading to certain environmental and social outcomes. In accordance with Wynstra et al. (2015), this study refers to actor roles in the overall supply chain, and in relation to other actors. Furthermore, it draws on basic brokerage roles from SNT (Obstfeld et al., 2014). Moreover, as these actors are interconnected, some relationships may be more effective than others at creating benefits for the actors in the chain and the end user. Similar to Östlin et al. (2008) this study examines the use of different types of supply chain relationships for product recovery. It does so by drawing on different types of ties from SNT (i.e. tie strength and creation) and applying them to the supply chain context (Borgatti and Li, 2009). Therefore, Research Question (2) investigates actor roles and relationship types in more depth:

**RQ (2a):** How can different actor roles in the supply chain contribute to surplus food recovery?

**RQ (2b):** How can different relationship types in the supply chain contribute to surplus food recovery?
### Purpose and research questions of the composite thesis and essays

<table>
<thead>
<tr>
<th>Purpose of this thesis</th>
<th>Research questions</th>
<th>Essay 1</th>
<th>Essay 2</th>
<th>Essay 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>To enhance our understanding of how supply chain structures can promote surplus food recovery and implications for developing sustainable supply chains.</td>
<td>RQ (1): Which elements of supply chain structures can be modified to enhance the development of sustainable supply chains?</td>
<td>This chapter illustrates that focusing on energy as part of sustainable supply chain development allows managers to unite economic and environmental reasoning in their decision-making and actions.</td>
<td>This study's purpose is to analyze the different supply chain structures that have emerged to make surplus food available to consumers. RQ (1): Which actor constellations and interactions have emerged in surplus food distribution? RQ (2): What are the roles of new actors in surplus food distribution?</td>
<td>Aim: To explore the formation of relationships for food redistribution that improve circularity and social sustainability at the end of the food supply chain. RQ1: What kind of relationships exist between business and not-for-profit actors in food redistribution? RQ2: How are circular supply chain relationships established in the context of food redistribution?</td>
</tr>
</tbody>
</table>
The following sections explore the overarching aim and research questions, and the three complementary essays provide insights into answering the research questions. Each essay concerns a different aspect of the phenomenon, with its own aim and research questions. Table 1 summarizes the purpose and research questions of the composite thesis and the essays.

The common distinction between efficiency and effectiveness helps explain the focus of the essays. In striving for performance (developing sustainable supply chains), both dimensions of efficiency and effectiveness are considered important. Efficiency can be defined as how well the resources expended are utilized (Fugate et al., 2010, p. 45), so is related to inputs vs. outputs. Efficiency refers to the wise use of resources (e.g. material, energy) and low waste generation within supply chains. On the other hand, effectiveness concerns the degree to which previously established goals and objectives have been met. At the same time, the goal can also be expressed in terms of aspiration levels (Van Weele, 2005, p. 255). Effectiveness seeks to accomplish other sustainability goals (e.g. material recovery) by the supply chain.

Essay 1 focuses on the efficient use of the energy resource within supply chains. This essay conceptualizes efficiency from an environmental perspective, using the concept of energy efficiency. This is a conceptual paper, with illustrative examples, and forms a basis for the two other papers, which shift focus to the effectiveness of the supply chain structure for advancing material reuse. Essay 1 mainly contributes toward RQ (1). This essay is co-authored, has gone through peer-review process, and is published as a chapter in the Handbook on the Sustainable Supply Chain.

Essay 2 studies emerging supply chain structures in the surplus food context by building upon aspects of Essay 1 and utilizing the concept of supply chain structure. This paper investigates actor constellations, which enable the flow of surplus food to new consumers. The concepts of actor roles and interactions are investigated through a multiple-case study to gain a more in-depth understanding of actor constellations. Essay 2 provides insights to all research questions, but mainly RQ (2a). This essay is single-authored and published in the International Journal of Logistics Management.

Essay 3 builds upon Essay 2 by empirically investigating NGO-led dyadic structures in more detail and focusing on the concept of actor relationships. It also deals with surplus food resource and its redistribution. The essay theorizes around the concepts of structural holes and structural embeddedness, and provides insights to all research questions, with an emphasis on RQ (2b). This essay is single-authored and has been submitted for review to an international journal.

1.3 Clarification of key concepts

The key concepts in this thesis include: Food waste hierarchy, supply chain structure, surplus food, sustainable development and sustainable supply chain. These concepts are defined below.

Food waste hierarchy is a priority order for managing surplus food and food waste. It has five levels (from most to least favorable): Prevention, reuse, recycle, recovery, and disposal (Papargyropoulou et al., 2014). Food recovery refers to moving the food up to the high priority levels in the hierarchy to prevent waste. Redistribution is one form of reuse when surplus food is distributed to food aid organizations for social purposes.
Supply chain structure can be defined as a constellation of actors that are linked together, enabling the flow of materials, services, finances and information to other actors in the constellation. Similar to Carter et al. (2015) the supply chain is here seen as a network, which allows for focusing on both actors and their relationships/interactions.

Surplus food is defined as ‘the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer’ (Garrone et al., 2014b, p. 130). This definition has an explicit focus on the consumer and on food aimed for human consumption at later stages of the supply chain (which is not yet considered waste). In contrast, food waste is broader, as it includes both edible and inedible food.

Sustainable development is recognized as development that meet the needs of the present, without compromising the ability of future generations to meet their own needs (WCED, 1987, p. 16). Sustainable development involves the process to reach this outcome (i.e., principles for sustainable development) (Robèrt et al., 2002, p. 198).

A sustainable supply chain integrates dimensions of sustainable development into the supply chain. It builds on the triple bottom line approach, while ensuring the long-term viability and continuity of the business, as well as, contributing to the future well-being of society (Christopher, 2011). This understanding of SSCs builds on the adopted supply chain definition. A supply chain is here defined as: “A network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users”(Christopher, 2011, p. 4).

1.4 Dissertation outline

This thesis has five chapters. Chapter 1 gives the background, introduces the purpose and research questions, and presents the key concepts. Chapter 2 presents the thesis’ theoretical background. Chapter 3 provides an overview of the research philosophy, methodology, and essays’ research methods. Chapter 4 summarizes the three essays. Finally, Chapter 5 discusses the dissertation’s key findings and theoretical contributions, and provides implications, limitations, and suggestions for future research.
2 SUPPLY CHAIN STRUCTURES, SUSTAINABILITY, AND SURPLUS FOOD

This chapter presents the theoretical background of this thesis. The chapter begins with explaining the supply chain structure concept (Section 2.1). The following section provides an overview of the literature around SSCM and CSCs (Section 2.2), while Section 2.3 discusses surplus food in the supply chain. Section 2.4 covers the main ideas of SNT and its applications to supply chains. Eventually, the theoretical framework in Section 2.5 integrates these literature streams.

Figure 1 illustrates the positioning of this thesis, and the dotted round circle labeled Supply chain Structures Promoting Development of Sustainable Supply Chains shows its relationship to related streams of literature. This thesis is positioned in the SSCM field and is mainly contributing to sustainable and circular supply chain research by drawing on literature about supply chain structure and surplus food, as indicated by arrows. Sustainability in supply chains are at the intersection of sustainability and SCM, which are depicted as large circles, since these are broader research fields.

Figure 1   Positioning of the thesis at the intersection of three fields

2.1 The supply chain as a structure

The understanding of supply chains I have adopted builds on Christopher’s (2011) definition (see Section 1.3). In his definition, the structure covers actors and their
interrelations, while he is open about the output. As an another example, Mentzer et al. (2001) provided an early definition of a supply chain, however, in their definition the structural dimension only included the actors (a set of three or more entities) and the output is business oriented (customer). Consistent with this approach, my worldview builds on supply chains as a system and is in line with the ‘soft’ system approach (Lindskog, 2012). This also assumes that structures within this network of connected organizations can be both managed and designed. It is in this management and design that sustainability can be incorporated in supply chains. In these structures, relationships take place and structures are therefore in movement. Furthermore, the individuals in the system have their own perceptions and goals. Since the SCM literature has not emptied these concepts, SNT will later be introduced (see Section 2.4) to elaborate on the individual’s behavior in supply chain structures.

The term supply chain structure has often been used interchangeably with supply chain design. According to Chopra and Meindl (2013) are decisions about supply chain design concerned with the roles and locations of manufacturing, storage or transportation facilities, and the allocation of capacity and markets to each facility (including supply source decisions). The process of designing supply chains is often captured through the proposal of typologies among different types of products and supply chain configurations (Calleja et al., 2018). Drawing on Mintzberg’s (1980) typology of elements of organizational structuring, this section presents an overview of seven perspectives on a supply chain structure as depicted in different literature streams (see Table 2). The seven relevant perspectives for the context of this research are: Forward structure, reverse structure, omni-channel structure, last-mile structure, humanitarian structure, network structure, and platform structure. When consolidated, these perspectives depict the heterogeneity of supply chain structures in the literature.

Table 2 below (the rows) include five different elements of supply chain structures: (1) an overall objective, (2) determinants, (3) shape, (4) configuration and (5) sustainability attributes. These elements were identified by findings similarities among categories across the seven different types of structures presented in the various literature streams. First, the overall objective of the supply chain structure refers to its main goal. Second, the determinant(s) are the combination of elements that form a configuration. Third, the supply chain shape refers to the involved actors and how they are connected. Fourth, a configuration can be seen as a stable form (Mintzberg, 1980) often presented as a typology (van der Valk and Axelsson, 2015). Fifth, the sustainability attributes refer to environmental and social factors considered in the structure. Last, all elements are affected by contingency factors, such as (1) the age of the supply chain structure and (2) its operating environment.

For the forward supply chain stream, it is important to find a good fit between the supply chain strategy, the supply chain structure and the product type (Fisher, 1997). Fisher (1997) put forward two supply chain configurations – one efficient and one responsive. The most suitable configuration is determined by the product type. For the reverse logistics stream, Blackburn et al. (2004) propose an efficient centralized structure and a responsive decentralized structure. The product’s marginal value of time (MVT) determines which structure is most suitable. For the omni-channel stream, structures should be designed to create a seamless shopping experience for the consumer, whether it takes place in a store or online. The structure includes a forward and a reverse chain, in which the forward chain concerns dispatch locations, while the reverse chain considers the flow of return products from the consumer to the organization (Hübner et al., 2016). Major concerns for the last-mile structure include the customer collection point, which also affects the structure’s energy efficiency (Halldörrsson and Wehner, 2020).
<table>
<thead>
<tr>
<th>Overall objective (goal)</th>
<th>Forward structure</th>
<th>Reverse structure</th>
<th>Omni-channel structure</th>
<th>Last-mile structure</th>
<th>Humanitarian structure</th>
<th>Network structure</th>
<th>Platform structure</th>
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</thead>
<tbody>
<tr>
<td><strong>Profit</strong></td>
<td></td>
<td>Asset value recovery</td>
<td>Sales</td>
<td>Fulfillment</td>
<td>Save lives &amp; use limited resources effectively</td>
<td>Network efficiency and effectiveness</td>
<td>Market access, supply-demand intermediation, and pricing strategies</td>
</tr>
<tr>
<td><strong>Physical function</strong></td>
<td></td>
<td>Return decision (reuse, refurbish, salvage, or recycle)</td>
<td>Integration between online and physical channels</td>
<td>Energy efficient distribution</td>
<td>Efficiency and effectiveness</td>
<td>Inter-organizational business relationships</td>
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<td><strong>Market mediation function</strong></td>
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<td><strong>Determinants (factors forming configuration)</strong></td>
<td>Products (functional vs. innovative)</td>
<td>Products’ marginal value of time Product differentiation</td>
<td>Warehouse- vs. store-based distribution system</td>
<td>Point of collection – location where the goods are offloaded from the commercial vehicle</td>
<td>Demand characteristics for unanticipated emergencies: demand depends on type and impact of the disaster, demographics, and social and economic conditions in the area</td>
<td>Facilitate transfer of knowledge, information</td>
<td>The stable set of capabilities and their structural relationships</td>
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<td><strong>Demand (predictable vs. unpredictable)</strong></td>
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<td><strong>Products’ marginal value of time</strong></td>
<td>Warehouse- vs. store-based distribution system</td>
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<tr>
<td><strong>Process oriented, from manufacturer to customer</strong></td>
<td>Return from customer, evaluating product at facility (late) or retailer (early, preponement), back to market</td>
<td>Forward: sources (supplier DCs, retailer DCs, stores) and destinations (home, store)</td>
<td>1. Retail store – household</td>
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<td>Return: sources (store, home) and destinations</td>
<td>2. a) Retail store-household b) Dark room – retail store-household</td>
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<td>3. Pickup point – household</td>
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<td>4. Locker station – household</td>
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</table>

| Shape of supply chain (actors, flow) | | |
|--------------------------------------| | |
| | | |
| **Process oriented, from manufacturer to customer** | | | | | | | |
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Table 2  Elements of supply chain structures
<table>
<thead>
<tr>
<th><strong>Configuration</strong> (output)</th>
<th><strong>Physically efficient</strong> supply chain designed to deliver products at low cost</th>
<th><strong>Market-responsive</strong> supply chain designed for speed of response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Centralize</strong></td>
<td></td>
<td><strong>Centralize</strong></td>
</tr>
<tr>
<td><strong>evaluation activity</strong> (efficient)</td>
<td><strong>Centralize</strong></td>
<td><strong>Centralize</strong></td>
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<tr>
<td><strong>Decentralize</strong></td>
<td><strong>distribution center</strong></td>
<td><strong>distribution center</strong></td>
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<td><strong>evaluation activity</strong> (responsive)</td>
<td><strong>Decentralize</strong></td>
<td><strong>Decentralize</strong></td>
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<tr>
<td>5. Home delivery</td>
<td><strong>Push-driven</strong>: High commercial vehicle fill rates, likely stimulate use of private car</td>
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<tr>
<td>6. In-car delivery – household</td>
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<tr>
<td>1. a) <strong>Push-driven</strong> (as above)</td>
<td><strong>Centralize</strong></td>
<td><strong>Centralize</strong></td>
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<tr>
<td></td>
<td><strong>activities</strong></td>
<td><strong>activities</strong></td>
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<tr>
<td>2. <strong>Postponement</strong>:</td>
<td><strong>Decentralize</strong></td>
<td><strong>Decentralize</strong></td>
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<tr>
<td>average commercial vehicle fill rates, use of private car may be avoided</td>
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<tr>
<td>3. <strong>Postponement</strong>:</td>
<td><strong>Centralize</strong></td>
<td><strong>Centralize</strong></td>
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<tr>
<td>low fill rates for commercial vehicles, use of private car may be avoided</td>
<td><strong>activities</strong></td>
<td><strong>activities</strong></td>
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<td>4. <strong>Postponement</strong>:</td>
<td><strong>Decentralize</strong></td>
<td><strong>Decentralize</strong></td>
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<tr>
<td>low fill rates for commercial vehicles, no private vehicle use</td>
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<td>5. <strong>Postponement</strong>:</td>
<td><strong>Centralize</strong></td>
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<tr>
<td>low fill rates for commercial vehicles, no extra driving</td>
<td><strong>activities</strong></td>
<td><strong>activities</strong></td>
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<tr>
<td></td>
<td><strong>Decentralize</strong></td>
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<tr>
<th><strong>Sustainability attributes</strong></th>
<th><strong>Not considered</strong></th>
<th><strong>Material efficiency</strong> (ability to handle returns &amp; end-of-life products)</th>
<th><strong>Not considered</strong></th>
<th><strong>Consumer role</strong> (active)</th>
<th><strong>Distance and fill rates</strong></th>
<th><strong>Not considered</strong></th>
<th><strong>Material efficiency</strong> (sharing and reuse)</th>
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<td><strong>Material efficiency</strong> (sharing and reuse)</td>
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Internal platform | Many-to-one | Many-to-many | Open network structure – structural holes exist | Closed network structure – all actors are connected | Internal platform | Many-to-many
<table>
<thead>
<tr>
<th>Contingency factors: Operating environment</th>
<th>Low</th>
<th>Low</th>
<th>High</th>
<th>High</th>
<th>High</th>
<th>High</th>
<th>High</th>
<th>High</th>
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<tbody>
<tr>
<td>- complexity</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Extremely high</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>- dynamism</td>
<td>Low/high</td>
<td>Low/high</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Age of supply chain structure (typically)</td>
<td>Old</td>
<td>Varies</td>
<td>Young</td>
<td>Varies</td>
<td>Varies</td>
<td>Young</td>
<td></td>
<td></td>
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<tr>
<td>Source</td>
<td>Fisher et al. (1997)</td>
<td>Blackburn et al. (2004)</td>
<td>(Hübner et al., 2016; Melacini et al., 2018)</td>
<td>e.g. (Halldórsson and Wehner, 2020)</td>
<td>(Balcik et al., 2010; Haavisto, 2014; Jahre et al., 2009)</td>
<td>(Kurt and Kurt, 2020; Vedel et al., 2016); grounded in sociological studies of interpersonal relationships (e.g., Simmel 1950)</td>
<td>e.g. (Thomas et al., 2014)</td>
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The humanitarian stream’s objective is saving lives and effectively using limited resources. Common logistics strategies, such as postponement, may be used to centralized stock to ensure preparedness through centralizing stocks of finished goods and investments in transport and goods handling capacity (Jahre et al., 2009). The network stream focuses on networks and inter-organizational phenomena. Its objective is to reach network efficiency or effectiveness (see Bayne et al., 2017). Structures are studied through direct and indirect relationships between actors, and the smallest unit for studying the network is the triad (Vedel et al., 2016). For the platform literature stream, the intermediary actor links supply and demand in various forms (Thomas et al., 2014).

Furthermore, supply chain structures can take up different forms, resulting in a variety of shapes and configurations. The structures also share common traits what regards the profit objective and aiming for efficient and/or effective configurations (in relation to the overall objective). The configurations are often determined to be centralized or decentralized, but the decoupling point tends to vary (as regards what activities to centralize or have decentralized). For instance, in a reverse structure this decision regards the evaluation activity, whereas in the last mile it regards the offloading point from a commercial vehicle. In contrast to the structures emerging from a supply chain perspective, the network structure in concerned with actor centrality and the existence, and strength of, actor connections (rather than the level of centralization). The determinants forming the configuration are often demand, or product, related, such as predictability of demand or product’s marginal value of time. Many of the structures do not consider sustainability attributes, while the ones that do, pay attention to material efficiency, consumer roles, distance and fill-rates (on a theoretical, but not necessarily a practical level) and social dimensions (by saving human lives). Furthermore, some structures are old, while others have emerged more recently (for example, due to development of e-commerce), and the structures can also be set up to function only temporary (as a response to an emergency).

2.2 Sustainability of, and by supply chains

There are two schools of thought regarding sustainability of, and by supply chains – the SSCM stream and the CSC stream.

SSCM is a subfield of SCM that emerged in the early 1990s. Today, it is one major area of research within the SCM discipline (Carter et al., 2019). It is deeply rooted in triple bottom-line thinking, which aims to integrate the economic, environmental and social dimensions of sustainability (see Carter and Easton, 2011; Seuring et al., 2008). It uses an inter-organizational level of analysis because supply chain activities, not activities within the focal company, that cause the most environmental and social harm. For instance, 80 percent of greenhouse gases, and 90 percent of the effect on air, land, water, biodiversity and geological resources, occurs within a company’s supply chain (Bové and Swartz, 2016). SSCM has become a mature field, indicated by the saturation in the number of literature reviews conducted on the topic (Carter and Washispack, 2018). Authors suggest that future work in the SSCM field should focus on developing mid-range theories and investigating the trade-offs and uncertainties managers face regarding decisions around SSCM (Carter et al., 2019). I adopt Christopher’s (2011) description of a SSC, which refers to integrating sustainable development into the supply chain and considers both business and societal outcome, since it is all encompassing what regards sustainability and complementary to his supply chain view.
The fields of closed-loop and reverse logistics have recently gained popularity, as circular economy principles build on reasoning from these fields (Lüdeke-Freund et al., 2019). The concept of the circular economy was mostly developed and utilized by practitioners (such as policymakers, business, NGOs, and consultants). Although SSCM reviews tend to omit reverse logistics and closed-loop, supply chain topics (e.g., Carter and Washispack, 2018; Fahimnia et al., 2015), these areas contribute by making supply chains more sustainable by enabling value recovery from products and materials. Other authors (Batista et al., 2018; Genovese et al., 2017) explain the commonalities between the fields of SSCM, green supply chains, reverse logistics and closed-loop supply chains. Batista et al. (2018) propose that the CSC is an extension of the closed-loop perspective, but with a broader scope and focus. In essence, circular supply chains also consider post-production stewardship to include forward feeding flows into alternative supply chains (in terms of scope) and focus not only on end of life returns, but also associated by-product synergies, services and waste flows (in terms of focus) (Batista et al., 2018, p. 446). Existing knowledge prioritizes a design for multiple cycles, at the expense of designing products for extending life cycles (Sehnem et al., 2019). Multiple cycles refer to returning product or material leftovers in the system to be used again (such as recycling), while extending product life cycles can be achieved by keeping the product longer or repairing it. In the circular economy literature, recycling is considered a lower-value alternative, while it is more favorable in the closed-loop literature (Sehnem et al., 2019).

![Supply chain components in the wider circular- and sustainable supply chain context. Adopted from Batista et al. (2018)](image-url)
Figure 2 connects the forward and reverse flows in traditional and recovery supply chains. While the SSCM perspective has a stronger focus on reducing environmental and social harm of supply chain operations, the CSC literature extends this perspective by viewing supply chains as enablers for material recovery. The return flows are the returned products and materials that can be used in the core process of an organization. The cascading flows make use of by-product synergies between firms. In this regard, both perspectives need equal attention, as sustainable supply chains must be efficient to minimize their harm, and be effective at reaching the objectives set by CSCs.

2.2.1 Attributes of sustainable and circular supply chains

As mentioned above, a vast number of literature reviews have been conducted on SSCM. Although the CSC perspective is more recent, it has built on earlier research. To gain deeper insights into the most common aspects of sustainable and circular supply chains, I conducted a literature search to identify common attributes (or characteristics) among papers that categorized the literature. The Oxford Dictionary (2020) defines an attribute as a quality or character considered to belong to or be inherent in a person or thing, a characteristic quality.

The literature search followed a similar methodology as van der Valk and Axelsson (2015) used for classifying services. The search was conducted in the Scopus database by using the search terms sustainable supply chain* OR circular supply chain* AND classification OR taxonomy OR typology OR category in the abstract, title, or keywords. The search included papers from 2009 to 2020. This first step identified 129 articles for further analysis. In a second step, the abstracts were reviewed to ensure that the papers included for further analysis focused on segmentation attributes of sustainable or circular supply chains. This narrowed the list down to 44 articles. In a third step, articles were screened by full text. Articles that did not provide insight into how to classify sustainability in supply chains were excluded from the analysis. Four more articles were included that were outside of this search (identified from the reference list in the articles in the set). This led to a final sample of 30 articles (see Appendix 1).

Table 3 below summarizes the attributes, and the authors who have identified this attribute, either within the field of SSCM or CSC. These were based on a complete classification that can be found in Appendix 1. Since CSC is a new field, fewer articles were included in the literature search, leading to themes being more commonly addressed in the SSCM literature. Despite few literature overviews produced about CSC, the table gives an overview of where the perspectives overlap and how they differ.

Twelve themes were prominent in the literature and are presented in the attribute column in the table. Many categories were addressed by both perspectives, except for three attributes that were not explicitly addressed by the CSC literature: Continuity, supplier assessment, and risk assessment. The top-down approach taken by the SSCM literature regarding supplier assessment and supplier continuity has not yet been as strongly focused upon within CSC literature. Risk management was one of the themes included in Carter and Roger’s (2008) review, which may explain their popularity in the SSCM literature. Furthermore, the CSC literature has been more explicit than SSCM literature regarding the use of renewable energy. For instance, Ripanti and Tjahjono (2019) view a shift to renewable energy as one of the core values of the circular economy. Although both perspectives note the importance of relationships, the SSCM perspective often emphasizes buyer-supplier relationships (Beske and Seuring, 2014), while the CSC perspective considers network collaboration across industries (Ripanti and Tjahjono,
The table also shows that supply chain design was considered by several authors, although it was not one of the more prominent themes, emphasizing that there is much room for further elaboration on this topic.

Table 3  Attributes of sustainable and circular supply chains

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
</table>
| Governance, regulatory/policy | - external legal regulation or regulatory pressure from government through laws, regulations and policies - internal governance practices, such as standards and practices within partnerships | 1. (Sodhi and Tang, 2018)  
2. (de Sousa Jabbour et al., 2019)  
3. (Ansari and Kant, 2017)  
4. (Centobelli et al., 2017)  
5. (Reefke and Sundaram, 2017)  
6. (Cloutier et al., 2020)  
7. (Packer et al., 2019)  
8. (Garcia-Torres et al., 2019)  
9. (Centobelli et al., 2018)  
10. (Dubey et al., 2017)  
11. (Saroha et al., 2020)  
12. (Kazancoglu et al., 2020) |
| Energy, material efficiency | - reduction of energy and material consumption in the supply chain - utilisation of renewable energy sources | 1. (Centobelli et al., 2020)  
2. (Saeed and Kersten, 2017)  
3. (Jadhav et al., 2019)  
4. (Kuik et al., 2011)  
5. (Vega-Mejía et al., 2019)  
6. (de Sousa Jabbour et al., 2019)  
7. (Centobelli et al., 2018)  
8. (Mejías et al., 2016) |
| Waste elimination | - reduction and elimination of the amount of waste produced in the supply chain | 1. (Jadhav et al., 2019)  
2. (Saeed and Kersten, 2017) |
| Continuity | - long term thinking applied to supply chain partnerships (e.g. partner development, close relationships) and supply chain performance | 1. (Beske and Seuring, 2014)  
2. (Gruchmann and Seuring, 2018)  
3. (Mejías et al., 2016)  
4. (Pagell and Wu, 2009) |
| Supplier assessment | - manage lower-tier suppliers’ sustainability performance (e.g. audits, codes of conduct) | 1. (Ansari and Kant, 2017)  
2. (Meinschmidt et al., 2018)  
3. (Chkanikova, 2016)  
4. (Jadhav et al., 2019)  
5. (Meinschmidt et al., 2018)  
6. (Pagell and Wu, 2009) |
| Knowledge | - awareness about SSCM and CSC practices | 1. (Beske and Seuring, 2014)  
2. (Gruchmann and Seuring, 2018)  
3. (Kaur et al., 2018)  
4. (Abbasi, 2017)  
5. (Saroha et al., 2020)  
6. (Kazancoglu et al., 2020) |
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
</table>
| Risk management                  | -reduction of reputational risk due to environmental and social non-compliance among suppliers | 1. (Carter and Rogers, 2008)  
2. (Ansari and Kant, 2017)  
3. (Reefke and Sundaram, 2017)  
4. (Beske and Seuring, 2014)  
5. (Mejías et al., 2016) |
| Life cycle assessment            | -assess the sustainability of the process, system or product                  | 1. (Beske and Seuring, 2014)  
2. (Dubey et al., 2017)  
3. (Mejías et al., 2016)  
4. (Julianelli et al., 2020) |
| Relationships, collaboration     | -manage relationships with stakeholders -enhance collaboration (e.g. enhanced communication, logistical and technological integration, shared goals and joint decision making) | 1. (Packer et al., 2019)  
2. (Cloutier et al., 2020)  
3. (Beske and Seuring, 2014)  
4. (Jadhav et al., 2019)  
5. (Ansari and Kant, 2017)  
6. (Morais and Silvestre, 2018)  
7. (Reefke and Sundaram, 2017)  
8. (Chkanikova, 2016)  
9. (Centobelli et al., 2020)  
10. (Garcia-Torres et al., 2019)  
11. (Kazancoglu et al., 2020)  
12. (Ripanti and Tjahjono, 2019)  
13. (Julianelli et al., 2020) |
| Transparency                     | -enhance transparency and traceability along global supply chains          | 1. (Rodríguez et al., 2016)  
2. (Carter and Rogers, 2008)  
3. (Garcia-Torres et al., 2019)  
4. (Mejías et al., 2016)  
5. (Kazancoglu et al., 2020) |
| Information sharing              | -enhance information sharing practices within the supply chain and with stakeholders | 1. (Ansari and Kant, 2017)  
2. (Cloutier et al., 2020)  
3. (Jadhav et al., 2019)  
4. (Morais and Silvestre, 2018)  
5. (Dubey et al., 2017)  
6. (Julianelli et al., 2020)  
7. (Saroha et al., 2020) |
| Supply chain design              | -considers an environmentally and social friendly structure for the supply chain -design of supply chain operations enabling products flow back into production systems | 1. (Cloutier et al., 2020)  
2. (Gruchmann and Seuring, 2018)  
3. (Meinschmidt et al., 2018)  
4. (Mejías et al., 2016)  
5. (Pagell and Wu, 2009)  
6. (Saroha et al., 2020) |
2.3 Surplus food in the supply chain

Food loss and waste occur at all stages of the supply chain. In developed countries, most of the losses occur in the later stages (Parfitt et al., 2010). Part of the food at risk of being lost or wasted is still edible by humans, so is recoverable. Action can also be taken at a policy level to mitigate food waste. For instance, Italy, France, and Spain approved national laws for preventing food waste and recovering surplus food (see Giordano et al., 2020).

Dora et al. (2020) analyzed the literature from 1998 to 2018 about food losses and waste in the supply chain. They proposed a conceptual model for food losses and waste prevention based on the circular economy. Their analysis included the on-farm, manufacturing, distribution and retail/wholesale, hospitality/service industry and the consumption stages of the supply chain. However, since their literature review omitted the inter-organizational causes and mitigation options, and more recent studies, this literature is reviewed next.

Studies of the retailer-supplier dyad show that performance indicators are usually related to cost, efficiency and availability, and that waste can be sacrificed for other indicators (Mena et al., 2011). For example, retailers only accept products with more than 70 percent shelf life remaining and prefer high stock levels, rather than stock outs. The risk of unsold products can be moved back in the supply chain through take-back agreements, which are most extensively implemented in the bread industry (Eriksson et al., 2017). In such instances, the retailer only pays for sold products, with unsold products returned to the supplier.

Studies of the supply chain, suggest that information sharing, in terms of demand and shelf-life data, can be used to reduce waste (Kaipia et al., 2013). In the three fresh supply chains studied, the supply chain structure was modified to speed deliveries (ibid.). This modification ensured shelf availability by omitting the logistics service provider (in all cases) and increased delivery frequency to shops from a few times a week to daily in one case (ibid.). In her multiple-case study of the food supply chain, Liljestrand (2017) stresses that collaboration between several actors in the food supply chain is important. Her paper addresses two types of waste and identifies nine logistics solutions. Mena et al. (2014) studied food waste in multi-tier supply networks in the UK. They find that when organizations remain internally focused, they may create more waste and worse practices through their pollution reduction practices. Until organizations move to the second or third tiers, stakeholders won’t see the added benefits of a holistic supply chain perspective (ibid.). Finally, Ciulli et al. (2019) investigated food supply chain brokers, who can create bridges between previously unconnected actors to recover surplus food.

2.4 Social network theory

The complexity of food supply chains does not allow for one-size-fits-all, simple solutions to the surplus food problem (Canali et al., 2017). This thesis uses SNT as a main theoretical lens since it provides a framework in which concepts can analyze and explain structural components through a multi-actor perspective. The following section presents the main ideas of SNT and its application to supply chains.

SNT has its roots in the field of sociology. Social network theorists strive to explain the social world in term of relationships that actors form (as they influence each other), rather than acting independently (Kurt and Kurt, 2020). It differs from theories such as
transaction cost, in which exchange is seen as purely transactional (Carter et al., 2007). Therefore, the social world for social network theorists is seen in terms of interactions, and the unit of analysis is the pattern of relationships (Kurt and Kurt, 2020). However, the researcher defines the network boundaries by choosing the nodes and ties to study (Borgatti and Halgin, 2011). Nodes and ties may not be incorrectly selected. Instead, the boundaries of the network are guided by the particular study’s objective and theory.

Two of the most well-known papers among social network theorists are Granovetter’s strength of weak ties (American Journal of Sociology, (1973). 78(6), 1360-1380) and Burt’s structural holes theories (Structural Holes: The Social Structure of Competition (1992). Harvard University Press, Cambridge, MA). Granovetter (1973) deals with network structures at the level of interpersonal ties. His first underlying idea is that the stronger the tie between two people, the more likely it is that their social worlds will look similar and they will have connections to the same third parties (Borgatti and Halgin, 2011). Tie strength is a combination of the amount of time, the emotional intensity, the intimacy (mutual confining), and the reciprocal services which characterize that tie (Granovetter, 1973, p. 1361). The second idea is that linking a person to someone not connected to any other friends (known as bridging ties) can be a potential source of novel information (Borgatti and Halgin, 2011). Therefore, weak ties are bridges and best potential sources of novel information. This idea is often used to explain individual social capital, in which people with many weak ties are more successful, and is a backbone of social capital theory (cf. Adler and Kwon, 2002). Burt (1992) uses the same logic as Granovetter (1973). They mainly differ in that Granovetter (1973) emphasize the strength of ties, whereas Burt (1992) opts for bridging ties. Furthermore, Burt (1992) takes a more instrumental and strategic view on why people form connections, as compared to Granovetter (1973). In essence, Burt (1992) emphasizes the nodes surrounding the focal actor in a network. A network can involve structural holes, in this case, a central actor may take on the role as a broker between unconnected actors, hence the holes (Kilduff and Brass, 2010). Network closure refers to the case when the central actor is densely connected to all members, hence, the closure (ibid.). More dispersed networks can produce more novel ideas.

Borgatti and Li (2009) explain how SNT can be applied to supply chain research. In particular, the network perspective views any system as a set of actors and nodes (ibid.). Figure 3 presents a typology of types of ties usually studied among individuals, with examples from organizations as entities. First, Borgatti and Li (2009) make a distinction between continuous and discrete types of ties. Continuous relations among firms are always on and can be considered relational states, whereas discrete ties are separate events, that may add up. At the next level, ties can be divided into four groups: Similarities, relations, interaction and flows. Similarities are pre-social occurrences, such as membership in the same group or working in the same space (such as, researchers attend the same conferences). Relations are continuously existing ties between firms (such as distribution agreements or friendships between employees in different companies). Interactions are events that occur over a period of time. The strength of such ties is determined by the number of interactions between two actors. A market transaction would be an example of such an interaction. Flow refer to content that is transferred between actors when they interact (hard flows are materials or money, while soft flows are ideas or information). The flows result from the other kinds of ties.
Figure 3 Typology of types of ties among firms. Adopted from Borgatti and Li (2009)

Critics to the application of SNT on a supply chain phenomenon would say that SNT is a theory for studying social networks and such micro theories of behavior have not sufficiently been tested and applied to organizations as unit of analysis (Galaskiewicz, 2011). While it is common in the supply chain discipline to borrow theories and concepts from other fields (Halldórsson et al., 2015), all concepts from SNT are not applicable to SCM which limits its full application to this thesis. What I do to overcome this limitation is to draw on certain concepts from SNT, such as, structural holes, structural embeddedness, brokerage roles and strength of interactions that are useful for understanding the interface among supply chain actors.

2.5 Theoretical framework

The theoretical framework (see Figure 4) operationalizes the purpose statement of this dissertation and integrates the above presented literature streams. In the center, the figure depicts the processual relationship between the main concepts, supply chain structure and development of sustainable supply chains.

RQ1 seeks to identify which elements of supply chain structure can be modified to enhance development of sustainable supply chains. The foundation for answering this research question comes from the literature review (Table 2 in Section 2.1) which introduces five modifiable elements of supply chain structure: Overall objective, involved actors (contributing to its shape), relevant determinants, level of centralization and attention to sustainability attributes. These elements are summarized at the bottom left in the figure and can be viewed as possible theoretical means for reducing energy, material use and waste generation within the supply chain.
Figure 4  Theoretical framework

The left side of the figure is based on traditional supply chain literature and RQ1 refers to modifiable elements of a typical supply chain. When moving from a typical supply chain to a supply chain structure that can deal with surplus food recovery, what the supply chain does and the elements it involves may need to be reconceptualized. This is captured by moving up and to the right side of the figure, where the empirical research context first is introduced. The two-parted RQ2, seeks to focus exclusively on two elements, actor roles and relationship types, to analyze how the supply chain better can accomplish the goal of recovering surplus food and aims to enrich traditional theory. The right side of the figure draws on SNT to analyze these two structural elements by shedding light on patterns of interaction between actors within supply chain structures. This theoretical framework will guide the forthcoming analysis, and forms the basis for discussing the results in Section 5.1 where a more developed framework combined with empirical material is presented.
3 RESEARCH METHODOLOGY

This chapter describes the ontological, epistemological and methodological underpinnings of this thesis. Furthermore, it describes the research process, research design and methods, and the quality of the undertaken research.

3.1 Research philosophy

Scientific research takes place within diverse research paradigms. A paradigm can be seen as a worldview, or a set of shared assumptions about the world, shared by a community of scientists (Guba and Lincoln, 1994, p. 107). There are four such paradigms: Positivism, critical theory, constructivism, and realism (Guba and Lincoln, 1994). The three elements of ontology, epistemology and methodology span across these paradigms. Ontology concerns questions about the world, or reality, that is under investigation. Epistemology deals with how knowledge (or understanding) is created and what can be known about the world. Methodology is about the techniques used to investigate the phenomena in which researchers are interested and follows their ontological and epistemological stances. This thesis adopts critical realism (CR) as its research philosophy, which can be seen as part of realism (O’Mahoney and Vincent, 2014). This choice is explained further in the following paragraphs.

CR believes that there is a real world out there to study, but what we can learn and know about this world is limited and contextually bounded (Wynn and Williams, 2012). For this research it means that while improvements to current surplus food management practices can be made, I must be certain that I understood the worldview of the participants, rather than presenting theoretical solutions to problems that do not exist in the empirical world. Moreover, CR distinguishes between three aspects of reality (ontology): Real, actual and empirical (O’Mahoney and Vincent, 2014). The real are the entities of structures and the casual powers that generate the actual world, together with the empirical. The actual are the events that occur in time and space. Finally, the empirical is what we perceive to be the case. These assumptions of CR guided my research, making me aim to identify the underlying mechanisms (reasons) for the empirical phenomenon of surplus food in the supply chain. At the same time, I also must be sensitive to the fact that I can only observe fractions of the actual and that this thesis cannot deliver a complete picture.

The principle of double recognition is distinctive to CR, in that an objective world exists, independently of people’s perceptions, language or imagination, but that subjective interpretations also influence how the world is perceived and experienced (O’Mahoney and Vincent, 2014). This means that I did not take all information the informants provided as inherently true (as participants also have their own perspectives and agendas, some stronger than others). Instead, if a participant provided an interesting piece of information, I would ask about it in forthcoming interviews with other participants who were familiar with the same issue. Another distinctive aspect of CR is that it sees reality as an open system. In other words, events cannot be studied or understood in isolation from their environment. Accordingly, Aastrup and Halldórsson (2008) state that logistics structures are made up of both material and non-material elements. This means that actors can enable or inhibit the surplus food flow as they interact in the supply chain structure. Due to nature of the aforementioned complexity of food supply chains, and this thesis’s purpose statement seeking to uncover structural issues, it follows an abductive research approach when moving from the empirical to the
real. The next sections elaborate on the research process, research design and the adopted methods.

### 3.2 Research process

This research project has lasted around 5 years. It started in September 2016 and ended in June 2021. The first 1.5 year I took courses that supported my learning journey towards this PhD. Essay 1 was initiated in fall 2016 and eventually published in April 2019. Most of the data collection for Essay 2 took place during spring 2018, and the paper was presented at the NOFOMA conference in 2018. After this, the paper was submitted to a journal and published in October 2020. Data collection for Essay 3 mainly took place in February and November 2019. Data analysis and paper writing was ongoing in parallel, until the paper was submitted to an academic journal in summer 2020. The writing of the final kappa manuscript mostly took place in fall 2020 and the internal manuscript seminar was held in November 2020.

Figure 5  Research process (CW=course work, DC = data collection, PW = paper writing, R= revisions, KW=kappa writing)

### 3.3 Research design and methods

The research process has not been linear. Instead it has been a continuous interaction between the theoretical and the empirical world through data collection, analysis and interpretation. This process could be described as abductive (Kovács and Spens, 2005). It is common in qualitative research to move back and forth between theory and data and make amendments as better insights emerge. Dubois and Gadde (2002) explain that an abductive approach means going back and forth between the empirical and theoretical, in a process called systematic combining. In systematic combining, the “theoretical framework, empirical fieldwork, and case analysis evolve simultaneously” (Dubois and Gadde, 2002, p. 554). Early in the research process, I consulted the literature around supply chains and surplus food to develop the interview guide. However, since the literature could not provide the complete picture, data collection allowed for openness and exploration. Essay 2 in particular changed form from the initial conference publication to final journal publication to better establish the link between the theoretical framework, the findings, and the theoretical contributions. Similarly, the theory choice,
SNT, came rather late in this research process. Since this research was phenomenon-driven (Schwarz and Stensaker, 2014), no theory was selected a priori, instead, openness was allowed for when collecting and analyzing the empirical data. Due to the iteration between the theoretical and the empirical (Kovács and Spens, 2005), alternative theories, such as, the industrial network approach and social exchange theory had been consulted before SNT eventually was chosen since it helped to elaborate on the relationships among the actors, as summarized in Table 4 on the next page. SNT was incorporated in Essay 2 at review stage and in Essay 3 at data collection stage.

As Gummesson (2017, p. 171) pointed out, creating knowledge is an interactive process between the knower (the researcher), the known (what we know about an issue) and the process of knowing (the research process and its methodology). In contrast, an inductive approach (such as grounded theory) would start with the empirical, since researchers believe that prior theoretical knowledge would otherwise influence the results through pre-understandings (Gehman et al., 2018). On the other hand, a deductive approach would aim to test the appropriateness of a theory.

This dissertation comprises a conceptual study and two empirical studies. Table 4 illustrates the three essays and their respective methods. Essay 1 is a book chapter, with most of the text written during my first year of the PhD program. It is an effort to integrate the sustainability literature, particularly sustainable supply chain literature, around the concept of energy. The book chapter was an important experience, as it enabled me to work with sustainability literature and learn how to conceptualize around the fuzzy topic of sustainability. The book chapter was developed after the literature had been screened for supply chain and energy related papers, and the reverse logistics and closed-loop literature had been reviewed. The paper identifies energy consuming attributes of supply chains. Furthermore, I also gained relevant experience in academic writing from collaborating with my two co-authors.

However, based on feedback from seminars and conference presentations, I altered the original idea of combining the food and energy nexus in my dissertation to focus mainly on the food product, and its recovery, in Essays 2 and 3. The concept of energy efficiency is commonly referred to as energy input in relation to output, with expected quantifiable results (cf. European Parliament, 2012). While life cycle assessments of food products have attributed minimal carbon footprint to food transportation in comparison to the raw material production processes and farming stages of the supply chain (Virtanen et al., 2011). The focus thereby shifted from efficiency to effectiveness of supply chain structures as the main focus of Essays 2 and 3. Effective supply chain structures are the mean through which by-products (i.e. surplus food) can be cascaded and delivered to new consumers.

As presented in Table 4, Essay 2 is an abductive study that uses a multiple-case study to investigate novel surplus food actors and identify actor constellations (including roles and interactions) that enable surplus food distribution. It does so by the means of a qualitative multiple-case study. Essay 3 also follows an abductive approach and uses a qualitative interview design to explore the formation of relationships for food redistribution at the donor-receiver dyad. The research methods adopted in Essays 2 and 3 will be explained further in the next sections.
### Table 4 Summary of methods

<table>
<thead>
<tr>
<th>Essay</th>
<th>Research design</th>
<th>Sampling</th>
<th>Data collection</th>
<th>Data analysis</th>
<th>Theory deployed</th>
<th>Results</th>
<th>Research question</th>
</tr>
</thead>
</table>
| 1     | Conceptual study| Profit and planet: energy efficiency | Literature:  
- Search 1: supply chain* and energy, fuel, gas, electricity, renewable, CO2  
- Search 2: reverse logistics and closed-loop supply chain | Selective coding of energy consuming attributes  
Integrative framework | Theory: no grand theory deployed  
Main concepts: energy efficiency, supply chain design, environmental sustainability  
Why: The main concepts are used to illuminate supply chain principles contributing to energy consumption, and identify areas for improvement | Energy consuming attributes of supply chains | 1 |
| 2     | Multiple-case study | Three novel actors working with surplus food | Pre-interviews:  
- 1 interview (novel actor, food waste restaurant)  
- 2 expert discussions  
Main data:  
- 10 interviews, 3 with novel actors (surplus food platform, online retailer, surplus food terminal)  
- 20h of observations  
- Documentary evidence  
Follow-up interview:  
- 1 interview (novel actor, social supermarket) | Initial coding of one interview, axial coding among organizations in a case, and comparisons of interviews between cases  
Within-case analysis  
Describing structural features, interactions and roles  
Cross-case analysis  
Comparing cases by recovery solution, supply chain structure, interactions and roles | Theory: SNT  
Main concepts: supply chain structure, actor constellation, actor roles, interactions  
Why: As the actors in the constellation were found to be interconnected, SNT could explain these relationships through its concepts of brokerage roles and interactions. | Identified actor constellations, and within these, actor roles, interactions and transportation impact | 1, 2a, 2b |
| 3 | Qualitative interview study | Donors and receivers of surplus food in Finland | Pre-interviews: -1 expert discussion  
Main data: -18 semi-structured interviews (10 receivers and 8 donors) | First, process coding was applied on first and secondary data which was analysed inductively and resulted in first order concepts.  
Second, similar codes were grouped into categories as patterns were identified to develop second-order themes.  
Third, second-order themes were abductively grouped into aggregate dimensions | Theory: SNT  
Main concepts: actor relationships, structural holes, structural embeddedness  
Why: Since the reasons to food waste were due to loose/non-existent ties between surplus food generators and potential receivers (thus, embedded in social relationship), SNT explains this outcome through tie content and existence of structural holes. | Identified four categories – (1) ongoing redistribution, (2) sporadic redistribution, (3) the establishment of new relationships, and (4) relationship imbalance of redistribution relationships | 1, 2a, 2b |
3.3.1 Multiple-case study

Case study research is an methodology used for studying the complexity of the real world, acknowledging that business, governments, society, and life in general are complex phenomena (Gummesson, 2017, p. 10). The complexity paradigm states that business and management are characterized by numerous factors and inter-relations, but that these are hard to identify and their behavior is hard to predict (Gummesson, 2017, p. 49). A case study methodology is useful when how and why questions are asked about a contemporary phenomenon, and the boundaries between the phenomenon and the context not are clearly evident (Yin, 2014). A case study methodology was found appropriate in Essay 2 to answer the study’s research questions, since rich explanations and deep insights about the novel actors’ supply chain structures were sought for.

3.3.1.1 Data collection and analysis

Case studies can be conducted on a single case, multiple cases or embedded cases (Yin, 2014, p. 50). Essay 2 is a multiple-case study, including three cases. The unit of analysis –the case - is the actor constellation of which the novel actors are part. The initiating actors were selected based on two criteria: (1) they are addressing the surplus food problem and (2) are a new actor in the supply chain. Data collection begun among the initiating actors (surplus food platform, online retailer, surplus food terminal) working with surplus food. The other actors in the case (the surplus food suppliers) were identified by snowball sampling. Table 4 further summarizes the interviews conducted.

Before the main study begun, I did internet searches, and attended events on food waste, to identify relevant actors and initiatives on food waste reduction. I first conducted a pre-interview with a local food waste restaurant, which provided important insights about the topic. However, this interview was not included in the analysis, since the interview was collected at an early stage and the other actors were considered to have larger potential for surplus food recovery. At this stage, I also met two experts in the field - one food waste researcher and expert working with food waste at the ministry. These discussions helped me gain insights about the latest policy developments and theoretical discussions and ensure the relevancy of my research.

As illustrated in Table 4, I began my analysis by writing initial memos summarizing the core of each actor’s perspective. I then compared each organization’s views by the means of axial coding, while common themes, patterns and categories were established (Boeije, 2002). After this, within-case analysis was conducted and the findings around the concepts of emerging supply chain structures, interactions in the supply chain structure and actor roles were derived. Finally, I conducted cross-case analysis and the findings around recovery solutions, supply chain structures, interactions and roles were compared and presented in table 2 in Essay 2.

After the study period had ended, a fourth actor (not-for-profit) had established itself in the field. I interviewed this social supermarket in December 2019. The supply chain structure was linear, similar to Case 3. Therefore, this actor was not included as a separate case for further analysis. It also shows that saturation had been reached within this geographical area.
3.3.2 Interview study

Within the qualitative research approach, multiple data sources (such as archives, field observation, and media documentation) are commonly used, while the semi-structured interview is the primary source of information in qualitative research (Gioia et al., 2013). To gain insights about dyadic relationships for surplus food recovery at an actor level, Essay 3 adopts semi-structured interviews as its main data source. This approach ensured that relevant topics were covered, while also allowing for discussions that emerged during the interview. Furthermore, questions could be revised, and issues that came up in one interview could be verified in forthcoming ones. To engage in the interviews, I needed to establish trust (by ensuring anonymity) with the participants to allow them to share information relevant for my research questions.

3.3.2.1 Data collection and analysis

Based on the outcome of an expert discussion, I decided to look in-depth into the cooperation between food donors and NGOs. Data collection begun from the receiver side of the dyad, and a list of food aid organizations was developed based on secondary sources. Most of the sampled organizations were geographically located around the Helsinki capital area, or in nearby cities, and were large charity organizations and food banks. I considered that organizations recovering larger amounts of food (in addition, most of the food industry is located close to the capital area), would be more involved in relationships than, would small, local charity organizations. This sampling strategy, known as intensity sampling, focuses on information-rich examples (Patton, 2015). The informants generally were project managers or founders, who provided both a broad picture of the organizations’ operations, the food aid field in general, and more detailed information about some specific relationships with food donors. Subsequently, I used a snowballing approach and maximum variation logic (Patton, 2015) to select donors. I included donors at different product categories (ambient and chilled) and different supply chain stages (distribution center, wholesale and retail). Frozen products were not included due to that considerably less surplus arises from this category (e.g., Garrone et al., 2014b). In total, 18 interviews with donors and receivers were collected as shown in Table 4.

Data analysis proceeded in three steps (see Table 4). First, ‘process coding’ (Miles et al., 2020) was followed when the first and secondary data was analyzed inductively until first order concepts emerged. Second, ‘second order themes’ (Gioia et al., 2013) were developed by grouping similar codes into categories. Third, the second-order themes were grouped into ‘aggregate dimensions’ (ibid.). The second and third stage of the analysis process was ‘abductive’ since I alternated between the empirical material and theory until the categories had been refined (Alvesson and Kärreman, 2007). A more thorough description of the data collection and analysis can be found in Essay 3.

3.4 Research quality

Rigor in research is important to ensure that the findings are worth paying attention to. Quantitative researchers rely on the four criteria of internal validity, external validity, reliability and objectivity for establishing rigor in research. Based on a similar approach, Yin (2014) uses the criteria of construct validity, internal validity, external validity and reliability for evaluating case study research. However, further modified criteria for ensuring the quality of the produced findings are more suitable for qualitative research.
This is known as trustworthiness. Table 5 summarizes the activities I undertook to improve the trustworthiness of the findings in this thesis.

Table 5 Criteria for establishing trustworthiness. Source: Lincoln and Guba (1985)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Definition of criteria</th>
<th>Application in this research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credibility</td>
<td>Truth value of the findings</td>
<td>- Triangulation of interview data sources, such as interview transcripts and secondary data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Triangulation of case study data sources, such as interview scripts, observations and documentary evidence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Verifying information in forthcoming interviews</td>
</tr>
<tr>
<td>Transferability</td>
<td>Application of findings in other contexts or with other subjects</td>
<td>- Thick description of case study context</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Description of research context</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Purposeful case and respondent sampling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Interviews with multiple respondents allows for a broader understanding of the context</td>
</tr>
<tr>
<td>Dependability</td>
<td>Possibility to replicate the findings with the same subjects or same context</td>
<td>- Case and participant selection are described</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Data collection process is carefully described</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Data analysis process is carefully described</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- A clear chain of evidence is established from data to interpretations by providing a rich set of quotations (see Figure 2 in Essay 3).</td>
</tr>
<tr>
<td>Conformability</td>
<td>Findings are determined by subjects and not by biases, motivations, interests, or perspectives of the researcher</td>
<td>- Interviews with multiple respondents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Triangulation of different data sources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Seeing informants as ‘knowledgeable actors’ (Gioia et al., 2013)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Coding stability was established by computing the intracoder reliability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Comparison of findings with literature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Presentation of results to an academic audience</td>
</tr>
</tbody>
</table>

Lincoln and Guba (1985) suggest four criteria for establishing trustworthiness in qualitative research. Credibility, transferability, dependability, and conformability. Halldórsson and Aastrup (2003) recommend these same four criteria for qualitative studies of logistics (and SCM), especially when the study is dealing with soft issues.

The first criterion is credibility, which refers to the truth value of the findings. In line with the critical realist perspective, reality exists in the minds of the informants and is contextual (Halldórsson and Aastrup, 2003). Therefore, the researcher should aim for creating a correct representation of the reality pictured by informants (ibid.). I addressed credibility by using multiple sources of data to triangulate the observations.
Furthermore, I verified information collected in one interview in subsequent interviews to draw conclusions based on multiple respondents’ perspective.

The second criterion is transferability. Transferability refers to providing sufficient detail about the time and context of the research so that the findings can be transferred to other contexts (Lincoln and Guba, 1985). However, not all findings are necessarily transferable. Instead, the findings should be contextualized (Halldórsson and Aastrup, 2003). It is important for the research to provide such details so that transfer to other contexts can be made. I addressed transferability by carefully describing the research context (developed country, food industry), purposefully selecting cases and interview respondents, and interviewing multiple respondents to allow for a broader understanding of the context.

The third criterion is dependability, which ensures that the findings can be replicated with the same subjects, or within the same context. Lincoln and Guba (1985) refer to a dependability audit, in which both the process and the product would be metaphorically auditable. In qualitative research it is usual to shift perspectives due to better insights, but this process must be well described (ibid.). I addressed dependability by describing how the cases and participants were selected. I then carefully detailed the data collection and analysis processes and established a clear chain of evidence from data to interpretations by providing a rich set of quotations (see Figure 2 in Essay 3).

The final criterion is conformability which ensures that the findings represent the result of the inquiry, rather than the researcher’s biases, motivations, interests, or perspectives (Lincoln and Guba, 1985). I addressed conformability by conducting interviews with multiple respondents, triangulating multiple sources of data, explicitly noting that respondents were knowledge holders, calculating the intracoder reliability for the developed coding scheme, and constantly comparing emerging findings with literature. Finally, the review process of the essay manuscripts helped establish the link to conformability by acting as an external auditor.
4 SUMMARY OF ESSAYS

This section summarizes the purpose, research methods, and main results of the three essays. The full essays can be found attached in the Appendix.

4.1 Essay 1: Sustainable supply chains and energy: where ‘planet’ meets 'profit'


This paper argues that energy efficiency can be a generative mechanism of sustainable supply chains because the physical movement of products and material (and, in turn, how much energy and what type is used in the supply chain) is an outcome of the supply chain’s structure and strategic priorities. It suggests that the supply chain’s structural attributes can be managed, by focusing on both actors and their relationships, so sets conditions for reaching more sustainable supply chains. The paper follows MacInnis (2011) integration approach, by aiming to unite energy as part of sustainable supply chains to allow managers to unite economics and environmental reasoning in their decision-making and actions. It does this by presenting a framework that identifies four system levels (technology, activities, actors, and design) in which improvements in energy efficiency should take place. At the supply chain design level, it argues that there is potential for slowing down the supply chain (McKinnon, 2016) and re-evaluating responsive supply chains since such just-in-time principles increase overcapacity and energy consumption, due to increased transport. Moreover, the paper discusses energy consuming attributes and energy efficiency potential based on four areas that cut across the supply chain: (1) freight capacity utilization, (2) last-mile fulfillment options, (3) sourcing and supply management, and (4) reverse logistics and closed-loop supply chains.

4.2 Essay 2: Supply chain structures for distribution of surplus food


The purpose of this study was to analyze the different supply chain structures that have emerged to make surplus food available to consumers. Since existing supply chain structures produce food waste (so, are unable to deal with the chain’s externalities), the paper investigates three new actors: A food sharing platform, an online retailer, and a surplus food terminal. They all form part of and have created supply chains that can handle surplus food. Since the topic is relatively unexplored, I chose a qualitative multiple-case study, including three cases as research method. Two of the cases involve for-profit actors, while the third was a not-for-profit actor. The other actors in each case (namely, the surplus food suppliers) were approached through snowball sampling. Data was collected in 2018, and included 10 semi-structured interviews, 20 hours participatory observations, and documentary evidence.

The results showed three novel actor constellations (triadic, tetradic, and dyadic microstructures) in the food recovery context. More specifically, they showed that a third
party has an important role in connecting actors with surplus food with consumers. The third party takes up different roles and contributes with different services, such as, logistics services, auditor or consultant. Furthermore, the results showed that the links among novel actors and surplus food suppliers are weak, fortifying the active role of the third party.

4.3 Essay 3: Circular supply chain relationships for food redistribution

Sundgren, C. Submitted for review to an academic journal.

This study explores the formation of relationships for food redistribution to improve circularity and social sustainability at the end of the food supply chain. In particular, the study investigates existing relationships between business and not-for-profit actors, as well as how such relationships can be established. This essay is an interview study with 10 semi-structured interviews among not-for-profit organizations and eight semi-structured interviews with business actors. Data was collected in Finland during February, November, December 2019 and January 2020. The semi-structured interview guide covered dyadic relational issues in the surplus food context by focusing on the involved actors, what kind of relationships were prominent and why, and identifying potential for further improvement.

The results derived show that redistribution can be either ongoing or sporadic, with most organizations investigated having some ongoing relationship, through which redistribution took place approximately on a weekly basis. An important part of these relationships was that the parties trusted each other, as there are concerns about donated food being sold or food organizations failing to comply with food safety. The food aid organizations experience challenges, due to the lack of information beforehand regarding amounts donated, which makes it challenging for them to plan the use of food. Furthermore, the quality of the donated food is sometimes an issue, as food which is no longer suitable for human consumption is donated to charity and companies exploit the resources of the food aid organizations. The results also showed a lack of knowledge about food waste and food aid organization activities among the SCM professionals. More surplus food could be recovered if the relationships were closer, as the parties could then discuss potential areas for further food recovery. The results further showed the vast number of different food aid organization, which are not always equitable when it comes to which food aid organization receive resources and how they are distributed.

Furthermore, the results show that when new relationships are established, they go through phases of awareness and exploration. Media coverage and personal contacts were used to get in contact with potential cooperation partners. Relationship imbalance occurred when the costs for suppliers were perceived as too high, such as if receivers engaged in bargaining. Finally, smaller quantities of surplus are also more challenging to efficiently recover.
5 DISCUSSION OF RESULTS AND CONCLUSIONS

This dissertation aims to enhance our understanding of how supply chain structures can promote surplus food recovery and implications for the development of sustainable supply chains. This chapter summarizes and discusses the key findings and contributions of this dissertation. The chapter ends with discussing this dissertation’s managerial and societal implications, outlining its limitations, and providing suggestions for future work.

5.1 Key findings

Figure 6 below sheds light on the overarching aim of this dissertation by presenting a developed framework based on the theoretical framework in Section 2.4 (Figure 4). The left side of the figure incorporates the findings from Essay 1 on energy efficiency of the structure, draws on the modifiable elements identified in Section 2.1, and compares these with the findings from Essays 2 and 3. This side of the figure encapsulates the supply chain structure itself becoming more sustainable. The right side of the figure draws on the empirical research from the surplus food recovery context. The findings from Essay 2 about roles among food supply chain actors, intermediary actors and consumers are discussed in relation to RQ2 (a). The findings from Essay 3 about different redistribution relationship types and contextual factors at the interface of business and not-for-profit actors are summarized in the figure and discussed in relation to RQ2 (b). The insights drawn from RQ2, provide knowledge about supply chains aiming for the goal of surplus food recovery. Next, the answers to the research questions are discussed in more detail.

**RQ (1): Which elements of supply chain structures can be modified to enhance the development of sustainable supply chains?**

Supply chain structures have an important task to develop into forms that cause less harm for the environment. The findings from the conceptual study (Essay 1) suggest that energy efficiency improvements can be addressed on different levels, with the highest level being supply chain design. A focus on supply chain design provides a holistic approach to sustainability. Several aspects can be modified in the structure to enhance energy efficiency.

For example, can customer response times and aggressive distribution strategies be reevaluated, as just-in-time tend to lead to less energy efficient modes of transportation (air, rather than sea) and low fill rates. Furthermore, sourcing decisions should favor local sourcing (to reduce long distance transportation) and favor renewable energy sources. Moreover, generous return policies should be re-evaluated to reduce the number of items that customers send back. Transportation can be made more efficient by switching to low carbon transportation modes. For instance, walking or biking should be promoted, particularly for the last-mile to avoid unnecessary use of private vehicles (Halldórsson and Wehner, 2020). Furthermore, better route planning, and adaptations to time slots in warehouses can reduce commercial vehicles driving distances, while fill rates can be enhanced through vehicle-sharing capacity to consolidate full truckloads (Essay 1).
Figure 6  Framework of supply chain structures promoting development of sustainable supply chains

Note: the numbers 1, 2, 3 refer to Essays 1, 2 and 3 in this dissertation
Based on the various perspectives presented in Table 2, five elements of the structure that can be modified for supply chains to develop into more sustainable forms were identified: Overall objective, relevant determinants, actors involved, level of centralization and attention to sustainability attributes. Each of these elements is discussed below and is compared to the empirical findings from Essay 2 and 3 (see Table 6).

First, beginning with the overall objective, supply chain structures are designed to reach one objective or multiple inter-related objectives. As Cuthbertson and Piotrowicz (2008) note, traditional supply chain objectives tend to be economic or operational, and related to cost, time, quality and the customer. However, such objectives are not related to sustainable development. Not surprisingly, the overview in Table 2 show that the overall objective give ground for the priorities in the supply chain structure. For instance, when a structure is designed for cost efficiency, supply chain operations will focus on minimizing physical costs through reducing inventory and maximizing production efficiency (Fisher, 1997). However, there is also support for including sustainable development objectives (which are features of humanitarian and other not-for-profit structures), and the findings in Table 6 show that reuse and redistribution can be the objective of supply chain structures. The literature similarly suggests that almost all sustainable organizations reconceptualized their supply chain’s objectives to be more aligned with natural, social, and economic objectives (Pagell and Wu, 2009).

Second, determinants form the configuration, as is shown in Table 2 with the product’s marginal value of time in reverse structures (Gobbi, 2011). However, the relevance of certain determinants can change while responding to contingency factors, as marginal value of time would be irrelevant in industries unaffected by rapid loss of product value (ibid.). Relationships and collaboration are important attributes of sustainable supply chains (Beske and Seuring, 2014), similarly these are relevant determinants in Essay 2 and 3. As presented in Table 6, the findings from Essay 2 show the configuration is formed by the presence of emergent actors, although interactions among traditional food supply chain actors and emergent actors are weak. Essay 3 highlights that availability and access to supply shape the configuration, which is found to be highly receiver-side driven.

Third, the main actors in supply chains tend to involve suppliers, focal firm and customers through which materials, services, finances or information flow. Typically, the supply chain configuration is bounded by the focal actor in the chain (Carter et al., 2015). However, the actors involved can be changed, or substituted (as would also be the case when a different supplier is selected), to create different configurations. The findings from Essay 2 show that the actors involved in these structures involve surplus food suppliers (in all cases), emergent actors (surplus food platform in case 1, online retailer in case 2, surplus food terminal in case 3), a logistics service provider (in case 2), and further downstream consumers (in case 1 and 2) and food aid organizations (in case 3). Depending on whether a food bank is involved or not, indirect or direct redistribution occurs in Essay 3. By shifting the focus away from the usual supply chain, to the supply chain structure, these examples show how surplus food can flow from traditional supply chain actors (the surplus food suppliers) to new consumers instead of being wasted. These findings support the argument that sustainable supply chains often include non-traditional supply chain actors (Pagell and Wu, 2009; Rodríguez et al., 2016).
<table>
<thead>
<tr>
<th></th>
<th>Triad (Essay 2)</th>
<th>Tetrad (Essay 2)</th>
<th>Chain (Essay 2)</th>
<th>Dyad (Essay 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall objective</strong></td>
<td>Selling surplus food (Reuse)</td>
<td>Selling surplus food (Reuse)</td>
<td>Redistribution</td>
<td>Redistribution</td>
</tr>
<tr>
<td><strong>Determinants</strong></td>
<td>Weak interactions</td>
<td>Weak interactions</td>
<td>Weak interactions</td>
<td>Supply (access and availability)</td>
</tr>
<tr>
<td><strong>Shape of supply chain</strong></td>
<td>Suppliers, surplus food platform, consumers</td>
<td>Suppliers, online retailer, logistics service provider, consumers</td>
<td>Suppliers, surplus food terminal, food aid organizations</td>
<td>Indirect redistribution: suppliers, food bank, charity organization, beneficiaries</td>
</tr>
<tr>
<td></td>
<td><strong>Configuration</strong></td>
<td><strong>Configuration</strong></td>
<td><strong>Configuration</strong></td>
<td><strong>Configuration</strong></td>
</tr>
<tr>
<td><strong>Configuration</strong></td>
<td>Decentralized structure</td>
<td>Centralized structure</td>
<td>Centralized structure</td>
<td>Centralized structure</td>
</tr>
<tr>
<td></td>
<td>Triadic actor constellation</td>
<td>Tetradic actor constellation</td>
<td>Dyadic actor constellation</td>
<td>Sporadic vs. ongoing dyadic constellations</td>
</tr>
<tr>
<td><strong>Sustainability</strong></td>
<td>Product reuse (new consumer base)</td>
<td>Product reuse (new consumer base)</td>
<td>Food redistribution</td>
<td>Food redistribution</td>
</tr>
<tr>
<td><strong>attributes</strong></td>
<td>Consumer arranges transportation</td>
<td>Inbound transportation by truck to warehouse and outbound transportation to service point</td>
<td>Arranges pick-ups and deliveries</td>
<td>Not considered/ Transportation arranged by receiver organization</td>
</tr>
<tr>
<td><strong>Contingency factors:</strong></td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Operating environment</strong></td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>-complexity</td>
<td>Emergent</td>
<td>Emergent</td>
<td>Emergent</td>
<td>Temporary</td>
</tr>
<tr>
<td>-dynamism</td>
<td>Typical</td>
<td>Typical</td>
<td>Typical</td>
<td>Permanent</td>
</tr>
<tr>
<td><strong>Age of supply chain</strong></td>
<td><strong>structure</strong></td>
<td><strong>structure</strong></td>
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<td><strong>(typically)</strong></td>
<td>Emergent</td>
<td>Emergent</td>
<td>Emergent</td>
<td>Temporary</td>
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</table>
Fourth, in accordance with earlier literature, the level of centralization is modifiable. Halldórsson and Wehner (2020) consider how the level of centralization influences energy efficiency of the commercial vehicle offloading point in the last mile leg. Although decisions about structure centralization are expected to be made in accordance with a product’s marginal value of time (Gobbi, 2011), the results from Essay 2 show that perishability influence the structure only in cases 1 and 2, where a decentralized structure for chilled products and a centralized structure for ambient products have been established. Meanwhile, the results from case 3 in Essay 2 and from Essay 3 show that centralized structures have been established in food redistribution for beneficiaries (although they deal with ultra-fresh products). To reach more decentral structures, preferable for most food products due to their perishability, food supply actors need to be further involved.

Fifth, managerial decisions about which sustainability attributes to consider in the structure or exclude (due to such factors as cost trade-offs) are related to managerial cognition and can be influenced. In practice, there are often trade-offs between the social, environmental and economic pillars of sustainability (Carter et al., 2019). As is shown in Table 6, the environmental benefits are considered by saving the surplus food, while e.g. how the transportation was arranged was not particularity important. Furthermore, redistribution has social benefits by providing beneficiaries with a low-cost or free meal or food products. As discussed in the beginning of the section, Essay 1 provides insights into several aspects SCM managers can consider to enhance the energy efficiency of the structure.

**RQ (2a): How can different actor roles in the supply chain contribute to surplus food recovery?**

In extant literature, traditional supply chain roles involve suppliers, labor, engineering, production, product, quality assurance, inventory, competitors and customers (Sampson and Spring, 2012). Coordinating these roles across various organizations and departments, is a cornerstone in managing supply chains. Furthermore, some of these roles are limited, while others are expanded. Similarly, actor roles give us an understanding about the tasks and motivations that traditional, intermediary, and other actors in the broader food supply chain undertake.

The findings from the multiple-case study (Essay 2) demonstrate that the emergent actors take up the brokerage roles of *conduit* and *tertius iungens*. *Conduit* brokerage is simpler, and aims at facilitating flows, while a *tertius iungens* have an active coordinating role by linking actors together (Obstfeld et al., 2014). More specifically, three roles were identified. Connector, logistics service provider and service provider. Three additional sub-roles were identified: Mediator, auditor and consultant. The main roles assumed all support linkages between those actors with the surplus food resource and new consumers. A digital platform can facilitate the flows (as in case 1) by connecting supply and demand, while physical distribution was essential to enable the flows of surplus food in cases 2 and 3. Ciulli et al. (2019) identified six brokerage roles (connecting, informing, protecting, mobilizing, integrating and measuring) and 15 sub-roles, among digital platform intermediaries facilitating surplus food recovery. The similarities and differences between these roles, and sub-roles, and the roles I identified in my research are covered in the discussion section in Essay 2.

In contrast, traditional supply chain actors have taken up a passive role. They supply input of material, but only want to invest limited resources. The largest potential for improving surplus food recovery, is in traditional actors taking a more active role,
especially when the amounts are large, due to the benefits they have regarding information about surplus food. However, this can be unrealistic in the short term, since traditional actors see surplus food as a low value by-product. For smaller amounts of surplus, having an intermediary (particularly a digital platform) can provide a decentralized distribution structure, in which consumers get access to the products without time delays.

The consumer role is different in food recovery, as compared with traditional supply chains, where supply chains are developed to generate customer satisfaction (Stock and Boyer, 2009). The consumer focus in traditional structures is downplayed, and the new consumer base gets less variety but a lower price (Essay 2). However, we can assume that environmentally conscious, and price sensitive consumers already see the appeal in taking the role of consumers in the surplus food supply chain. It is more challenging to convince the consumer who expects impeccable quality, and long expiration dates. Policy updates and consumer education will likely contribute to changing this mindset.

RQ (2b): How can different relationship types in the supply chain contribute to surplus food recovery?

The findings from Essay 3 particularly show that different varieties of relationships exist between donors and receivers in surplus food recovery. Essay 3 reveals four categories: ongoing redistribution, sporadic redistribution, the establishment of new relationships and relationship imbalance. The first three of these categories are relationship types that contribute to surplus food recovery.

Whether a redistribution relationship is ongoing or sporadic, is determined by their durability. A prerequisite for these types of relationships is supply availability and regularity. The contextual factors of supply uncertainty and limited power affect the demand side since supply side organizations claim that amounts and product types are unknown until the internal sell-by date has passed. Ongoing redistributions feature weekly exchanges, while sporadic redistribution occurs on an ad hoc basis. Sporadic redistribution requires more flexibility and coordination from the demand side. Supply consistency, fairness and trust were prominent factors within the theme of ongoing redistribution. In terms of effectiveness, relationship closeness was not necessary for redistribution which supports the idea by Touboulic and Walker (2015b) that full collaboration may not be needed for SSCM. However, in line with the previous authors, there are obvious benefits with closer relationships, since these enable more stable flows and pave the way for more efficient use of the resource by receivers. For example, NGOs can plan gatherings, meals and baskets etc. when they know there will be surplus food available. Furthermore, potential joint development opportunities are lost when relationships remain distant.

Ongoing and sporadic redistribution occur in the context of asymmetrical relationships, where the demand side is the weaker party. In a typical large buyer/small supplier relationship, the large organization has more resources (Touboulic et al., 2014; Touboulic and Walker, 2015b). However, in redistribution relationships, the small organization contributes with more resources and capabilities into the relationship, while the larger party’s contribution is more limited. The alternative for the demand side would often be to waste the surplus, as it is no longer has economic value. These findings indicate that business actors easily take advantage of not-for-profit actors. If large organizations had more ambitious sustainability goals regarding surplus food recovery, they would make more financial and human resources available. The findings from Essay
As new relationships are established, structural holes can be tapped into and surplus food can be recovery. Transparency about surplus food amounts is a key factor for filling structural holes. Transparency enables SSCs through enhanced information flows (Beske and Seuring, 2014). In addition, interpersonal relationships were found critical for initiating and continuing relationships, by building trust between donors and receivers. These findings confirm the importance of interpersonal connections for successful resource recovery (Touboulic and Walker, 2015b).

5.2 Theoretical contributions

The main contribution of this dissertation is its holistic approach to supply chain structure as a concept that can enhance sustainability in the supply chain. The research shows how structures can develop for resource recovery and it offers surplus food recovery improvement implications. The theoretical contributions of this dissertation are threefold.

First, this dissertation contributes with novel insights to the emerging stream of research on non-traditional actors in the supply chain (Rodríguez et al., 2016). My findings specify the roles and motivations (contextual factors) among both business and not-for-profit actors that support and hinder surplus food redistribution in a dyadic constellation. This unveils the weak position of non-traditional actors integrated in the supply chain and although resources are being recovered it is not sufficient; more balanced relationships are required to ensure fair SSCM.

Second, this research contributes to a more nuanced understanding of structure in supply chains. Supply chains tend to be viewed as existing (Cloutier et al., 2020; Lambert and Cooper, 2000), while this research explored how novel structures emerge to respond to a problem, namely, food waste. This new knowledge advances our understanding of how structures can emerge and evolve in response to sustainable development challenges and shows that such structures can include non-traditional supply chain actors. Furthermore, it suggests that the supply chains’ goal can be broader than in conventional definitions (Mentzer et al., 2001). Consequently, it complements current definitions by considering the effectiveness of the supply chain to respond to a challenge as a desirable outcome; together with more established objectives, such as, cost efficiency.

The third contribution of this research is that it provides new empirical findings of surplus food recovery options in practice, especially in a developed country context. The food waste problem exemplifies unsustainability issues in the supply chain, and shows the process in which secondary materials can be cascaded to other actors outside the focal supply chain (Batista et al., 2018) and identifies how new supply chains can be established (Knight et al., 2015). This research responds to the increasing interest by researchers and practitioners to improve resource recovery and reduce raw material use through sustainable and circular supply chains.

5.3 Managerial and societal implications

This research has important implications for practitioners, managers and policymakers. Transitions to more sustainable supply chains are highly relevant in today’s society and
operationalized through policies such as, the European Green Deal, under which carbon emissions must be reduced by 55 percent until 2030. As policies aiming toward net-zero emissions are implemented, business must find ways to make their supply chains generate less pollution. These findings highlight the valuable partners non-traditional actors can be for businesses on this path. Policymakers may want to explore how they can support closing structural holes in the supply chain. For example, a database where actors could insert information about their by-products could be established to enhance transparency and facilitate cascading by-products to new actors.

Based on my findings, the receiver organizations are at risk of being utilized by food donors, and policymakers could intervene through regularly action to support the receiver organizations’ right to collect edible food (not biowaste). Furthermore, policymakers could look over waste management costs to further enhance food donation (and other reuse options) over biogas or energy generation food waste management options due to the identified passivity among traditional supply chain actors.

Moreover, the findings show that cognition about sustainability is limited among managers in many businesses. For example, several mangers seem unaware of the reasons to why the surplus food is donated and by whom it will be utilized. Hence, sustainability managers have an important role in educating internal employees if the firms, and their supply chains, are to become more sustainable within the following decade. Furthermore, entrepreneurs who seek business opportunities within the circular economy can draw inspiration from the triadic, tetradic, and dyadic microstructures in the food recovery context and implement similar structures in other contexts (such as, textile).

5.4 Limitations and suggestions for future research

This research also has some limitations that are worth mentioning, which can provide interesting avenues for future research. First, due to the nature of the phenomenon, a qualitative and explorative research design was adopted. However, qualitative research cannot provide normative directions such as how much greenhouse gases can be saved from surplus food recovery among different structures. Further research could use real data to quantify emissions consumed by the transportation leg and emissions reduced through surplus food recovery to provide accurate comparisons of the environmental impact and benefits of different supply chain structures enabling reuse. Second, empirical data of this research is from the rather specific food industry context. The food industry poses certain conditions on the duration and conditions of storage, processing and transportation due to perishability and food safety requirements (Fredriksson and Liljestrand, 2015). Other industries may have more reuse solutions making use of centralized structures, but this remains a topic to be explored in future research. This research strongly focuses on the environmental dimension of sustainability. Although especially redistribution has particularly important social benefits (such as in terms of employment), elaborating on the concept of social sustainability was outside the scope of this dissertation. Future research could more thoroughly address the three dimensions of sustainability and investigate trade-offs regarding reuse solutions. Fourth, this research focused on the second level of the food waste hierarchy - the reuse/redistribution option. Further research could focus more on preventive measures, as well as investigate enablers and barriers for cascading resources from lower levels to higher ones. Fifth, the supply chain structure concept may come across as unspecific to professionals aiming to design sustainable supply chains since is at a high level of analysis, spans across various organizations, and the problem owner, and their roles in
the organization, is unclear. This research drew on actor constellations, which would also be recommended for future empirical studies as regards, for example, material recovery in other sectors. Sixth, this thesis advances our understanding about surplus food recovery by adopting a theoretical perspective focusing on inter-organizational aspects and the concepts of structural holes, tie strength, and structural embeddedness. Further research should adopt other theoretical perspectives or investigate intra-organizational relationships.
REFERENCES


# APPENDIX 1  OVERVIEW OF SUSTAINABLE SUPPLY CHAIN MANAGEMENT SEGMENTATIONS

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Field</th>
<th>Method/data</th>
<th>Type of categorization</th>
<th>Segmentation attributes</th>
<th>Intended implications</th>
</tr>
</thead>
</table>
| 1. (Julianelli et al., 2020) | CSC | Systematic literature review n=66 | Taxonomy | • Material planning and management  
• Life cycle assessment  
• Industrial sustainability  
• Information and communication technology  
• Promoters and relationships | Consolidate and evaluate the available knowledge of circular economy and reverse logistics |
| 2. (Cloutier et al., 2020) | SSCM | Systematic literature review n=404, years 1992-2018 | Categories | • Relationship management → raise awareness, voluntary commitment (83 %)  
• Joint practices → joint planning or joint executions to achieve joint goal (74 %)  
• Technological and information sharing needs → enabling communication and collaboration (67 %)  
• Governance practices → Define goals and responsibilities and how to achieve them (65 %)  
• Contractual and economic practices → Legal commitment; Clearly state expectations, responsibilities, and cost/benefit sharing agreement (63 %)  
• Assessment practices → Develop accountability; Prioritise improvement initiatives (43 %)  
• Supply chain design → Enabling SC commitment to sustainability (30 %) | Collaborative mechanisms as a critical success factor when aiming for a sustainability-oriented initiative |
| 3. (Centobelli et al., 2020) | Transport and logistics | Survey | Practices | **Single firm practices**  
**Transport:** Alternative fuels, Alternative transportation modes, Alternative vehicles (e.g., electric and hybrid), Eco-driving, Empty running reduction, Full vehicle loading, Routing techniques to minimise travel distances  
**Warehousing:** Alternative energy sources, Energy-efficient warehousing  
**Logistics service:** Materials recycle, Packaging recycle | Identify which green practices are adopted in the transportation and logistics industry |
<table>
<thead>
<tr>
<th>4. (Saroha et al., 2020)</th>
<th>CSC</th>
<th>Literature review and experts’ opinion</th>
<th>Categorisation</th>
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<table>
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<tr>
<th><strong>Governmental pressures/barriers</strong></th>
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<tbody>
<tr>
<td>• Lack of vision for CSCM</td>
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<td>• Lack of implementation of laws and policies</td>
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<td>• Ineffective policies for waste management and recycling</td>
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<td>• Lack of system standardisation</td>
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<th><strong>Financial pressures/barriers</strong></th>
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<tr>
<td>• Higher investment cost</td>
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<td>• Higher raw material cost</td>
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<tr>
<td>• Lack of funding</td>
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<tr>
<td>• Difficulties in product cost fixing</td>
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<tr>
<td>• High production cost</td>
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<td>• Recycled materials are expensive</td>
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<tr>
<th><strong>Technological pressures/barriers</strong></th>
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<tr>
<td>• Lack of knowledge about CSCM</td>
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<td>• Lack of quality product</td>
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<td>• Lack of follow-up of recycled material</td>
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<tr>
<td>• Difficulties in designing of reused material</td>
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<tr>
<td>• Lack of information sharing in material tracking</td>
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<tr>
<td>• Difficulties in disposal of material to biosphere</td>
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<tr>
<th><strong>Knowledge and skill pressures</strong></th>
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<tr>
<td>• Lack of quality information sharing to the customers</td>
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<tr>
<td>• Lack of awareness in public</td>
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<tr>
<td>• Lack of skilled worker</td>
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</table>

- **Management**: Certification (ISO 14001), Employee training, Environmental performance measurement and monitoring

**Supply chain practices (management)**
- **Management**: Coordinated logistics and transportation programmes,
- coordinated certification programmes and green goals,
- information diffusion on carbon footprint, collaboration with customers,
- collaboration with other freight transporters,
- information diffusion on greenhouse gas goals

Identify barriers to circular supply chain implementation
- Lack of knowledge about refurbishment

**Management pressures**
- Lack of support of top management
- Lack of priority in supply chain
- Lack of structure for CSCM

**Social pressures**
- Lack of passion towards CSCM
- Negative thinking about reused/refurbished products

**Market pressures**
- Lack of standardisation for refurbishment products
- Difficulties in ownership of benefits of reused products
- Difficulties in collection of used products from other sources
- Lack of availability of reused products

5. **(Kazancıoğlu et al., 2020)**

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<thead>
<tr>
<th>Categories</th>
<th>5. Literature review, focus group</th>
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<tbody>
<tr>
<td><strong>Barrier to circular supply chains in the textile industry</strong></td>
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<tr>
<td>(a) management and decision-making</td>
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<td>(b) labor</td>
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<tr>
<td>(c) design challenges</td>
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<td>(d) materials</td>
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<td>(e) rules and regulations</td>
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<td>(f) lack of knowledge and awareness</td>
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<td>(g) lack of integration and collaboration</td>
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<td>(h) cost</td>
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<td>(i) technical infrastructure</td>
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6. **(Muñoz-Torres et al., 2020)**

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<thead>
<tr>
<th>Categories</th>
<th>6. Simulation</th>
<th>Categories</th>
<th>6. Analysis of the textile industry environmental hotspots</th>
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<td><strong>Environmental impact</strong></td>
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<td>a) Climate change</td>
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<td>b) Ozone depletion</td>
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<td>c) Human toxicity—cancer effects</td>
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<td>d) Human toxicity—non-cancer effects</td>
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<td>e) Particulate matter</td>
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<td>f) Ionizing radiation—human health effects</td>
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<td>g) Photochemical ozone formation</td>
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<td>h) Acidification</td>
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<td>i) Terrestrial eutrophication</td>
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<td>j) Freshwater eutrophication</td>
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<td>k) Freshwater ecotoxicity</td>
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<td>l) Water resource depletion</td>
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</table>
7. (Ripanti and Tjahjono, 2019) CSC Literature review Attributes

- System thinking
- Collaborated network
- Built-in resilience
- Shift to renewable energy
- Circularity
- Optimisation of change
- Cascades orientation
- Maximisation of retained value
- Leakage minimisation
- Waste elimination
- Environmental consciousness
- Economic optimisation

Reformulate the existing circular economy principles into circular economy values (or tenets) in a format or structure that supports the design of a circular, closed-loop supply chain and reverse logistics.

8. (Jadhav et al., 2019) SSCM Literature review, survey Categories

Internal Supply Chain Coordination
- strategic meetings of internal supply chain members
- problem-solving initiatives taken by internal supply chain members
- communication and information exchange amongst internal supply chain members
- top management support for internal supply chain members
- collaborative work between internal supply chain members
- communication between internal supply chain members

Collaboration and Communication
- joint decision making
- Communication channels
- establishing shared goals and vision
- establishing shared operating philosophies and priorities

Internal Supply Chain Sustainability Practices
- IT support for information exchange across internal supply chain

Identify the difference between the effects of different supply chain orientation constructs on external supply chain sustainability performance.
• monitoring and measuring internal supply chain processes
• implementation of sustainability policies
• contribution of internal supply chain members to sustainability policies
• benchmarking of sustainability practices for the internal supply chain
• waste elimination practices
• energy efficient practices
• renewable energy usage
• recycled materials practices
• CO2 emissions management
• community engagement
• supplier codes of conduct
• Ensuring commitment of suppliers to supplier code of conduct

External Supply Chain Environmental Sustainability Performance
• waste elimination
• energy usage efficiency
• utilisation of renewable energy supplies
• water usage efficiency
• incorporation of recycled materials
• CO2 production resulting from transportation

External Supply Chain Social Sustainability Performance
• reduction of discriminatory employment practices
• elimination of child labour
• elimination of bonded and compulsory labour
• compliance with government regulations
• community engagement

9. (Packer et al., 2019) CSR Content analysis Categories

Corporate social responsibility activities:
Power (supply chain control)
Practices (internal improvements)
Partnerships (with private actors, NGOs, scientist etc.)
Public policy (developing regulations and policies)
Philanthropy (philanthropy and awareness)

...understand how mid-chain seafood suppliers engage in sustainability efforts.
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<tr>
<th>No.</th>
<th>Source</th>
<th>Methodology</th>
<th>Attributes</th>
<th>Economic attributes</th>
<th>Environmental attributes</th>
<th>Social attributes</th>
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<tr>
<td>10</td>
<td>(Vega-Mejía et al., 2019)</td>
<td>Optimization criteria</td>
<td>Attributes</td>
<td>Minimize costs&lt;br&gt;Minimize traveled time/loading or unloading times&lt;br&gt;Minimize distance traveled&lt;br&gt;Minimize number of vehicles/containers&lt;br&gt;Minimize energy/fuel consumption&lt;br&gt;Minimize driver overtime&lt;br&gt;Minimize wasted container space/Maximize used volume&lt;br&gt;Maximize transported weight/number of items&lt;br&gt;Minimize container size&lt;br&gt;Minimize deviation of center of gravity&lt;br&gt;Maximize level of service</td>
<td>Minimize distance traveled&lt;br&gt;Efficient route planning&lt;br&gt;Speed&lt;br&gt;Load factor&lt;br&gt;Minimize energy/fuel consumption&lt;br&gt;Minimize GHG/CO2/NOx emissions&lt;br&gt;Minimize deviation of center of gravity</td>
<td>Minimize driver overtime&lt;br&gt;Minimize deviation of center of gravity&lt;br&gt;Maximize level of service&lt;br&gt;The number of jobs created, the damage to workers and security measures, the population’s health and education, local development policies, access to healthcare, the impact on real estate, and the customers’ concerns for using recycled materials&lt;br&gt;Wages</td>
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<td>11</td>
<td>(García-Torres et al., 2019)</td>
<td>Literature review, conceptual framework</td>
<td>Categorization</td>
<td>Governance category</td>
<td>Traceability for sustainability as a meta-capability</td>
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• Audit-related problems (barrier)

Collaboration category
• SC collaboration (enabler)
• Long-term relationships (enabler)
• Partnerships (enabler)
• Alliances (enabler)
• Local/cultural aspects and cultural distance (barrier)
• Lack of shared vision and/or values (barrier)
• Lack of integration (barrier)

Tracking and tracing category
• Visibility (enabler)
• Transparency (enabler)
• Traceability systems (enabler)
• Outsourcing/subcontracting (barrier)
• Complexity (barrier)
• Lack of standards (barrier)
• Costs (barrier)
• Lack of resources/capabilities (barrier)

12. (de Sousa Jabbour et al., 2019)

SSCM Literature review Categorization

| a) Economic | Identify drivers and barriers to the adoption of low-carbon operations management practices in response to climate change |
| b) Policy/regulatory | |
| c) Technology | |
| d) Governance | |
| e) Market | |

13. (Gruchmann and Seuring, 2018)

SSCM Conceptual Categorization

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<th>Dynamic SSCM capabilities</th>
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<tr>
<td>1. Reflexive control</td>
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<td>2. Knowledge management</td>
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<td>3. Co-evolution</td>
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<td>4. Partner development</td>
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<td>5. Supply chain re-conceptualization</td>
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<th></th>
<th>(Meinlschmidt et al., 2018)</th>
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<th>Multiple case study</th>
<th>Categorization</th>
<th>Environmental uncertainty</th>
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<td>1. Stakeholder salience</td>
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<td>2. Structural supply network complexity</td>
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<td>3. Product and industry salience</td>
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<td><strong>Behavioral uncertainty</strong></td>
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<td>1. Past incidents in the supply network</td>
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<td>2. Socio-economic and cultural distance</td>
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<td><strong>Asset specificity</strong></td>
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<td>1. Lower tier supplier dependency</td>
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<tr>
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<th>Classification</th>
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<td>• Investment costs</td>
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<td></td>
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<td>• Company size</td>
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<td>• Decrease in service offered</td>
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<td>• Uncertain recovery</td>
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<td>• Ecological complexity</td>
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<td>• Market volatility</td>
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<td>• Price increase</td>
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<td>• Organization support</td>
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<td>• Standard guidelines</td>
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**Drivers** |

• Company size |
• Human resource capability |
• Standard regulations |
• Customer pressure |
• Competitiveness pressure |
• Network |
• Profitability |

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Social sustainability initiatives in emerging economies

Lower tier supplier sustainability, from a transaction cost economics perspective

Factors influencing energy efficiency and environmental sustainability initiatives
<table>
<thead>
<tr>
<th>ID</th>
<th>Authors</th>
<th>Method</th>
<th>Theme Type</th>
<th>Classification</th>
<th>Details</th>
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<tbody>
<tr>
<td>17.</td>
<td>(Kaur et al., 2018)</td>
<td>GSCM</td>
<td>DEMATEL</td>
<td>Knowledge related barriers:</td>
<td>Identify main barriers in the context of electronic goods and Canada</td>
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<td></td>
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<td>- lack of awareness of the environmental impacts on business</td>
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<td>- lack of training courses/consultancy/institutions to train, monitor/mentor</td>
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<td>progress specific to each industry</td>
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<td>- lack of technical expertise</td>
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<td>- difficulty in identifying environmental opportunities</td>
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<td>Commitment related barriers:</td>
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<td></td>
<td>- lack of corporate social responsibility</td>
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<td>Product design related barriers:</td>
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<td></td>
<td>- complexity of design to reuse/recycle used products</td>
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<td>18.</td>
<td>(Sodhi and Tang, 2018)</td>
<td>SSCM</td>
<td>Thematic</td>
<td>Theme 1: stakeholder pressure</td>
<td>This paper seeks to capture the diverse research themes in the literature on large companies' efforts on 'social sustainability' in their supply chains and to integrate these themes into a thematic map</td>
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<td></td>
<td></td>
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<td>Theme 2: governance</td>
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<td>Theme 6: barriers and enablers</td>
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<td>Theme 7: performance</td>
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<td>Theme 8: optimization for improving and trading-off performance</td>
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<td>19.</td>
<td>(Saeed and Kersten, 2017)</td>
<td>SSCM</td>
<td>Content analysis</td>
<td>Environmental</td>
<td>Identify supply chain sustainability performance indicators based on standards and guidelines</td>
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<td>- Energy efficiency</td>
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<td>- Supplier assessment</td>
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<td>(Ansari and Kant, 2017)</td>
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<td>The most common constructs in the frameworks were:</td>
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<td>1. Regulatory pressures/legal requirements (N=16)</td>
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<td>3. Information transparency (N=10)</td>
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<td>4. Green purchasing (N=9)</td>
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<td>Analyze novel and adopted framework of SSCM</td>
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<td>(Centobelli et al., 2017)</td>
<td><strong>GSCM</strong></td>
<td>Literature review, years 1960-2014</td>
<td>Taxonomy</td>
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<td>Most prominent drivers addressed in papers</td>
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<td>1. Regulations pressure</td>
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<td>2. Market factors and competitiveness</td>
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<td>3. Quality of human resources</td>
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<td>4. Customers pressure</td>
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<td>5. Organization support</td>
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<td>Most prominent barriers addressed in papers</td>
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<td>1. Regulations and standards</td>
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<td>2. Investment costs</td>
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<td>3. Small size firm</td>
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<td>4. Complexity of green initiative</td>
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<td>Green initiatives in the logistics service industry</td>
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<td>22.</td>
<td>(Dubey et al., 2017)</td>
<td><strong>SSCM</strong></td>
<td>Literature review</td>
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<td>1. Green design, packaging, distribution and warehousing</td>
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<td>2. Conservation</td>
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<td>3. Life cycle concept</td>
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<td>Social values and Ethics</td>
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<td>Provide a theoretical framework that articulates the different</td>
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</table>
1. Code of conduct
2. Employee welfare
3. Equity
4. Public awareness and ethics

Economic stability
1. Profitability
2. Strategic collaboration and information sharing
3. Logistics optimization

Operational performance assessment
1. Audit and assessment
2. Standardization

Internal factors
1. Organizational culture
2. Technology
3. Corporate strategy and commitment

External factors
1. Government rules and regulations
2. Customer pressure
3. Competition

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<th>23. (Reefke and Sundaram, 2017)</th>
<th>SSCM</th>
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<th>Key themes: planning, execution, coordination, and collaboration</th>
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<td>• Categories of governance, risk, compliance, performance management, and the sustainability dimensions</td>
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<td>Offer a prioritization of sustainability initiatives for practitioners</td>
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<tr>
<th>24. (Abbasi, 2017)</th>
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<td>• Human-centric,</td>
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<td>• Focal organization-centric,</td>
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<td>• Supply chain-centric</td>
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<td>• Governance-centric</td>
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<td>Challenges:</td>
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<td>• Inadequate and asymmetric knowledge</td>
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<td>• Difficulties of operationalization</td>
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<td>• Shifting the values</td>
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<td>• Subjectivity in evaluation</td>
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<td>• Difficulties of SMEs</td>
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<td>• Sustainability fade</td>
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<td>Explore and classify the pattern of themes and challenges in developing socially sustainable supply chains</td>
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<td>No.</td>
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<td>Type</td>
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<td>Differences in sustainable purchasing relationships</td>
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<td>26</td>
<td>(Mejías et al., 2016)</td>
<td>Literature review</td>
<td>Categories Sustainable practices (innovation-level) Sustainable best practices in SCM</td>
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<tr>
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<td><strong>SSCM</strong></td>
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<td>• Local supplier development • Sustainable purchasing and supply strategy • Transparency and ethics in purchasing • Supply chain risk management strategies • Environmental management technologies-cleaner production • Closed-loop supply chains • Environmental conscious design • Life-cycle analysis • Lean and green operations</td>
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<td>(Beske and Seuring, 2014)</td>
<td>Conceptual; Key references (Pagell and Wu, 2009; Seuring and Müller, 2008)</td>
<td>Categories Orientation (strategic values) Continuity (structure) Collaboration (processes) Risk management (processes) Proactivity (processes)</td>
<td>Identify key categories and practices of SSCM to ensure sustainable performance</td>
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<tr>
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<td>• Dedication to the TBL • Dedication to SCM • SC partner development • Long-term relationships • SC partner selection • Enhanced communication • Logistical integration • Technological integration • Joint development • Standards and certification • Selective monitoring • Pressure groups • Proactivity (processes) • Learning • Stakeholder management • Innovation 4. Life-cycle assessment</td>
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<td>28. (Winter and Knemeyer, 2013)</td>
<td>SSCM</td>
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<td>Social, environmental and economic dimensions SCM elements: business processes (n=196), network structure (n=56) and components (n=22)</td>
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<td>29. (Kuik et al., 2011)</td>
<td>SSCM</td>
<td>Conceptual development</td>
<td>Framework</td>
<td>Framework of reduce, recover, redesign, reuse, recycle, remanufacturing</td>
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<td>30. (Pagell and Wu, 2009)</td>
<td>SSCM</td>
<td>Case study</td>
<td>Classification</td>
<td>Bundle 1: commonalities, cognitions and orientations Bundle 2: ensuring supplier continuity Bundle 3: reconceptualise the chain Bundle 4: supply chain management practices — sourcing management Bundle 4: supply chain management practices — operations Bundle 4: supply chain management practices — invest in human capital Bundle 5: Measurement</td>
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<td>31. (Carter and Rogers, 2008)</td>
<td>SSCM</td>
<td>Literature review, Conceptual</td>
<td>Framework</td>
<td>• Strategy • Risk management • Transparency • Organisational culture</td>
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</table>
APPENDIX 2  ESSAY 2: SAMPLE INTERVIEW GUIDE

Supply chain design for resource- and energy efficiency

Identify how supply chains can be redesigned to reduce energy consumption and facilitate efficient recovery of resources: Which actors and roles, how do they interact?

Background/Context/Vision
What you are working with on a daily basis?
What is your previous experience?
Why is [your organization] working with food waste?
How would you describe your business environment?
How is [your organization] planning to improve /develop your operations in the future?

Key actors/stakeholders in the network (structure + interaction)
Use the triad / dyad as a representation of the food network.

Who are your suppliers? Are the products donated? What do the suppliers think about your services?
Who are your customers?
What kind of relationship exist between you and the other actors? (e.g. contractual (why? How long?), continuous relationship (loyal customers?)
How do you get in contact with new potential suppliers?
What have been the challenges with respect to the suppliers?
How continuous is the supply of products? How can [your organization] ensure that products are recovered at the right time?

Energy and resource efficiency
What does your logistics operations look like?
• Supplier location? Weekly truck? truck fill rate?
Which activities do you perform? How? Why?
• reverse logistics (move product)
• quality checking, sorting, disposition
• refurbishing according to waste hierarchy
• re-marketing.
What could be done more efficiently?
Whom else should I contact for interviews? Suppliers, LSPs?

Thank you very much for your cooperation and for your time!
Note: Also ask how, why (e.g. have you decided to do this), and for examples.
APPENDIX 3  ESSAY 3: INTERVIEW GUIDE FOR RECEIVER ORGANIZATIONS

Background/Context/Vision
What are working with on a daily basis?
What is your previous experience?
What is your own motivation for working with this project/in this organization?
How has the organization ‘developed’ (if applicable) over the years?
What are the plans for the future?
How do you see your organization’s role in society?

Actors
From whom do you receive surplus food regularly?
Do you have some irregular donors?
To whom do you distribute the surplus food further?
Who receives aid through your organization/network?
  • How many?
  • Are they local?
  • Do you know them?
  • Are they new/same?

Roles
What activities are performed by your organization? (sorting, moving etc.)
How is the food distributed/served (food bag, meals etc.) to beneficiaries?
What ‘services’ are you offering the beneficiaries and other actors (e.g. employment)?
  • Who initiates the contact?
  • With donors
  • With charity organizations
  • With beneficiaries
How is the variability of surplus food handled?

Relationships
Could you describe a relationship with a donor that in your opinion is working well.
What is it that is working especially well?
What would some challenges be?
What kind of relationship do you have with the donors?
  • Contractual relationship?
  • Do you have joint activities/discussions with donors? How often?
What benefits are there for you to receive the donated food?
How is the quality of the received food?
  • How much is still edible?
  • How does the food received cover the nutritional needs of the beneficiaries?

General Questions
Are you collaborating with other charity organizations with respect to surplus food?
  • Do you have joint activities with other charity organizations?
What is your opinion about self-regulation?
Do you have the resources for performing the activities that you would like to?
Do you receive economic support from Fund for European Aid to the Most Deprived (FEAD)?

Final Observations
In an ideal world, how would surplus food be handled?
Do you have data on surplus food that you would be willing to share? (e.g. amounts picked up, possible trends, products)
Is there anything that you think that I have missed, but could be of importance?
Is there someone (charity organization, donor) I would benefit from contacting to learn more?
APPENDIX 4  ESSAY 3: INTERVIEW GUIDE FOR DONOR ORGANIZATIONS

1. Background/food waste
   What are you working with on a daily basis?
   Are you actively working with reducing food waste in your organization? How?
   How often do you have surplus food?

2. Actors
   Are you donating regularly?
   - To whom?
   - How many charity organizations are you cooperating with?
   Do you have irregular donations?
   - Whom do you contact first?
   What type of products are you donating? Can you donate everything?
   If you have several receivers, how is it managed? Who picks up when and what do they pick up?

3. Relationships
   Could you describe a relationship with a receiver that in your opinion is working well.
   - What is it that is working especially well?
   - What would some challenges be?
   How have the relationships ‘developed’ (if applicable) over the years?
   How do you manage the donation process?
   - What additional resources (time, storage etc.) does donations require from your side?
   What kind of relationship do you have with the receivers?
   - Contractual relationship?
   - Do you have joint activities/discussions with receivers? How often?
   - It is you or them who are in contact?
   What benefits are there for you to donate the surplus food?
   - How do you ensure the quality of the donated food? (note: more relevant for actors at later stages in the supply chain)
   Who is handling the transportation of the surplus food?

4. Final Observations
   Do you have data on surplus food that you would be willing to share? (e.g. amounts, possible trends, products)
   Is there anything that you think that I have missed, but could be of importance?
   Is there someone (other NGO, donor) I would benefit from contacting to learn more?
APPENDIX 5 CONSENT FOR PARTICIPATION IN A RESEARCH INTERVIEW

Supply chain structures as means to promote environmental sustainability: the case of food waste

funded by Hanken School of Economics, Marcus Wallenberg Foundation, The Foundation for Economic Education, Otto A. Malm Foundation, Svenska Litteratursällskapet, Paulo Foundation

I agree to participate in a research project led by Doctoral Student Caroline Sundgren from Hanken School of Economics in Helsinki, Finland. The purpose of this document is to specify the terms of my participation in the project through being interviewed.

1. I have been given sufficient information about this research project. The purpose of my participation as an interviewee in this project has been explained to me and is clear.

2. My participation as an interviewee in this project is voluntary. There is no explicit or implicit coercion whatsoever to participate.

3. Participation involves being interviewed by a researcher from Hanken School of Economics. The interview will last approximately 60 minutes. I allow the researcher to take written notes during the interview. I also may allow the recording (by audio) of the interview. It is clear to me that in case I do not want the interview to be taped I am at any point of time fully entitled to withdraw from participation.

4. I have the right not to answer any of the questions. If I feel uncomfortable in any way during the interview session, I have the right to withdraw from the interview.

5. I have been given the explicit guarantees that, if I wish so, the researcher will not identify me by name or function in any reports using information obtained from this interview, and that my confidentiality as a participant in this study will remain secure. In all cases subsequent uses of records and data will be subject to standard data use policies at the Hanken School of Economics (Data Protection Policy).

7. I have read and understood the points and statements of this form. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

8. I have been given a copy of this consent form co-signed by the interviewer.

Participant’s Signature ________________________ Date ________________

Researcher’s Signature ________________________ Date ________________

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APPENDIX 6  APPENDED PAPERS

Essay 1

This is a post-print version of the chapter.

The final version is available in Handbook on Sustainable Supply Chains edited by J. Sarkis, published in 2019 by Edward Elgar Publishing Ltd
https://doi.org/10.4337/9781786434272.00029

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Sustainable Supply Chains and Energy: Where “planet” meets “profit”

Abstract

This chapter focuses on sustainable development of supply chains through energy efficiency with particular focus on logistics. It is argued that energy efficiency allows managers to unite economic and environmental reasoning in their decision making and actions. First, consideration of different system levels such as activities, technology, actors, and design of supply chain opens for a broad range of improvement options. Managers must identify system levels in which improvements should take place. Second, managers must understand how principles of supply chains such as flexibility, cost efficiency and responsiveness set the conditions for energy consumption of logistics activities. To illustrate how improvement efforts can be addressed, the chapter presents examples of four different system levels: Freight capacity, last-mile fulfillment options (down-stream), sourcing and supply management (up-stream), and reverse logistics and closed loop supply chains.

Keywords: Sustainable supply chain; logistics, energy efficiency; improvement; profit; planet
1. Introduction

The United Nations (UN) sustainability goal of “Sustainable consumption and production” promotes energy efficiency. All those who work with logistics in the wider context of supply chains are well-placed to influence this; freight truck emissions are not a mere issue of an engine that is running, or the fuel used. Rather, the truck is powered by energy sources to move goods by freight transport and logistics service providers that in turn can be seen as the core of supply chain execution; that is, the physical movement of goods and materials from suppliers to the point of consumption. How this physical movement of goods and materials is conducted, including how much energy and of what type is used, is influenced by the particular supply chain’s underlying structure and strategic priorities. Some supply chain designs entail long distances, but consolidate energy-saving transport modes, whereas others may favour short distance, but use more energy-intensive transport modes and less efficient vehicles. Further, some designs facilitate the use of large trucks with high fill rates, whereas others may be motivated to use passenger cars for moving goods from the retail store to the home of consumers. By this, environmental sustainability is not only a matter of logistics services providers and freight transport operators; on the contrary, it is, to a high degree, also an issue for their customers at both business-to-business and business-to-consumer supply chain levels.

Energy sources are a significant supply chain cost, and are simultaneously directly related to environmental performance through use of non-renewable sources (fossil fuel) as well as CO2 emissions. As unit of analysis, energy lies at the intersection where environmental sustainability meets economic performance; it captures two P’s of the triple-bottom line, that is, planet and profit, in a unique way that allows managers to work with some of the root causes of climate impact in their supply chains, and perhaps more importantly, ensure improvements are simultaneously driven by economic and environmental agendas. Energy efficiency is, for example, directly related to reduction of railway system operating costs (De Martinis and Weidmann, 2015). This “convergent” feature of energy efficiency, of getting profit to go in the same direction as planet, as well as its relationship with the supply chain, sets the foundation for this chapter. This chapter will illustrate that focusing on energy as unit of analysis can improve sustainable supply chain development. In particular, this chapter will:

- Illustrate that focus on energy as part of sustainable supply chain development allows managers to unite economic and environmental reasoning in their decision making and actions
- Identify system levels in which improvements should take place
- Illustrate how principles of supply chains set the conditions for energy consumption
- Present areas of improvement that should take place at different system levels:
  - Freight transport capacity
  - Last-mile fulfillment options (downstream supply chain)
  - Sourcing (upstream supply chain)
  - Reverse logistics and closed-loop supply chains

The chapter provides a perspective on Sustainable Supply Chains and Energy, with clear implications: profit must meet planet. The chapter begins with a brief explanation of key concepts and explanatory logic of energy efficiency as a mechanism of sustainable supply
chains (section 2). This is developed further through a systems-level perspective as a means of scoping the potential for energy efficiency improvements (section 3). Then, a set of four types of logistics situations that cut through the supply chain illustrate “how supply chains set conditions for energy consumption and improving energy efficiency” (section 4). Finally, the chapter ends with a brief summary (section 5).

2. Energy efficiency as generative mechanism of sustainable supply chains

2.1 Key concepts

Supply chains: structures that set scope for actions

Supply chains deal with the flow of materials, finances, services and information, as well as the networks within a company and across its supply chain (Stock and Boyer, 2009). As a structural unit that sets boundaries for analysis and managerial actions, they can be defined as “set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer” (Mentzer et al., 2001). A scope like this allows for a systemic view of environmentally sustainable supply chains; it suggests a focus on both actors (organizations) and their relationships (interactions).

Design of supply chains set performance priorities: efficiency and responsiveness

A company’s supply chain can be seen as a structure that can be managed through inter-organizational relationships (Halldórsson et al., 2007). The specific structural attributes of a supply chain, and the way by which this is managed, set conditions for performance in logistics. A particular supply chain can prioritize, for example, cost efficiency or lead-time as strategic performances objectives. Fisher (1997) presented two supply chain design types that have become popular, and that illustrate clearly this performance difference.

Efficient supply chains entail focusing on costs and economies of scale via effective utilization of resources and capacity, for example, transportation and warehousing. This structure is suitable in a stable customer demand environment, but it would entail higher costs to create flexibility or short lead times. Responsive supply chains, on the other hand, focus on responding quickly to changes in customer demand. This uncertainty appears in various forms, ranging from unexpected and disruptive events (for example, flooding affecting one or more levels in the food supply chain) to fast demand shifts (due to for example, marketing campaigns). Flexibility can be achieved by keeping goods in stock where inventory costs are outweighed by high product margins. Also through short lead times through using transport modes (often the use of vehicles) or even interoperability of transport modes (smooth transition from one mode to the other) may allow for fast and flexible deliveries. This flexibility is especially evident in the downstream parts of the supply chain, close to consumer markets.

This distinction between efficient and responsive supply chains was put forward 20 years ago. During that period environmental sustainability and resource scarcity both in terms of costs of energy and type of energy, were not widely questioned. This situation has led to an array of new solutions such as “slow-steaming”. Slow steaming is an imported maritime concept that prescribes that both cost and environmental benefits can be gained from “slowing down” the flow of goods and materials in the supply chain. From this solution, cost efficiency and
utilization for efficient supply chains is prioritized over speed as performance objective (cf. responsive supply chains).

Green and sustainable Supply Chain Management

Defining sustainable and green Supply Chain Management (SCM) challenges managers who need to improve environmental performance. Ahi and Searcy (2013) found 34 unique definitions for sustainable and green SCM in the literature. The definitions of green and sustainable SCM range from focus on “green activities” (Zhu and Sarkis, 2004), that is, something distinct to current practices, through “integration of environmental thinking” into current practices (Srivastava, 2007). Seuring and Müller (2008) specify these practices by referring to characteristics of SCM such as flow of materials and information, as well as supply chain cooperation. Carter and Rogers’ (2008) definition incorporates the triple bottom line, as well as a stakeholder and long-term focus, and it refers to the SCM characteristics of coordination, relationships, and performance (Ahi and Searcy, 2013). Another aspect of these definitions is to focus on output itself, for example, “improved environmental performance” (cf. for example, Walker et al., 2008). The implications of this are twofold:

1) Energy efficiency should be regarded as a part of the company’s environmental performance, and expressed in distinct terms, not merely incorporated into, for example, logistics costs.

2) Improving energy efficiency should be integrated into current supply chain practices rather than being seen as a separate, ad hoc improvement effort.

But what makes up a “sustainable supply chain”? One view is that environmental sustainability dimensions are added to and/or integrated with current SCM principles. This chapter views energy efficiency as the focal point for designing and managing supply chains. Such an energy-centric perspective allows for assessment of some common principles and practices as regards supply chains’ ability to contribute to reduced energy consumption and/or increase energy efficiency.

2.2 The energy efficiency challenge

Business processes consume energy. These processes are shaped by the wider context of supply chain structures (responsive or efficient, cf. e.g. Fisher, 1997), as well as strategic priorities of energy-consuming operations such as transportation. Total transport sector energy consumption is steadily increasing and emissions are concentrated in urban areas (OECD/IEA, 2015). As example, the Swedish Transport Administration projects a 50 percent increase in freight transport (exclusive air freight) by 2030 compared to 2006, whereof road freight transportation will grow the most (Saxton, 2016). For the future, the International Energy Agency expects transportation energy consumption to increase even further by almost 30 percent by 2030 and 80 percent by 2050 and the transported volume to nearly double by 2050 compared to 2006 (OECD/IEA, 2009). Energy efficiency is defined in the Directive 2012/27/EU of the European Parliament and of the Council as “the ratio of output of performance, service, goods or energy, to input of energy” and energy efficiency improvement as “an increase in energy efficiency as a result of technological, behavioural and/or economic changes”. In the context of supply chains, we need to take a broad view on energy efficiency; in addition to the more conventional input/output ratio, we need to regard energy consumption in general. In this chapter, both the amount and type of energy (fossil fuel vs. renewable) are seen as directly related to sustainable development, and will constitute our
broad approach to energy efficiency. In line with this, the improvement of energy efficiency is regarded as a managerial task, shaped by both behavior and organizational structures.

2.3 Triple bottom line: People, Planet, Profit

The term the triple bottom line (TBL) includes, in addition to the traditional economic perspective, the social and environmental performance dimensions (Elkington, 1997). TBL seeks to balance the three dimensions (Coffman and Umemoto, 2010). The terms profit, planet, and people were first adopted by Shell in Shell Report. Today, TBL is a widely-known concept, and has become a core reference in “sustainable SCM” (Carter and Rogers, 2008). TBL has been used as a synonym for sustainability. However, Montabon et al. (2016) pointed out that, even though TBL is a dominant concept, there are schools of thought that still only focus on environmental and economic aspects; for example, “green supply chain management”.

Profit: Energy is a part of logistics costs, and a resource that contributes to customer service. In the context of energy, “profit” refers to fuel costs, and even fossil fuel dependency to deliver such customer expectations as high speed and short lead times, as well as flexible and reliable deliveries. Restructuring the supply chain toward energy efficiency can raise short-run prices, for example, for implementing new management solutions and operation systems. A change would promote lower prices in the long run because excessive capacity could be reused, services adapted, and resources saved. Furthermore, restructuring the supply chain promotes independency from fluctuating oil prices. Although world oil prices are currently low, history has shown that prices are coupled to world affairs, wars, and natural catastrophes and can rapidly change. Therefore, energy efficiency simultaneously promotes supply security (European Commission, 2011b).

People: For energy efficiency, the “people” dimension is associated with healthy life expectancy through decreased emissions (Helliwell et al., 2017). Decreasing environmental impacts can also promote greater sustainability awareness, which can lead again to further actions, like walking, biking, and a healthier lifestyle. Sustainability’s social component also profits from reduced energy consumption in the supply chain. Less energy from fossil fuels means fewer emissions, which contributes to better air quality. In cases where, for example, better capacity utilization reduces the number of vehicle trips, then fewer trucks are driven on streets. This situation positively impacts road safety, not only for private cars, but also for cyclists and pedestrians. Local products purchase to reduce transport distances can also aid local producers and stores.

Planet: Non-renewable energy resources and emissions are particularly relevant aspects of planet in the context of energy efficiency. This can be seen as an immediate issue for combating climate change and staying within the planetary boundaries (Rockström et al., 2009). Efforts to improve energy efficiency, i.e. reduce energy consumption and substitute use of fossil fuel with renewable energy resources through supply chain design will reduce supply chain carbon emissions.

As supply chains are large energy consumers, they also need to do their part in reducing logistics-based emissions. Hollos et al.’s (2012) analysis of supplier TBL cooperation found that it does not have any significant effect on performance, whereas environmental practices result in cost reduction and improved performance. Further, they found a strong positive relationship between supplier cooperation and green and social behaviors, which reinforces how a corporation is only as green as its suppliers.
3. Supply chains set conditions for “planet” and “profit” -- energy-consuming attributes

How supply chains are designed and managed underpins particular processes’ environmental performance, as well as the supply chain as a whole. Strategic priorities such as flexibility and short lead times may result in combined cost and value advantages. However, from the perspective of environmental sustainability, these may require energy resources to the extent that the benefits are outweighed.

3.1 System levels -- setting boundaries for energy efficiency improvements

The systems approach can be useful as a framework for setting the scope for supply chain energy efficiency efforts (potential and possible actions). Figure 3.1 presents four distinct levels that summarize different types of system boundaries for initiatives in logistics and supply chain management. Whereas the two lower levels (technology and activities) are directly related to energy consumptions of operations, the upper levels (actors and structure) represent organizational and behavioral issues that set energy efficiency conditions.

Figure 3.1 System levels for improving energy efficiency in logistics

Technology is important, but not sufficient: Examples of energy-efficiency logistics technologies range from cleaner engines and vehicles that can be powered by renewable energy to make freight transport as independent of fossil fuels as possible to infrastructure such as electric highways. Further, effective information technology solutions for better route planning and scheduling can increase capacity utilization and decrease average transport distance, and hence augment energy efficiency (see for example, Stelling, 2014). While new technology (level 0 in Figure 3.1) plays an important efficiency role, it is not sufficient to meet rising energy demand for logistics services and to meet the governmental goals set for 2050 in which all EU member countries committed themselves to reduce GHG emissions by 80 to 95 percent by 2050 compared to the level of 1990 (European Commission 2011, 2011a; European Commission 2011, 2011c). This requires a reduction of GHG emissions of at least 60 percent in the transport sector alone (European Commission 2011, 2011c). For example, electric vehicles are not free of greenhouse gas (GHG) emissions; depending on the primary energy...
source, GHG emissions can be generated when the electricity is produced (Piecyk et al., 2015). To achieve competitive and resource-efficient supply chains, logistics operations have to reduce energy consumption and GHG emissions, and supply chain operations need to change. Further, changes are needed in behavior pattern (Aronsson and Huge-Brodin, 2006; Chapman, 2007), which urges managers to actively redefine the boundaries of sustainable supply chains by moving from the bottom and upward in Figure 3.1.

Supply chain activities drive energy consumption: Supply chain activities like transportation and warehousing (level 1 in Figure 3.1) consume significant amount of energy. The energy consumption during transportation (1a) is related to vehicles used for physical movement of goods and efficiency of capacity utilization. Traditionally, capacity utilization in transportation refers to the physical ability of a vehicle to transport goods as well as its fill rates. The level of utilization here must be seen in relation to warehousing capacity (1b). Different components, like “packaging”, “boxes”, “pallets” and the “truck” are interrelated; how products are stacked on a pallet is relevant for all following supply chain activities. Energy efficiency can thus be improved by viewing capacity as an interactive concept. Better resource efficiency can be reached through better utilization, for example, a higher load factor and tracing of vehicles (Aronsson and Huge-Brodin, 2006). How a vehicle (for example, a truck) is filled with products is directly influenced by the size and shape of the packaging because reduced packaging requires fewer vehicles (Wu and Dunn, 1995, Kalenoja et al., 2011).

In warehousing (1b), the interactive capacity is brought further into play; capacity in warehousing is affected directly by filling of boxes, their arrangement on pallets, the ability of loading and receiving goods and the adaption to time slots. Furthermore, the location of the warehouses has also a direct influence on energy consumption. When warehouses and production sites are centralized, products are transported over greater distances and sent in smaller quantities (Aronsson and Huge-Brodin, 2006). Just-in-time deliveries have the advantage of less inventory, less tied-up capital, and a focus on speed (responsive supply chains), but the disadvantage of a higher energy consumption (McKinnon, 2016).

Actors’ behavior influences energy consumption: Another supply chain level can be explained through the actors -- logistics service provider (LSP), shipper, and consumer -- who make decisions about activities and processes that consume energy. The degree of collaboration between different actors (2a) is crucial for supply chain energy consumption. Energy efficiency can be improved by sharing know-how and expertise (Plambeck, 2012). Information technology can help to share this knowledge and match free logistics system capacity with products that have to be moved. Furthermore, sharing the vehicle’s capacity not only allows companies to achieve economies of scale, but also allows smaller companies to consolidate full truckloads (Lee et al., 1997).

Although reduced energy consumption impacts costs, other cost drivers can nonetheless be more crucial. Shippers (2b), who are the customers of logistics services, set the LSP requirements vis-à-vis delivery as well as lead times. These demands often lead to an increased energy consumption and contribute to inefficiencies such as underutilized transport capacity. The end consumer (2c) sets also demands and requirements for upstream logistics activities by asking for short delivery times and door-to-door solutions, hence contributes to higher energy consumption. On the other hand, LSPs will not offer resource protection, energy preservation, and lower GHG emissions in cases if higher investments are needed, but instead target lower costs if the end consumer does not demand those environmental-friendly measures and is willing to pay for them. The “last mile”, the transportation leg to the end consumer’s household, is of great importance when considering improving energy efficiency of the supply chain. For example, Browne et al. (2006) illustrated that the transport during the last mile can emit as much GHG emissions as are emitted during all the previous transportation activities in the supply chain.
Supply chain design sets conditions for performance achievement: The supply chain design sets conditions for energy consumption through its attributes, just as transport modes (for example, rail, air, road, sea) do in freight transport, but at a different system level, cf. Figure 3.1 above. The highest, but also most complex level focuses on the supply chain design. This is based upon the notion that energy efficiency improvements in supply chains can only be achieved holistically (Bottani et al., 2014). Sustainability should hence be integrated in supply chain management and not be viewed as separate concepts (Abbasi and Nilsson, 2012).

Further potential is seen in slowing down the supply chain (McKinnon, 2016). Responsive supply chains consume much more energy than efficient ones. Therefore, just-in-time principles should be re-evaluated. While just-in-time delivery reduces inventory cost and is characterized by flexibility and rapidity (Chapman, 2007), it increases the energy consumption and creates over-capacity because of its numerous transport operations. Restructuring the supply chain toward more energy-efficiency must include all different actors. More than 20 years ago, Wu and Dunn (1995) described the need for managers to understand their environmental responsibilities and the importance of a company to manage every element of the supply chain. Furthermore, this requires top-management commitment; Björklund (2011) described the inclusion of the top management as one of the greatest enablers for purchasing of environmental transportation services.

The framework in Figure 3.1 illustrates the importance of comprehensiveness and systems thinking when shaping an energy-efficient supply chain. Changes are needed at and across all levels: technology, activities, actor behavior and supply chain design. In the next section, causes and initiatives are presented that set conditions on all levels for energy consumption and improving energy efficiency.

4. Causes and initiatives: How supply chains set conditions for energy consumption and improving energy efficiency

4.1. Energy-consuming features in the supply chain

As stated in section 2, performance objectives such as flexibility, reliability, speed quality, cost-efficiency set priorities in logistics that shape energy consumption of processes that deliver customer value. When energy costs are defined merely in terms of fuel, they are often given low priority. To understand the conditions that shape energy consumption and efficiency, four different types of logistics situations that cut through the supply chain have been selected on the basis of the energy trajectories outlined by Halldórsson and Svanberg (2013):

- **Capacity in freight transport**: Often defined in terms of vehicle fill-rate (how well resources and capacity are used)

- **Last-mile fulfillment**: Customer-oriented perspective, considering the most energy-intensive parts of the supply chain

- **Sourcing**: Supplier-oriented perspective, appreciates the opportunity of engaging with and managing the supplier base for improved energy efficiency

- **Reverse logistics and closed-loop supply chain**: Volatile and difficult to plan, source of energy waste as well as great opportunity for energy recovery

Although these four areas are primarily concerned with the logistics and transport part of the supply chain, there are other activities and processes that also can be considered as a part of
the energy efficiency effort. Manufacturing and production of products and services, and even use of products, are additional consumers of energy. Moreover, extraction of materials in the closed-loop supply chain, can be added to that list, but is not only energy consuming activity but contributes also to recovery of energy out of products and materials at their end of use or end of life.

4.2 Energy-consuming attributes of the supply chain

Freight capacity utilization

The average capacity utilization in freight transport is relatively low, and the load factor in Europe between 1997 and 2007 was generally below 50 percent (European Environment Agency, 2010), it seems that increasing capacity utilization can contribute to energy efficiency improvement. The energy efficiency arguments is that a combination of both environmental and economic reasons have great potential for driving improvements. Capacity utilization in freight transportation depends on how the systems boundaries are defined (Kalenoja et al., 2011) and on the loading capacity, defined as the physical ability of a vehicle to carry freight during a certain period of time (Konings et al., 2008). In a narrow view, the system boundaries are drawn around the transport vehicle, but not so much how it interacts with other parts of the logistics system. A more extended view on capacity would resemble a complex interaction of different components (Hayes et al., 2005); a physical space in a vehicle interacts with other materials-handling equipment, operating rates, human resources, system capabilities, company policies, and suppliers’ rates and dependability. Ultimately, moving upward in Figure 3.1, freight transport capacity utilization is shaped by the supply chain design. In an efficient supply chain, the demand is steady, which makes a constant delivery of goods possible. In a responsive supply chain, fluctuations in demand make it difficult to forecast and plan capacity use.

Improving capacity utilization in logistics is a key operation for many companies. First, capacity itself, that is, the physical resource availability that sets the upper limit for the system at a particular point in time, can be illustrated by increasing the load factor of transport vehicles. Different initiatives of logistics service providers include the following:

- Consolidation of products: utilizing the truck with regard to weight and volume, for example, corn in the bottom and taco shells on top
- Effective product and packaging designs: products are designed so that they fill out a package; several packages fit exactly on a pallet; and, in the ideal case, double-stacked pallets fill out the height of the truck
- Considering product characteristics when calculating routing: this way, not only the best route can be driven, but the truck starts the milk run with a high load factor

Expanding the system boundaries to include other actors such as the end consumer, the movement and storage of products can be taken into account and capacity utilization be improved. Initiatives in the end of the supply chain that can increase energy efficiency through increased capacity utilization include the following:

- Ride-sharing of products: end-consumers share the transportation of goods during trips via piggyback
- Use of information and communication technology (ICT): using ICT to track the delivery and reduce the failure rate for home deliveries
• Extending the system boundaries: Including new actors that are normally outside the system boundaries, such as from freight transportation, or taxi drivers and bus drivers

*Last-mile logistics fulfillment modes*

Last-mile deliveries are among the most energy-intensive logistics operations in the supply chain. The opportunities to improve energy efficiency depend partly upon the type and availability of fulfillment mode, and partly the roles key actors have in these. First, last-mile distribution of goods can take place through different fulfillment options, for example:

- Distribution center → Retail outlet → Consumer collects and brings home
- Distribution center → Retail outlet → Home delivery
- Distribution center → Home delivery

These differ along dimensions such as *origin of the shipment* (for example, distribution centers, terminals and stores), by its *destination* (for example, retail outlet, other collection points, household), as well as performance priorities of the *delivery processes* (for example, speed and flexibility) (Fernie and Sparks, 2009, Hübner et al., 2016b, Hübner et al., 2016a).

The first fulfillment option entails both large vehicles and, most likely, passenger cars as part of the distribution system. The latter options use primarily large vehicles that may be more energy-efficient than small vehicles, but the trade-off is largely dependent upon the large vehicle’s capacity utilization, and the extent to which the delivery is successful (consumer at home to receive the goods or possible for logistics service provider to leave the shipment at the home). Missed deliveries make shipping goods in large trucks even less energy efficiency if customers are not at home to receive them. This leads us to the second last-mile aspect: a distinction can be made with regard to the *involvement* of different actors; logistics service providers, retailers, and end consumers. Especially, the involvement of the end consumer into logistics operations influences the last-mile energy consumption. End consumers can be involved in the last-mile fulfillment by either collecting (*active role*) the goods, for example, from a store pickup or point, or by receiving (*passive role*) them by a home delivery.

The last mile of the supply chain is thus characterized by different attributes, like the vehicle (private or commercial), vehicle size, load factor, involvement of the end consumer (passive or active), average driven distance, and frequency of pick-up points and stores. Depending if an efficient or responsive supply chain design is at hand, the demand can be predicted or not. In summary, initiatives for improving energy efficiency in the last mile may include the following:

- Use of distribution fulfillment modes that allow for better use of freight transport capacity
- Use of transport modes that are powered by renewable energy rather than fossil fuel
- Avoid failed deliveries and empty running by customers that are able to receive goods at the time of delivery
- Engage customers actively in receiving goods, for example, by using pick-up points close to their work to reduce distance driven in passenger cars
**Sourcing and supply management**

Sourcing and supply management impacts energy efficiency in different ways, ranging from energy usage for inbound flow, structure of the supplier base, and the freedom supply management (or the purchasing) function in the firm has to drive improvement efforts on their own. Direct impact of so-called “responsible sourcing” (e.g., Mitra and Datta, 2014) is achieved through, for example, auditing suppliers, a supplier conduct code, cooperation with suppliers, and supplier selection based on environmental criteria. A more indirect impact builds upon benefits through sourcing from the local community and a supplier base that allows for decreasing transportation distances.

**Inbound energy usage:** The energy consumption of sourcing can be addressed by taking into account inbound logistics of goods and materials. Companies can reshape their sourcing toward using more local suppliers, since long-distance transportation generates CO2 emissions and does not give any societal benefits (Porter and Kramer, 2011). The supplier location, and thereby the inbound logistics, can be decided by the purchaser, which can influence the overall energy consumption. The mode of transport can also be influenced by the sourcing team. Auditing and choosing suppliers that use renewable energy is another way in which energy can become cleaner. Further, taking into account the life cycle of a product can be another way of reducing the energy consumption as a good quality product does not need to be replaced as quickly, or spare parts to be transported excessively.

**Significance of the supplier base:** Focal companies in many industries buy a great amount of resources from suppliers, and often more than 50 percent of their total spending is used to pay for products and services from the supplier base. As consequence, the focal company has only limited control of and impact on their own environmental footprint, and they need to engage with suppliers to do so. Purchasing managers are well aware of this, and have started integrating environmental requirements into their sourcing strategies. Here, energy efficiency falls within the scope of sustainable supply management, or green purchasing. Sourcing has the opportunity to both directly (energy efficiency measures) and indirectly (sourcing-related measures) influence their suppliers, as well as own practices in purchasing and supply management to improve performance. To engage suppliers in such practices, sourcing strategies must be collaborative and create win-win situations rather than exercising bargaining power (Porter and Kramer, 2011). Table 4.1 provides examples of common ways of working with energy efficiency through sourcing.

<table>
<thead>
<tr>
<th>Table 4.1 Involving sourcing in improving energy efficiency</th>
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<tbody>
<tr>
<td><strong>Energy consumption (amount of energy)</strong></td>
</tr>
<tr>
<td>Indirect</td>
</tr>
<tr>
<td>● Supplier selection:</td>
</tr>
<tr>
<td>○ Sourcing location (transportation distance)</td>
</tr>
<tr>
<td>Direct</td>
</tr>
<tr>
<td>● Supplier selection:</td>
</tr>
<tr>
<td>○ ISO certification</td>
</tr>
<tr>
<td>○ Energy efficiency requirements</td>
</tr>
<tr>
<td>○ Programs for energy efficiency improvements</td>
</tr>
<tr>
<td>○ Long-term purchasing agreement with supplier</td>
</tr>
<tr>
<td>○ Large volume (bulk) purchases</td>
</tr>
<tr>
<td>Type of energy (fossil fuel vs. renewable)</td>
</tr>
<tr>
<td>Indirect</td>
</tr>
<tr>
<td>● Supplier selection and assessment:</td>
</tr>
<tr>
<td>○ Modes of transportation used for inbound and outbound deliveries</td>
</tr>
<tr>
<td>○ Supplier development through education or investment</td>
</tr>
<tr>
<td>Direct</td>
</tr>
<tr>
<td>● Supplier selection and assessment:</td>
</tr>
<tr>
<td>○ ISO certification (14001 and 50001)</td>
</tr>
<tr>
<td>○ Share of renewable energy used by supplier</td>
</tr>
</tbody>
</table>
Organizing sourcing for increased energy efficiency: Ellram and Tate (2015) identified four roles Supply Management (SM) has in an organization when sourcing services. Using their terminology, it is possible to outline ways in SM that can contribute to energy efficiency. Supply management as **primary owner** (standardized products and services) implies that:

- SM collects understanding of energy requirements to suppliers from internal users.
- SM screens the supplier market for most energy efficient suppliers.
- SM manages contracts with suppliers (ongoing).

When products and services become more complex, but not used frequently, SM must also act as a **guide** to others in the organization:

- SM ensures that all suppliers get same requirements as regards energy efficiency.
- SM provides a process that helps internal users to manage the purchase via, for example, templates and contractual terms.

For very complex products and services of high value, SM acts as **consultant** in the early phases by, for example, the following:

- Assists in market research and identifies suppliers (local and/or global) that comply with the company’s energy requirements.
- Prepares proposal requests that state energy requirements in clear terms.
- Acts as an expert in energy efficiency, negotiating with suppliers, outlining energy efficiency expectations in a service-level agreement, and even tracking energy and carbon footprints on the goods that their suppliers are delivering.

Finally, SM can act as a **process owner** in situations where energy efficiency efforts cut across business units or functional areas. Improving energy efficiency through better fill-rates, for example, may require input from R&D (packaging materials, product size), logistics (buying logistics services), and marketing and sales (terms of delivery to customers). This would also entail supplier development, e.g. providing expertise and knowledge to suppliers, and even support through joint investments.

In summary, activities that can influence the energy consumption from sourcing include, sourcing from environmentally friendly suppliers, collaborating with suppliers to minimize environmental impact, following responsible guidelines, and supplier development. Additionally, if the firm decides to make the purchase decision based on the total cost of purchase, product usage, and waste management and disposal, this could be seen as taking into account the life cycle of the product and could benefit the environment.

**Reverse logistics and closed-loop supply chains**

Reverse logistics -- a customer service or energy waste? Many products sent to the market are returned by end-consumers, or by the retailers and resellers (Jayaraman and Luo, 2007). This pertains to all sorts of products, ranging from fashion items, through electronics equipment to spare parts (for example, the automotive and aerospace industry). Reverse logistics has emerged as a branch within logistics and SCM as a means of structuring product returns, and
has grown substantially as consequence of increased use of e-commerce. It entails movement, sorting, handling, and storage of products from the point of purchase or use to another company, usually one tier up in the supply chain, or to a dedicated service provider. Although reverse logistics is seen as part of "customer service", established as policy and function in the company to create customer confidence and loyalty, allowing customers to return products in an unused condition for up to several months from initial purchase, it can also be regarded as contributor to waste. Surprisingly, many retailers, both brick-and-mortar stores as well as e-tailer, provide quite generous return policies to their customers, sometimes ranging from 100-360 days. The consequence may be that consumers buy more goods than they need, for then to return these later. Not only are the returns a waste in terms of excessive transport and energy consumption, but also these items are sent back to a supply chain point far away from customer, for example a distribution center or a return facility. Products being returned makes the initial forward flow for that particular item excessive. It is a waste of time, money, and effort, when it comes to energy efficiency. By taking an energy-centric perspective on this, companies can improve efficiency by managing:

- **Aggressive distribution that leads to overstocks**: Downplay aggressive supply chain distribution strategies that are guided by transportation fill-rates. Do not fill the truck as much as possible when shipping products down the supply chain, then relying upon reverse logistics in cases where the products do not sell or must be returned.

- **Overshooting customer service**: Understand that generous return policies (3-12 month return policy) can create excessive transport.

- **Fix items on site**: Dealing with poor product quality (complaints, product recalls) where the problem occurs, and avoid sending the items back in the supply chain.

**Closed loop supply chains (CLSCs) and energy hot spots**: CLSCs are further developments of reverse logistics and provide valuable principles for the circular economy. CLSCs also relate to the UN’s sustainable development goals with links to responsible production and consumption, and climate change (cf. United Nations, 2017). CLSCs aim to keep products alive as long as possible, or, alternatively, to harvest value from them directly (materials or energy recovery), or by diverting these materials as raw material input into production elsewhere. Challenges with return flows, in comparison to forward flows, include lack of stability and uncertain quality of returned goods. For these reasons, the energy footprint of the CLSCs can be considerably higher than in the forward supply chain.

**After-market services are important**: E-commerce, flexible return policies and product recalls that contribute to large volume of return flows have a distinct impact on energy efficiency in the supply chain. In addition, servitization of manufacturing, which implies that firms are moving towards a business model where products are “sold as a service”, can be expected to increase the need for firms to handle return flows of e.g. spare parts in the future. To counteract this, CLSCs prescribe opportunities for value creation during the whole product life cycle. This is significant in industries where production is energy intensive. Kalenoja et al. (2011), for example, identified that production accounts for two-thirds of the energy consumption along the supply chain of paper and metals, while raw materials account for one-fifth and transportation around 12-13 percent. For these types of products, it is not transportation, but production that is energy intensive.

From the perspective of energy efficiency, CLSCs provide opportunities for increasing the length of materials’ life cycle, thereby decreasing the need for raw material extraction and new production. This situation provides opportunities for effectively managing return flows by early sorting, and linking relevant companies together in the return flow to avoid excessive transportation, and to harvest value out of products at their end of life or end of use.
Servitization extends offerings into the aftermarket and can also offer services to customers to improve energy efficiency of operations, and to plan for improved maintenance of the installed base. Some manufacturers, for example, offer engine efficiency monitoring services to their customers, or training and education to increase operational efficiency and fuel efficiency of the equipment they produce and sell. With increased use of censor technology, the items in use (e.g. machines, vehicles and trucks) can be analysed remotely for optimized performance and customers can be given fuel consumption reduction advice.

Recovery options and energy: Blackburn et al. (2004) classified options for returned goods into direct reuse, refurbishing, repairing and remanufacturing, salvage, or recycling. These options are known as waste hierarchy, where the highest monetary value can be recovered with a greater environmental gain by the first option of reuse. Direct reuse and refurbishing allows the product to be sold in the first market at full price, whereas opportunities for repaired and remanufactured goods can be sold in resale markets. Remanufacturing typically turns previously sold and worn out products into “like new” ones that have the same performance and quality as new products. Remanufacturing can reduce production energy usage by up to 85 percent (Giuntini and Gaudette, 2003). Recycling allows the raw materials harvested to be used again, while the rest of the product can be turned into energy for electricity or heating through incineration. In case no other return option is possible, salvaging the product for parts and recycling of materials are still a better alternative than landfill. Examples of such recovery include food waste that can be turned into bio-gas car fuel and parts from returned mobile phones used for warranty repair.

Energy consumption in manufacturing vs. the use phase of products: Life cycle assessments of electronic equipment show that the energy-consuming hot spots along the supply chain differ across product categories. For example, refrigerators, washing machines, and TVs consume most energy during the use phase, 75–96 percent of total energy consumption, while mobile phones and computers consume most energy in manufacturing, or approximately 60 percent of total energy consumption (Quariguasi Frota Neto et al., 2010). The high consumption of energy in manufacturing is mainly due to the scarce integrated electronic pieces such as semiconductors and printed circuit boards. In response, the most efficient way to reduce energy consumption of products with high-energy consumption during the use phase will be to incorporate energy saving at the design stage (Quariguasi Frota Neto et al., 2010). In contrast, when most of the energy is consumed in manufacturing, the most efficient measure to reduce energy will be to extend the product’s lifetime through reuse, remanufacturing, refurbishing and reusing spare parts (Quariguasi Frota Neto et al., 2010). In the examples above, transportation is often a smaller fraction of the total energy consumption, but this will depend on the product as well as on where the parts, components, and final products are assembled.

Triggers of energy consumption: In principle, return shipments generate excessive transportation. Whether or not these returns are necessary or could be avoided in the first place should be of high priority. Example triggers of energy consumption include e-commerce, generous return policies, marketing campaigns, warranty and product recalls, human mistakes and product defaults. The first three triggers increase the risk that consumers buy products that they do not really need (or buy too many) or buy a product which they retrospectively realize was not exactly suitable for them. All of these reasons may lead to product returns, which will take place through logistics services or consumers returning the product. Warranty returns and product recalls are best prevented at the design and testing stage. Human mistakes should be prevented; in case they happen, they should be analyzed to prevent recurrence. Even if the return flows’ focus is on preventing post-production waste, efficient reverse logistics should not be used as an excuse for poorly managed quality in the first place.
Reducing energy consumption: In reverse supply chains, the marginal value of time will influence the possible re-use option; for example, computers can lose value up to one percent per week (Blackburn et al., 2004). In cases when the return option will only be recycling or salvaging for parts, the focus is on material value rather than the original functionality of the product, and the marginal value is expected to be of less importance. Here, an efficient reverse supply chain can be used where ultimately a larger volume of material can be consolidated to be shipped by a slower and more energy-efficient mode of transport. However, if a return option higher up the waste hierarchy is possible, then a responsive supply chain would enable most value being recovered. In this case, it is worth considering whether transportation can be avoided through selling, repairing, or refurbishing the product at the point of return (e.g. a retail store) or at a local warehouse.

Firms have also started to create opportunities for additional value creation through materials recovery. For example, app platforms are available on smart phones for restaurants to get in touch with consumers and sell leftover meals from the day. This innovation is creating additional revenues for restaurants and is reducing food waste that is a large contributor of GHG emissions. Another example is office furniture manufacturers that have extended their offerings to sell both refurbished or remanufactured furniture as a complement to new furniture. The furniture manufacturers have implemented a business model that allows them to lease and sell the furniture on a buyback plan, thereby allowing them to take advantage of refurbishing the products once they have served their time at one customer. Similarity, equipment manufacturers have started to offer remanufactured products at around half the price compared to new products. They have put in place a pricing structure that allows them to salvage parts from returned products that can be used for example in warranty replacements and allowing them to create effective reverse flows. From an energy perspective, the benefit of remanufactured products is extending the product’s life. Further, remanufacturing can often be done locally which avoids the need for long transports.

Logistics service providers (LSP) also have a role in making transportation more energy efficient and less carbon intensive. Several LSPs have made promises to reduce the carbon emissions of their operations. This is done for example through switching to alternative fuels, switching mode of transport and optimizing the carbon efficiency by better route planning. Further, LSPs can also be part of enabling efficient reverse flows in terms of utilizing their networks to facilitate efficient reuse, remanufacturing and recycling of products. In summary:

- Reverse flows are unstable and returned goods are of unknown quality. This leads to the energy efficiency in reverse flows being lower than in forward flows.
- The CLSCs perspective provides a more holistic view of energy consumption than SCM. Therefore, thoroughly understanding the energy consuming “hot spots” of a product will ensure that the most efficient energy reduction measures can be adopted first.
- Reverse flows enable for reuse of materials. Returned materials should aim to stay as high up the direct reuse, refurbishing, repairing & remanufacturing, salvage or recycling hierarchy as possible.
- Firms are increasingly realizing the benefits both for the planet and bottom line of having a CLSC approach; several examples of best practices can be found.
5. Future research direction

Although this chapter identifies a range of principles for sustainable development of logistics in the supply chain, more research is needed to understand the complexity of sustainable development supply chains through energy efficiency. Future research should focus on:

- Innovations in technology and business models that facilitate more sharing of logistics resources
- Energy efficient resource recovery and reverse logistics
- Managing energy efficiency and decisions
- Energy efficiency in production

Future research could look into innovations in technology that facilitate resource sharing through collaborative platforms. Sharing space in trucks, in containers and on vessels as well as creating possibilities for connecting with new customers can save both energy resources and generate additional revenue for firms. LSPs have the opportunity to enhance this trend of increased sharing of resources and turn it into their competitive advantage. Innovation in technology must be complemented by innovation in business models and logistics services.

Another promising future research direction would be to look into the energy efficiency of recovery supply chains. Although, some work has been done in this area, especially with respect to the Waste, Electric and Electronic Equipment (WEEE) directive implementation, incorporating energy thinking as a key dimension of reverse logistics could be a way to ensure that the environmental and economic benefits of resource recovery are optimized.

A third research direction could be to look into how energy efficiency can be managed. Carter et al. (2015) state that the supply chain is a network consists of nodes and links and that the visible horizon for managers is influenced by physical distance, cultural distance and closeness centrality. Therefore, understanding which nodes and links are managed actively, and the implications of this for energy efficiency could be studied further. Since limited visibility among managers can contribute to sub-optimal solutions in term of energy efficiency and costs, one way to study this would be to look at the decision-making process of SC managers. In particular, the decisions determining the efforts in supply chain operations in relation to implementing carbon reduction policies could be studied to see if the actions are targeted first at the energy consuming “hot spots” in the supply chain or if actions are left to be waiting for improvements in technology although many environmental solutions are already cost efficient.

This chapter has foremost focused on energy efficiency from the logistics aspects of supply chain management. Therefore, future research could incorporate energy efficiency in production as a further aspects of supply chain management and add an additional level to the framework of system levels. Here, energy consumption from resource extraction, fabrication, operations, and manufacturing can be studied in connection to developments as the Industry 4.0.

6. Summary and conclusion

Efficient and responsive supply chain design goes hand-in-hand with the ability to improve energy efficiency. Sustainable supply chains will benefit from taking energy as unit of analysis; it can be directly related to two key dimensions of the TBL, that is, profit and planet,
Energy consumption is directly affected by logistics decisions that have implications across the supply chain.

Improving energy efficiency, here defined in broad terms, is a viable pathway to realize the positive environmental impact supply chains can have. An important step is to acknowledge the causal relationship between supply chain designs and the amount and type of energy needed to move products from point of origin to point of consumption, and even further to repair, refurbish, or dispose of them. To complement this, in line with the nature of supply chains as structures, managers must be able to move across system levels, ranging from technology and activities towards the behavior of actors and design of supply chains as an emerging scope for such improvement efforts. To illustrate energy-consuming attributes and how to realize the potential of energy efficiency embedded in a supply chain perspective, the chapter presents four distinct areas of application in the supply chain: for freight capacity utilization, the last-mile logistics fulfillment mode, sourcing, and reverse logistics as well as closed-loop supply chains.

Acknowledgements
This work has been carried out with support from The Transport Area of Advance at Chalmers University of Technology, the Swedish Energy Agency, Logistik & Transport Stiftelsen and the Hanken Foundation. The support is gratefully acknowledged.

7. References


Supply chain structures for distributing surplus food

Abstract
Purpose – New actors have emerged in the food supply chain in response to the increased awareness of food waste and the need to distribute surplus food. The purpose of this study is to analyse the different supply chain structures that have emerged to make surplus food available to consumers.

Design/methodology/approach – This study adopts a qualitative multiple-case study of three new surplus food actors: a surplus food platform, an online retailer and a surplus food terminal. Data sources included interviews, documentary evidence and participatory observations.

Findings – Three different types of actor constellations in surplus food distribution have been identified: a triad, a tetrad and a chain. Both centralised (for ambient products) and decentralised supply chain structures (for chilled products) have emerged. The analysis identified weak links amongst new actors and surplus food suppliers. The new actors have adopted the roles of connector, service provider and logistics service provider and the sub-roles of mediator, auditor and consultant.

Original/value – This paper contributes to research on closed-loop or circular supply chains for the reuse of products in the context of surplus food distribution.

Keywords: sustainability, reverse logistics, case study

Paper type: Research paper
1. Introduction

It is estimated that 88 million tonnes of food are wasted each year in the European Union at a cost of 143 billion Euros (Stenmarck et al., 2016). Food losses and waste occur at all levels of the supply chain (SC) (Parfitt et al., 2010). Food waste is costly, has a significant negative impact on the environment and is unethical, considering that 118 million people in the EU live at the risk of poverty or social exclusion (Eurostat, 2018; Matopoulos et al., 2015).

A lot of food waste could be avoided. According to a recent Canadian study, the potential for food waste recovery is highest at the processing and manufacturing stage, while 11.2 million tonnes, valued at $49.46 billion, is recoverable in the SC (Nikke et al., 2019). Furthermore, data from Italy shows that 181,400 tonnes (0.4 per cent of sales) is recoverable surplus food (SF) in the manufacturing and retail sectors (Garrone et al., 2014a). In recent years, scholars and practitioners have made significant efforts to identify the underlying causes of food waste and address the problem. There is now a growing recognition that food waste is more manageable than has previously been assumed (Muriana, 2017).

Since the early 1990s, environmental issues in SCs have been increasingly examined (Ansari and Kant, 2017), with related streams of research on closed-loop SCs and reverse logistics (Guide, Jr. and Wassenhove, 2009) and, more recently, circular economy (CE) principles in SCs (Genovese et al., 2017; Ripanti and Tjahjono, 2019). The closed-loop and circular SC literatures are concerned with finding recovery options (such as repair, reuse, remanufacture, or recycling) to slow down and close resource flows. However, previous literature on closed-loop flows has tended to focus on technical products (Islam and Huda, 2018; Mishra et al., 2018), while the perishable nature of food products and the need to comply with food safety standards pose different requirements for the duration and conditions of storage, processing and transport (Liljestrand, 2017).

With regard to food waste in particular, SC actors tend to focus on internal waste reduction and local optimisation, which leads to sub-optimal results for the entire SC (Mena et al., 2014). The main reason for SF in the manufacturing and retail sector is that the internal sell-by date has been reached (Garrone et al., 2014b), although this does not necessarily mean that the food has reached its ‘end-of-life’.

Given that strategies and structures have been developed to optimise forward food SCs (based on a linear thinking), the food SC produces waste and SF as by-products that cannot be dealt with in a sustainable manner (Parfitt et al., 2010). However, food that risks becoming waste can be made available to consumers through new SC structures that can provide efficient and effective SF distribution. According to the literature, structures tend to change, particularly when a new actor enters the network or an actor disappears and takes its connections with it (Halinen et al., 1999).

At the same time, actor constellations that facilitate closing the loop tend to vary depending on the recovery option (repair, reuse, remanufacturing etc.) (Gobbi, 2011; Lüdeke-Freund et al., 2019). This means that an effective actor constellation for the repair recovery option would not immediately fit food recovery for human consumption, and actor constellations that are able to provide effective SF distribution have emerged only recently. Furthermore, even though recovery options are dependent to some degree on cooperation with other actors (such as customers, business actors, other actors in society), details about the roles of these key actors tend to be missing in earlier literature (Lüdeke-Freund et al., 2019). Also, establishing a cooperation that can enable recovery requires interactions among several actors.

Against this background, a SC approach is useful for studying the SF phenomenon. The purpose of this paper is to analyse the different SC structures that have emerged to make SF available for consumers. The purpose is operationalised into two research questions: Which
actor constellations and interactions have emerged in SF distribution? What are the roles of new actors in SF distribution?

This study makes four main contributions. First, it contributes to an enhanced understanding of food reuse options by simplifying complex actor constellations into triadic, tetradic and dyadic microstructures and thus adds to the closed-loop SC literature. Second, it provides insights into the centralisation and decentralisation aspects of products with a high recovery value and adds to the reverse SC design literature. Third, it adds to the sustainable SC and CE literature by identifying the roles of more rarely studied actors in for-profit and not-for-profit SCs in developing more circular SCs. Fourth, it evaluates the environmental impact of new SC structures and thus contributes to the related food waste literature.

The remainder of the paper is structured as follows. Section 2 provides an overview of the relevant literature and presents the research framework. This is followed in Section 3 with an overview of the applied research method. Section 4 describes and analyses the findings, while Section 5 discusses the results in relation to the existing literature. Finally, Section 6 concludes the paper and suggests managerial implications, offers recommendations for future research and outlines the study’s limitations.

2. Theoretical background

This section begins with an overview of the causes of food waste in the SC and presents the main recovery solutions. After this, the SC structure concept is discussed in relation to reuse. Subsequently, the conceptual framework is presented together with social network theory, thereby providing a lens for explaining actor roles and interactions.

2.1 Food waste in the supply chain and recovery solutions

Several reviews of the causes of food waste have been conducted in recent years (see Canali et al., Chen et al., 2017; Muriana, 2017). Although a thorough review of these studies is beyond the scope of this paper, the causes can be divided into three categories: technological, institutional and social (Canali et al., 2017). The causes of food waste that occur in-between actors include overproduction and overstock due to short-term delivery orders, retailers wanting products with an overly high remaining shelf-life, reduced tolerance among retailers of delivery errors and a tendency to transfer the risks of unsold products and related costs of disposal to suppliers or customers (Canali et al., 2017). Other factors that contribute to food waste include policies for the free return of unsold or damaged products, the possibility of last-minute cancellations of orders, market power imbalances, failures in stock and order forecasting, market destabilisation effects of certain sales campaigns and other marketing practices (ibid.). Similarly, Muriana (2017) summarised the 11 main causes of food waste in a SC consisting of producers, manufacturers, wholesalers and retailers as follows: demand variability, sudden events, transport/packaging mistakes, quality standards, manufacturing defects, pricing policies, inventory/shelf control policies, promotions, short shelf life, a lack of SC coordination and over production (ibid.). If food becomes waste, it leads to significant inefficiencies in the use of natural resources. Many of the causes could be addressed by improved coordination between different food SC actors (Canali et al., 2017).

The food waste hierarchy presents a framework with options for food waste management and prevention (prevention, reuse, recycling, recovery for energy generation and disposal) (Papargyropoulou et al., 2014). In the food context, the higher recovery options (prevention, reuse) are most beneficial, with the reuse (or redistribution) option meaning that the food is ‘given a second chance’ to be consumed by people (ibid.). A useful term here is ‘surplus food’,
which is defined as ‘the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer’ (Garrone et al., 2014b, p. 130). Herein, ‘food waste’ refers to both avoidable and unavoidable waste. The lower recovery options are not addressed in this paper because the environmental and social benefits are considerably lower and too often used without considering the higher levels (for example, the overproduction of bread as input for biogas production).

The relevant practices for managing SF that are illustrated in the literature are: (1) repacking products, (2) selling with discounts or promotions, (3) selling in secondary sales channels, (4) distributing through sponsorships for marketing purposes, (5) distributing products internally and (6) partnering with food aid organisations (Garrone et al., 2016; Holweg et al., 2016). Furthermore, several logistics solutions that can reduce food waste are described by Liljestand (2017), who identifies solutions such as collaborative forecasting (for example among a producer and wholesaler), allocating more lead time for consumers, meetings to determine the correct levels of safety stock, postponing manufacturing until stores place orders, adjusting the service level, joint product group revisions meetings and packaging development.

2.2 Supply chain structures and reuse

Surplus food recovery can be facilitated by redesigning SC structures (Östlin et al., 2008) and including non-traditional actors as part of the structure (Pagell and Wu, 2009; Rodríguez et al., 2016). A SC structure is a constellation of actors that are linked together and define the boundary of the studied SC. ‘Link’ refers to cooperation between the actors in the SC, where various links between the actors contribute to a whole SC (Lambert and Cooper, 2000).

The concept of SC structure has often been used interchangeably with SC design. A detailed review of SC design literature can be found in Calleja et al. (2018), together with a discussion of the frameworks and tools available for decisions relating to the design of the SC (including definition of the SC objectives, reverse SC, finance and generation and use of scenarios). However, due to the increasing complexity of SC design decisions, Calleja et al. (2018) reveal several shortcomings in the frameworks as being insufficient to help SC practitioners. Their study highlights that reverse logistics (and closed-loop SCs) deserve full consideration at the beginning of the SC design process.

Relevant in this regard is the green SC design literature, which includes environmental aspects of the SC. Transportation is considered to have the largest environmental impact, with road transportation being responsible for 70 per cent of greenhouse gas emissions (European Commission, 2016). The last mile, when consumers travel from home to the store by car, has been shown to be especially carbon-intensive due to low load, although this depends on the distance travelled (Browne et al., 2006). Therefore, the mode of transportation, distance and fill-rates are important environmental considerations in SC structures.

In addition to green SC design decisions, the reverse logistics literature has proposed the ‘efficient’ and ‘effective’ typology for handling products that are returned by consumers (Blackburn et al., 2004). These authors suggest two alternative SC structures: centralised for low marginal value of time (MVT) products and decentralised for high MVT products. In a centralised structure, the returned product is sent to a central location for evaluation, whereas in the decentralised structure the product is handled locally. The centralised structure provides benefits from economies of scale in both transportation and processing, but is slower at bringing the product back to the market. A decentralised structure facilitates early product differentiation and rapid ultimate disposition but requires decentralised activities and decisions, which are more costly. Similarly, Gobbi (2011) relates the product residual value (PRV) to high and low recovery options and develops the argument around decentralised structures. While Blackburn et al. (2004) suggest a decentralised structure for products with
high PRV and high MVT, Gobbi (2011) states that the decision to implement a centralised versus decentralised reverse SC structure for these products could be driven by the size of incoming volume and need for expertise in reconditioning (ibid.).

Many of the studies of the reuse option in closed-loop SCs have only considered durable products that are intended to be used multiple times (Carrasco-Gallego et al., 2012), where temporality is less significant than for food products. In parallel, the CE builds on the design of closed-loop SCs, where reuse and redistribution mean giving the product a second chance to be used for the purpose for which it was initially intended with little modification (Lüdeke-Freund et al., 2019). To illustrate, second-hand stores, both in-store and online, have created new marketplaces in the clothing industry. Some manufacturers, especially those of higher valued products, have started to offer their own second-hand markets, and redistribution can also be organised among consumers.

2.3 Conceptual framework

As discussed above, the food SC is a complex network of actors that generally involves all the stages from primary production to final consumption (the main stages of the food SC are shown in ‘forward flow’ in Figure 1).

As the traditional SC produces SF and waste that cannot be passed on to consumers (Papargyropoulou et al., 2014; Parfitt et al., 2010), food processors, manufacturers, wholesalers, retailers and restaurants are the supply base in SF distribution. Also, as the degree of recoverability is low for most agricultural products and for household food waste (Garrone et al., 2014), these segments are not part of the supply base in the figure and are not represented in the empirical study (although examples of 'shared fridges' among consumers do exist).

The focus here is on the reuse option in closed-loop or circular SCs and specifically on the actor constellations that bring the SF to consumers. This requires a reconceptualisation of what is generally seen as the SC structure since it includes different actors. Hence, the first task is to identify the actors that use the SF and manage the physical flows. Furthermore, in these SC structures the actors involved will take up different roles and interact within the structure. Thus, in order to identify and explain actor constellations in SF distribution this paper draws on social network theory.

Social network theory can be applied to the SC context by regarding a SC actor as an entity (Borgatti and Li, 2009). Social network research analyses the ties between actors that constitute a structure that can be studied (Borgatti and Li, 2009). A lot of social network research has been concerned with identifying how the four different types of links – similarities, social relations, interactions and flows – within dyadic relations affect each other (ibid.). The first two types are continuous links (i.e. relational states), while the other two are applicable to this context because they refer to discrete events. Interactions imply an underlying relation and serve as a proxy for the strength of the social relation (e.g. sent an email, talked in the last month). When actors interact, flows consisting of hard types (materials, money etc.) and soft types (such as information) are moved between actors.
Social network theory research is largely underpinned by the work of Granovetter (1973) and Burt (1992). Granovetter (1973) emphasises the strength/weakness of a link and specifically sees weak links as being important for performance, given that new information is more likely to come through weak links than from an actor in the same network. In contrast, Burt (1992) focuses on the lack of direct connection between actors in a network, known as a structural hole. Structural holes create opportunities for third parties to engage in brokerage by facilitating interactions between certain disconnected actors. Brokers may influence, manage or facilitate interactions between other actors in one of the three basic roles of brokerage: conduit, tertius gaudens or tertius iungens (Obstfeld et al., 2014). Conduit brokerage is the simplest version and encompasses transmission of flows, while tertius gaudens uses the interactions for its own purposes by keeping certain actors apart (Burt, 1992; Obstfeld, 2005). Tertius iungens links selected actors together and can have an active coordinative role (Obstfeld, 2005; Obstfeld et al., 2014). Ciulli et al. (2019) builds on the structural hole concept and explores brokerage roles amongst digital platform organisations in the food waste context.

In sum, the present study is positioned in the reuse of SF as a means of mitigating food waste. Prior research has disclosed the challenges and conceptualisation of the SC that leads to waste but has overlooked the significance of suitable SC structures needed for recovery. Further, when it comes to expressing how new actors can advance waste recovery, research has not yet caught up with practice. Hence, this article extends the limited qualitative research on SC structures by investigating the actor constellations that facilitate SF distribution.

3. Methodology

This research concerns emerging SC structures that can handle SF. Hence, the research context is the food industry and the unit of analysis is the different emerging SC structures. As the topic is relatively new, a qualitative case method approach has been adopted to acquire a detailed understanding of the phenomena and to develop substantive theory (Gummesson, 2017). Case studies are especially suitable when the research and the theory are in the early stages of development (Eisenhardt, 1989).

3.1 Sampling

In order to develop rich explanations and deep insights into SC structures, a multiple case study (consisting of three cases) is used as the research strategy (Eisenhardt and Graebner, 2007). The selection criteria are that the initiating actor (1) works with the SF problem and (2) is new in the SC. The reasoning behind this is theoretical sampling, as the cases are found to be appropriate for illuminating and expanding relationships and logic among constructs (Eisenhardt and Graebner, 2007; Yin, 2014). Details of the organisations and interviewees are presented in Table 1.

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The empirical cases are geographically located in a Scandinavian country in which a few large retail and wholesale chains dominate the market. Importers and food processors constitute significantly more actors. Two of the initiating actors are for-profit organisations, namely the SF platform (in Case 1) and the online retailer (in Case 2), while the SF terminal (in Case 3) is a not-for-profit organisation. As the cases operate in the same geographical market, they
interact with the same food SC actors and traditional SC structures. In this geographical context, no further successful initiatives were identified during the study period.

Subsequently, SF suppliers were approached using snowball sampling. In Case 1, the SF suppliers were chosen because they had been early adopters of the platform. In addition, the informant at the food market could provide insights into several of its stores’ perspectives. In Case 2, the informants provided a typical picture of their relationships with the online retailer. The bread and dairy suppliers in Case 3 were chosen because they donated the largest volumes (based on internal documents) and the retail chain had several stores from which food was donated.

3.2 Data collection

The data was collected using multiple sources, including interviews, participant observations and documentary evidence. Multiple sources of data help to provide a closer representation of the studied cases and evidence to triangulate the findings (Yin, 2014).

The data was collected between January and November 2018. First, documentary evidence, including sustainability reports, company websites, news reports and annual reports, was gathered prior to each interview and informed the interview guide. Internal documents, photographs and email conversations complemented the documentary evidence.

In each case, semi-structured interviews were conducted with initiating actors and SF suppliers. The informants for the initiating actors were the CEOs (in Cases 1 and 2) and the project manager (in Case 3). These key informants provided information about the background and vision of the initiative, identified the other actors in the SC structure, gave insights into their relationships and described how the solution facilitated SF management. All the interviews with SF suppliers covered background information, current reasons for food waste and practices for reducing waste, other actors in the SC and their relationships, and logistics operations around food waste reduction. A total of 10 in-depth interviews were conducted with 12 people, with each interview lasting approximately one hour. Nine of the interviews took place face-to-face and one was conducted via Skype because the individual was located far away.

Finally, a third source of data was generated from participatory observations (Yin, 2014) in Case 3 at the physical site where the initiating actor managed the SF distribution (in Cases 1 and 2 the physical sites were handled by other actors in the constellation). The researcher conducted the observations in the role of a volunteer. This role involved picking up donated food from various SF suppliers across the city and transporting it from the SF terminal to various food aid organisations. During the course of the volunteer work the researcher had informal conversations with the staff (delivery van drivers, other volunteers and a terminal coordinator), which gave insights into operational issues and cooperation (for example, at one supplier the donated food was clearly inedible) and how the volume fluctuated over time. In total, the volunteer work (including informal interviews) took place over a 20-hour period. During each observation day, field notes with photographs were produced.

3.3 Data analysis and research quality

The data analysis was based on an iterative process, in which the empirical material that was generated during the data collection process was repeatedly compared to existing theory (Dubois and Gadde, 2002). All the interviews were recorded and transcribed, which resulted in 117 pages (61,512 words) of interview transcripts. Field notes from the observation days and
meetings with informants, other documents, photographs and transcripts were combined. All the data sources were imported into NVivo 12 software to support content analysis. First, initial memos were written summarising the core around each organisation’s perspective and finding the consensus in interpretation. Initial coding included an in-depth analysis of each organisation around the concepts derived from the interview questions and through the coding process. Next, the organisations’ views in a case were compared by means of axial coding while looking for common themes, patterns and categories (Boeije, 2002). Finally, comparisons between the cases contributed to triangulation.

The quality of this study has been evaluated by assessing its credibility, transferability, dependability and conformability (Lincoln and Guba, 1985). The credibility of the study was established through the triangulation of data sources, such as interview scripts, observations and documentary evidence, to ensure that the findings constructed by the researcher matched the real case investigated. The transferability of the findings was limited to contexts featuring similar conditions as the food SC. The thick description of the data collection procedure found in this paper contributes to transferability. Dependability was established in the research design, the case study protocols and in the selection of cases based on theoretical sampling. Conformability was achieved by carefully selecting the relevant participants and by asking questions about the other actors in the SCs, which made it possible to draw conclusions based on multiple informants’ shared views.

4. Findings

This section presents the empirical results based on the conceptual framework presented in Section 2.3. The dyadic initiating actor and SF supplier perspective is discussed, followed by a within-case analysis and the results of the cross-case analysis.

4.1 The initiating actor and supplier perspective

The term ‘SF supplier’ is used for a firm supplying the initiating actor with food, even though that is not its main business activity.

4.1.1 The perspective of the initiating actor

The SF platform (in Case 1) provides a platform on which restaurants, cafés and grocery stores can sell leftover food. The reason for the actor’s SF is that in restaurants and cafés food is prepared before it is sold and it is therefore more profitable to have too much food (which goes to waste) than miss out on sales. The SF platform emphasises convenience for consumers who can, for example, enjoy a take-away meal at a competitive price at the same time as food waste is reduced. This means that the SF food platform can reach many different customers and not just environmentally conscious consumers. Since it was established in 2015, the SF platform has significantly increased its supply and customer base and expanded into new geographical markets.

The online retailer (in Case 2) was established in 2016 and purchases surplus batches of ambient food and utility products from producers and importers. The products are either close to their sell-by date, have already expired, or cannot be sold to retailers for other reasons (such as changes in packaging, large batches etc.). This actor has significantly increased its operations since its establishment and has had to find new warehouse partners with increased capacity.
The SF terminal (in Case 3) was inaugurated in 2015 and handles surpluses from grocery stores, wholesalers and producers. The SF terminal was established to recover more SF in the area, which has inspired stakeholders in several cities to hold serious discussions about how to better coordinate around SF. The food aid field has been ‘a mess’, largely because food aid organisations sometimes lack skills related to professionalism, quality and knowledge about food handling. Furthermore, there is limited tracking of SF flows. However, it should not be the responsibility of food aid organisations to handle inedible food waste from business actors – their priority needs to be prevention. In the words of one interviewee: ‘Are they all [consumers] really that demanding [as the food industry claim]?’

4.1.2 The perspective of the surplus food supplier

All the suppliers at the retail stage made a statement along these lines: ‘Zero SF is not feasible without sacrificing quality and availability, because it would mean that there would be too little to sell in grocery stores’. Most of the interviewees stated that price reduction (a day before or on the sell-by date) is a tool that is regularly used in grocery stores (Retail chain, Case 3; Food market, Case 1). In Case 1, a store manager explained that red price tags (indicating price reductions) were not used because they were regarded as lowering the quality of the store in the eyes of the consumers, which meant that the SF platform was a good partner for that store (Retail store, Case 1). Another SF supplier mentioned that the SF platform was used as one of several food waste management tools (Food market, Case 1).

In Case 2, one of the reasons why food products became SF was because they could not be sold to traditional retailers with strict sell-by date requirements. One interviewee explained: ‘[Retail chain X] is most demanding, it requires 70 per cent of the shelf life left at delivery ... which for our products is 9 months. [Retail chain Y] now requires around 50−60 per cent, and we can sometimes reach a compromise ... but we still have a long way to go’ (Importer, Case 2). When the products cannot be sold to retailers, soft discount stores are the next option. However, it is difficult to sell products with only one or two months of remaining shelf life to soft discount stores, so the online retailer then becomes a good partner (Manufacturer and importer, Importer, Case 2). Importers have minimum batches that need to be purchased (Food market, Case 1; Importer, Manufacturer and importer, Case 2) in order to keep prices competitive.

In Case 3, the main issue causing SF in the bread industry was overproduction, due to a lack of demand data. As the interviewee explained: ‘We need to start baking, making our dough before we get the orders in. So basically, our production is 75 per cent or more based on how we estimate how much bread is going to be ordered for the following day. And hence, there is always a bias between how much is produced and how much is ordered and delivered’ (Bread producer, Case 3). Further, as the sellable freshness of bread was only one day, a greater variety of bread offerings made it difficult to estimate production (Bread producer, Case 3). According to the interviewee, the overproduction of dairy products was due to the constant supply of raw materials, the large batch sizes at the production facility and changes in customers’ tastes and demands (Dairy manufacturer, Case 3).

4.2 Within-case analysis: Components of the emerging supply chain structures

Three types of constellations were derived: a triad, a tetrad and a chain. These constellations are presented in Figure 2.
4.2.1 Emerging supply chain structures

In Case 1, a decentralised SC structure emerges. The SC structure takes the form of a triad and the initiating actor has the position of broker (*tertius iungens*). In this position, the SF platform handles the payments from consumers (a fee per transaction), information about SF supplier behaviour (such as providing support and monitoring their pricing) and customer behaviour (such as ensuring that supply is available at the right time and place for customers). The products flow directly from SF suppliers to consumers and many suppliers are located where consumers move (that is, transportation hubs).

In Case 2, the SC structure takes the form of a tetrad ‘group of four’. The actors involved are SF suppliers, the online retailer, consumers and the additional actor of a logistics service provider (LSP). The online retailer manages the key activities, which are SF supplier relationships (takes up a margin between purchase price and sold products), the online store and marketing activities. Consumers can purchase food at a 20–90 per cent discount. The third party LSP handles warehousing, picking and packing and logistics activities. This tetrad is centralised, in that all the products are transported to the warehouse (located around 150 km away from many suppliers) before being shipped out to a service point for consumer collection. This SC structure creates some demand for truck transport. The emission levels also depend on the mode of transport used by the consumer to get to the service point.

In Case 3, the SC structure is a linear chain of SF suppliers – SF terminal – food aid organisations. The SF terminal arranges daily pick-ups from the SF suppliers with which it has an agreement (products are received at no cost) and deliveries to food aid organisations (where the food is cooked into a meal or the products are distributed in bags to beneficiaries). At the terminal, boxes of food for distribution to food aid organisations are picked and packed, meat is frozen to extend its shelf life and fresh food is refrigerated. Centralising the distribution has reduced the need for transportation by independent food aid organisations, which often takes place by private cars. Some of the challenges in the chain include low loads (due to limited supply of SF shared between several actors in an area) and failed pick-ups (e.g. when the SF is already inedible) (observations, Case 3).

4.2.2 Interactions in the supply chain structure

All the initiating actors indicate that they have a lightweight contract with the supplier from which the SF is distributed, including the grounds for cooperation (who does the collecting, the pick-up time, terms of delivery, food security etc.). In the triad, the ‘physical’ links between the actors are weak. Everything usually works smoothly (because it is automated) and it is quick and easy to make the products available for sale on the platform (CEO, Food market, Case 1). SF suppliers are often active on the platform on a daily basis and more rarely communicate directly (only in the case of a problem with using the service or the need to adjust pricing). The SF platform has noted that customers who have used the platform a couple of times tend to become regular users. However, some SF suppliers are concerned that customers will learn when to buy the products at a discounted price through this channel. On the other hand, the SF platform can bring consumers into the restaurant, many of who then come back to get restaurant experience (CEO, Case 1).

In the tetrad, the online retailer wants to be a good buyer, for example by always responding to emails, indicating that it is in a weak position towards SF suppliers and wanting the interactions to develop so that suppliers proactively communicate their surpluses (CEO, Case
2). Its suppliers especially appreciate the transparent pricing and model (importer, manufacturer and importer, Case 2). The interactions have been infrequent recently because there are no near-to-expiry products (Importer, Manufacturer and importer, Case 2). The customer base is considered loyal and active (CEO, Case 2).

In the chain, the SF terminal describes itself as a more demanding partner (e.g. it only accepts edible food) than other food aid organisations, but also that the relationship usually works well once suppliers have learned how it works (Project manager, Case 3). The suppliers see the actor as professional and trusted. Furthermore, it is one of the few organisations in the third sector to have raised the issue of efficiency in logistics operations (Dairy manufacturer, Retail chain, Case 3). When the contract has been signed, their interactions are regular but brief. At the food aid organisations stage of the chain the SF terminal aims to create stronger connections between the different actors in the food aid network.

4.2.3 Actor roles in the supply chain structure

In the triad, the SF platform has assumed the role of a *tertius iungens* and links SF suppliers with customers (as a ‘connector’). Subsequently, identifying commonalities between the actors on timing and place is a key role (as a ‘mediator’). As described earlier, once consumers have used the platform a couple of times they tend to remain active users.

In the tetrad, the online retailer has assumed the position of *tertius iungens* in the role of a ‘service provider’ by linking different actors to a good consumer service. The online retailer actively helps SF suppliers to sell their excess stock, organises the deliveries and makes food available at discount prices for consumers. The customers are described as active (e.g. they provide positive feedback about the service, comment on Facebook posts etc.).

The main role assumed by SF terminal is that of a ‘LSP’ – which is similar to *conduit* behaviour – which means managing the flows by arranging pick-ups, storage, picking, packing and delivery. The SF terminal is more active in its sub-roles in that it visits all the actors in the food aid network (as an ‘auditor’) and helps the network to improve the food aid distribution and the well-being of the person eating the food (as a ‘consultant’). All the SF suppliers exhibit passive behaviour towards the relationships.

4.3 Cross case-analysis

The observations made across the cases are discussed in this section and the results are shown in Table 2.

Insert Table 2. Cross-case analysis of supply chain structures and recovery solutions around here

For Cases 1 and 2, the solution is food recovery by selling the food. The difference between the two is that Case 1 is a platform organisation that can be used via a smartphone, whereas Case 2 uses the internet to provide a new sales channel and is therefore comparable to e-commerce. Internet shopping has led to retailers no longer being the sole interface with consumers, while smartphones have made consumers’ shopping behaviour more mobile. Both cases thus make use of technology. Case 3, in contrast, handles the physical distribution to food aid
organisations. This requires physical capacity (warehouse, vans etc.) and labour and is feasible because the city, together with associations, cover the operational costs.

For Cases 1 and 2, the degree of perishability correlates with the SC structure that has emerged: *decentralised* (chilled products) and *centralised* (ambient products). In Case 3, a distinct *centralised* channel is established that separates paying and non-paying consumers (i.e. as beneficiaries are not picking up directly from SF suppliers they receive the products earlier). However, a trusted actor is needed to establish relationships with SF suppliers. In comparison, price discounts are a decentralised solution.

In all the SC structures the consumer (and in Case 3 the beneficiary) is responsible for the last mile, as there are no home deliveries. Therefore, it is up to the consumer to ensure that the mode of transport has a low environmental impact (such as walking or cycling). The cases also show differences in how the transportation activity is organised. In Case 1 the consumer undertakes the activity, in Case 2 it is outsourced to a third-party LSP and in Case 3 it is undertaken by the initiating actor. The transportation solution in Case 1 is the most cost-efficient from the initiating actor’s perspective, as the consumer has this role.

The links between initiating actors and SF suppliers are weak in all the cases. The interactions with suppliers are frequent (daily) in Cases 1 and 3 and sparse (monthly) in Case 2. This means that even though the interactions are more frequent, it appears that suppliers invest limited resources and that the relationships are of low value. It is remarkable that the suppliers themselves do not take more advantage of the potential value the SF can create. Instead, the new actors are addressing the SF suppliers’ waste problem while creating value from it.

In all three cases the initiating actors link actors together in ways that were not previously possible and have an active role in the structure. Interestingly, the distance between the actors on both sides of the initial actor varies. For instance, in Case 1 the SF platform has shortened the distance between the two other actors (SF suppliers and consumers), while in Cases 2 and 3 the distance between consumers/food aid organisations and SF suppliers remains long. This means that the initiating actor in Cases 2 and 3 have a continuing facilitation role, as direct links have not been created. Also, the direction of the initiating actor targets differs, in that the SF platform is equally active in both directions in the triad, while the online retailer is more active upstream and the SF platform is more active downstream.

5. Discussion

This study has analysed the different SC structures that have emerged to make SF available for consumers by building on the recent literature’s argument that food waste should not be seen as an inevitable externality of the food industry (Muriana, 2017) and that waste occurs between SC actors (Mena et al., 2014). In this section, the identified actor constellations are discussed in relation to the existing literature and the main contributions presented.

As shown in this study, and indicated in earlier research (Canali et al., 2017; Mena et al., 2014), demand variability, minimum production and purchasing batches, strict sell-by dates by retailers and short delivery times all lead to overproduction and extra buffer capacity in SC and put food products at risk of becoming waste. Strict sell-by dates are likely to be more prominent in concentrated primary retail markets where retailers exercise power (Hingley et al., 2015) and drive suppliers to use secondary channels after the time window for the primary market has been missed (Garrone et al., 2016). These findings suggest that retailers are reluctant to negotiate sell-by dates with their suppliers. Thus, existing and emerging redistributive SC structures play a key role by linking actors and coordinating interactions with the aim of facilitating the physical flow of SF to consumers.
5.1 Actor constellations in surplus food distribution

While earlier literature has analysed the relationship constellations in aftermarkets (Wagner et al., 2018), this study derives three novel actor constellations in the SF recovery context (i.e. triadic, tetradic and dyadic microstructures). Digital brokers’ roles in food waste recovery have been investigated by Ciulli et al. (2019) in a variety of relationships (i.e. B2B, B2C, B2NGO and C2C). However, in contrast to Ciulli et al. (2019) who in their analysis aggregate different relationship types (i.e. B2B, B2C, B2NGO and C2C) and market intermediary platform organisations (i.e. smartphone apps and software platforms), this study finds tertius iungens behaviour in the B2C cases and a conduit role in the B2NGO case. This suggests that distinctions between relationship types and digital technology implementation are necessary in defining actors’ linking roles.

Regarding the first actor constellation, i.e. triad, this constellation links unconnected suppliers and consumers by means of a smartphone app. The ‘connector’ role is also identified by Ciulli et al. (2019). Although their ‘balancing supply and demand’ role is similar to the ‘mediator’ sub-role identified here, the SF platform also emphasises temporality. For example, in the ‘mediator’ sub-role the SF platform influences the suppliers to make the food available at a time when people want to eat it. While a tertius iungens is interested in the unity of the triad (Obstfeld, 2005), consumers show more active behaviour in the triad, whereas SF suppliers feel comfortable adopting a more passive role because this structure is not their main sales channel. Moreover, decentralised structures are designed for fast delivery and lower volumes (Gobbi, 2011), since speed of delivery is important when food products and portions are at the end of their life, and the triadic formation facilitates ad hoc link creations by having a large user base.

The tetradic actor constellation identified here is an online channel. Prior research on omni-channel retailing has highlighted the importance of last-mile delivery solutions (Taylor et al., 2019) and that broad assortments and perishability are obstacles to centralised distribution in grocery retailing (Wollenburg et al., 2018). However, this study shows a centralised structure due to a rather low product variety and dry food products in the assortment, while the last-mile is arranged through delivery to a pick-up location close to the customer’s home. The initiating actor has a ‘service provider’ function in that it links different actors and manages the interactions to deliver ‘cheap and saved food’ as a service for the consumer. Whereas Ciulli et al. (2019) relate their brokerage roles to supply and demand connectivity, these findings show that physical distribution in the form of a LSP as a fourth actor facilitates service provision and SF distribution.

As to the third actor constellation, i.e. the linear chain, the results show that the initiating actor functions as a LSP in that it provides a logistics service for suppliers and food aid organisations. When large quantities of surplus food are recovered, logistics and warehouse functions are important. While a triadic formation would improve flexibility and be facilitated by close buyer/supplier relationships and information technology (Larson and Gammelgaard, 2001), both these factors are limited in this case. The passive behaviour adopted by SF suppliers requires an active third party who can create trust and influence the links. Although conduit behaviour facilitates simple transactions (Obstfeld et al., 2014), its sub-roles of ‘auditor’ and ‘consultant’ indicate a more coordinative behaviour that benefits the chain’s downstream actors. However, while MVT tends to drive structure decisions (Gobbi, 2011), this formation handles both dry food and ultra-fresh products. A centralised structure is efficient (ibid.), but a shorter (decentralised) SC would be better at handling ultra-fresh products. Hence, different logics for serving customers or beneficiaries are (still) present because separate channels are created. Third party actors are therefore important for protecting firms’ reputations when it comes to food donations (Ciulli et al., 2019).
5.2 Theoretical implications

First, this study contributes to the closed-loop SC literature. The majority of past studies have reported on the reuse of durable products (Carrasco-Gallego et al., 2012), whereas this study’s identification of triadic, tetradic and dyadic microstructures provides a more comprehensive understanding of food reuse options than that presented in earlier literature (cf. Garrone et al., 2016). This study also extends the after-sales actor constellation perspective (Wagner et al., 2018) to the food network context in order to understand the complex actor relationships that facilitate product recovery. By keeping a broad empirical focus on all the actors and their interactions in the constellation, the findings show that food recovery is always the shared responsibility of SF suppliers (donating/selling SF), consumers (purchasing/eating SF) and third party actors bringing these together. Ultimately, is it the actors’ willingness to participate and interact in the new SC structure that influences the actual food that is recovered in the SC structure and its possible termination.

Second, the study provides insights into the centralisation and decentralisation aspects of products with a high recovery value (Gobbi, 2011). It also confirms that MVT corresponds to the type of structure in for-profit cases, as dry products (which are less perishable) are handled in a centralised structure. Interestingly, the logic is not directly applicable to a not-for-profit context because costs and separate distribution channels are more important than speed. However, beneficiaries would be better served if a shorter SC structure could be developed, particularly for ultra-fresh products.

Third, this paper contributes to the sustainable SC and CE literature by shedding light on more rarely studied for-profit and not-for-profit SCs (Lüdeke-Freund et al., 2019; Rodríguez et al., 2016), where new actors have a strong role in the development of more circular SCs. The study contributes to Ciulli et al.’s (2019) digital brokerage roles by identifying offline newcomers and physical roles that connect actors (i.e. the ‘LSP’ and ‘service provider’ role), the temporality of the mediator role and the downstream roles of ‘auditor’ and ‘consultant’. As two-sided interactions are investigated, the passive behaviour of SF suppliers is exhibited, thereby emphasising the importance of new actors for initiating change.

Fourth, the goal for all the identified SC structures is to address the environmental problem of food waste. It is therefore important to evaluate the environmental impact (such as carbon footprint) of the identified solutions to ensure that SC structures have a low overall environmental impact – a factor that previous food waste studies have overlooked (e.g. Garrone et al., 2016; Liljestrand, 2017; Teller et al., 2018). This study identifies several potential energy-intensive areas, including low load, failed pickups and the last mile. These results advance our understanding of how structures with low environmental impact can be designed in the food recovery context.

6. Conclusions

A major motivation for this research is the fact that large volumes of SF are unnecessarily wasted and that different actors are starting to recognise the environmental, social and economic benefits of bringing SF to new consumers. This research provides evidence of novel actor constellations (see Table 2) being led by newcomers in the food SC that enhance SF distribution. It also identifies that structural holes can be closed by actors in ‘connector’, ‘LSP’ and ‘service provider’ roles. In the main, all these roles facilitate actor linkages and information flows, while logistics connectivity is present in the two latter roles (of which, the ‘service provider’ role is most progressive). The study shows that the sub-role of ‘mediator’ facilitates improved actor connectivity and the ‘auditor’ and ‘consultant’ sub-roles enhance
sustainability in a not-for-profit SC. Lastly, the findings reveal some potential energy-intensive areas that can be addressed to improve the environmental sustainability of the structures even further.

Accordingly, this research offers implications for practitioners. First, it recommends that SC managers understand (by reducing information asymmetries) and influence intra- and inter-organisational food waste in order to prevent waste across the food SC and improve SC sustainability performance. Second, it shows that by establishing links with emergent actors, businesses may experience reputation benefits and reduced waste management costs. Third, the findings suggest that it is possible to delay the material decoupling point at which SF turns into waste, and that store managers could explore dynamic pricing even further. For instance, store managers could try to better understand how demanding customers really are by using information campaigns to inform consumers that a product may currently be out of stock, thus creating less food waste. Fourth, the findings show potential new entrants how both business- and NGO-led initiatives can create SCs through which surplus is recovered.

This study has some limitations, which provide direction for future research. First, it only considers the inter-organisational relations of actors, whereas technology, such as artificial intelligence, makes demand estimates more accurate and reduces SF (although this would not target the underlying causes). Policy instruments (i.e. tax incentives for food donations) affect SC structure dynamics and are not accounted for in this study. Moreover, this research is exploratory and additional evidence from other contexts would be needed to ensure transferability. For example, future research could quantify the efficiency and effectiveness of SC structures enabling food recovery. Further, as recent literature has viewed CE integrated in business models (e.g. Lüdeke-Freund et al., 2019), it would be beneficial for future research to investigate redistributive SCs for products other than food. These findings also hint at complexities and social dilemmas amongst the different food aid actors working for the same purpose and these should be explored further. For instance, the third sector’s role in recovering SF is needed but cannot be exploited. Finally, the research has only been conducted in one Scandinavian country. Future research should therefore investigate other European markets to determine which solutions are context dependent (e.g. differences in consumer behaviour) and which are globally suitable to enhance SF recovery.

References


Figure 1. Conceptual framework for the study. Adopted from Papargyropoulou et al. (2014)
Figure 2. Three types of emerging supply chain structures

Case 1: triad
- SF suppliers
- SF Platform
- Consumers

Case 2: tetrad
- SF suppliers
- Online retailer
- LSP
- Consumers

Case 3: chain
- SF suppliers
- SF food terminal
- Food aid organisations

Surplus food flow interactions
<table>
<thead>
<tr>
<th>Cases</th>
<th>Organisation [confidential alias]</th>
<th>Year of establishment and type</th>
<th>Supply and perishability</th>
<th>Interviewees</th>
<th>No. of interviews</th>
<th>Documentary evidence</th>
<th>Observations</th>
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</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Initiating actor [Food sharing platform]</td>
<td>2015; B2C: for-profit</td>
<td>Restaurants, cafés, grocery stores; chilled</td>
<td>CEO</td>
<td>3</td>
<td>Website, news reports</td>
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<td>Surplus food suppliers:</td>
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<td>Store manager</td>
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<td>Initiating actor [Online retailer]</td>
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<td>Website, news reports</td>
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<td>Grocery stores, wholesalers, producers; frozen, chilled and ambient</td>
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<td>Website, news reports, photos, field notes, internal documents</td>
<td>20 h participant observations</td>
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Table 2. Cross-case analysis of supply chain structures and recovery solutions

<table>
<thead>
<tr>
<th>Case 1: Triad</th>
<th>Case 2: Tetrad</th>
<th>Case 3: Chain</th>
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</thead>
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<td><strong>Re-use recovery solution</strong></td>
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<td><strong>Bringing products to the online retail market at a lower price</strong></td>
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<td><strong>Actors: suppliers, online retailer, LSP, consumers</strong></td>
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<td><strong>Centralised structure</strong></td>
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<td><strong>Environmental impact (transportation)</strong></td>
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<td></td>
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<tr>
<td><strong>Scope: consumer arranges transportation</strong></td>
<td><strong>Scope: Inbound transportation by truck to warehouse and outbound transportation to service point</strong></td>
<td><strong>Scope: Arranges pick-ups (from suppliers) and deliveries (to food aid organisations)</strong></td>
</tr>
<tr>
<td><strong>Risks: last-mile mode of transportation</strong></td>
<td><strong>Risks: last-mile mode of transportation</strong></td>
<td><strong>Risks: failed pick-ups (only picks up edible food); low load</strong></td>
</tr>
<tr>
<td><strong>Interactions</strong></td>
<td><strong>Online retailer – supplier dyad: initial meeting, monthly follow-up through email</strong></td>
<td><strong>Online retailer – supplier dyad: contractual agreement, daily/weekly brief interactions during pick-up</strong></td>
</tr>
<tr>
<td></td>
<td><strong>SF platform – supplier dyad: daily online activity, but infrequent social interactions</strong></td>
<td><strong>SF terminal – supplier dyad: collaborative, daily/weekly brief interactions during delivery</strong></td>
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<td></td>
<td><strong>SF platform – consumer dyad: weekly/monthly online activity</strong></td>
<td><strong>Supplier role: Passive</strong></td>
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<td><strong>Supplier – consumer dyad: brief physical interactions when food is picked-up for take-away</strong></td>
<td><strong>Consumer role: Active</strong></td>
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<td></td>
<td><strong>Supplier role: Passive</strong></td>
<td><strong>LSP role: Passive</strong></td>
</tr>
<tr>
<td><strong>Roles</strong></td>
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<tr>
<td>SF platform role: initiating actor; connector (active), mediator (active)</td>
<td>Online retailer role: initiating actor; service provider (active)</td>
<td>SF terminal role: initiating actor; auditor (active), consultant (active), logistics service provider (passive)</td>
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<tr>
<td>Supplier role: Passive</td>
<td>Supplier role: Passive</td>
<td>Supplier role: Passive</td>
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<tr>
<td>Consumer role: Active</td>
<td>Consumer role: Active</td>
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Essay 3

This version of the article was submitted for review to an Elsevier Journal (AJG2018 2, Impact factor 2.4).

Circular supply chain relationships for food redistribution

Abstract

The issue of food waste has received increased attention in recent years, from both researchers and practitioners, due to the unethical and negative environmental implications of wasting food. Recovering waste effectively depends on existing or emergent relationships between food waste generators and receivers that facilitate food redistribution. Although earlier studies have identified the importance of the relational aspect for achieving circularity, the extant literature has not yet fully explored redistribution in practice. To fill this void, the present study explores the formation of relationships for food redistribution that improve circularity and social sustainability at the end of the food supply chain through 18 interviews in the food donor-receiver dyad. The results of the study reveal four categories – (1) ongoing redistribution, (2) sporadic redistribution, (3) the establishment of new relationships, and (4) relationship imbalance – which highlight that redistribution is supply-driven and thereby depends on a highly responsive demand side. The results are synthesised into a framework that presents improvements in surplus food recovery.

Keywords: Food waste; Sustainability; Supply chain relationships; Circular supply chain

Acknowledgements

The author wishes to thank Árni Halldórsson for his helpful comments on earlier versions of this manuscript. This work was supported by the Society of Swedish Literature in Finland, Marcus Wallenberg Foundation for Economic Education, Otto A. Malm Foundation, the Paulo Foundation and the Foundation for Economic Education (Liikesivistysrahasto). The support is gratefully acknowledged.

Declaration of interest

None.
1. Introduction

Achieving sustainability is today mainly dependent on its implementation by different actors, such as, politicians, businesses, scientists, engineers and civil society (Howieson, Burnes, & Summers, 2019). Implementation also requires businesses to be open to solutions outside own organisational boundaries, by developing inter-organisational relationships for achieving more circular supply chains (SC). In this regard, food waste (FW) remains a significant unsustainability problem, and the Food and Agriculture Organisation (FAO) estimate that approximately one-third of edible parts of food is lost or wasted globally (Gustavsson, Cederberg, & Sonesson, 2011). FW is highly unethical considering that 820 million people in the world suffer from food deprivation (FAO, 2019). Extant sustainability literature has illustrated how FW is present at all stages of the SC (e.g., Canali et al., 2017; Papargyropoulou, Lozano, Steinberger, Wright, & Ujang, 2014; Parfitt, Barthel, & Macnaughton, 2010).

In recent years, supply chain management (SCM) scholars, and the sub-field of sustainable SCM, have had a strong focus on sustainability integration in SCs. For instance, studies have analysed sustainability reports (Turker & Altuntas, 2014) and discussed recognition as a foundation of sustainable SCM (Gold & Schleper, 2017). In parallel, the closed-loop SC and reverse logistics literature has studied the operational, technical and economic aspects of products taken-back from customers for recovery purpose (Guide, Jr. & Wassenhove, 2009). More recently, the closed-loop SC literature has provided ‘an important backbone’ for research on the circular economy (CE) (Lüdeke-Freund, Gold, & Bocken, 2019, p. 38). The CE is a new economic model that aims to integrate economic activity and environmental wellbeing in a sustainable way (Murray, Skene, & Haynes, 2017). Here, the three Rs (‘reduce, reuse and recycle’) principle of the CE (Yong, 2007) can be applied to the food SC. Reuse refers particularly to the redistribution of surplus food (SF) for human consumption. SF can be reused for commercial purposes or redistributed to food aid organisations (Garrone, Melacini, Perego, & Sert, 2016). Despite the importance of redistributive SCs for SF recovery, the relationships with the food donor that precede such redistribution are not well understood.

Relying on reused products as input is, in several ways, more complicated than obtaining supply from the market, as would be the case in a forward SC. Used products are difficult to access, while their quality and timing of availability is unknown (Östlin, Sundin, & Björkman, 2008). While such uncertainty can be reduced through becoming involved in closer relationships, doing so can create more risks for the involved ‘reuse’ supplier. Moreover, missing relations between potential SC partners – a concept known as ‘structural hole’ (Burt, 1992) – lead to the inexistence of redistributive SCs. Previous research on dyadic SC relationships has focused prominently on business actors (e.g., Ellram & Ueltschy Murfield, 2019; Gölgeci, Murphy, & Johnston, 2018; Touboulc & Walker, 2015). Although FW research has touched upon donor-receiver interactions (e.g. Ciulli, Kolk, & Boe-Lillegraven, 2019; Garrone, Melacini, & Perego, 2014b) previous research has not produced an in-depth understanding of effective donor-receiver relationships for food recovery. In addition, researchers have pointed out that, specifically, the relational aspect is lacking from earlier CE research (Lüdeke-Freund et al., 2019) and that the inclusion of non-traditional actors, such as not-for-profit actors, can help for-profit SCs become more sustainable (Rodríguez, Giménez Thomsen, Arenas, & Pagell, 2016). Accordingly, the present paper explores the formation of relationships for food redistribution that improve circularity and social sustainability at the end of the food SC. Two research questions have guided this study: What kind of relationships exist between business and not-for profit actors in food redistribution? How are circular SC relationships established in the context of food redistribution?

To answer these questions, the current study adopts a qualitative approach to shed light on the phenomenon under investigation. Data from eight companies on the supply side and 10 organisations on the demand side were collected and analysed. Social network theory was used
as the theoretical framework, with a focus on the concepts of structural patterning and structural holes.

This paper contributes to the closed-loop or circular SC literature by explicating how new relationships are needed and developed to enhance redistribution and close resource flows, and thereby advances the area of improvements for sustainability (Gold & Schleper, 2017; Turker & Altuntas, 2014). Moreover, the present paper contributes to the SC literature by showing that redistribution chains are driven by supply availability requiring high responsiveness from the demand side in order to recover food products.

This remainder of the article is structured as follows. Section 2 provides an overview of the theoretical background, before Section 3 gives an overview of the applied research method. Section 4 presents the findings, Section 5 discusses the relevance of the findings in relation to literature, and Section 6 concludes.

2. Theoretical background

This section summarises the literature that characterises food redistribution and circular SC relationships, then introduces the theoretical lens of social network theory. This section culminates with the research framework for the study (Figure 1).

2.1 Food redistribution and circular supply chains

Due to the negative environmental, social and economic consequences of wasted food, the EU Directive 2018/851 has the target of reducing per capita FW of 30 per cent by 2025 and 50 per cent by 2030. To reach these targets, Member States should ‘prevent and reduce food waste’, provide ‘incentives for the collection of unsold food products at all stages of the food SC and for their safe redistribution, including to charitable organisations’ and ‘measure progress’ (EPC, 2018, p. 114). Following Garrone et al. (2014a, p. 130), ‘surplus food’ is referred to herein as ‘the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer’. SF can be managed by the means of the food waste hierarchy (Papargyropoulou et al., 2014). However, its application can result in conflict between different levels, while the waste hierarchy should be applied to favour priorities where the food is used for human consumption (over options such as animal feed, energy recovery). For instance, as SF is a valuable resource for poverty alleviation, food assistance may be threatened if surplus is prevented (Galli, Cavicchi, & Brunori, 2019).

Food redistribution takes place through more or less structured exchanges. The structure is either direct (the products flow through a charitable organisation) or indirect (when the products move to an intermediary/food bank before going to a charitable organisation that distributes the food to beneficiaries) (European Commission, 2017). Reported barriers to redistribution involve food safety, hygiene and tax legislation; a lack of knowledge among donors about foodstuffs suitable for donation; insufficient logistical structures for large-scale donation; and the large burden on charities in managing food surplus redistribution (European Commission, 2017; Galli et al., 2019). Garrone et al. (2014b) analysed the food donation process to food banks from the donor perspective and present capabilities (such as logistics, transparency and capillarity) that help food banks handle redistribution. First, to recover

1 See, for example, Table 1 in Priefer, Jörissen and Bräutigam (2016) for the main reasons for food waste at different supply chain stages.
surplus from large industrial donors, logistics capabilities are essential for maintaining cost efficiency for donors. These logistics capabilities include an ability to handle transportation, administration, quality control, cold chain management, tracking, as well as frequent collection and distribution. Second, strengthening donor confidence transparency is essential. Transparency is achieved through establishing a clear and open process for food redistribution, which involves the ability to track flows and assure product quality. Third, capillarity refers to maintaining (and setting up) effective donor-intermediary-beneficiary communication, both at the local and national level, that helps to establish operational procedures that can reduce costs. In light of these social, environmental and economic consequences of improper FW management, it is important to improve food recovery, and the CE provides a useful perspective here.

Implementing CE principles through logistics and SCs is referred to as circular SCs (Batista, Bourlakis, Smart, & Maull, 2018). Circular SC research builds on literature from both sustainable SCM and closed-loop SC. Accordingly, circular supply chains can be defined as: ‘the coordinated forward and reverse SCs via purposeful business ecosystem integration for value creation from products/services, by-products and useful waste flows through prolonged life cycles that improve the economic, social and environmental sustainability of organisations’ (Batista et al., 2018, p. 541). In circular SCs, waste for one actor can be input for one or more actors (Murray et al., 2017) and product recovery is dependent on connections between organisations and/or individuals for the transfer of products at risk of becoming waste. Moreover, Lüdeke-Freund et al. (2019) stated that circular SCs rely on partnerships and cooperation with other organisations. Hence, circular SCs require a different approach than ‘traditional’ SCM, where the SCs generally is bounded by a focal actor, to a specific product and driven by demand, leading to important non-traditional actors being left out (Carter, Rogers, & Choi, 2015; Fisher, 1997). Some researchers have suggested reconceptualising the SC to include non-traditional (Pagell & Wu, 2009; Rodríguez et al., 2016). In the context of the present study, the SC conceptualisation is around the reuse of SC and includes not-for-profit actors.

### 2.2 Dyadic relationships

Research on dyadic buyer–supplier relationships is vast and has been studied by both marketing and SCM scholars. In marketing, Dwyer et al. (1987) described the phases through which relationships evolve, but later research disputed that business relationships follow life cycles, while each relationship should instead be viewed as unique and the parties should focus on managing the processes and outcomes of interaction (Medlin, 2004). SCM scholars have studied the development of partnerships, cooperation and coordination. In closer forms of relationships, such as collaborations, firms establish trust, share critical information, make joint decisions and even integrate SC processes to create a competitive advantage (Soosay & Hyland, 2015). However, the few studies that have investigated the relational aspect for reaching closed-loop or circular SCs have focused mainly focused on remanufacturing (cf. Kalverkamp, 2018; Lind, Olsson, & Sundin, 2014; Östlin et al., 2008). In light of this, the present study on donor-receiver relationships fills a gap in the literature as it concentrates on circular SC relationships outside of the focal food SC.

### 2.3 Social network theory and the research framework

Social network research has argued that exchange is embedded in social relations, that dyadic relationships do not occur in isolation but rather in complex structures, and that there is utility of network connections (Kilduff & Brass, 2010). Carter et al. (2007) stated that social network theory (SNT) is a useful approach for examining interactions in SCs, since it conceptualizes the
SC’s structure from a relational perspective. In contrast to transaction cost theory, SNT sees that transactions occur within a context of social relationships. SNT is not a formal theory but it does present key concepts that can be used for analysis. In particular, the concepts of structural patterning and structural holes were found useful for the present study because they tie into loose/non-existent ties between SF generators and potential receivers, as depicted in Figure 1. The research framework describes the actors on the supply side who have the SF resource, and those actors on the demand side who can make use of it. While there are for-profit actors who have demand for the SF resource, and there can be conflict between those groups, this empirical research only concerns the not-for-profit actors on the demand side.

---Insert Figure 1 about here----------------------------------------

Structural patterning refers to the focus on the content of ties that may explain differences in outcomes in relationships. Social networks can include several different types of ties, both strong and weak, and the particular combination of ties can result in a different depiction of the network (Kilduff & Brass, 2010). Tie strength can be seen in terms of time, intimacy, emotional intensity, and reciprocity (ibid.). Weak ties are occasional, market-like exchanges that generate new information and diversity that is crucial for triggering innovation and creating opportunities for network participants (Granovetter, 1973). Strong ties are seen as repeated, affective, relational exchanges that facilitate the emergence of trust, create social norms and promote cooperation (ibid.).

A structural hole is known as the lack of direct connection between two actors in a network (Burt, 1992). The functions of third parties, acting as brokers between two otherwise unconnected actors, have been investigated when structural holes are present (Obstfeld, 2005; Obstfeld, Borgatti, & Davis, 2014). While research on structural holes tend to focus on the benefits in terms of information advantages and knowledge, the present study follows the approach of Ciulli et al. (2019) and views structural holes in terms of waste not being valued by its owner, and potential recipients not recognizing the value of the waste. Therefore, if structural holes are present, this leads to the food being discarded by its current owner.

3. Research design

The research context for this study is the food SC in Finland and the interface among business and not-for-profit actors in food redistribution is the main unit of analysis. Finland is a Nordic welfare state, and food redistribution there mainly started during the deep economic recession of the early 1990s (Silvasti, 2015). It was meant to be a temporary response by churches and non-governmental organisations, but it has become a permanent way of helping people in weak social and economic situations (ibid.). Since 2017, several national projects have been established that have sought to develop the current food aid. Given the relevance of FW for business and society, the food SC can be seen as an appropriate setting for exploring relationships for resource recovery. Due to the relatively unexplored phenomena, this research takes a qualitative approach (Patton, 2015) with semi-structured interviews used as the main form of data collection.
3.1 Sampling procedure and sampled organisations

A purposeful, non-random, sampling approach was followed (Patton, 2015) for selecting the organisations in this study. Data collection started by identifying receivers. A list of potential organisations was developed from secondary sources of information, such as organisations’ websites, presentation materials and news articles, which informed the sampling decisions. This initial step could be seen as desk research and the sources were later used for triangulation.

Next, an ‘intensity sampling’ strategy (Patton, 2015) was followed by focusing on information-rich examples of the phenomenon. Specifically, large charity organisations and food banks (in terms of visitors and SF recovered) were selected, along with organisations involved in a national project to develop SF distribution and food assistance, since it was considered that these would be more involved in relationships with other actors than, for example, a small, local charity organisation. A snowball sampling approach was followed for donor selection. The receivers identified potential participating firms, who were regular donors, and the author asked them to participate. Subsequently, a ‘maximum variation’ logic (Patton, 2015) was followed to ensure that different product categories (ambient and chilled) and different SC stages (distribution centre, wholesale and retail) were included.

The informants were considered ‘knowledgeable agents’ (Gioia, Corley, & Hamilton, 2013) and the role as researchers is to report their ideas. Specifically, informants who were knowledgeable about food donations at their organisation were selected and included members such as project managers or founders at the not-for-profit organisations, and quality managers at the companies. Table 1 provides an overview of the organisations and shows the list of interviewees.

3.2 Data collection

Primary data collection consisted of 18 semi-structured interviews that were conducted between February 2019 and January 2020. Before conducting the interviews, secondary data was collected from governmental sources, publicly available websites and articles from media sources. Moreover, internal documents and brochures were collected in combination with the interviews and these also form part of the secondary sources of data. A semi-structured interview guide was followed during the interviews, which stipulated dyadic relational issues in the SF context by focusing on who the actors involved are, what kind of relations were prominent and why, and identifying potential for further improvement. The interview style was flexible and allowed for the exploration new themes that emerged in the interview situation. Secondary data and new themes arising from earlier interviews were used to engage in discussion. The majority of the interviews were conducted face-to-face at the interviewees’ premises; each interview lasted between 20 and 90 minutes. At each company or organisation, the author was frequently introduced to more than one interviewee and shown around their premises, which deepened the researcher’s understanding of the context. All interviews were recorded and transcribed verbatim by the author. Data collection continued until no more interviews would provide new information on the concepts, meaning that theoretical saturation had been reached.
3.3 Data analysis and research quality

In the first stage of data coding, ‘process coding’ (Miles, Huberman, & Saldaña, 2020) was applied on first and secondary data, which was analysed inductively. The analysis started by summarising informant quotes in each interview and making comparisons between the two subsamples (supply and demand side). The NVivo 12 software was used to simplify the analysis process. Interviews and secondary material were imported into NVivo and summaries and notes were written using the ‘memos’ function. In the second step of analysis (described below), a hierarchical node tree was developed in NVivo.

At the second stage of coding, similar codes were grouped into categories as patterns in the data were identified. The analysis process was iterative, moving between the data and existing theory, and refining categories as the analysis proceeded. This research process at this stage can be described as ‘abductive’ (Alvesson & Kärreman, 2007). A hybrid approach was used to develop codes, combining data-driven and research-driven approaches (Boyatzis, 1998). When relevant, theme labels were borrowed from earlier literature, building on labels from the relationship development process by Dwyer et al. (1987). In other cases, own formulations in-line with the data-driven approach (for example, with the term ‘no redistribution’) were used.

Intracoder reliability was calculated using NVivo’s ‘coding comparison’ and resulted in strong reliability. In a third stage of analysis, the second-order themes were grouped into aggregate dimensions (Gioia et al., 2013) in an ‘abductive’ manner. Figure 2 provides an overview of how the research proceeded from the raw material to more general terms and theoretical concepts (Gioia et al., 2013).

The quality of this research has been evaluated by assessing its credibility, transferability, dependability and conformability (Lincoln & Guba, 1985). The credibility was ensured by the triangulation of data sources, such as interview transcripts and secondary data, to ensure that the findings matches the investigated setting. Due to the explorative approach of this research, the transferability of the findings is limited to the food SC in a developed country context. Dependability was established in the research design, through purposeful sampling, and in the data analysis process, by making the generation of categories and concept transparent, as depicted in Figure 2. Finally, conformability was established by ensuring coding stability by computing the intracoder reliability.

4. Findings

This section is structured in two parts. First, the types of redistribution relationships are derived, then the phases for establishing new relationships are investigated. The discussion follows the data structure in Figure 2.

---Insert Figure 2. Data structure about here---

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\[ \text{One interview from each subset was coded again (approximately 10 per cent of sample) and the Cohen’s kappa was computed with reliability of 0.75.} \]
4.1 Contemporary redistribution relationships

The informants were asked to describe their current food redistribution activities. Based on these descriptions, two categories were identified: ongoing and sporadic redistribution.

4.1.1 Ongoing redistribution

A majority of the food aid organisations and companies had ongoing relationships, with redistribution taking place approximately on a weekly basis. The author sought to obtain data on amounts of SF, but the informants would not disclose this information because it was confidential. The findings suggest that the ties are slightly stronger in an ongoing redistribution relation as the parties show commitment, but the mutual adjustment is low and the relational resources are demand-sided. Table 2 represents different types of redistribution relations across product groups and SC stages.

The findings show that that the parties showed a commitment to continue the relationship. A continuous relation often begun by signing an agreement (or a contract), which guided the food redistribution. The agreement covered aspects such as actor responsibilities and liabilities, date markings (products with a use-by date may be donated until 12.00 p.m.), a promise to offer the products free of charge, pick-up times, and non-accepted products. After agreeing to cooperate, the parties developed an ongoing relationship. The informants explained that their regular communication included brief interaction during pick-up and, in some cases, the confirmation of SF quantities beforehand. If an issue arose, discussions were held to resolve the problem. However, joint meetings or discussions to develop the relationship further were not prominent in the data. When asked to describe the redistribution relationships, the informant at Company 2 said: ‘We have been working with these two organisations for I’d say 10 years. So I’d say, it’s very simple. Because everything is clear.’ Similar to the above statement, the findings show that many relations had a long duration. Moreover, it is important to establish trust, as many companies are sceptical towards food aid organisations. Their main concerns were that the products would be sold or that the cold chain would be broken. The informant at Company 2 described a well-functioning relation as follows:

‘They always pick up when they say they will. And there have been cases when they have called me. For example, if they plan to arrange food aid distribution in combination with a demonstration and whether it’s okay to distribute our products there. And there are a few times when I’ve said no, preferably for some other cause. [...] We have the trust. We can trust they do what they say. And they ask if there is any doubt.’

Moreover, many companies had ongoing relationships with several organisations, which poses challenges in terms of dividing the surplus fairly. One measure was to have dedicated pick-up days, while the comment below illustrates strong efforts being made:

‘We try to check which product is suitable for which organisation. To match supply and demand [...] and if one product went last week to one organisation, then we try to give it to another organisation the following week.’ (Company 3)

The results show that the parties, especially on the supply side, showed limited adjustments in the relationships. For receivers, the supply control (see also Table 2) is generally low, making planning difficult. Companies state that they cannot promise any amounts of specific products since their aim is not to have any surplus at all. A lack of control over the supply will always be inherent when working with SF. However, to improve the flow of information, discussions are ongoing for taking into use a digital platform: ‘We know that we will get something [tomorrow] from this donor. But it would be a huge help if you could get it in the app, already in the morning or evening.’ (Organisation A)
Furthermore, the quality of supply could be an issue at later stages in the SC (such as the retail stage). In addition, personal efforts were noted as the informant at Organisation I described:

“There are retail stores that don’t give bio-waste. That it’s clearly thought out that they really want to help. Then there are those stores where the employees have not been well informed … for which purpose the food is redistributed. From there, there may sometimes come products that are like waste. There is no intention behind. But there is also usable surplus food with it.”

Many organisations feared that if they did not accept all the food, the relation would be terminated. The interviewee at Organisation H responded to this question as follows: ‘Donors give what they give. We take what we get and we have people here who go through it.’

Some informants described different forms of closer involvement. This could mean that the company is well aware of the purpose the SF is going for. For example, the claims supervisor at Company 7 had spent time ‘in the field’ distributing food aid to beneficiaries. Moreover, several companies freeze products (such as meat) to extend its life cycle and enable food aid organisations to recover products that would have expired during the weekend (as pick-ups are usually not arranged then). Furthermore, at Company 7 the informants mentioned that there would be potential to develop the relationships further. For example, additional batches of fruits and vegetables could be donated if the redistributing organisations had resources to go through batches manually and save the food.

Both the supply and demand sides contributed resources to the relationship. In all of the cases, the demand side arranged the transportation of the SF from the supplier to their premises. In doing so, the companies’ costs remained low, while transportation is one of their largest cost for the food aid organisations. Moreover, food aid organisations with larger warehouse capacity (and downstream networks) tend to have an advantage over other organisations. As one company representative put it: ‘When the volumes are large, the other party needs to be large’ (Company 6). One solution that food aid organisations resort to (when the volumes offered are many times larger than their own warehouse) is to delay pick-up and pick-up several times. The main resources that suppliers contribute to the relationship are labour hours (in addition, transportation boxes are often borrowed). However, the interviewees reported that it does not take considerably more work to prepare the food redistribution than to sort out the bio-waste; and one interviewee implied that they are saving money by donating because they save on waste management costs.

4.1.2 Sporadic redistribution

Sporadic redistribution occurred when there is no agreed pick-up schedule among the company and the food aid organisation. The food company contacts the food aid organisation when it detects SF, or the food aid organisation may contact potential suppliers. Therefore, the relationship is less predictable compared to ongoing redistribution.

The results show that if the surplus is variable, companies are likely to have an agreement with one or two organisations whom they contact when there is surplus. This was explained effectively by the informant at Company 5: ‘Sometimes we see today that this is the situation and we would need them here now. So, of course it is easier if it’s okay for them to come when we need.’ Hence, the supplier appreciates the flexibility in the relationship.
On the other hand, some SF occurs even less regularly. As the co-founder at Organisation D described, examples could include: ‘when the cold chain have been interrupted, then the importers call us...’ Moreover, food aid organisations are also actively approaching firms that have irregular surplus, as described by the supply coordinator at Organisation C: ‘I check the food authority website for recalls, and then I contact the firm.' These types of transactions are more distant and terminate immediately.

4.2 Development of new redistribution relationships

Because SCs are needed for food redistribution, the process for developing new relationships and their main reasons for their termination are identified in this section.

4.2.1 Establishing relationships

New relationships need to be established to connect SF suppliers with the demand side. Because amounts of SF not are reported, it is unknown exactly where and how much SF occurs on a daily basis. Similarly, the demand-side is decentralised and no database with information about food aid organisations is openly available. Hence, it is a challenge for the supply and demand sides to find each other. The findings suggest that the organisations employed two phases – creating awareness and exploration – when new relationships were established.

First, to initiate a relation it was necessary to create awareness. In general, media coverage about the FW problem and the difficult situation for many beneficiaries has influenced how the supply-side food SC actors relate to their SF (for example, many companies are actively managing their surplus according to the FW hierarchy). Although many firms have donated for a long time, they have, in the past, preferred to do so with a low profile. However, when it comes to finding a suitable food aid organisation to partner with, it is common to rely on interpersonal contacts. The quality manager at Company 5 reported that their relationship had been initiated after ‘someone heard about the organisation, from somewhere, that this is an easy way to get rid of extra food.’

After awareness had been created, the parties explored whether or not they would begin cooperating. For the supply side, this means considering whether they have surplus that can be donated, as well as to whom it should be donated. The demand side is in a weaker position, as the SF is a crucial resource for their operations. A majority of the organisations express that they are in need of more SF (as demand is growing), while the data also show that some organisations get more than they need themselves and thus distribute it further (both to organisations in Finland and abroad). In general, the demand side is eager to engage with suppliers as their benefits are high. The initial contact can come from both sides, but it is more common that the food aid organisation is in contact. The interviewee at Company 4 said: ‘We of course get contacted by food aid organisations. We have specific criteria which we use to ensure. What kind of organisation it is.’

If the partners agreed to initiate cooperation, the terms were agreed upon. At this stage, a representative from the food aid organisation would, in some cases, visit the supplier to discuss the way of working. For example, what products the demand side can recover (for instance, many organisation cannot take fresh fish), the location where the volunteers can pick up the surplus, and the timing of pick-up. Because more actors are carrying out SF distribution now than in the past, the supply is often divided among several organisations and it is necessary to select partners. When asked about the consequences of less SF for food aid organisations, the project manager at Organisation A answered that:
'I think we need some kind of guidelines. Or some kind of understanding for all actors involved. [...] and then donors would need to have an understanding that there are now many more actors than before. [...] Firms would need to think to which organisation they want to give, and then stick to that decision.'

Hence, they would prefer that the relations become ongoing, fostering reliable and repeat transactions.

4.2.2 Relationship imbalance

There is always the possibility of withdrawal from a dyadic relationship by the parties. The relation can be terminated at any stage: exploration, ongoing redistribution or sporadic redistribution. Moreover, redistribution may not take place at all, whether due to a lack of awareness, perceived high costs for suppliers or a lack of resources among receivers.

A common reason why suppliers terminate a relationship is a lack of trust, in which case the relation would not enter into a more committed phase. Moreover, in many cases, suppliers appeared to be reluctant towards organisations that engage in bargaining and may decide to end the relation with organisations who do so. The interviewee at Company 2 said, 'We used to have cooperation with [food aid organisation], but they started wanting to choose products. Oh, do you only have natural yogurt? Don’t you have this and that?' Furthermore, it is a voluntary option for suppliers to donate their surplus. The grocery trade association’s guidelines state: ‘Stores collaborate with food aid organisations when possible, considering amounts of surplus food and the practical logistical arrangements.’ Hence, if suppliers consider the effort or costs to be high, they may decide to not donate their surplus and instead use a lower option in the waste hierarchy.

No redistribution is often a result of a lack of connection between the supply and demand sides. One reason is that partners lack awareness while it could be the case, especially in more rural areas, that there are no food aid organisations close by. Of course, the largest amounts of SF will occur in areas where food production is concentrated. However, if the demand is irregular (for example, if a church in the area is having a coffee gathering twice a week) or the capacity is low (when the food aid organisation can only handle a small part of the surplus), the suppliers have trouble finding feasible partners. For instance, Company 2 faced challenges in finding good partners in southern Sweden, but it eventually solved this problem by transporting their SF around 100 km to Denmark, where there are organisations that can take larger quantities.

5. Discussion

This study has explored the formation of relationships for food redistribution that improve circularity and social sustainability at the end of the food SC. The findings reveal the roles and motivations that supply- and demand-side actors have in the process of recovering SF, while also showing that current practices are not optimal for food recovery. Based on the findings, this research provides a framework that reflects both sides of the donor-receiver dyad and aims to improve actor connections (see Figure 3). The main elements shown in Figure 3 are the differences in context and actor behaviour in the dyadic constellation, which influence tie strength and creation.
The contextual factors of supply uncertainty and limited power affect the demand side. Moreover, internal factors of limited resources, growing food aid demand and competition over the SF resource influence in the demand side’s downstream network. The supply side’s SF resource is critical to carry out the transaction. However, the availability of amounts or product types for redistribution purpose are considered unknown until the internal 'sell-by' date has passed. Moreover, the supply side has various options for SF management and, therefore, desire low redistribution transaction costs. The findings further indicate that the availability of regular SF was found to be a prerequisite for stronger ties, while, if the surplus become available sporadically, it requires more flexibility and coordination from the demand side to enable its recovery.

Previous research has shown that the management of relationships is especially important in closed-loop SCs because the supplier of cores and the customer are often the same person or company (Östlin et al., 2008). However, the literature has not contemplated that, in addition to supply uncertainty, features of the food SC (that is, temperature zones, perishable inventories and rapid delivery requirements) makes relationships for food redistribution even more complex. Hence, the following propositions are put forward to enhance SF recovery:

**Proposition 1:** The disconnect among supply and demand side exhibits untapped food supply potential that could be used for the purpose of redistribution.

Relating back to SNT, structural holes are present when actors lack access or trust in one another (Obstfeld et al., 2014). Because accurate data of available SF is unavailable and estimates are timeworn,3 enhanced transparency of supply availability and demand-side activity is likely to improve actor connectivity. While the supply side sees their SF amounts as a business secret, greater transparency would allow the products to be moved in a timely manner to ensure their utilization. The role of a broker in creating connections between supply and demand are well documented (Burt, 1992; Obstfeld, 2005). However, in this research only partial brokerage behaviour was found, mostly related to creating trust, exhibited solely among indirect redistribution organisations. Instead, inter-personal connections had an influence on how new connections were created. Hence, further coordinative action by non-profit actors would be beneficial for creating additional connections; for instance, by means of a nationwide digital broker (cf. Ciulli et al., 2019). Currently, the ability to tap into structural holes lie mainly at the demand side. This leads to the following proposition:

**Proposition 2:** An active demand side fosters the emergence of redistributive supply chains, as long as disposal costs are considerably low.

A number of interviewees from both the supply and demand side described that initial contact was commonly sought by the demand side. This is because individuals at the demand side (volunteers, parish unions, etc.) are actively seeking ways to act on the FW and poverty challenges, and therefore making an effort to contact potential food donors so that redistributive SCs can be established. This behaviour by the demand side actors relates to Howieson et al. (2019) who acknowledge that sustainability can be achieved when a collection of actors, facing the same problem, decides to organise themselves around it. Furthermore, the ability of the redistributive SC to recover SF depends on established repeat transactions for continuous flows, and the demand side’s ability to create new connections and get access to sporadic flows. If suppliers would see strong benefits in these relationships, they would be expected to contribute with more resources. However, stronger supply-side advantages can be

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3 Data on the amounts of surplus food in Finland was collected in 2009–2010; see Katajajuuri, Silvennoinen, Hartikainen, Heikkilä, & Reiniikainen (2014).
created through reputation benefits (Czinkota, Kaufmann, & Basile, 2014); for instance, by having a sustainable development target of redistributing all surplus for human consumption. Therefore, we propose the following:

**Proposition 3:** Food aid organisations need to gain legitimacy and establish trust, but the continuity of redistribution is dependent on the personal awareness about food redistribution of the food SCM professionals working with the surplus.

Food aid organisations depend on establishing trustworthiness by carrying out their activities in accordance with the donor’s expectations, as also suggested by Garrone et al. (2014b). Parallels from food redistribution can be drawn to inter-firm alliances, where: ‘it is a very small community in which certain people have established credibility and reputation. The key is who you know’ (Larson, 1992, p. 84). Strong relational ties are characterized by consistency, durability and regular interactions, while factors of trust, fairness and closer involvement are specific for some relations. However, differences can be noted among SCM professionals responsible for managing FW in terms of their knowledge about the waste hierarchy and, in particular, food redistribution for social purposes. Hence, an effective measure would be to address knowledge gaps among SCM professionals through education, and for companies to realise that FW occurs at all SC stages, as described in the literature (cf. Parfitt et al., 2010). Thereafter, firms could engage in responsible redistribution, where such implementation depends more on personal knowledge than on the food product segment. Regarding the demand side, the following proposition is put forward:

**Proposition 4:** Developing stronger horizontal ties among peripheral actors can reduce competition among demand side and lead to better use of surplus food.

Food aid organisations can be seen as peripheral actors in the food SC, by being loosely connected to the focal actor (Borgatti & Everett, 1999). Since some organisations have stronger connections to the supply side, it can be faster and less costly for other actors to connect through those actors with close ties than to develop their own ties. Hence, the demand side can have benefits in terms of accessing supply by having strong horizontal ties. Our findings are in line with Hodges & Howieson (2017) who state that not-for-profit organisations are driven to collaborate, on the same time as they are balancing between preserving their own place in the network. Activities that the interviewees cited as creating stronger horizontal ties were sharing information among other food aid organisations about food aid redistribution events for beneficiaries, and jointly organising logistics for SF. In practice, many organisations are working on their own and may be reluctant to share their events openly because they risk losing their ‘customers’ or their ability to provide food for a larger number of beneficiaries. Stronger horizontal ties were found among indirect redistribution organisations but such practices should be developed even further, e.g., through adopting visionary leadership in food aid organisations (cf. Hodges & Howieson, 2017), since strong networks give access to more demand channels and makes redistribution SCs better to deal with products at the end of their life-cycle.

### 6. Conclusions

This research provides evidence of the activities at the supply and demand side that occur in the process of food redistribution by identifying what current redistribution looks like and how redistribution relations are established by studying a variety of segments and stages along the food SC. By adopting an interpretive research design, this paper identifies contemporary redistributive relationships that deliver supply from dairy, ready meals, and bread producers and the wholesale, distribution centre and retail stages of the food SC. The analysis led to a
framework of dyadic food redistribution and the formulation of propositions for improvements in SF recovery.

6.1 Theoretical contributions

First, this research contributes by identifying and conceptualising how non-traditional actors engage in SCs and allow food to be redistributed. Although similar practices as in traditional SCM are applied for the purpose of storage and transportation of SF – referred to as ‘logistics capabilities’ by Garrone et al., (2014b) – the present study has shown that SCs led by not-for-profit actors can create more socially sustainable and circular food SCs, thereby extending earlier studies about the leading role that not-for-profit actors play in implementing sustainability in the SC (Rodríguez et al., 2016).

Second, a novel observation about the source of supply is that the redistributive SC is supply-driven, which has led to the predictability of supply shaping the relationship to being either ongoing or sporadic. This means that effective and efficient redistributive SCs require a profound understanding of the nature of supply among different supply actors in a network. These findings are substantially different from those in the extant SCM literature, which has mainly considered SCs as driven by demand. In particular, Fisher (1997) suggested efficient or responsive SCs on the basis of whether the product’s demand pattern is predictable or uncertain, while the present study’s findings incur demand responsiveness.

6.2 Implications for practice

This study has implications for managers and policymakers. Based on the findings, policymakers should explore how they can support the work of food aid organisations even further. For example, local city authorities can provide support (space, resources) and create awareness campaigns that bring up the environmental, economic and social losses of FW. Another task that policymakers could take on would be to ensure that the food is distributed fairly among food aid organisations in the country. Furthermore, policymakers should facilitate the improved transparency around FW, this would encourage food operators to publish their amounts of SF and FW at each level of the FW hierarchy so that food aid organisations can more easily partner up with organisations that have edible surpluses.

Based on these findings, managers should re-evaluate how they relate to FW within their organisation and whether they are applying the FW hierarchy responsibly. Research has shown that FW is not an inevitable externality; instead, it is highly manageable but requires small changes in practices, awareness and openness. Sustainable firms will take the necessary managerial action as costs are relatively low.

6.3 Limitations and directions for future research

The study also has certain limitations. First, while this study has focused on the ‘reuse’ level in the waste hierarchy and on redistribution for social purposes, good redistribution relationships should not come at the expense of preventive measures and continuing overproduction of food – prevention should always be the first step. Second, this study has examined different relationships but does not provide a clear answer about how strong the relationships are; this could be a future avenue for quantitative research. Third, this research focuses on the actor level of relationships while future research could look at selected relations. Finally, while the present study was conducted in the food industry, further studies could explore how circular
SCs emerge in coordinated activities together with stakeholders around by-products in other industries, such as redistribution in the fashion industry (cf. Turker & Altuntas, 2014).

References


Kilduff, M., & Brass, D. J. (2010). Organizational social network research: core ideas and key debates. *Academy of Management Annals, 4*(1), 317–357.


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**Figure 1. Conceptual framework for the study. Adopted from Ciulli et al. (2019)**

- **Supply side**
  - Food producers
  - Food distributors
  - Wholesalers
  - Central warehouses
  - Food retailers
  - Canteens

- **Demand side**
  - **Not-for-profit**
    - Redistributing organisation
    - Charity organisation
  - **For-profit**
    - The suppliers themselves
    - Platform organizations
    - Online retailers
    - Food waste restaurants

- **Weak ties**
  - Less frequent, less close contact

- **Structural holes**
  - No connection

- **Surplus food**
  - Potential receivers
First order concepts

- Having a formal contract/agreement
- Having scheduled pick-ups
- Having worked with the same organisations for many years
- Having same contact persons
- Communicating to confirm quantity of surplus food
- Interaction during pick-up
- Actively offering surplus when there is
- Diverting surplus food between receivers
- Donating large amounts to receivers with more warehouse capacity
- Ensuring cold chain
- Asking when uncertain if surplus food can be used for specific purpose

- Not promising what products will be donated
- Adopting to receiver needs when possible
- Donating products also with longer dates
- Developing digital tool for surplus food management
- Some donors [retail stores] are donating inedible food
- Receivers are checking everything donated to ensure food safety
- Lower quality fruits & vegetables which could be saved if the receiver can check manually
- Visiting food aid organisations

- Receiver is arranging transportation
- Having a workforce
- Having warehouse capacity
- Donations are taking little additional time in comparison to throwing away the food

- Donating surplus which occurs irregularly (e.g. product recalls, interrupted cold chain)
- Checking with donors who have sometimes donated
- Being flexible by accepting that if donor calls in the morning they can pick up in afternoon

- Relying on word of mouth
- Personal connections
- Calling to ask whether the other party want to start a collaboration
- Establishing way of working
- More receiving actors than before

- Referring to internal guidelines to not donate surplus food
- Saying that they are donating to somebody else
- Wanting to protect brand image
- Ending relationship b/c receiver wanted to choose products
- Lacking trust in receiver organisation (cold chain, warehouse capacity etc.)

- Potential for establishing relationships with more actors
- Demand is considered too irregular
- Receivers lacking capacity

Second order themes

Aggregate dimensions

Commitment
- Consistency
- Durability
- Communication
- Fairness
- Trust

Ongoing redistribution

Mutual adjustment
- Supply control
- Supply quality
- Closer involvement

Sporadic redistribution

Resources
- Transportation
- Demand - resources
- Supply - resources

Spot
- Irregular supply
- Flexibility

Establishing new relationships

Awareness
- Intra-personal contact

Exploration
- Initial contact
- Establishing way of working
- Selecting partners

Ending
- Voluntary: costs considered high for suppliers
- Lacking trust or bargaining

No redistribution
- Lacking awareness about possible partners
- Demand irregular or lacking capacity

Relationship imbalance

Figure 2: Data structure
Figure 3. Framework of supply- and demand-side connections for improvements in surplus food recovery
Supply Chain Structures Promoting Development of Sustainable Supply Chains

The Case of Surplus Food Recovery

Reducing anthropogenic carbon emissions and food waste are complex global sustainability challenges that are impacted by supply chain activities. This thesis examines structural aspects of the supply chain in relation to sustainable development by drawing on empirical material from food waste reduction. The overall purpose is to enhance our understanding of how supply chain structures can promote surplus food recovery and implications for developing sustainable supply chains. Specific focus is on the distinction between supply chain efficiency, to ensure the wise use of energy and material resources within the supply chain, and supply chain effectiveness, to enhance sustainability goals, such as, material recovery by the supply chain.

The thesis comprises one conceptual (Essay 1) and two empirical studies (Essay 2 and 3). Essay 1 argues that energy efficiency can be a generative mechanism of sustainable supply chains because the physical movement of products and material (and, in turn, how much energy and what type is used in the supply chain) is an outcome of the supply chain’s structure and strategic priorities. Essay 2 analyzes different supply chain structures that have emerged to make surplus food available to consumers. The study involves three novel surplus food actors: a surplus food platform, an online retailer, and a surplus food terminal. It builds on semi-structured interviews, participatory observations, and documentary evidence. Essay 3 explores the formation of relationships for food redistribution that improve circularity and social sustainability at the end of the food supply chain with empirical material from 18 semi-structured interviews in Finland.

This thesis primarily adds to discussions about sustainable and circular supply chains. First, it contributes with novel insights to the emerging stream of research on non-traditional actors in the supply chain by specifying the roles and motivations (contextual factors) among both business and not-for-profit actors that support and hinder surplus food redistribution in a dyadic constellation. Second, this thesis contributes to a more nuanced understanding of structure in supply chains by showing how structures can emerge and evolve in response to sustainable development challenges. Last, this thesis adds by providing new empirical findings of surplus food recovery options in a developed country context.