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Impact Pathways: Unravelling the Hybrid Food Supply Chain – Identifying the Relationships and Processes to Drive Change

Abstract

Purpose – This paper explores the nature and operations of the supply chain that serves disadvantaged groups. With the increasing reliance on supplementary food provision through food aid, we seek to emphasise efficiency and sustainability in these supply chains.

Design/methodology/approach – Semi-structured interview data from 32 senior managers and experts from both commercial and food aid supply chains were abductively analysed to develop a relationship-based map of the food chains that serve disadvantaged groups.

Findings – Disadvantaged groups are served by a hybrid food supply chain. It is an interconnected supply chain bringing together the commercial and the food aid supply chains. This chain is unsurprisingly plagued with various challenges, the most critical of which are limited expertise and resources, operational inefficiencies, prohibitive logistics costs and a severe lack of collaboration.

Originality/value – Our study identifies the currently limited role of logistics companies in surplus food redistribution and highlights future pathways. Additionally, we present useful actionable propositions for managers, practitioners and policy makers.

Keywords Surplus food; redistribution; food aid supply chain; food crisis; disadvantaged groups

Paper type – Impact Pathways

1. Problem and Background

Global food insecurity has been rising steadily over the past decade. Lockdown measures during the COVID-19 pandemic worsened this, as it adversely affected food production, supply and accessibility (Schleper *et al.*, 2021). Post-pandemic, nearly 60% of low-income countries were in or at high risk of debt distress (Husain, 2022), leading to a global cost-of-living crisis. The Russian-Ukrainian war further exacerbated this, especially as both countries are important sources of energy, fertilisers and food globally. There are worries about impending food shortage.

In the United Kingdom (UK), twenty-two percent of the population is food insecure (Butler, 2023). The country has one of the highest levels of income inequality (using the Gini coefficient) in Europe (Francis-Devine and Orme, 2023), with dependence on food banks tripling in the last decade (Trussell Trust, 2022). The UK's worsening food insecurity is not unique as it mirrors the situation in other developed countries for the sub-populations most affected. There have, therefore, been calls for transformed food systems towards improved socio-environmental sustainability. Benton *et al.* (2022) suggest policies to disincentivise food waste and provision adequate social safety nets for disadvantaged households. Despite the relatively low levels of food waste in the UK food supply chain (FSC), very little surplus food is redistributed for human consumption. Yet, surplus food redistribution (SFR) has become a key source of food for many across Europe. SFR for human consumption involves the collection and distribution of surplus food (edible food that would otherwise be used for alternate purposes or disposed of) to organisations, communities or individuals for consumption (Midgley, 2020). It is therefore seen as a 'win-win' solution, in that, it addresses food waste and food insecurity simultaneously while salvaging the food's energy and nutrient content. It also ensures that the economic and environmental costs incurred in food production are not futile. Thus, efficient SFR can contribute to achieving the United Nations (UN) Sustainable Development Goals (SDG) 2 (Zero Hunger), 12 (Responsible Consumption and Production, especially target 12.3 (halving food waste)) and 13 (Climate Action). However, research to optimise SFR supply chain operations for disadvantaged groups is limited.

We, therefore, set out to investigate the supply chain that provides food to UK disadvantaged groups to provide operational insights and explore opportunities for improved efficiency and sustainability. Within this context, disadvantaged groups refer to individuals or communities with limited (geographical, physically or socially impaired, technological or financial) accessibility to consistent healthy food supply, thereby necessitating a recurring or continued partial or total dependence on charitably redistributed surplus food. In the UK, this would typically be those in the highest 20% of Indices of Multiple Deprivation. By engaging actors in both the commercial and food aid supply chains, we present unique insights that underpin the proposition of specific interventions and impact pathways towards operational excellence in SFR.

2. Food Waste and Charitable Surplus Food Redistribution

There is increased attention to food waste prevention due to insights into its environmental impact. For instance, Scherhaufer *et al.* (2018) suggest that food waste in Europe accounts for 186 million tonnes (Mt) of CO_2-eq emissions, while Tonini *et al.* (2018) observe that the carbon footprint per tonne of discarded food in the UK ranges between 2000 to 3600 $kgCo_2$-eq. To address this, the food waste hierarchy has been prescribed. It is a framework of handling options, with prevention as the most sustainably desirable option, followed by a series of sequentially mandated surplus/waste food usage options until the unusable waste reaches landfills/sewers (see Papargyropoulou *et al.*, 2014). Although prevention is most desirable, supererogatory food is inevitable due to factors such as overproduction, mislabelling, logistical errors, and unnecessarily stringent quality and cosmetic requirements (Midgley, 2020). With increasing food poverty and insecurity, SFR can mitigate both food poverty and waste in developed countries.

Redistribution requires logistics and supply chain operations. Yet, studies focused on these within SFR are sparse. Studies have focused on the redistributors (e.g., Alexander and Smaje, 2008), SFR policy and governance (e.g., Midgley, 2020) or debating SFR as a sustainable solution to food waste and/or food poverty (e.g., Midgley, 2014; Papargyropoulou *et al.*, 2014). Despite the relevance of these discussions, operational excellence is critical for SFR (Garrone *et al.*, 2014). Garrone *et al.* (2014) and Bloise (2020) look at some actors in the commercial FSC and their interactions with food redistributors while Thapa *et al.* (2021) engaged 10 third-sector redistributing organisations to discuss SFR supply chain operations in a city. Though useful, insights have been solely from the purview of redistributors or from unique donor-redistributor operations.

Building on these studies, our research engages actors at each stage of the commercial FSC as well as redistributors to present a holistic view of operations, challenges and solutions.

3. Methodology

A relationship-based supply chain mapping approach is adopted to analyse the UK's FSCs serving disadvantaged communities. This approach provides a visual representation of the supply chain relationships and material flows, and facilitates the identification of related challenges and improvement opportunities (Lambert *et al.*, 2008). An examination of relevant literature and organisational reports helped design the "basic" map of the commercial FSC. Using this, thirty-two different stakeholders were interviewed. This included top managers in three primary producers, five food processors/manufacturers, three wholesale and three retail distributors and two logistics companies. For the redistributors, we interviewed three food aid wholesale distributors and four food aid service organisations. Two government officials, two industry experts and five academic professionals were also interviewed. Table I provides further details on the interviewees. Using an inclusive stakeholder approach to sampling, a combination of expert and typical-case purposive sampling methods were followed to target representative stakeholders with the capability to facilitate the development of impact (and impact pathways). An extended discussion of our research design, mapping approach and sampling is presented in Appendix A.

Insert Table I

The resultant data were then analysed through an abductive thematic analysis method using NVivo R1. The abductive approach allowed us to predefine overarching codes for the actors of both the commercial and food aid supply chains, processes, challenges and solutions while allowing descriptive sub-codes to inductively emerge from the data (King *et al.*, 2019). To ensure validity and reliability, at least 2 different actors per stakeholder category were engaged and agreed codes required multiple references. An iterative engagement with literature and industry & academic experts ensured emergent insights were not spurious. The following sections will utilise representative quotes to demonstrate our findings.

4. The Hybrid Food Supply Chain, its Challenges and Impact Pathways

4.1 Overview

Within the commercial FSC, disadvantaged groups are generally an afterthought. This means product pricing, store location and similar commercial decisions are not taken with them in mind. Such consumers, therefore, supplement the food they can afford commercially with donated food. Thus, the supply chain that serves these disadvantaged groups is hybrid. It is an interconnection of the commercial FSC and food aid supply chain, linked through the redirection of donated surplus and non-surplus food, as well as, discounted purchased food from the commercial FSC into the food aid supply chain (see Figure

1). Some distinctive features of this food chain serving disadvantaged consumers, relative to the commercial FSC that serves "ordinary" consumers, are presented in Table II.

Insert Figure 1

Insert Table II

The food aid chain consists of food aid wholesale distributors (FAWD) (such as FareShare, City Harvest, His Church and Company Shop) and food aid service organisations (FASO) (which includes organisations such as foodbanks, soup kitchens, social retailers, schools, medical centres, prisons, nurseries, day centres, out-of-school clubs, community centres and cafés, and other community-led initiatives). Like Thapa *et al.* (2021), our findings show that food product flow is from actors in the commercial chain to the food redistributors (FAWDs and FASOs) in the food aid supply chain. This happens at regional and local levels. The FAWDs collect the food in high volumes from the large-scale actors in the commercial chains. They typically own trucks, warehouses and distribution facilities from where collected food is processed and repackaged (if necessary) and distributed to FASOs. FAWDs may either be charities or social enterprises that supply discounted or donated food to FASOs for free or at discounted rates. FASOs may additionally access food from local donors. End-users access the food through FASOs as ready meals, packaged parcels or as purchasable discounted products. Information flow is bidirectional, non-standardised and usually ad hoc, especially at the local levels. Charitable financial flows are unidirectional, mainly from governmental agencies, but may also be from both food and non-food sector corporations (see Figure 1 and Table II).

4.2 Key Challenges

The hybrid FSC is fraught with many challenges, especially as there is no 'focal' company driving the attainment of specific goals. Being a form of humanitarian supply chain (Shaheen *et al.*, 2023), it suffers from the ills of differing and often misaligned motivations of various actors (Midgley, 2020). Concerns with fraudulent users, food perishability, quality and appropriateness of donated food, restrictive government legislation and company policies, social cost and limited awareness were identified. These, among others, have been classified and presented in Figure 1 according to the part of the hybrid FSC they affect. However, the challenges identified by stakeholders across the hybrid chain as the most debilitating were the following.

4.2.1 Inadequate Expertise, Resources & Capacities of Food Redistributors: Our findings reveal that the food aid chain is incapable of handling available surplus food. Limited FASOs' capacity is the major bottleneck. Many FASOs are underfunded and heavily reliant on volunteers. Consequently, they easily fail with disruptions as happened during the coronavirus pandemic. A senior manager from a FAWD indicated:

> "During the pandemic, 4000 of our charity groups [that is, FASOs] closed, just disappeared. We recruited 4,000 new ones and half of those probably won't exist in a couple of months..." – FAWD02

This fragility, therefore, creates instability with demand as FASO numbers continually fluctuate. Even the stable ones often have limited logistics capacities, which some large donors indicated as a barrier to donations as they prefer working with FAWDs with the requisite logistical capacities. Overreliance on volunteers and the absence of core technical personnel limit expertise cripple their operations.

4.2.2 Process & Resource Inefficiencies: Processes and resource use in the hybrid chain are very inefficient. The product types, quality, quantities and delivery times of donated food are inconsistent, making it difficult for redistributors to plan and match the supply to demand. Additionally, our findings indicate that the cumbersome decision-making surrounding surplus food processing by logistics companies and their manufacturing and retail clients causes delays, which leave redistributors little time before expiration. Infrastructural requirements for various food products (ambient, frozen, chilled, ready-meals) further create process complexities that cannot be adequately handled by available expertise.

4.2.3 Cost of Redistribution & Associated Processes: SFR costs are disincentivising both donors and redistributors. Some primary producers considered alternatives such as animal feed and anaerobic digestion as more economically rewarding. For manufacturers with automated order fulfilment warehouses, the human intervention required to handle surplus is an economic deterrent. There is little motivation to invest in systems that incorporate SFR. For food redistributors, logistics costs are also a major challenge, especially for FASOs who are typically underfunded.

4.2.4 Severe Lack of Collaboration: The food aid supply chain is heavily fragmented and uncoordinated. FASOs tend to be insular, thereby inhibiting integration and development. Both vertical and horizontal competition were identified to hinder the needed collaboration. Horizontally, FASOs considered each other as competitors for both financial and food donations (Thapa *et al.*, 2021). Vertically, some FASOs consider the FAWDs as disruptive. The Chief Executive Officer of one FASO said:

> "So I know there are many great organisations that do this, some of them charge charities for this service...they are a threat to us who are independent charities, who already had those relationships with the supermarkets and we're working at a really local level." – FASO03

In the commercial FSC, limited inter and intra-organisational collaboration was identified. Some retailers prevent their suppliers from redistributing rejected branded products even when fit for consumption. An interviewed Head of Supply Chain in a processing firm also bemoaned the absence of a redistribution strategy, leading to ad hoc practices across the firm's sites. Despite their impact on SFR, inter-government departmental collaboration was limited, thus, hindering.

4.3 Impact Pathways for Operational Excellence

We present some interventions derived from our studies for operational improvement. How each intervention differs within the hybrid FSC, and the impact pathways related to the interventions are presented in Table III.

4.3.1 Improved Operational Efficiency: A standardised SFR operations model can improve (both process and resource) efficiency by exploiting existing supply chain relationships and partner competencies (Matopoulos *et al.*, 2015). Redistributors and waste management companies could be equipped to collect all surplus and waste food from the commercial actors and process them so that unpreventable surplus can be redistributed for human consumption before moving further down the food waste hierarchy. This will facilitate more accurate measurements of surplus and waste food for better governmental oversight and more reliable corporate social responsibility reporting for companies. The Chief Executive Officer of a FAWD, in agreement with the practicality of this proposition, indicated:

> "So, one of the things we need to really think about is how to become a one-stop shop. How can we work with waste management companies, so that we've got an hierarchy of things that we can do? So, we can say yes to the industry and then create the most social and environmental value through a filtering system." – FAWD03

Consequently, in relation to this intervention, we present four Impact Pathways (1-4) for further research in Table III, exploring existing and needed capabilities, sectoral innovation with private-third sector collaboration and waste (time, process or material) reduction through food value chain analysis (see Francis *et al.*, 2008) of the hybrid FSC. Other interventions from our findings are also presented in Table III.

Insert Table III

4.3.2 Improved Collaboration: Better sector-wide collaboration can improve the efficiency and resilience of the hybrid FSC. In commercial FSCs, retailers – the most powerful actors – can encourage SFR, relevant knowledge sharing and consolidated SFR. For redistributors, forming umbrella bodies could foster awareness and drive collaboration. This can lead to improved access to funding through joint bids (Thapa *et al.*, 2021) and improved operational expertise through commonly shared talent pools. With the sector's high talent turnover, collaboratively exploiting industry expertise from commercial partners

can be useful. For example, umbrella redistributor groups could bring in logistics experts from commercial partners to voluntarily train their staff and discuss solutions to pertinent logistical challenges. Impact Pathway 5 in Table III presents an opportunity to explore collaboration in different types of relationships in the hybrid FSC to identify barriers and enablers.

FAWDs might benefit from the hub-and-spoke cooperative logistical approach (Zäpfel and Wasner, 2002). The hub-and-spoke model is characterised by an interconnection of multiple single depots (the spokes) that serve customers in a specific location through at least one transhipment centre (the hub) where shipments are consolidated and redirected to receiving spokes. Its application in the hybrid FSC could help FAWDs optimise their logistics facilities usage and improve the assortment of donated food to better match the unique demands of the FASOs they service. We therefore highlight Impact Pathway 6 as an opportunity for further research.

Furthermore, improved communication between donors and redistributors can help address the quality and appropriateness of donated food, while inter and intra-organisational collaboration in the commercial food chain and in government can lead to improved funding and food donations. Notwithstanding, some stakeholders may be hesitant due to risks of data breach, power imbalance, misaligned goals etc. (Vlachos and Bourlakis, 2006). With the increasing use of Industry 4.0 technologies to address issues of supply chain collaboration, Impact Pathway 7 is proposed for further research.

4.3.3 Increased Economic Incentives: Despite the moral appendage to SFR, when it becomes economically prohibitive, many donors explore alternatives. Cost recovery for the production and (re)distribution of surplus by low-end donors can mitigate this. An interviewed Director for a large primary production company (a multi-hundred million pounds company) dealing with numerous large UK grocery retailers and who also represents more than 46,000 farming businesses, expressed a perspective consistent with other interviewed primary producers, and mentioned:

> "I have to package stuff...transport it; that costs me money. And I've got to grow the stuff in the first place... But if we can cover the direct costs, the labour, packaging and distribution, then yeah, we would be quite happy to support that [redistribution] sector more" – PP01

Furthermore, government subsidies, funded food purchases by redistributors and direct public sector procurement from primary producers can help lower the price of good nutrition for the disadvantaged while adequately compensating the farmer.

To encourage funding SFR logistics operations, evidencing in comparable economic terms, the benefits to various stakeholders (including donors, the government, beneficiaries and the overall community) is required. Considering outcomes such as nutrition, food affordability, food waste reduction, mental and physical wellbeing and healthcare costs, there are multiple research opportunities, some of which are indicated in Impact Pathways 8,9 and 10 in Table III.

4.3.4 Defining a SFR Role for Logistics Companies: Logistics Companies currently play a limited role in SFR. They provide discounted rates to large FAWDs and fulfil their customers' delivery requests to redistributors. Despite acknowledging the critical role of logistics in SFR, there has been limited discussion on the participation of logistics companies as actors in the commercial FSC in SFR. A clearly defined role for logistics companies in SFR could be transformational. They provide storage and distribution services for actors across the commercial FSC. Thus, they are primally placed to:

- detect surplus early,
- consolidate redistribution,
- improve visibility,
- eliminate waste activities and delays, and
- reduce procedural complexity.

As one interviewed logistics manager indicated:

> "We design, manage, operate and improve supply chains every day for food manufacturers. So, if this was something that they wanted to do, they could very easily extend it on to existing operations...Wouldn't it be nice to think that we could use one of the depots we run as a consolidation point for a group of food manufacturers who were prepared to push surplus/aged stock into those disadvantaged communities? And we would quite happily utilise the skills and capabilities that we've got within those operations to consolidate, break down and repick specific orders for the communities. That's something we could do very easily. We do it for stores." – LC01

Such an intervention will improve operational efficiencies by optimising lead times for redistributors and make overall operations more cost-effective. Emergent research avenues following this outcome of our work, involve exploring the current barriers, but also enablers of this intervention and how it may be actioned. We specify two of these as Impact Pathways 11 and 12 in Table III.

5. Implications on Policy, Practice and Research

Central to the success of these interventions is government. Governments must initiate and coordinate the needed collaboration for successful implementation while being cognisant of the effects of their decisions (e.g., Brexit) on FSCs (Hendry *et al.*, 2019). Regardless of isolated initiatives, governmental involvement is the conduit to realign the varying actor motivations in the hybrid FSC. This can be done through policy and informed action. Policy, regulatory and legislative reforms that encourage efficient and cost-effective SFR are needed. At present, UK government policies (such as the Resources and Waste Strategy, the Waste Prevention Programme and the Waste Management Plan 2021) only provide statutory guidance for handling surplus or waste food using the food waste hierarchy. Thus, beyond legislative interventions (e.g., in Italy, the US and France) that encourage SFR, we propose policy reforms that impact the entire hybrid FSC. Not only should redistribution be mandated across the commercial FSC, SFR and resultant carbon emissions savings could be required in corporate sustainability reporting (e.g., Scope 3 greenhouse gas reports).

Practically, a government-led restructuring of surplus and waste food collection is proposed where waste hierarchy adherence is shifted from donors to waste collection companies. This will significantly address many of the logistical challenges. Table III has provided actionable solutions to address some current challenges. Also, governments can identify the largest logistics provider in their countries to pilot the SFR role defined above. A sector-wide implementation can then follow. Furthermore, practical steps towards coordinating government's activities such as interventions targeted at disadvantaged groups (e.g., universal credit), food insecurity, poverty, SFR and others, are required.

Beyond the impact pathways indicated in this study, it is important that as empirical research on this topic grows, we ensure insights are theoretically grounded to facilitate deeper scholarly understanding. There are numerous opportunities to examine, test and potentially extend extant theories.

6. Conclusion

The global cost of living crisis has made inescapable the urgent need for SFR. Unfortunately, limited attention has been given to the hybrid FSCs that serve the increasing disadvantaged population, partly because some authors have highlighted the band-aid nature of SFR. Regardless, food surplus/waste remains a challenge for which proper management is urgently needed. In this paper, we have identified the nature of the FSC that serves disadvantaged groups, and its key challenges, and presented research, policy and managerial pathways for operational optimisation. Social sustainability in the food supply chain management, particularly in addressing rising food insecurity is demanding increased scholarly attention

(Shaheen *et al.*, 2023; Thapa *et al.*, 2021). We have presented twelve Impact Pathways related to sustainable food waste operations management, supply chain collaboration, innovative logistics management and funding of SFR logistics operations, all targeted at efficiently making surplus food accessible to disadvantaged consumers. Furthermore, we have suggested actor-specific management interventions for surplus food donors, redistributors and governments towards improved logistics and supply chain operations and have proposed relevant policy reforms. These propositions are expert-derived and have long-term sustainability implications even if food poverty is addressed. Research into the logistics and supply chain management of SFR's hybrid FSC is limited. We have provided some pointers to begin addressing this.

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Figure 1 Food products, information & charitable financial flows, and some challenges in the Hybrid Food Supply Chain that Serves Disadvantaged Communities

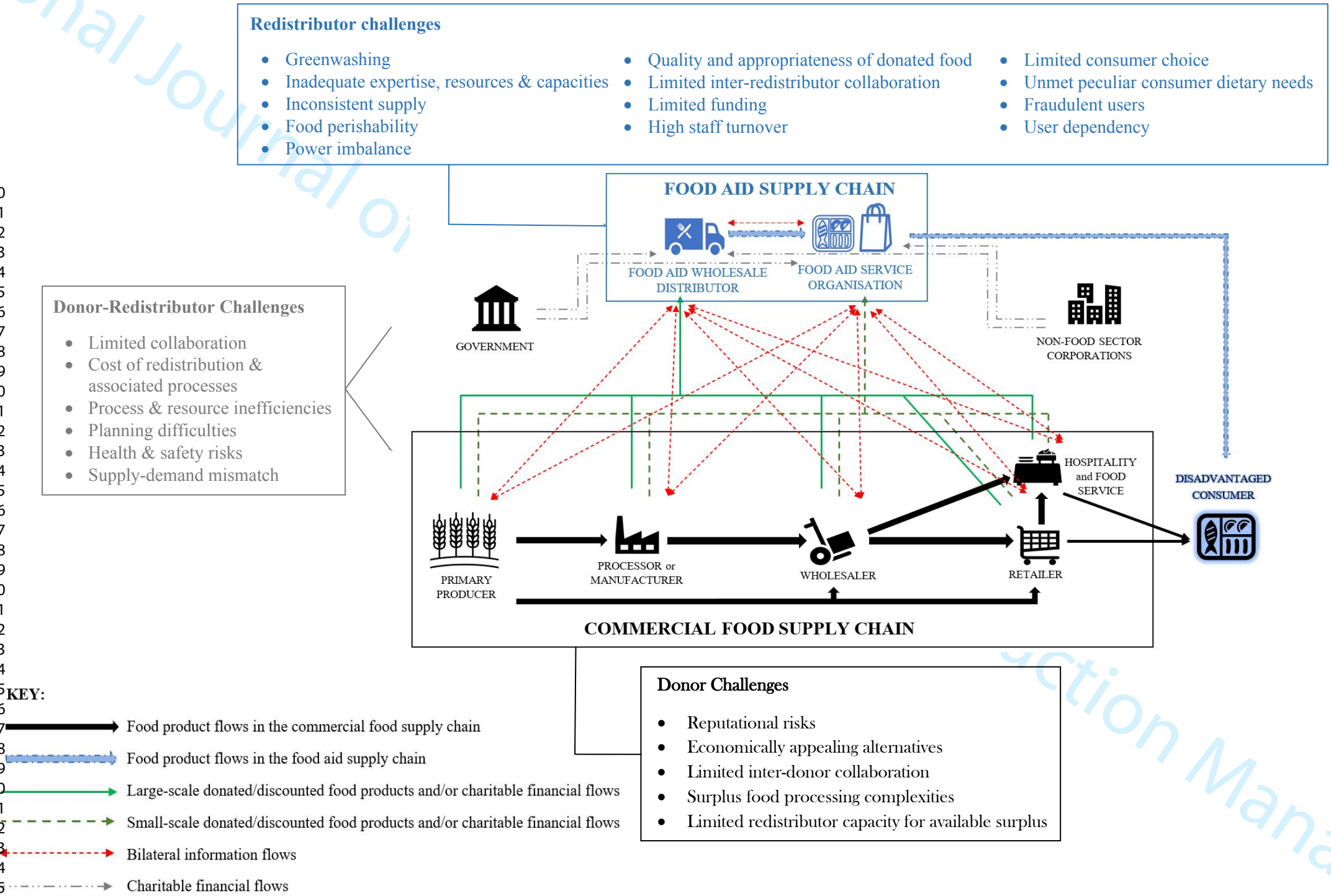

Table I Interviewee Positions, Anonymised IDs and Stakeholder Categories

No.	Interviewee Position	Interviewee ID	Actor/Stakeholder Type
1	Agricultural Director	PP01	Primary Producer
2	Managing Director	PP02	Primary Producer
3	Marketing Co-Ordinator	PP03	Primary Producer + Processor
4	Head of Supply Chain	FM01	Processor/Manufacturer
5	Supply Chain Director	FM02	Processor/Manufacturer
6	Vice President-Sustainability	FM03	Processor/Manufacturer
7	Logistics Manager	FM04	Processor/Manufacturer
8	Procurement Manager	FM05	Processor/Manufacturer
9	Policy Director	WD01	Wholesale Distributor + Logistics Company
10	Chief Executive Officer	WD02	Wholesale Distributor + Industry Expert
11	Technical Manager	WD03	Wholesale + Retail Distributor
12	Quality Director	RT01	Retailer
13	Head of Policy	RT02	Retailer
14	Head of Supply Chain	RT03	Retailer
15	Managing Director	LC01	Logistics Company
16	Site Director	LC02	Logistics Company
17	Head of Food	FAWD01	Food aid Wholesale Distributor
18	Director of Network and Operations	FAWD02	Food aid Wholesale Distributor
19	Managing Director	FAWD03	Food aid Wholesale Distributor + Food aid Service Organisation
20	Executive Member	FASO01	Food aid Service Organisation
21	Senior Strategic Manager	FASO02	Food aid Service Organisation
22	Chief Executive Officer	FASO03	Food aid Service Organisation
23	Chief Executive Officer	FASO04	Food aid Service Organisation
24	Food Resilience and Security	CG01	Government
25	Food Waste Prevention	CG02	Government
26	Chief Executive Officer	IE01	Industry Expert
27	Business Development Manager	IE02	Industry Expert
28	Associate Professor	AP01	Academic Professional (Food Systems Expert)
29	Professor	AP02	Academic Professional (Food Supply Chain Management Expert)
30	Reader	AP03	Academic Professional (Expert in Economic Sociology)
31	Professor	AP04	Academic Professional (Sociology Expert)
32	Associate Professor	AP05	Academic Professional (Expert in Community Engagement)

Table II Distinguishing features between the commercial food supply chain and the hybrid food supply chain

Feature	Commercial FSC (serves "ordinary" consumers)	Hybrid FSC (serves disadvantaged consumers)
Demand	Stable	Very volatile
Supply	Consistent, predictable and tailored towards customer needs	Unpredictable and typically informed by surplus availability
Information flow	Well-structured and formal	Usually ad hoc
Financial flow	Bilateral and uncharitable	Largely unilateral and charitable.
Actors	Motivations driven by co-opetition	Diverse and not aligned motivations
Product shelf life	Short, medium and long shelf life	Primarily, products are usually close to expiration
Labour	Skilled employed workers	Heavily reliant on volunteers downstream (i.e., among redistributors)

Table III Proposed Supply Chain Interventions and Associated Research Avenues and Pathways for Operational Excellence in the Hybrid Food Supply Chain

Supply Chain Intervention	Role-Specific Interventions (Empirical sources)	Impact Pathways
Improved Operational Efficiency	**Donors:** a. Improved visibility (RT01; FM03; FM04) b. Streamlined decision making (LC02; WD01; PP03) c. Consolidated logistics and distribution to redistributors (PP02; FM02; FM03; LC01) **Redistributors:** a. Accessing surplus food further upstream (IE02; FASO03) b. Exploitation of Industry experience (AP02; AP04; FM05) c. Elimination of waste activities and delays (LC02; WD01; FASO04) d. Consolidated distribution and logistics hubs (LC01; AP01; CG02) e. Waste management companies operating a standardised SFR model (FAWD03; FM05; FM02) **Government:** a. Restructuring of surplus and waste food collection to shift adherence to the waste hierarchy to the waste collection companies (AP02; CG02)	1. What is the current role of waste management companies in food supply chains and how can they contribute to the operational efficiency of SFR? How will this impact sustainability across the food supply chain, specifically for SDGs 2, 12 and 13? 2. What new capabilities must be developed by waste management companies and/or FAWDs to optimise adherence to the food waste hierarchy for improved SFR? 3. How can the for-profit model of waste management companies and the not-for-profit/social enterprise model of redistributors be merged into a functional SFR model? 4. Identify opportunities for waste reduction and optimised SFR, by conducting a food value chain analysis, focusing on the dyadic relationship between a donor (specifically, either a large retailer or manufacturer) and a redistributor.
Improved Collaboration	**Donors:** a. Retailer-led collaboration in the food chain (RT02; FM05; FAWD01) b. Consolidated distribution (PP02; FM02; FM03; FM05; LC01) c. Knowledge sharing among donors (AP03; RT02; FM05)	5. What are the barriers and enablers for collaboration in the following types of relationships in the hybrid food supply chains that serve disadvantaged groups? a. Donor-donor b. Donor-redistributor c. Intra-organisational d. Inter-governmental department e. Redistributor-redistributor

	d. Provision of industry expertise to redistributors (AP04; FM05; FAWD02) **Redistributors:** a. Joint fund bidding (CG02; FASO03) b. Shared talent pool (AP04; FAWD02) c. Formation of umbrella redistributor groups (FAWD01; CG02) d. FAWD hub-and-spoke model (AP03; PP02; FM02; FM03) **Government:** a. Inter-governmental department collaboration on SFR and schemes targeted at disadvantaged groups (FAWD02; FASO04). b. Coordinating donors and redistributors for improved SFR operations (FASO03; FM02; FM03)	6. Considering facility capacity and location constraints of FAWDs and FASOs, how can the hub-and-spoke approach be adopted in SFR for optimised food redistribution and improved sustainability? 7. How can the adoption of Industry 4.0 technologies improve visibility, information sharing, trust and collaboration in SFR?
Increased Economic Incentives	**Donors:** a. Buying surplus food at cost (AP02; PP01; PP02; FM03) b. Tax reprieves (and similar economic stimuli) to incentivise adherence to food waste hierarchy (PP01; FM02; IE02) c. Cost recovery for low-end food donors (FAWD02; PP01; PP02) **Redistributors:** a. Easier access (education, sources, less bureaucracy) to funds (FAWD03; IE03) b. Discounted distribution costs (FAWD03; IE03; PP02; LC01; LC02; WD01) **Government:**	8. How can redistributors evidence the impact of their work economically to donors to justify funding their logistics operations? 9. How can the impact of financial and surplus food donations of donors be evidenced within their supply chains for sustainability reporting and to encourage increased donations and funding of SFR logistics activities? 10. How can governmental funding and other economic incentives be justified empirically based on extensive analysis of the impact of SFR?

	a. Provision of tax reprieves to donors (PP01; FM02; IE02) b. Funding production and processing costs for low-end donors (FAWD02; PP01; PP02) c. Incentivising funding from non-food sector organisations through policies and legislation (IE02; CG02)	
Defining a SFR Role for Logistics Companies in SFR	**Donors:** a. Expedited decision making on surplus food (LC02; WD01) b. Funding of the distribution of their surplus food (LC02; PP02; FM03; FM04; FM05; WD01) **Redistributors:** a. Enhance storage, material handling and logistics capacities to efficiently redistribute increased volumes of surplus food (FASO04; PP02; PP03) **Government:** a. Coordinate all relevant actors to fund and pilot an enhanced role of logistics companies in SFR (FASO03; FM02; FM03) b. Facilitate sector-wide implementation (FASO02; FASO03; FM02; FM03)	11. How can logistics companies in food supply chains intervene in addressing the logistics challenges of SFR? What are the barriers and enablers of such an intervention? 12. How can such an intervention be implemented from a food systems perspective to ensure surplus food is efficiently and sustainably redistributed?

Appendix A

A1. Research Design

Supply chain mapping is a utile tool for improved supply chain understanding, helping to identify linkages and relationships, processes and infrastructure within the specified supply chain. The facilitates operational efficiency, and the improvement in the sustainability of business processes and the resilience of the supply chain (Fabbe-Costes *et al.*, 2020; Manavalan and Jayakrishna, 2019; Mubarik *et al.*, 2021; Sanderson, 2016). In deciding the most appropriate mapping approach, we chose the relationship-based approach, as opposed to the activity-based approach (Dujak, 2017; Lambert *et al.*, 2008) for multiple reasons. First, it provides a visual representation and analysis of the supply chain relationships (both direct and indirect) of a firm. Secondly, it helps identify and eliminate internal and external waste processes. Further, it helps identify the most critical relationships for the success of the supply chains for improved relationship management (Lambert *et al.*, 2008). Moreover, it allows for resource optimisation by helping determine the type and volume of resources needed to manage the different relationships. Thus, this study seeks to elaborate on our patched knowledge of the supply chains that serve disadvantaged communities by going beyond the charitable organisations involved in food aid, to engage actors in the commercial food supply chain, for a holistic understanding of the relationships, processes and infrastructure.

A2. Mapping Approach

Despite the absence of an overarching format for mapping (Roy, 2011), Kumar *et al.*'s (2013) relationship-based mapping approach to undertaking the sector mapping of food supply chain products was instructive in this study. Our approach involved four stages. First, an extensive examination of the relevant literature and organisational reports facilitated the production of a generic structure of the commercial food supply chain, identifying the actors, key stakeholders and the linkages between them (Anastasiadis *et al.*, 2020). Next, we collected data from the identified supply chain actors to affirm the generic map and its relationships, as well as explore how each of these actors serve disadvantaged consumers. "New" actors were identified from the collected data. This led to an extension of the generic map and further data collection from these actors. These first three stages helped us get a "complete" picture of supply chain that serves disadvantaged groups, its challenges and practitioner insights on attendant solutions. An iterative engagement with literature helped to link the emergent insights with extant knowledge (Eisenhardt, 1989). Finally, we engaged subject matter experts (Anastasiadis *et al.*, 2020) from industry and academic institutions for additional insights on the supply chain and for triangulation (Denzin, 2017).

A3. Data Collection

As an explorative research, qualitative data were collected through semi-structured interviews (Yin, 2018). Sampling was purposive, based on relevance, supply chain member, expertise, identified stakeholder and familiarity with the topic. With a combination of expert and typical case purposive sampling methods (Etikan *et al.*, 2016), we targeted stakeholders with the capability to facilitate the development of impact and impact pathways. Interviews were then conducted with relevant top managers in each organisation. These were selected for their seniority and level of knowledge of their organisation's supply chain and their efforts towards serving disadvantaged groups. The selection of experts was based on their long-term empirical participation in the food industry, food supply chains or food access for disadvantaged groups (Anastasiadis *et al.*, 2020). Interviews lasted between 38 and 83 minutes and were conducted face-to-face at a location and/or mode of participant's choosing. They were recorded and transcribed for analysis.