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Supply chain structures for distributing surplus food

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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).

-- Insert *Figure 1. Conceptual framework for the study. Adopted from Papargyropoulou et al. (2014)* about here----

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.

---------- *Insert Table 1. Overview of data sources around here*----------

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.

----------*Insert Figure 2. Three types of emerging supply chain structures around here*----------

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, Case1). 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, Case1).

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 forfuture 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.

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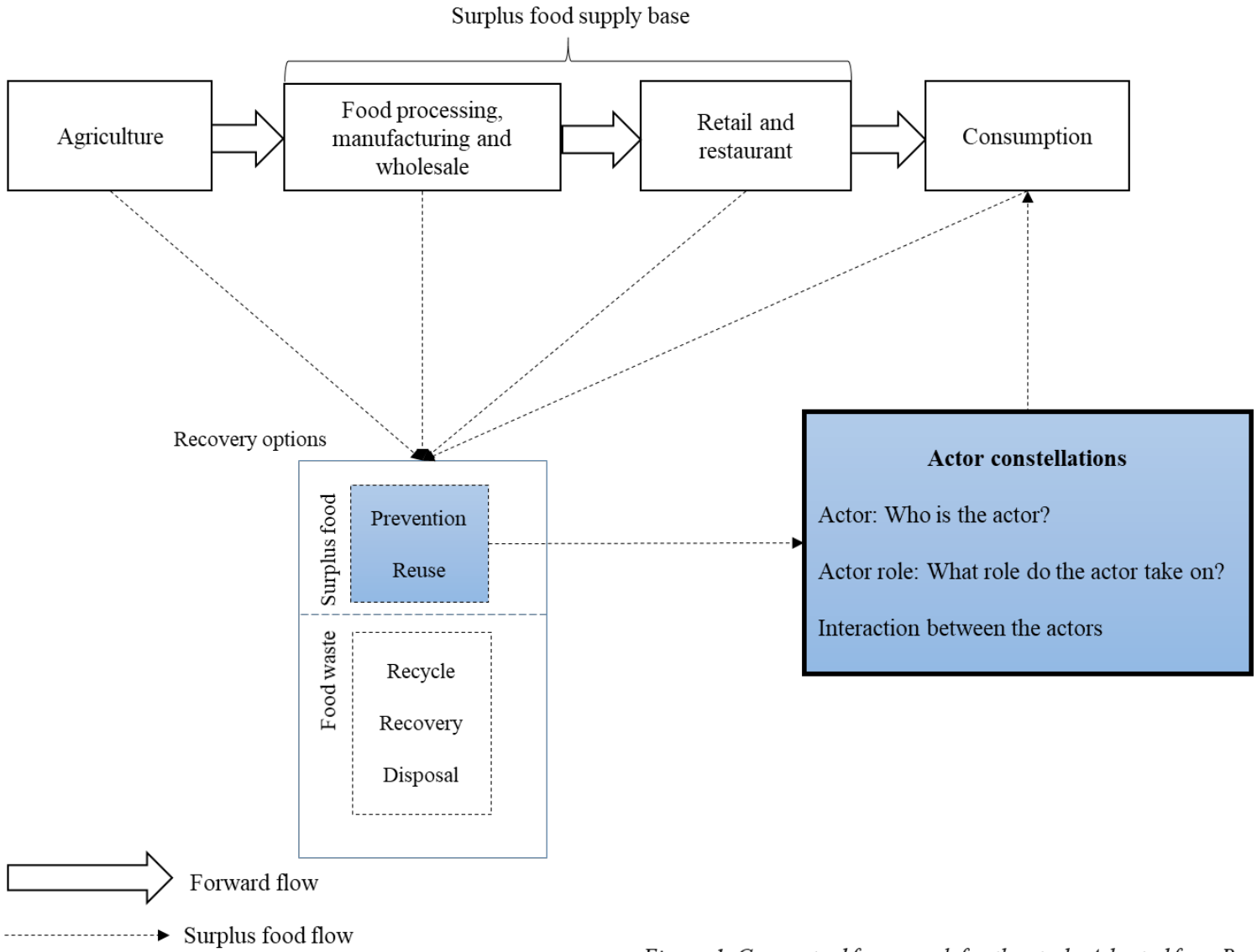

Figure 1. Conceptual framework for the study. Adopted from Papargyropoulou et al. (2014)

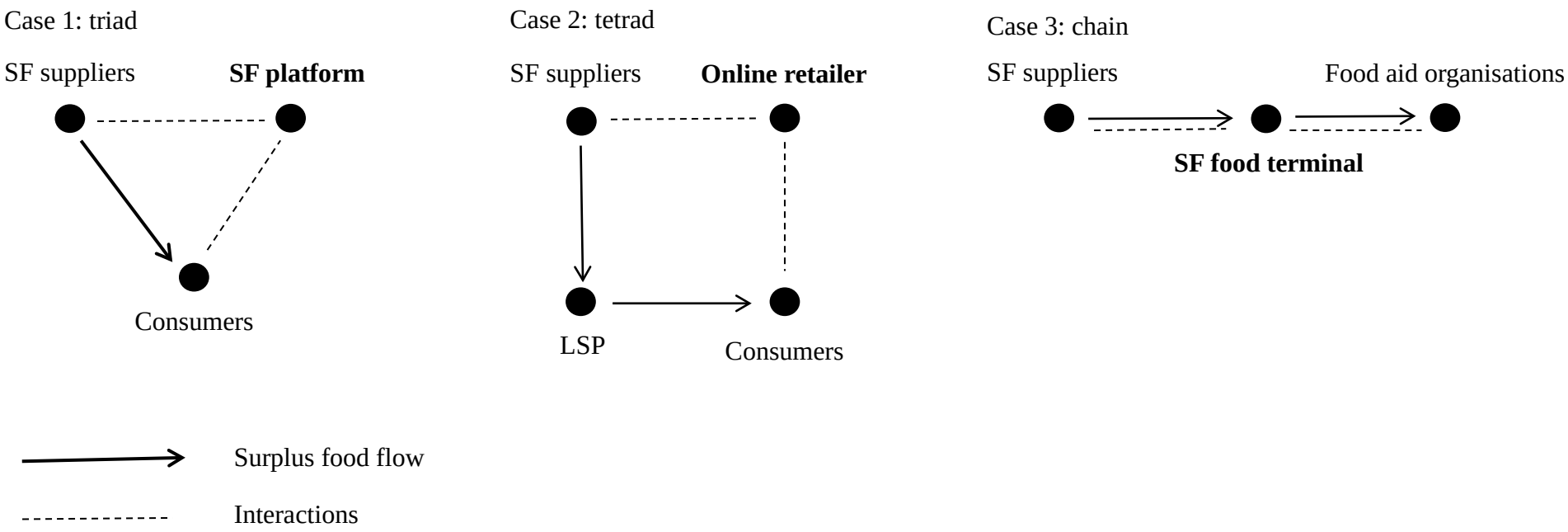

Figure 2. Three types of emerging supply chain structures

Table 1. Overview of data sources

Cases	Organisation [confidential alias]	Year of establishment and type	Supply and perishability	Interviewees	No. of interviews	Documentary evidence	Observations
Case 1	Initiating actor [Food sharing platform]	2015; B2C: for-profit	Restaurants, cafés, grocery stores; *chilled*	CEO	3	Website, news reports	
	Surplus food suppliers: [Food market]			Purchasing & marketing manager		Website, news reports	
	[Retail store]			Store manager		Website, news reports	
Case 2	Initiating actor [Online retailer]	2016; B2C: for-profit	Importers, producers; *ambient*	CEO	3	Website, news reports	
						Website, news reports, annual reports, sustainability reports	
	Surplus food suppliers: [Import firm]			Country manager			
	[Manufacturing and import firm]			Sales manager		Website, news reports, annual report, sustainability report	
Case 3	Initiating actor [Surplus food terminal]	2016; B2NGO: not-for-profit	Grocery stores, wholesalers, producers; *frozen, chilled and ambient*	Project manager	4	Website, news reports, photos, field notes, internal documents	20 h participant observations
	Surplus food suppliers: [Retail chain]			Environmental manager		Website, news reports, field notes, internal documents, sustainability report, annual report	
	[Industrial bread producer]			Commercial manager			
	[Dairy manufacturer]			Distribution manager, quality & environmental specialist, logistics project coordinator		Website, news reports, sustainability report, annual report	
						Website, news reports, sustainability report, annual report	
				Total	10		

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

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