The adoption, use, and climate implications of online food hubs

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Thesis submitted for the degree of Doctor of Philosophy
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July 2022

Abstract

Online food hubs challenge the emission-intensive mainstream model of food provision by re-localising supply chains and connecting producers with consumers. One example is *Open Food Network*, which provides an open source direct marketing platform in 20 countries. This thesis answers three questions: 1) how does using an online food hub affect household food behaviours? 2) what are the drivers and context of adoption which could affect a scaling up of online food hubs? 3) what are the greenhouse gas emission implications of using an online food hub? The Diffusion of Innovations theoretical framework was used to analyse empirical data collected through a collaboration with *Open Food Network UK.* Interview respondents (n=20) reported eating a healthier, more seasonal diet and wasting less food since joining their local hub. A questionnaire survey explored perceptions of online food hubs among users and non-users (n=595) to assess the scope for increasing adoption. Both groups were positive about the food quality and environmental attributes, but non-users were less certain about compatibility with their existing shopping routines and preferences. Finally, hub users' (n=94) shopping data was combined with Life Cycle Analysis literature to estimate the effects of altered food behaviours and switching supply chains on emissions. Six mechanisms were identified which indicate potential emission reductions, albeit within large uncertainty ranges. Encouraging a healthier diet was the most impactful mechanism, with savings up to 5853 kg CO_2-eq. household^{-1} year^{-1}. These findings can inform policy with respect to climate mitigation and public health goals, as well as providing insights into the adoption of low carbon digital innovations.

Key words

Online food hub, Open Food Network, low carbon, digital innovation, consumer, household food behaviour

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Acknowledgements

This research was made possible through the generosity and support of a number of people and I would like to express my gratitude to each of them. My sincere thanks to all of the survey and interview respondents for taking the time to participate. Several food hub managers played a crucial role in assisting with the design and distribution of the survey. I appreciate the contributions of Rachael Forster, Sara Rock, Simon Platten, Ruth Redgate, Alex Geldenhuys, Rosie Jacobs, Becks, Karen and Katie. I would particularly like to thank Lynne Davis for her patience, support and positivity throughout this collaboration. She always made the time for me and I am very grateful.

My PhD was part of the 'Social Influence and *disruptive* Low Carbon Innovations' (SILCI) project. The project was funded by the European Research Council and I would like to thank the council for supporting this research (Starting Grant #678799).

I am very grateful to my supervisors, Professor Charlie Wilson and Professor Andrew Lovett, for guiding me through the process and for their invaluable advice during the planning, analysis and writing phases. They always had a useful suggestion or a fresh perspective to offer. My thanks also to the members of the SILCI team: Hazel Pettifor, Emilie Vrain, Barnaby Andrews, Laurie Kerr and Emma Cassar. Each of them helped me at various stages during the past four and half years. I am especially grateful to Emilie for her enthusiasm and her willingness to read my chapter drafts.

Finally, I would like to thank my family who encouraged me, provided a roof over my head for two years, listened to me and supported me in so many other ways. I genuinely could not have done this without their help.

1 Introduction

This PhD thesis considers the climate mitigation potential of one consumer action - the adoption of an online food hub. The study provides unique insights into how using this innovation alters multiple household food behaviours, with consequent implications for reducing greenhouse gas (GHG) emissions. This research is therefore situated at the intersection between everyday food habits, the digitalisation of daily life, and climate mitigation.

1.1 Climate change, agriculture and supply-side mitigation

Climate change is a threat to all aspects of human life. To avert the worst outcomes, the world's leaders signed the Paris Agreement to limit global warming to well below 2°C, preferably to 1.5°C, of the pre-industrial level (UNFCCC, 2015). Implementation of the Paris Agreement requires economic and social transformation across all sectors in order to rapidly bend the emissions curve downwards towards a climate neutral world by the middle of this century (IPCC, 2018). Many emission reduction pathways have been proposed which vary in their emphasis of how to accomplish this goal. Some focus on supply-side mitigation, for instance accelerating the switch to renewable energy or exploring the feasibility of negative emission technologies (van Vuuren et al., 2018; Haszeldine et al., 2018). Others advocate demand-side approaches such as encouraging more sustainable lifestyles or changing consumption patterns (Schanes, Giljum and Hertwich, 2016; Committee on Climate Change, 2019).

Agriculture and food sector emissions

Reducing emissions from the agriculture and food sectors is crucial to achieving global mitigation targets. Agriculture, forestry and other land use contributes approximately 23% of total net anthropogenic GHG emissions. If the emissions associated with post farm-gate activities are included[1], this figure rises to between 21-37% (IPCC, 2020; Crippa et al., 2021). Emissions from agriculture have risen by 14% since 2000 and this is accompanied by a significant increase in emissions from food transportation, processing, packaging, retail and waste (ibid; FAO, 2018). In 2019, food supply chains overtook agricultural production to become the largest GHG component of agri-food system emissions in Global North countries (Tubiello et al., 2021a & 2021b). The trend is going in the wrong direction for almost every aspect of the food system.

More demand, less land

There are several major challenges to decarbonising global food production. First, reducing emissions from agriculture must be achieved without compromising the food security of millions of people (Wollenberg et al., 2016; Frank et al., 2017). Second, the total demand for food is expected to increase by 35% to 56% between 2010 and 2050. This is attributed to a growing global population that is projected to reach 10 billion by 2050, and the tendency to eat a more resource-intensive diet

[1] The emissions associated with post farm-gate activities (e.g. food manufacture, distribution, storage and retail) have previously been counted in other sectors - energy, transport and industry - in the IPCC assessments (IPCC, 2021).

as income increases (Ranganathan et al., 2018; van Dijk et al., 2021). Third, half of the world's habitable land is already used for agriculture and there is limited scope for further expansion into forested areas (Ritchie and Roser, 2019). Fourth, agriculture is likely to face competition for land from bioenergy with carbon capture and storage (BECCS) and reforestation programmes which aim to sequester carbon (Kreidenweis et al., 2016; Smith et al., 2016). Finally, climate change is already exacerbating land degradation processes, flooding, and drought frequency and severity, all of which limit agricultural productivity (IPCC, 2019).

Other environmental and social impacts of food production

Rising emissions are only one of the problems associated with food production. Land use change and the application of pesticides have resulted in a precipitous decline in global biodiversity. Conventional farming practices exacerbate erosion and flooding. Fertiliser run-off causes eutrophication of water systems. The rise in atmospheric CO_2 has led to warming and acidification of the oceans, threatening many marine ecosystems, and a third of the world's fish stocks are trawled at unsustainable levels (Steffen et al., 2015; FAO, 2020; WWF, 2020). A fundamental failing in global food distribution has resulted in 1.9 billion overweight adults, while 462 million are underweight (Willett et al., 2019; WHO, 2021). The intensification farming model is characterised by asymmetric power relations between food retailers and producers (Antonini and Argiles-Bosch, 2017; Pulker et al., 2017).

Supply-side mitigation

Various supply-side initiatives aim to reduce emissions from the agriculture and food sectors. Countries in the Global South are incentivised to avoid deforestation and forest degradation through REDD+ programmes (UN-REDD, 2021). Farmers in the UK are encouraged to adopt land management practices which preserve or sequester carbon in soils and trees (Business Wales, 2019; DEFRA, 2021a). There is ongoing technological innovation to increase farm process efficiency such as precision agriculture or on-site waste management (Balafoutis et al., 2017). Food retailers are coming under greater scrutiny regarding their supply chains and most UK supermarkets have pledged to reduce the environmental impact of a weekly food shop[2].

1.2 Demand-side mitigation

The importance of reducing supply-side emissions should not be discounted, but ultimately all production is linked to households and consumer demand for goods and services. Consumption activity in the food, mobility, home, and energy domains account for over three quarters of emissions, as well as 70% of land use, 81% of fresh water use and 48% of materials (IPCC, 2014; Ivanova et al., 2016). Our lifestyle choices and consumption decisions therefore have a considerable

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[2] BBC, 2021. COP26: Supermarkets promise to halve environmental impact by 2030 - BBC News
BBC, 2019. Supermarkets' sustainable palm oil not fully traceable - BBC News
Forest500.org, 2020. Are UK supermarkets doing enough to address deforestation? | Forest 500

impact on emissions and other resource footprints. Figure 1 shows consumer influence extending 'upstream' in the various supply chains required for providing a good or service, as well as 'downstream' for recycling and waste disposal. Each phase in the supply chain has implications for emissions (and resource use) and so each phase represents a leverage point for mitigating climate change. Considering the gravity of the climate situation, all possible levers should be pulled and this includes reducing or shifting demand.

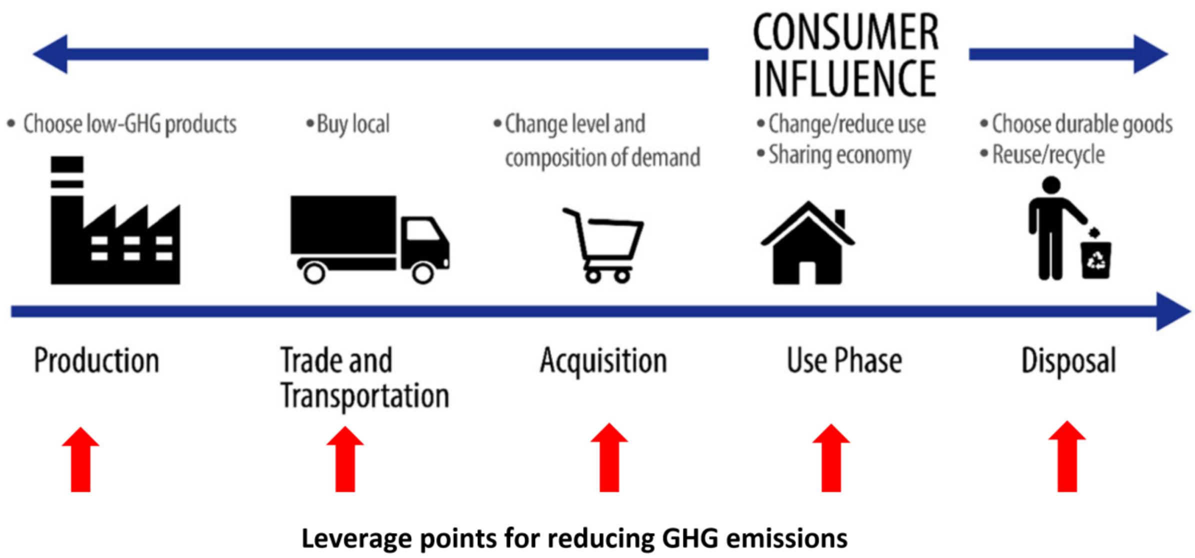

Figure 1, Consumer influence on the supply chain (adapted from Moran et al., 2020)

The notion that consumers have an active role, or even a responsibility, in tackling global environmental challenges has gained support in recent years. Responsible consumption and production is the twelfth UN SDG and specific targets include halving per capita global food waste at the retail and consumer levels by 2030, and ensuring people have the relevant information to live a sustainable lifestyle (UN, 2018). Two mitigation pathways in the IPCC (2018) Special Report on 1.5 °C focus on 'lowering energy demand' and 'a shift towards sustainable consumption patterns'. These international policy mandates are important in providing a direction of travel to reduce emissions but they contain minimal information regarding how to achieve sustainable consumption patterns[3]. This has prompted a growing research focus on consumption-based carbon accounting to identify exactly which behaviour changes would be most effective in reducing emissions (Stavros et al., 2016; Creutzig et al., 2018; Lacroix, 2018; Moran et al., 2020).

[3] Sustainable consumption is likely to be explored in the upcoming 6th IPCC assessment report (Chapter 5 - demand, services and social aspects of mitigation, Working Group III).

1.2.1 Consumer actions to reduce food emissions

What might demand-side mitigation look like with respect to food? There are essentially three main ways consumers can reduce their food carbon footprint:

1. waste less food, within the household and when they eat out
2. buy (or grow) food which has less embodied emissions in its production, packaging, storage and transportation
3. shift their diet towards less emission-intensive foods

Dietary shift is generally accepted as the most impactful way of reducing emissions due to the high carbon intensity of particular foods such as red meat and dairy products (Alexander et al., 2016; Willett et al., 2019). Wasting less food, particularly within the household, also has a significant reduction potential (Aschemann-Witzel, 2016; Tonini, Albizzati and Astrup, 2018). The emission implications of sourcing food through alternative supply chains are least understood, largely because of the complexity of conducting a Life Cycle Analysis (LCA) for food products (Garnett, 2014; Arzoumanidis et al., 2017). These three actions are not mutually exclusive and combining all of them represents the greatest mitigation potential.

1.2.2 Three approaches for changing consumer behaviour

There are different approaches to changing consumer behaviour in order to achieve environmental objectives, one of which is awareness-raising. This is a well-established strategy of presenting relevant information to consumers so they intentionally decide to alter their habits or preferences. This can relate to a specific product in the form of energy efficiency or carbon labelling, although previous efforts to apply this to food did not have a discernible effect on consumer behaviour (Gadema and Oglethorpe, 2011; Hornibrook, May and Fearne, 2015). It can also relate to a practice such as wasting food. *Love Food, Hate Waste* is a salient UK example and between 2007-2018 the campaign succeeded in reducing per capita household waste by 24%. However, this figure remains well short of the Courtauld Commitment of a 50% reduction by 2030 and there is evidence of a tapering off, suggesting the easy yards may have been made (WRAP, 2014, 2018 & 2021). Awareness raising initiatives are effective but may be insufficient on their own to bring about a transition at the scale and speed of what is required. Moreover, there is evidence they can provoke inertia among some members of the target audience (Moser, 2016; Luís et al., 2018).

A second approach is government policy. Incentivisation in the form of grants, tax breaks or feed-in tariffs are commonly used to encourage household investment in expensive low carbon technologies such as solar panels, heat pumps or electric vehicles[4]. It is difficult to imagine how this method could be applied to something as composite and variable as the weekly food shop. More interventionist strategies have been suggested, such as a carbon tax levied on emission-intensive foods (Wirsenius

[4] GOV.UK, 2018. Smart Export Guarantee (SEG): earn money for exporting the renewable electricity you have generated - GOV.UK (www.gov.uk)
GOV.UK, 2021a. Domestic Renewable Heat Incentive (RHI) - GOV.UK (www.gov.uk)
GOV.UK, 2021b. Grant schemes for electric vehicle charging infrastructure - GOV.UK (www.gov.uk)

et al., 2011; Springmann et al., 2016). However, the UK government has no apparent appetite for directly influencing people's food choices[5]. BEIS recently deleted an article from their website which recommended people shift dietary habits towards plant-based foods to achieve climate targets, stating it was published in error and that they "have no plans whatsoever to dictate consumer behaviour in this way." [6]

A third approach is the adoption of end-user innovations which provide useful goods and services *and* which stimulate behaviour change. These technological and business model innovations are characterised by novel attributes or functionality and so they offer something different to consumers from what is available in existing markets. The potential to reduce emissions lies in the capacity of the innovation to provide private benefits while also shifting consumers away from emission-intensive or wasteful practices (Wilson, 2018; Wilson et al., 2018).

1.3 Consumer innovations which reduce food emissions

Figure 2 shows a wide range of end-user innovations currently being adopted in the food domain identified in the literature and an internet search (see Appendices 1.1 & 1.2). On the y axis, the categorisation is binary; the innovations are either digital or non-digital. For long-established activities which occur in non-digital form, such as veg boxes or business to business (B2B) surplus food redistribution, the innovation is the digitalisation of that activity using an app or platform. The arrow on the x axis represents a continuum, as some innovations display both consumer-facing and upstream characteristics. 'Upstream' in Figure 2 refers to innovations which consumers may be aware of and can engage with to a limited extent, as opposed to less visible supply chain innovations where consumers have no decision-making role, for instance precision agriculture. The emission reduction mechanisms - reducing food waste, sourcing low carbon food, and dietary change - are indicated by the numbers and some innovations are described by the service providers as reducing emissions in multiple ways.

[5] The '5-a-day' campaign is considered awareness raising, rather than a direct intervention. See: Why 5 A Day? - NHS (www.nhs.uk)

[6] BBC, 2021. Climate plan urging plant-based diet shift deleted - BBC News

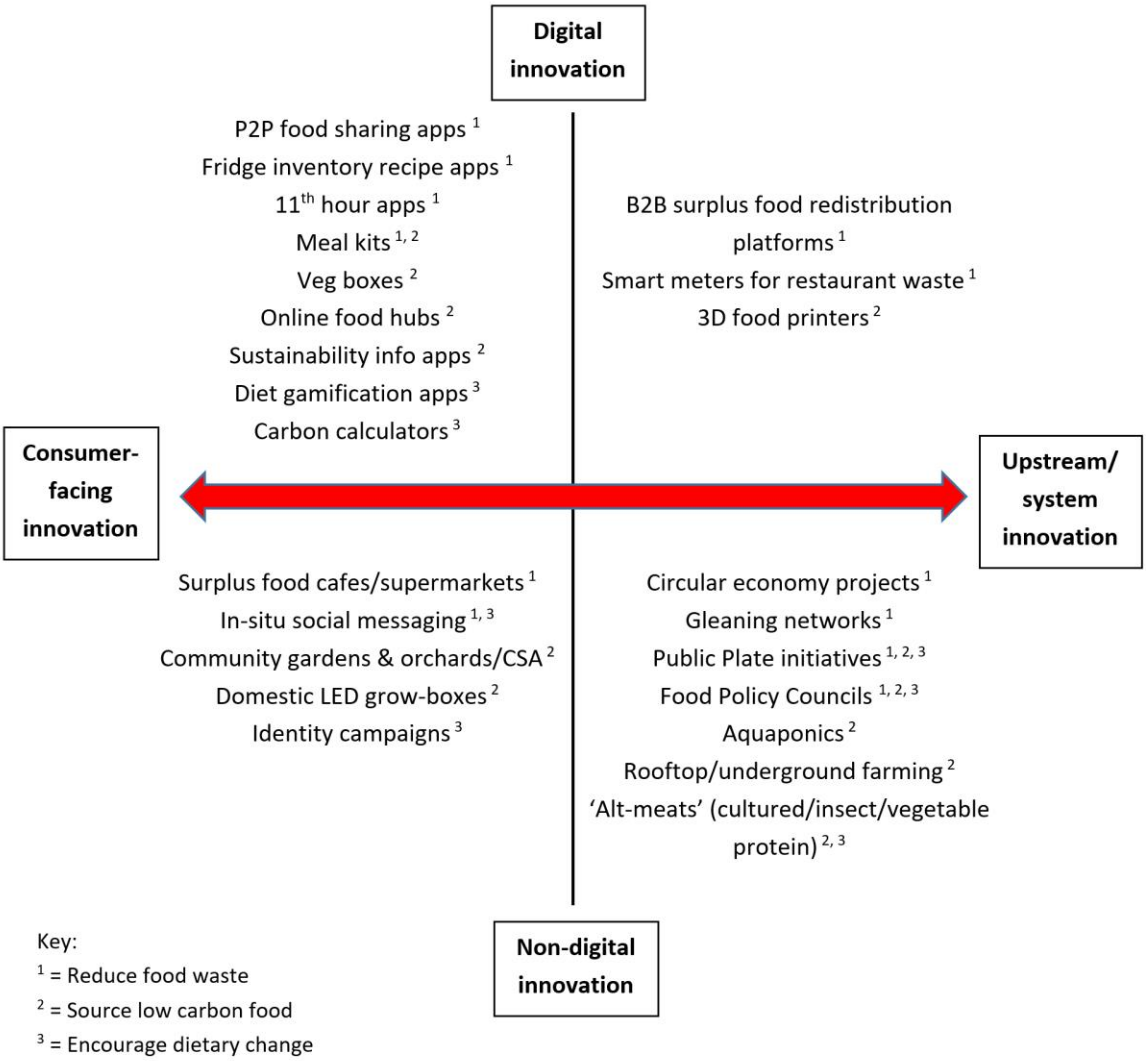

Figure 2, Categorisation of low carbon innovations in the food domain

These innovations cover a broad spectrum of how people can participate in the food system, primarily as consumers but also as producers, sharers and policy advisors. This thesis considers the cluster of innovations in the upper left quadrant of Figure 2 and there were three reasons for this. First, some of the innovations in the other quadrants, such as community gardens and food policy councils, have already received significant academic attention. Second, the innovations on the left of Figure 2 are more user-centric and so research in this area would contribute to our knowledge of demand-side mitigation approaches. Third, the digital medium can be very effective in proliferating a fringe activity into a mainstream one. The fast diffusion rate of digital innovations can already be observed in the ubiquity of digitally mediated services for communication, entertainment, transport and shopping[7] (IEA, 2017; Ciriello, Richter and Schwab, 2018). The challenge is to understand how this diffusion dynamic can be harnessed to reduce emissions in food-related sectors which are proving difficult to decarbonise.

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[7] BBC, 2021. [People devote third of waking time to mobile apps - BBC News]

1.3.1 Focus of this study – online food hubs

Within the array of food apps and platforms, 'online food hubs' are of particular interest and were chosen as the focus of this study. Some of the other food apps target one reduction mechanism, whereas online food hubs potentially impact food consumption behaviour for all three consumer mitigation mechanisms, thus expanding the scope for emission reduction (see Figure 3). Moreover, they create alternate supply chains and so directly challenge the emission-intensive mainstream model of food provision. Consumer influence extends not only to the choice of product, but also to how those products are produced and distributed.

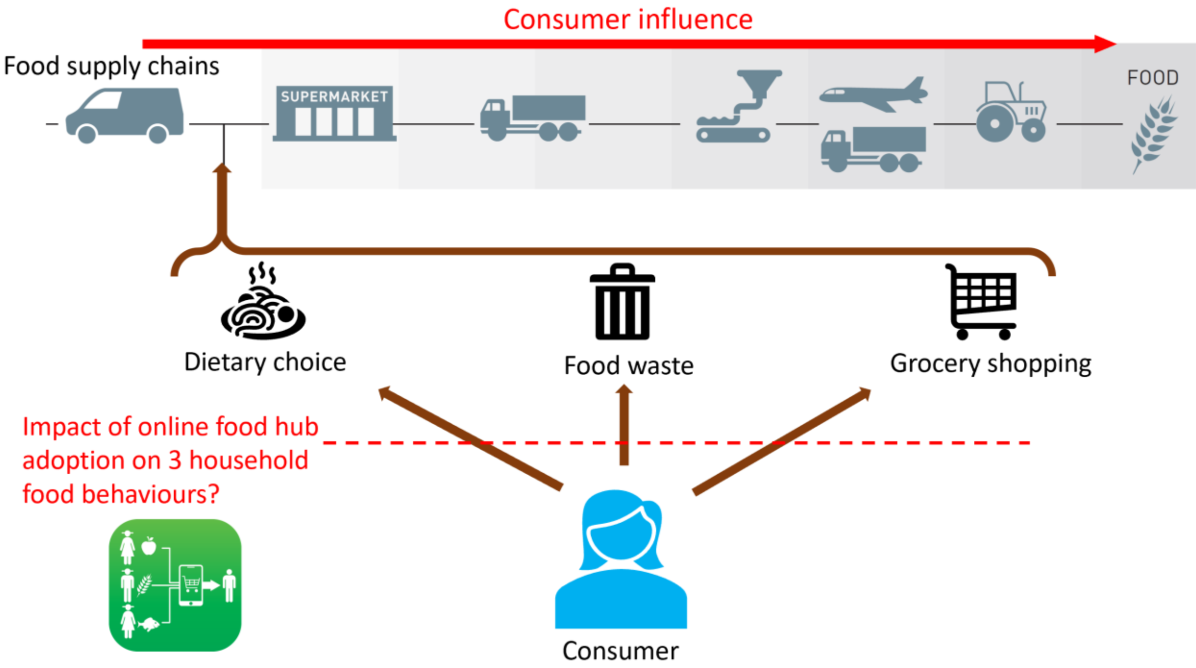

Figure 3, The potential impact of online food hub adoption on consumer food behaviours and supply chains

1.3.2 Definition of 'online food hub'

Online food hubs allow consumers to buy fresh produce directly from multiple local producers using a single platform. Consumers can choose which items they want (rather than a box subscription) and specify their shopping preferences according to diet, production method, or the distance the food is transported. Detailed information about individual producers and their farming practices is provided on the platform. The produce is delivered to consumers' homes or a local collection point, usually on a weekly basis.

Other terms are sometimes used in the literature or media coverage such as 'digital farmers' markets', 'online farmers' markets' or 'digital hubs for local food'. 'Online food hub' is used in this study because this is the term used by the people involved in running the hubs. Examples include *Open Food Network* (available in 20 countries), *The Food Assembly* (8 countries), and *Neighbourfood* (41 hubs in Ireland). *Open Food Network UK* collaborated with the author for this study.

How are they different from veg box providers?

Online food hubs are similar to veg box providers in that they offer locally-sourced fresh produce and a home delivery service. They both use direct marketing and typically have a strong social and environmental ethos. From a consumer's perspective, the distinction may not be obvious.

There are, however, three main differences. First, the larger food hubs tend to have a wider selection of products than veg box providers, with the exception of *Abel and Cole*. A hub's product range is of course determined by the number of participating producers in the area and the types of food they supply. Second, some food hubs have a premises such as a café or shop. *Riverford* also has this, but other veg box providers do not. This social space may bring a sense of embeddedness within the local community - a physical location rather than just a digital one. Third, online food hubs use a different business model. Veg box providers are companies, co-operatives or B corporations which sell food they grow themselves or source through contractual agreements with other local producers. They manage their own platforms and sell within a geographic area which they determine. Online food hubs, in contrast, use open source platforms which are managed by a software provider. Some of these such as *Open Food Network* also offer business support and tools to get started. Individual producers can choose to set up their own digital shop or they can join an existing food hub. This means a new food hub can be established with minimal effort anywhere in the country, on any scale, for any products. It is this ability to establish alternative food networks, using a proven model, in locations which may be under-served by both veg box providers and supermarkets that differentiates online food hubs.

Despite the overlap between the two innovations in terms of what they offer to consumers and the purported environment benefits, online food hubs are of interest because of the novelty of using an open source platform to change the food system and the scaling up potential this creates. These aspects have yet to receive any significant academic attention.

1.4 Research aim

To understand the GHG emission reduction potential of using online food hubs.

This PhD thesis is structured as follows:

- Chapter 2 reviews the relevant literature on innovation adoption, household food behaviours and the associated emissions, and online food hubs
- Chapter 3 describes the research design and how the data was collected
- Chapters 4 - 7 present the empirical results
- Chapter 8 synthesises findings from the preceding chapters to identify the scope and scale of a potential emission reduction
- Chapter 9 discusses the main implications of the study and identifies areas for further research

2 Literature review

The literature review comprises five sections: innovation adoption; household food behaviours and the GHG emission implications; values and food choices; food preferences and habits; and online food hubs.

2.1 Innovation adoption

The theoretical framework chosen for this thesis is Everett Rogers' (2003) *Diffusion of Innovations* (DoI). Three key tenets of this framework determine the rate of adoption and are described below, together with some of the main themes in the diffusion literature.

2.1.1 Innovation attributes

The first key tenet of DoI is the attributes of innovations. An individual's perception of these attributes is very important in their adoption decision. Rogers (2003) presents five types of attribute: 'relative advantage' is the degree to which an innovation is perceived as being better than the idea it replaces; 'compatibility' considers whether the innovation is consistent with the existing values, past experiences or needs of potential adopters; 'complexity' focuses on how easy or otherwise an innovation is to understand and use; 'trialability' describes the extent to which an innovation can be experimented with before committing to using it; and 'observability' is the degree to which using an innovation is visible to others. Thus, different attributes fulfil different functions and correspond with distinct aspects of appeal.

One important theme in the literature is which attributes, or configurations of attributes, are most important in determining adoption and under what contexts does this vary. Scholars have identified attribute clusters using various classifications such as 'core and non-core' (Levitt 1980; Armstrong et al., 2014), 'threshold, performance and excitement' (Kano et al., 1984), 'primary, secondary and tertiary' (Brechan, 2006; Lee, Khan and Mirchandani, 2013) and 'primary, facilitating and green' (Slevitch et al., 2012). Core or primary attributes describe the innovation's basic function (what it does/provides), whereas non-core or secondary attributes describe indirect or lifestyle benefits (how it makes life easier/increases enjoyment/saves time). These framings have been used to explore whether different adopter groups vary in their perception of attributes and whether customer satisfaction is primarily derived from the performance of the core attributes or the added value of the non-core attributes (ibid; Vasseur and Kemp, 2014; Sanguinetti, Karlin and Ford, 2018).

An emerging theme is the adoption of eco-innovations which provide private benefits for consumers, but also societal benefits such as reducing CO_2 emissions or protecting the environment and this creates another dimension of end-user appeal (Wilson et al., 2018; Pettifor et al., 2020). These public good attributes are appraised relative to private benefits in determining adoption and are used to identify eco-innovation market segments (Slevitch et al., 2012; Schuitema and de Groot, 2015). The role of eco-innovation adoption in driving sustainable transitions is considered, alongside policy and behaviour change measures (Karakaya, Hidalgo and Nuur, 2014; Wilson et al., 2020). Another important contribution is the recognition of symbolic attributes and their impact on the adoption decision (Axsen and Kurani, 2012; Sovacool and Axsen, 2018). Noppers et al. (2014, p.52) suggest that "people may be motivated to adopt sustainable innovations because of their positive environmental and symbolic attributes, that is, they benefit the environment and can be used to signal positive characteristics to oneself and others". Thus, innovations are adopted not just for their function, but also for what they may represent.

A final observation is the broad applicability of DoI, with several scholars noting that Rogers' attribute classification can be used to explain adoption across multiple innovations and domains (Tornatzky and Klein, 1982; van Oorschot, Hofman and Halman, 2018; Pettifor et al., 2020). The theory has been applied in diverse disciplines such as agriculture, health care and marketing (Kapoor, Dwivedi and Williams, 2014; Sriwannawit and Sandström, 2015).

2.1.2 Adopter categories and the distinctiveness of early adopters

The second key tenet of DoI is the differentiation of individuals in a social system into adopter categories, depending on the order in which they adopt (Figure 4). These categories are 'ideal types', with individuals in each category assumed to have traits in common which determine their relative adoption propensity. 'Innovators' are venturesome and take an active interest in trying new innovations. 'Early adopters' are also not averse to risk, are informed, and are more socially interconnected than the innovators. The 'early majority' follow the early adopters' example but will deliberate their adoption decision for longer. The 'late majority' and the 'laggards' have a low degree of innovativeness and require minimal uncertainty before choosing to adopt.

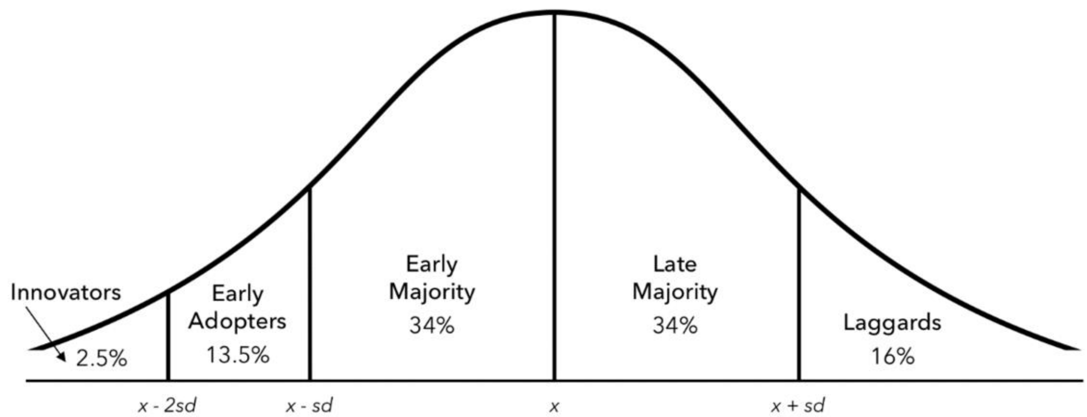

Figure 4, Rogers' adopter categorisation on the basis of innovativeness (2003, p.281)

The early adopters are of particular interest because they play a vital role in the dissemination of the innovation to larger market segments. They have a low adoption threshold which means they require fewer of their peers to have adopted prior to their own adoption. They display novelty seeking behaviour, price insensitivity and competence in using technology. They typically have more years of formal education and a higher social status than later adopters (Rogers, 2003; Valente, 2010; Dedehayir et al., 2017).

Despite these shared characteristics, some scholars suggest a generic distinctiveness of early adopters may not apply to all situations. For example, Reinhardt and Gurtner (2015) assert that early adopters of disruptive innovations have a greater understanding of product function and performance than later adopters, whereas early adopters of sustaining innovations do not necessarily have more product knowledge. Others maintain that sociodemographic traits are not always useful for differentiating the adopter groups and that attribute perception is more strongly associated with adoption than generic characteristics (Holak and Lehman, 1990; Goldsmith and Hofacker, 1991; Arts, Frambach and Bijmolt, 2011).

Other developments in this field include adding sets of variables to Rogers' original characterisation of the early adopters. For instance, Gustavsen and Hegn (2020) use the 'big five personality traits' to explore consumers' propensity to try local food specialties and found 'openness to experience' to be an important predictor. Reflecting the increasing digitalisation of daily life, others include measurements of technophilia (Atkin, Hunt and Lin, 2015; Martínez-Corcoles, Teichmann and Murdvee, 2017). These examples highlight the malleability of the DoI framework; other variables can be integrated as required without undermining the integrity or cohesiveness of the theory.

2.1.3 Interpersonal communication and social influence

The third key tenet of the DoI framework is the early adopters' interpersonal communication and social influence. Rogers (2003) argues that diffusion is a social process where information about an idea or innovation is communicated to others within a social system. Someone with knowledge or experience of the innovation, such as an early adopter, conveys information to another individual which makes them aware of the innovation in the first instance, or it reduces their hesitancy or perceived risk in adopting because other people they know have already adopted. Interpersonal communication can create a critical mass of adopters, the point after which enough individuals in a social system have adopted the innovation that further adoption becomes self-sustaining (ibid; Moore, 2014). There are different dimensions of interpersonal communication: peer effects and trust, social network structure, and social norms.

Opinion leadership and trust

Opinion leadership is "the degree to which an individual is able to informally influence other individuals' attitudes or overt behaviour" (Rogers, 2003, p.300). Opinion leaders play a crucial role in diffusion because they are able to directly and indirectly influence the perception of potential adopters with respect to the innovation (ibid; Flynn and Goldsmith, 1996). Opinion leaders use a variety of information sources such as specialist media or expert advice, whereas opinion seekers are more likely to look to opinion leaders for information (Palm, 2017; Jansson, Nordlund and Westin, 2017). For example, purchasing food with purported environmental attributes requires confidence that the supplier uses particular farming practices and so new customers seek trusted information from existing customers (Persaud and Schillo, 2016; Buskens, 2020).

Another important theme is the context in which social influence occurs. Word of mouth communication among family members or social connections is often more effective in shaping attitudes than outside influences such as marketing campaigns or government policy. Thus, social influence is especially effective in prompting behaviour change at the household or community level (Keys, Thomsen and Smith, 2010; Goldsmith and Goldsmith, 2011; McMichael and Shipworth, 2013). It should be noted that social influence works both ways; it can deter adoption if opinion seekers receive negative information about an innovation from their peers (Xiong, Payne and Kinsella, 2016). Moreover, its impact may not be consistent for all potential adopters. Gracia, de Magistris and Nayga (2012) found that social influence positively affects a willingness to pay more for local foods among women, but the effect is negative for men.

Social network structure

Homophily describes the tendency for individuals to form social ties with others who are most similar to themselves. This is contrasted with *heterophily*, which describes the degree to which individuals interact with others who are different in certain respects, such as their sociodemographic characteristics (Rogers, 2003). Information received though homophilous connections is more likely to result in adoption as people within a social group have shared social norms and high levels of trust (Valente, 2010). However, it can also act as barrier to diffusion because information can circulate in social clusters without reaching individuals from outside the cluster. Thus, heterophilous connections link different social groups and so act as a bridge for the diffusion of information (Barnes et al., 2016; Muller and Peres, 2019).

This structural aspect of interpersonal communication has generated research interest in social networks, particularly those of early adopters given their high degree of social influence. Choi, Kim and Lee (2010) argue that diffusion in homophilous networks is important early in the diffusion process to establish a critical mass of adopters, whereas heterophilous connections become more important later in the process to avoid redundancy. In a similar vein, Muller and Peres (2019) suggest homophilous clustering is crucial for the diffusion of innovations which are perceived as complex. Vrain and Wilson (2021) found early adopters of smart home technologies to be active in their communication about the innovations but their social networks are highly clustered and this diverges from Rogers' (2003) expectation of early adopter heterophilous networks. Understanding why homophily occurs is challenging because social influence can be difficult to disentangle from social selection (Borgatti et al., 2009; Barnes et al., 2016)

Social influence in the digital realm

Information and communication technology removes some of the structural barriers of social networks because it enables the rapid spread of information among individuals who are otherwise not connected socially or may be geographically distant (Valente, 2010). Social media platforms are often used by consumers to share their experiences (Voramontri and Klieb, 2018), but there are two bespoke digital mechanisms for providing information. The first is consumer review or rating platforms such as *Trustpilot* or a built-in review function on the websites of many large retailers

(Buskens, 2016; Littlechild, 2021). The second is referral schemes, which many companies prefer over traditional marketing approaches because a friend or family member referral entails greater credibility, as well as potentially accessing new customers that conventional marketing may not reach (Berman, 2016). Both mechanisms replicate peer social influence by providing trusted information from those who have more experience.

Social norms and neighbourhood effects

Social norms are described as what people believe others do (descriptive norms) and what they think others may approve or disapprove of (injunctive norms) (Cialdini et al., 1991). Individuals interpret social norms on the basis of the observed behaviour or social signalling of their peers and are motivated by a desire to conform to what is expected of them (Bicchieri, 2016; Sanders and Hume, 2019).

A number of articles explore the impact of social norms on food habits or pro-environmental behaviours. Cannuscio et al. (2014) investigated the social dynamics of healthy food shopping and found consumers tend to choose shops frequented by people who shared their ethnicity, income and education level. Vázquez et al. (2019) identified generational differences in the choice of grocery retailer, with the older demographic prioritising trust and interpersonal relationships with market vendors, whereas younger consumers prefer convenience stores for product range and flexible opening hours. Some scholars assert that social norms are activated by context and so people conform only if certain conditions, such as observability and normative expectations, are met (Higg, 2015; Farrow, Grolleau and Ibanez, 2017).

A neighbourhood effect is the influence of seeing what others who live nearby are doing and following their example. Neighbourhood effects usually relate to highly visible actions, for example installing rooftop photovoltaic panels (Wolske, Gillingham and Schultz, 2020). Bjørkhaug and Blekesaune (2013) found evidence of a neighbourhood effect for farmer adoption of organic agriculture in Norway, where particular regions have a higher concentration of organic farms. Other explanatory factors were a greater density of potential customers living nearby, along with social norms for shopping at farmers' markets or speciality grocery stores.

2.1.4 DoI applied to consumer food innovations

There is an extensive body of research which uses DoI to understand farmer adoption of agricultural technologies or approaches, for instance the uptake of hybrid crops or climate smart agriculture (Simin and Janković, 2014; Long, Blok and Coninx, 2016). However, DoI has not been widely applied to consumer adoption of food innovations[8] and only eight articles were discovered. Four studies rely on Rogers' characterisation of adopter groups to develop marketing strategies for novel, value-added foods (Ronteltap et al., 2007; Iliopoulos, Theodorakopoulou and Lazaridis, 2012; Barska, 2014;

[8] DoI has been extensively used in market research of consumer preference for food brands, but this is not considered an end user innovation and so is not relevant for this study.

Barrenar, García, and Camarena, 2015). Dedehayir et al. (2019) present strategies for overcoming the diffusion curve 'chasm' to access the mass market for vegan food products. Inwood et al. (2009) explored the role of restaurant chefs as opinion leaders in promoting the consumption of locally produced food to their customers. Shelomi (2015) and Weinrich (2019) use DoI to investigate consumer reluctance to eat meat substitutes and found the main obstacles to be incompatibility with existing diets and negative perceptions of taste or appearance. Aside from these last two articles, DoI has not been applied to any of the food apps or platforms presented in Figure 2, so far as the author is aware.

2.1.5 Criticism of DoI

DoI has been criticised on a number of points. Rogers (2003) himself provides a critique of the theory, highlighting four issues: the pro-innovation bias, the individual-blame bias, the recall problem, and issues of equality. The pro-innovation bias assumes that all innovation is positive and therefore everyone in a social system should adopt, therefore disregarding whether the innovation is actually appropriate to an individual's needs or context (Florman, 2000; Dedehayir et al., 2017). Indeed, many innovations fail and this can lead to the individual-blame bias, whereby the fault of non-adoption is attributed to the individual, rather than an incompatibility with their situation or ineffective communication of the relative advantages. Talke and Heidenreich (2014) suggest understanding why innovations fail is central to diffusion research and they differentiate between 'passive innovation resistance', a consumer's generic predisposition to resist innovations, and 'active innovation resistance' which results from an unfavourable evaluation of the innovation. Others have criticised the linearity of the model, asserting that diffusion is often an unstructured and iterative process, particularly for innovations where adopters are required to substantially change their behaviour (Moore, 2014). A further criticism is the external social context of adoption is not included in the framework (Shove, 1998; Lyytinen and Damsgaard, 2001).

Summary

What we know

DoI is a well-established theoretical framework for explaining how, why, and at what rate new ideas or technologies spread among a social system. The relative strengths of DoI are understanding the innovation appeal, characterising different adopter groups to explain the diffusion process, and identifying the pivotal role of the early adopters in communicating information to others.

What we do not know

The adoption of consumer innovations in the food domain is not well understood and DoI has not been widely applied to this topic.

2.2 Household food behaviours and the associated GHG emissions

This section reviews the literature on household food behaviours which have emission implications and which form the context for the adoption of online food hubs. The section is structured according to the three main ways consumers can reduce their food carbon footprint: shifting to a lower carbon diet, wasting less food, and buying food from supply chains that are less emission intensive.

There are a number of activities within each of these three broad mitigation approaches. Table 1 is duplicated from Schanes, Giljum and Hertwich (2016) and it provides a useful overview of these activities and how they reduce emissions. *Reduction* measures imply consuming less of something (waste less food) or choosing a low carbon alternative (switch to a vegetarian diet). *Improvement* measures focus on more efficient ways of doing something (source food from suppliers who use less emission intensive farming practices). GHG emissions are reduced either through *direct* actions (avoid/limit personal consumption) and *indirect* actions (a change in consumption patterns which averts further use of materials or energy, e.g. food sharing). Reduction or improvement measures[9], whether direct or indirect, infer behaviour change at the individual or household level. Consumers may be motivated by concerns about climate change but there are many possible reasons for a behaviour change, for instance a desire to save money or to improve health.

[9] This is a variation of the 'avoid-shift-improve' framework, which has been applied within and across consumption domains to understand the mitigation implications of different activities (Creutzig et al., 2018; Wilson et al., 2020).

Table 1, Mitigation options for consumers to reduce their food-related GHG emissions. Adapted from Schanes, Giljum and Hertwich (2016, p.1040)

	Improvement strategy	Sub-strategy	Examples for specific actions
Direct reduction	Consumption reduction	–	Avoid meat (vegetarianism, veganism and flexetariarism) Eat less meat (one meat-free day a week, eating smaller portions of meat) Reduce over-purchasing and avoidable food waste Eat less (no more than needed to maintain a healthy body) Consume fewer foods with low nutritional value e.g. alcohol, tea, coffee, chocolate
	Curtailment	–	N/A
	Shift between consumption categories	–	Shift from spending money on food to e.g. cultural activities or education
Indirect reduction	Changes of consumption patterns	Reuse	Reuse unavoidable food waste directly for animal feed, as fertilizer and/or compost
		Do-it-yourself	Grow your own food, Community gardening, Community supported Agriculture
	Changes in using behaviour	Sharing/Renting	Food sharing
		Repair/Maintain	N/A
	Changes in disposal patterns	Donate/Resell	Food sharing
Direct improvement	Purchase of efficiently produced products	Material efficiency	Purchase food that would otherwise be thrown away (funny carrots, close-to-expiry-date produce)
		Energy efficiency	Choice of lower carbon intensive alternatives within the same product group e.g. changing from GHG-intensive meats (ruminants) to less intensive meats (pork and poultry) Substitution of meat and dairy products by plant proteins Substitution of meat products by insects Purchase of seasonal food Purchase of food that is more efficiently produced (e.g. less fertilizer)
		Carbon intensity	Purchase of food that is produced in unheated greenhouses Purchase of food that is produced in biomass heated greenhouses
	Purchase of products that are more efficient in use	Energy efficiency	N/A
		Carbon intensity	N/A
Indirect improvement	Changes in disposal behaviour	–	Collect unavoidable food waste separately (use for animal feed, as fertilizer, compost, or to recover energy from anaerobic digestion)

Key: red lines = dietary shift; blue lines = food waste reduction; green lines = source food with less embodied emissions

2.2.1 Dietary preference

Livestock-related GHG emissions represent nearly two thirds of the global emissions from agriculture (FAO, 2016; Willett et al., 2019). Reducing consumption of meat and dairy products is therefore advocated as the single most impactful way that consumers can reduce their carbon footprint, not just within the food domain but of any pro-environmental behaviour (Lacroix, 2018). This section reviews the literature on the emission implications, the approaches used to encourage people to change their diet, and the obstacles to achieving this. 'Health' and 'seasonal' are also considered as alternative dietary change pathways for reducing emissions.

Diets and emission scenarios

A number of articles quantify the emissions of different dietary preferences and they are consistent in their findings; there is insufficient land available (without significant further deforestation) if the global population adopted the meat-intensive 'Western diet' which is typical in Northern Europe and the US. Moreover, the emission implications of this diet are entirely incompatible with current global mitigation targets (Garnett, 2011; Alexander et al., 2016; Boehm et al., 2018; Jarmul et al., 2020). For example, Röös et al. (2017) present four 'livestock futures': further intensification of livestock systems; livestock production restricted to the use of 'ecological leftovers' (grass from pastures, food waste); a move towards artificial meat and dairy; and a transition to plant-based eating. There is insufficient cropland for the first two scenarios and, in order to achieve climate mitigation goals, the other two scenarios can only be realised with accompanying reductions in food waste. Hoolohan et al. (2013) quantified the emissions embodied in 66 different foods and estimated the current UK-average diet to be 8.8 kg CO_2-eq. person^{-1} day^{-1}. They present various 'realistic consumer choices' for reducing emissions; eliminating meat would result in a 35% reduction, compared to 12% for preventing food waste and 5% for avoiding foods grown in heated greenhouses or air-freighted to the UK. Some authors try to define what a 'sustainable diet' looks like (Friel, Barosh and Lawrence, 2012; Scarborough et al., 2014). The 'Mediterranean' and 'Atlantic' diets (a high proportion of fish and salad) have high nutritional value and low carbon footprints, as does the 'Indian' diet (a high proportion of vegetables and pulses) (Alexander et al., 2016; González-García et al., 2018; Esteve-Llorens et al., 2019). Sustainable diets have multiple environmental benefits in addition to limiting GHG emissions, such as reduced nitrogen emissions or land use change (Westhoek et al., 2014 & 2021; Willet et al., 2019).

Dietary preference and resistance to change

95% of the UK population eat meat and, until very recently, per capita meat consumption in the UK remained steady at 54 kg year^{-1} (Statista, 2018a). There is growing media coverage[10] on the link between dietary choice and the climate, and a Swedish supermarket chain even took the unprecedented step of advocating dietary change to reduce emissions (FCRN, 2018). However,

[10] BBC 2018, From burping cows and food miles to greenhouse gases - BBC News
BBC 2019, Climate change food calculator: What's your diet's carbon footprint? - BBC News
BBC, 2021. Can the food we eat help tackle climate change? - BBC News

increasing public awareness has seemingly had little impact and so a number of scholars explore the reasons behind this resistance to changing diet. Some people have a strong emotive attachment or identity association with eating meat and so arguments against meat consumption only serve to entrench their meat-eating justifications (Graça, Calheiros and Oliveira, 2015a & 2015b). Some remain sceptical of scientific evidence linking meat consumption to climate change or inaccurately believe their personal consumption levels to be low (Macdiarmid, Douglas and Campbell, 2016). Others simply like the variety of eating different meat-based meals (de Boer, Schosler and Aiking, 2017). There are also cultural links between eating meat and the celebration of special occasions, meat as a signifier of hospitality, or an expression of social status (Lund et al., 2017; Biermann and Rau, 2020). In the last few years, however, there has been a counter trend with many people choosing to adopt a more plant-based diet (Waitrose, 2018; YouGov, 2019a). As with the committed meat-eaters, some people choose a vegan, vegetarian or flexitarian diet as an expression of personal identity. A concern for the environment, animal welfare or personal health are also important motivations (Chuck, Fernandes and Hyers, 2016; de Boer, Schosler and Aiking, 2017).

Public awareness of climate impacts

Some articles explore the level of public awareness of the association between meat consumption and climate change. Kause et al. (2019) and Polleau and Biermann (2021) presented respondents with various dietary and food production scenarios and asked them to identify which entailed the highest carbon footprint. They found participants struggled to identify the most emission intensive scenarios or to estimate the associated emissions, a finding supported by Macdiarmid, Douglas and Campbell (2016). O'Keefe et al. (2016) explored consumer responses to altering food practices to mitigate climate change. Changes that are consistent with existing food competencies were viewed more positively, for instance a marginal decrease in meat consumption would not require learning multiple meat-free recipes. Some individuals feel a sense of obligation to reduce their carbon footprint but perceive altering non-food related behaviours as a greater priority for mitigation (de Boer, de Witt and Aiking, 2016; Stubbs, Scott and Duarte, 2018).

Healthy diets

There is a large body of literature focusing on the strong association between a sustainable diet and a healthy diet (Springmann et al., 2016; Quam et al., 2017). For example, Scheelbeek et al. (2020) found that eating in accordance with the UK government 'Eatwell Guide'[11] would result in improved cardiovascular health, reduced cancer risk and a 30% reduction in GHG emissions. However, adherence with these recommendations is currently low among the UK population. Macdiarmid et al. (2012) and Aston, Smith and Powles (2012) found similar health and climate benefits from adopting a flexitarian diet which would reduce emissions by 0.45 tonnes CO_2-eq. person^{-1} year^{-1}. Clark et al. (2020) present a range of policy interventions for encouraging healthy diets, including making the economic case of reducing national health care costs and curtailing fiscal support for

[11] UK government, 2022: "The Eatwell Guide is a policy tool used to define government recommendations on eating healthily and achieving a balanced diet." See: [The Eatwell Guide - GOV.UK (www.gov.uk)]

resource-intensive food production. Another strategy is the use of smartphone apps, which have been effectively used to nudge users towards healthy dietary behaviours (Lowe, Fraser and Souza-Monteiro, 2015; Gilliland et al., 2015). Aleksandrowicz et al. (2016) observe that healthy foods are often more expensive than unhealthy foods and so policies must ensure any dietary shift is both affordable and culturally appropriate.

Seasonal diet

Eating a more seasonal diet is another proposal for reducing the environmental impact of food. Macdiarmid (2014, p.372) observes that "seasonality can be defined as either globally seasonal (i.e. produced in the natural production season but consumed anywhere in the world) or locally seasonal (i.e. produced in the natural production season and consumed within the same climatic zone)." Global seasonality provides a more varied supply of fresh produce year round, but there are associated environmental costs in the country of production. Eating locally seasonal food may avert these impacts but does not necessarily reduce GHG emissions.

Hospido et al. (2009) explored different scenarios for UK lettuce consumption and found UK field-grown has the lowest emission impact during the summer. In the winter, however, lettuce is typically grown in heated greenhouses in the UK and so field-grown lettuce transported by road from Spain has a lower emission intensity. Röös and Karlsson (2013) discovered seasonal production of field-grown carrots and tomatoes reduced emissions by 60%, but the consumption pattern was highly restrictive as they are only available for three months during the Swedish summer, a finding supported by Martin and Brandão (2017). Michalsky and Hooda (2015) present three scenarios for domestic production vs imported fruit and vegetables in the UK. The least dramatic change (a 25% reduction in non-European imports and increasing domestic production by the same amount) could save 28.9 kt CO_2-eq. year^{-1}, while the 50% and the 75% reduction scenarios could result in savings of 57.8 kt and 86.7 kt respectively. Hoehn et al. (2021) considered the relative impact of four scenarios to achieve a 25% GHG emission reduction by 2040. They found 78.5% of the emission reduction target could be achieved by switching to a more plant-based diet, although choosing a more seasonal diet (14.9%) and eating more locally produced food (6.3%) were also found to reduce emissions. The general consensus is that seasonality has a role in reducing food emissions but should be considered together with modes of production and transportation to identify the optimal option at a given time (Garnett et al., 2016).

2.2.2 Food waste

The second way consumers can reduce their food carbon footprint is by avoiding waste. This section reviews the literature on the causes of household food waste, the associated GHG emissions, and the main approaches to avoiding it.

Quantifying food waste and the associated emissions

Up to one third of food is spoiled or squandered before it is consumed by people and this represents considerable GHG emissions (FAO, 2011). In the UK, households generate 71% of the post-farm gate waste (excluding inedible parts), compared to 13% in the hospitality sector, 12% in food processing and 4% in retail (WRAP, 2021). UK household food waste amounts to 7,050,000 tonnes annually (of which 1,157,000 tonnes is composted) and a further 3,140,000 tonnes of waste occurs in the supply chain, post-farm gate (WRAP, 2018).

A number of studies estimate the GHG emissions associated with food waste. Salemdeeb et al. (2017) find that UK food waste prevention could lead to reductions in the order of 706-896 kg CO_2-eq. $tonne^{-1}$ of food waste, with 78% of the savings resulting from avoided food production overseas. Martinez-Sanchez et al. (2016) estimate even greater avoidable emissions of 1200 kg CO_2-eq. $tonne^{-1}$ of food waste. Corrado et al. (2019) calculated the emissions for food production, cooking and household waste and found the latter to account for 11-13% of the total emissions. Some emissions could be avoided through waste management processes such as anaerobic digestion or incineration with energy recovery (Eriksson, Strid and Hansson, 2015). However, WRAP (2021) suggest efforts to avoid waste should focus on prevention rather waste management, as indicated in their food and drink material hierarchy (see Figure 5). The emission savings from avoided food production (by not wasting food in the first instance) are greater than the emission savings attributed to energy recovery.

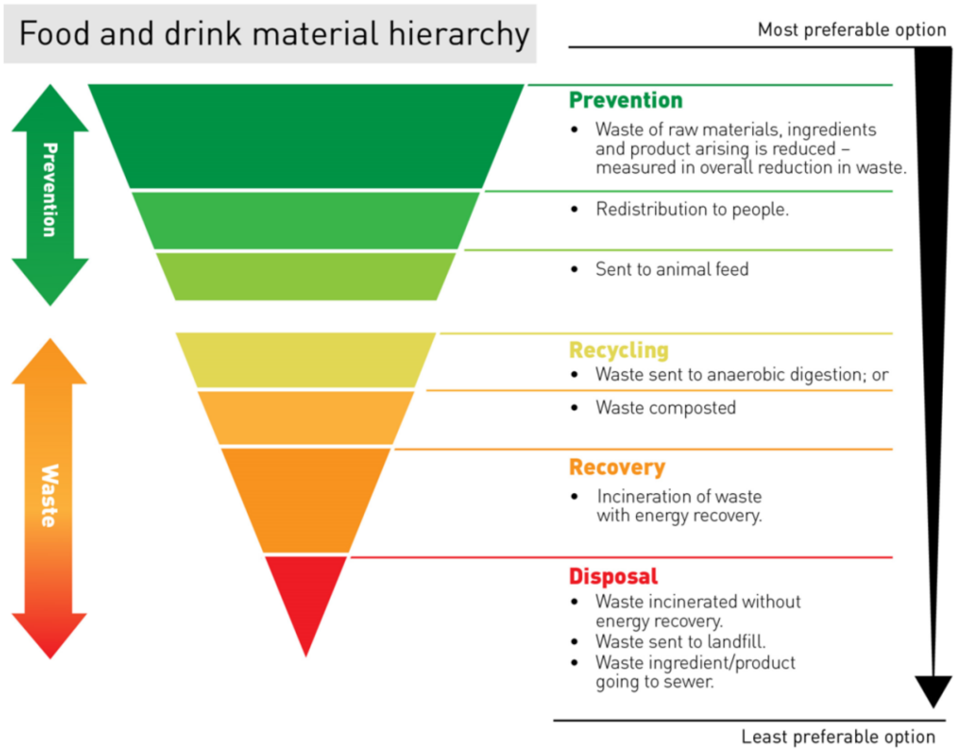

Figure 5, Food and drink material hierarchy (WRAP, 2021)

Causes of household food waste

The scale of household waste is perhaps surprising considering people tend to feel a sense of guilt about wasting food. This paradox has led to a number of scholars exploring the context and reasons for domestic food waste and they identify several contributing factors (Aschemann-Witzel et al., 2017; Schanes, Dobernig and Gozet, 2018). Some relate to skills, for instance a misunderstanding of food expiration labels or over-estimating the quantity of food required for a meal. Others relate to social norms such as offering an abundance of food to dinner guests or buying healthy food with good intentions but ultimately reverting to family favourite meals. A third cause of waste relates to the perception of perishable food in the 'in-use phase' (when the container has been opened but not yet consumed), during which the food gradually devalues until it is discarded as a safety precaution (Evans, 2014; Devaney and Davies, 2017). A fourth factor is a possible lack of communication between household members regarding shopping and meal planning, leading to over-provisioning. There are also demographic associations, for example families, younger people, single occupancy households and those on higher incomes waste relatively more (Evans, 2014; Farr-Wharton et al., 2014; Aschemann-Witzel, 2016). These studies highlight that people's attitudes towards food or the environment are generally not the cause of waste. Some scholars suggest food waste is the result of multiple, interacting household or lifestyle activities and this leads to separation between the activity and its consequences. For example, people tend to buy the same things when grocery shopping, having not eaten the identical items bought in previous shopping trip. Disruptions to weekly routines such as eating out for a social engagement or a spontaneous decision to buy a takeaway can also result in waste (Quested et al., 2013; Evans, 2014).

Waste reduction interventions

Policy interventions typically focus on waste reduction or surplus redistribution in supply chains, rather than changing consumer behaviour. Awareness raising is the main strategy for addressing household food waste and campaigns have been successful up to a point, although wasteful practices persist (WRAP, 2014 & 2021; Priefer, Jörissen and Bräutigam, 2019). Levies imposed on household waste, known as 'pay as you throw', have proved effectual in some countries (ibid; Schanes, Dobernig and Gozet, 2018). Hebrok and Boks (2017) and Reynolds et al. (2019) conducted systematic literature reviews of waste avoidance strategies. Cooking classes, smart fridges, colour coded storage containers and food sharing apps were all reported as being effective, although the authors raise concerns regarding the quality/absence of empirical evidence to support these interventions.

2.2.3 Sourcing food with less embodied emissions

The third way consumers can reduce their food carbon footprint is by buying food which has less embodied emissions. LCA is commonly used to determine the environmental impacts associated with all stages of a product's manufacture, use and disposal. It is frequently applied to the agriculture and food sectors to assess the carbon intensity (and other impacts) of farming practices, transportation, storage and waste in food supply chains (Bala et al., 2010; Arzoumanidis et al., 2017). It is also applied to consumer behaviour to measure the emissions associated with dietary choice, cooking practices and household waste (Garnett, 2014; Hoolohan et al., 2016). Consumers' motivations for choosing supply chains which may be less emission intensive are discussed in section 2.3.

The term 'food miles' became synonymous with the environmental impact of food in the late 2000s. However, many scholars are sceptical of the validity of buying local as a way of reducing the climate impact of food, for two main reasons. First, different modes of transportation have different carbon intensities and so 'distance travelled' is an insufficient metric without considering how the food is transported. Second, the emissions associated with transportation are usually outweighed by those involved in production (Pretty et al., 2005; Edwards-Jones et al., 2008; Coley, Howard and Winter, 2009). In terms of transportation, air freighted foods have a particularly high carbon footprint (Jungbluth, Keller and König, 2015; Michalsky and Hooda, 2015). The 'last mile' emissions associated with using private vehicles to drive to the supermarket are also considerable (Siikavirta et al., 2003; Edwards, McKinnon and Cullinane, 2009). Regarding food production, several studies highlight the emission intensity of heated greenhouses, a common practice across Northern Europe (Ntinas et al., 2017; Theurl et al., 2017). Organic farming is often less carbon intensive than conventional farming practices, largely because of the energy required to manufacture synthetic fertilisers (de Backer et al., 2009). Pérez-Neira and Grollmus-Venegas (2018) found organic farming consumed 43% less non-renewable energy per kg of fresh vegetables than conventional farming and direct distribution reduces emissions between 64%-91%. Primary production waste is another significant contributor to food system emissions (Porter et al., 2018; WRAP, 2019). Further down the supply chain, refrigeration is responsible for nearly half of the energy consumption by the retail and supermarket sector. Cold chain activities now account for around 5% of global food-system emissions (Garnett, 2007; Crippa et al, 2021).

The LCA literature on food and agriculture is vast and the articles mentioned above are but a selection. Despite the growing understanding of the various emission hot spots in food supply chains, there has been minimal progress on mitigating overall food system emissions (Tubiello et al., 2021a; Crippa et al., 2021).

Summary

<u>What we know</u>

Consumers can significantly reduce their food emissions through various reduction and improvement actions. Changing consumers' attitudes through awareness raising has proved only partially successful and the challenges of shifting away from emission intensive diets or reducing household food waste persist.

<u>What we do not know</u>

There is a small but growing literature which focuses on changing embedded food behaviours or the context in which they occur as an alternative way of achieving more sustainable food consumption patterns. However, this remains an under-explored approach.

2.3 Values, pro-environmental behaviour and food choices

DoI considers the role of social norms in the adoption decision, but personal values do not feature in the framework. Environmental and societal values form part of online food hubs' value proposition to their customers (discussed in section 2.5). It was anticipated that, for some food hub users, these values may constitute an important element in their adoption decision. This section briefly reviews the literature on values and food attributes.

2.3.1 Values, identity and ethical consumption

Values are considered antecedents of environmental attitudes which can be a strong determinant of behaviours (Schwartz, 1992; Bardi and Schwartz, 2001). Pro-environmental actions can be motivated by an individual's personal norms - an internalised sense of obligation to act in a certain way that is consistent with their values (Stern et al., 1999; van der Werff, Steg and Keizer, 2013). People who perceive themselves as environmentally and socially aware display a strong preference for products supplied by companies with similar values and responsible business practices (Pícha and Navratil, 2019). However, people simultaneously manage multiple identities with respect to their own consumption and do not always act on biospheric values if they are not supported or activated by the context (Gatersleben, Murtagh and Abrahamse, 2014; Steg, 2016). The perception of having insufficient time, money or power can moderate pro-environmental choices (Ertz, Karakas and Sarigöllü, 2016). Green product attributes can be important in influencing consumer choice but are secondary to egoistic product attributes (Schuitema and de Groot, 2015).

2.3.2 Food product attributes

Alongside established attributes such as price, quality or convenience, some consumers display a preference for particular farming practices such as 'organic'. Hughner et al. (2007) conducted a systematic review and identified health as the most important motive for buying organic, driven by desire to avoid the chemicals used in conventional farming. Environmental concern and a perception that organic food tastes better were also important reasons, whereas high price is the primary deterrent. Some scholars find subjective norms to be a more powerful predictor of organic purchasing than attitudes or cost. Consumers who strongly identify with environmental causes are more likely to perceive symbolic benefits (Seyfang, 2008; de Maya, López-López and Munuera, 2011; Qasim et al., 2019). Marketing of organic products should therefore focus on creating brand identity that is consistent with consumers' ethical values and self-image (Persaud and Schillo, 2016). Grunert (1993 & 2006) suggests consumers are increasingly interested in the 'story' associated with food and argues that an individual's values, the mode of shopping or the anticipated consumption situation can all affect how a product is perceived.

'Local' is another commonly sought product attribute, although there is no accredited label or accepted definition (Vargas et al., 2021; Jia, 2021). Bentsen and Pedersen (2020) conducted a systematic review and identified three interpretations: 'local' as a food production characteristic, often regarded as synonymous with 'organic'; 'local' as a food ideology or identity, where it is associated with social movements such as 'food sovereignty' or 'slow food'; and 'local' as a food practice which supports alternative food networks and provides attributes such as traceability and quality. Adams and Salois (2010) suggest that consumer demand for local food arose primarily in response to corporate co-option of the organic food market, which undermined many of the values originally associated with 'organic' such as sustainable farming practices and supporting small scale producers. Similarly, Seyfang (2006) argues that 'local' is often vested with meanings that transcend food and is interpreted by consumers as a form of 'ecological citizenship' through which they can create resilient communities, support the local economy, and dissociate from mainstream retailers. Pearson et al. (2011) found consumers are motivated by freshness, taste, provenance and the availability of niche products. Several scholars observe that consumers are willing to pay more for foods identified as locally produced (Thilmany, Bond and Bond, 2008; Hu et al., 2012; Feldmann and Hamm, 2015).

Some studies investigate whether sociodemographic characteristics are associated with food consumption choices. Education is a strong predictor of sustainable product selection, age is negatively correlated with environmental concern, and men have lower pro-environmental attitudes than women (Panzone et al., 2016; Pearson et al., 2013). However, other studies observe a lack of homogeneity in attitudes or demographic traits and so reject the archetype of the affluent ethical consumer (Seyfang, 2008; Thom and Conradie, 2013).

Summary

What we know

Values and self-identity are important in motivating pro-environmental behaviours and have a strong association with the intention to buy organic or locally produced food. However, context and personal circumstances can moderate pro-environmental choices.

What we do not know

The extent to which using an online food hub affirms consistency with personal values is unknown. There is only limited research on the moderating influence of an individual's circumstances on their use of food hubs.

2.4 Food preferences, habits and interventions

Understanding existing food preferences and habits is an important antecedent to identifying how food behaviours may be changed. This section considers four aspects: shopping preferences, routinised food behaviours and potential interventions, food apps, and the impacts of the pandemic on consumer food behaviour.

2.4.1 Grocery shopping preferences

Consumers look for various product attributes when grocery shopping, with the most important being price, quality, taste, use by date, health, range and special offers (Huddleston et al., 2009; DEFRA, 2015). Consumers typically use 'fast and frugal' heuristics when choosing items and make decisions based on one or two attributes, often trading-off between price and health. Two thirds of customers select the item they are looking for without making any brand comparison (Kalnikaite, Bird and Rogers, 2013; Machín et al., 2020). Minimising time spent in store is important to customers and so a confusing lay-out, long checkout queues or too many options for similar products can deter people (Schwartz, 2004; Paul and Hogan, 2015; Herbert, Robert and Saucède, 2018). Collectively, these articles characterise food shopping as a habitual, functional activity which should entail minimal investment of time and effort.

Consumers are increasingly avoiding the retail environment altogether and switching to online grocery shopping (Food Standards Agency, 2019). Jiang, Yang and Jun (2012) suggest convenience is one of the principal motivations and identify five distinct aspects, including the ability to shop at any time of the day or to locate particular items more swiftly than in-store. de Kervenoael, Elms and Hallsworth (2014) found shopping online is carried out in a disjointed manner alongside various domestic tasks and social activities. It is viewed as a means of reorganising time rather than saving it, but it facilitates lifestyle choices. Guillen-Royo (2019) states some people reduce impulse purchases when shopping online and so avoid over-provisioning. Online grocery shopping is not for everyone and some consumers prefer shopping in-store to select the products they want, to take advantage of special offers, or because it presents an opportunity for social interaction (Bagga and Bhatt, 2013; Yeo, Goh and Rezaei, 2017).

2.4.2 The challenge of habitual food behaviours

A number of scholars describe food behaviours as highly routinised and this presents a challenge to altering diets or food shopping habits. This section reviews the literature on habitual food behaviours and interventions which can disrupt food habits.

Routinised food behaviours

Dyen et al. (2018) understand food behaviours as a 'tangle of practices' which are interrelated, ritualised and embedded in daily routines. They differentiate between routines comprising of systematic practices, where activities such as cooking or shopping are optimised due to time pressures or life commitments, and routines consisting of occasional practices, where food preparation and eating form the context for social interaction. In a similar vein, Riet et al. (2011) assert that food habits are triggered by situational cues and are powerful predictors of eating behaviour, in contrast with intentions which are relatively poor predictors. Interventions which apply habit-formation principles are therefore more likely to establish desired eating patterns. Nash, Whittle and Whitmarsh (2020) explore how habitual food behaviours are disrupted by an important or sudden change in life circumstances or context, described as a 'moment of change'. These moments can be endogenous life-course events (e.g. having a child, retiring) or exogenous to the individual (e.g. environmental hazards, political upheaval). Moments of change present an opportunity for the adoption of more sustainable food practices, although interventions should be orientated to specific groups based on culture, gender, income or age. Relating to this last point, Burton et al. (2017) consider the role of key decision-makers, termed 'household food gatekeepers'. These individuals are responsible for most food-related tasks in the home and so can influence the attitudes, behaviours and nutritional knowledge of family members. Gatekeepers with high food literacy are more likely to engage in healthy food practices.

Interventions which alter food behaviours

A small number of studies investigate interventions which alter or disrupt existing food behaviours and evaluate the effect on people's attitudes, intentions and food habits. Huyard (2020) explored the impacts of a veg box subscription combined with a structured training course on food preparation and cooking. The aim was to assess whether enhancing food literacy and skills would contribute to a healthier and more environmentally sustainable diet in the long term. The participants reported eating more fresh vegetables, wasting less food, planning meals and grocery shopping to complement the veg box contents, and experiencing less decision fatigue in choosing what food to buy. Verame et al. (2018) considered veg box customers' experience of 'agency delegation' (having minimal control over what produce arrives). The customers justified this delegation for various reasons such as better tasting food and good value for money, although they prefer to retain a degree of agency by 'blacklisting' items they dislike. A healthy diet was 'enforced' by the regular delivery of fresh produce, a finding that is consistent with a separate study by AbuSabha (2016). O'Neill et al. (2022) found users of online food hubs ascribe greater value to the food sourced through the hub because of its local or environmental attributes. Consequently, hub users invested extra effort to avoid waste by engaging in creative cooking and preservation practices to transform and store unfamiliar vegetables. Using the hub requires flexibility in meal choice and regular auditing of food stocks which ultimately become part of the household routine. Finally, Devaney and Davies (2017) conducted a 'HomeLab' study where five households were provided with training and socio-technological interventions designed to support sustainable food behaviours. These interventions enabled participants to question and reconfigure their food acquisition, storage, preparation and waste practices. They reduced their overall food waste by 28% and expressed a commitment to eat vegetarian meals more frequently. Despite these successes, the authors highlight the resource intensity, cost and time of deploying change agents to alter people's food practices.

2.4.3 Digital consumer innovations

Some of the interventions described above are digitally mediated and this represents another form of intervention which can alter food behaviours. Four review articles explore the function of food apps and platforms[12]. Svenfelt and Zapico (2016) identify four main applications: monitoring environmental impact; enhancing supply chain transparency; creating networks between food system actors; and encouraging sustainable food practices. Bruaer et al. (2016) suggest five functions which characterise 22 food apps: collaborate (donate food), educate (sustainable shopping behaviour); gamify (food chain learning game); inform (carbon calculators); and transform (connecting farmers to markets). Samoggia, Monticone and Bertazzol (2021) found 42% of studies focus on digital innovations which enable direct marketing, compared to creating consumer networks (32%), offering health advice (30%) and providing food information (23%). Vogels et al. (2018) compiled an inventory of household food management and waste apps and explored consumer perspectives of their functionality.

A further two articles focus more explicitly on studies which quantitatively measure how using apps impacts food behaviours. Wilson et al. (2020) appraised six food apps that challenge emission-intensive mainstream consumption practices[13]. Synthesising findings from 15 studies, they calculated the percentage change in activity, energy use or carbon emissions which arise from the adoption of the innovation and found clear evidence of potential emission-reduction benefits. Hedin et al. (2019) discovered only 15 peer-reviewed articles that present empirical results of altered food behaviours. They emphasise a pressing need for studies that measure actual changes in behaviour, rather than just raising awareness, as a result of using a digital tool. In particular, they identify a need for research on aspects other than food waste, such as the type of food consumed - more climate friendly, more ecological, more plant-based, locally produced - and the climate implications of digitally mediated changes in consumption behaviour. This is the research gap where this PhD study is situated and seeks to make a contribution.

2.4.4 Impacts of the pandemic on food behaviours

The Covid-19 pandemic is an ongoing global societal disruption that triggered strict government regulation of how people live and work, most notably the 'stay at home' directive and the temporary closure of major economic sectors such as hospitality and leisure. This sudden social upheaval provided an intriguing research topic and consequently there was a proliferation of articles about the effects of national lockdowns on household food behaviours and shopping habits.

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[12] The literature on food apps is reviewed in more detail in Appendix 1.2

[13] Elements of this literature review section (2.4.3 & Appendix 1.2) were published in the article below. I am a co-author but did not lead on any of the writing and so there is no duplication of text between my PhD thesis and this article. See: Wilson, C., Kerr, L., Sprei, F., Vrain, E. and Wilson, M., 2020. Potential Climate Benefits of Digital Consumer Innovations. *Annual Review of Environment and Resources,* 45, 113-144. DOI: https://doi.org/10.1146/annurev-environ-012320-082424

Household food behaviours

There are three main themes relating to household food behaviours. Concerning diet, a number of studies identified stronger intentions to eat more healthily, but calorific intake increased and nutritional quality decreased during the first lockdown as people resorted to snacks, alcohol and processed meat as a mood alleviation response (Robinson et al., 2021; Marty et al., 2021). Other studies revealed a mixed picture, with younger people eating healthier but those with a high body mass index eating less healthily (Laguna et al., 2020; Poelman et al., 2021). Another reported behaviour change was a greater emphasis on managing domestic stock levels and avoiding food waste through meal planning, writing shopping lists and ensuring leftovers were eaten (Principato et al., 2020; Günday et al., 2020). The third change is that people were spending more time preparing meals and baking (Marty et al., 2021; Fanelli, 2021).

Shopping habits

In terms of shopping habits, 'panic buying' hit the news headlines[14], but researchers found the situation was more nuanced with households employing a multi-faceted resilience strategy. This included modest extra procurement, trying alternative retailers and buying for neighbours who were shielding (Cavallo, Sacchi and Carfora, 2020; Benker, 2021). People shopped less frequently, although overall grocery expenditure increased because they were no longer eating out (Principato et al., 2020; Poelman et al., 2021). There was a rise in sales of storable foods and also products with perceived health benefits (Laguna et al., 2020; Cavallo, Sacchi and Carfora, 2020). Some people began buying cheaper brands or switching to budget retailers as price sensitivity became more pronounced (Günday et al., 2020; Ellison et al., 2021). There was also a marked shift towards using small local stores to reduce the risk of infection, but also because neighbourhood shops were perceived as offering a stronger social connection with their customers. Moreover, these stores supported vulnerable people in the community by guaranteeing deliveries (Cavallo, Sacchi and Carfora, 2020; Benker, 2021).

Another change was a rapid upscaling of online grocery shopping (Dannenberg et al., 2020; Alaimo, Fiore and Galati, 2020). This was most notable among the older demographic, many of whom had never previously used digital platforms to order food (Cavallo, Sacchi and Carfora, 2020). There was a structural expansion of home delivery specialists such as recipe boxes and online food hubs (Butu et al., 2020; Dannenberg et al., 2020; Günday et al., 2020). A survey of 101 veg box providers in the UK found demand had doubled during the first lockdown. As with local stores, these providers were seen to take a proactive role in their local communities by prioritising key workers or the vulnerable (Wheeler et al., 2020).

Permanency of the behavioural changes?

It is clear the pandemic has shaken up previously resistant food behaviours, particularly for grocery shopping, but what is less certain is the permanency of these changes. The majority of the articles

[14] BBC, 2020. Coronavirus: Supermarkets ask shoppers to be 'considerate' and stop stockpiling - BBC News

focus on the onset of the pandemic in the spring of 2020 and so describe the situation during the first lockdown in Europe. Given the ongoing and changeable pandemic situation, the relevancy of these findings to describe contemporary conditions may be short-lived. Only three articles consider the potential lasting impacts of the pandemic, one of which predicts a gradual return to bricks and mortar stores (Dannenberg et al., 2020). The other two expect a steady but slower migration to online shopping and an increased interest in ethical product attributes (Günday et al., 2020; Cavallo, Sacchi and Carfora, 2020).

Summary

What we know

Shopping and cooking decisions are determined by food attributes such as taste and quality but are also shaped by broader factors such as social context, values and convenience. Many food behaviours are highly routinised and are therefore difficult to change.

What we do not know

An intervention such as a regular food delivery from an alternative supplier can influence people's attitudes towards food, disrupt embedded habits and encourage more sustainable behaviours. Only a few studies have explored this approach and so there is space for more research in this area.

2.5 Online food hubs

This section reviews the literature about online food hubs and, where relevant, draws upon the wider literature on alternative food networks. A number of themes were identified: the value proposition, challenging mainstream food retailers, considerations relating to scaling up, and the impact of using a hub on household food behaviours.

2.5.1 The value proposition of online food hubs

There are many definitions of the term 'food hub'. Berti and Mulligan (2016) reviewed the extant literature and grouped these definitions into two broad conceptualisations according to their function and value proposition for different actors in the food system.

Benefits for producers

Although this PhD study focuses on consumers as early adopters of online food hubs, the producers who participate are also early adopters. This is reflected in the first conceptualisation, "values-based agri-food supply chain", where food hubs are understood as innovative business models which enable small scale producers to coordinate their activities and aggregate supply to meet growing demand for locally produced food. For example:

> "A regional food hub is a business or organisation that actively manages the aggregation, distribution, and marketing of source-identified food products primarily from local and regional producers to strengthen their ability to satisfy wholesale, retail, and institutional demand.'' (Barham et al., 2012, p.4)

Food hubs seek to maximise producer profits through product differentiation based on provenance, sustainability and quality. The profit mark-up is significant; producers supplying *FarmDrop* receive 80 percent of the price the consumer pays[15], rather than the 40 to 50 percent they would receive through conventional supply chains (Carolan, 2017). Other benefits include greater autonomy in running their business, creating rural employment and more recognition as responsible land stewards (Matson and Thayer, 2013; Milestad, Kummer and Hirner, 2017). Although the quote above mentions distributors and institutional buyers, food hubs are increasingly selling direct to consumers (Kurnia et al., 2015a).

The advent of digital platforms further reduces barriers by facilitating financial transactions, streamlining delivery logistics, and providing real-time information regarding demand which is important for perishable products (Berti and Mulligan, 2016; Della Gala and Reed, 2017). Moreover, they enable food hubs to reach new customers, support knowledge exchange among producers, and share in the platform brand value (Kurnia et al., 2015a & 2017). *Open Food Network UK* define their platform as:

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[15] Producers for *Tamar Valley Food Hubs* receive 85 pence per pound, which is comparable with Carolan's findings. See: [Producers | Tamar Valley Food Hubs]

> "A community and software backbone for food systems across the UK working for food sovereignty. Our network of community-driven food enterprises put people and planet first. We build the software, tools and peer learning community so they can focus on building food systems that work." (2021, p.2)

Their value proposition is orientated towards food hub managers and producers rather than consumers, although core values of 'food sovereignty' and 'people and planet first' are articulated alongside the business operation benefits.

Benefits for the community or society

Berti and Mulligan's (2016) second conceptualisation is "sustainable food community development", where food hubs are perceived as community-based organisations with primarily social goals:

> "Networks and intersections of grassroots, community-based organisations and individuals that work together to build increasingly socially just, economically robust and ecologically sound food systems that connect farmers with consumers as directly as possible. Social justice dimensions include participatory, accessible, inclusive, culturally appropriate and health-based considerations. Economically robust means the food system keeps as much money as possible in local economies, provides a living to farmers and food that is economically accessible. Ecologically resilient implies regeneration and transformation." (Blay-Palmer et al., 2013, p.524)

In this definition, facilitating alternative supply chains and supporting farmer livelihoods are stated goals, but are less prominent. Social and environmental objectives are included, along with reference to the grassroots collaboration and a broader assemblage of community food actors striving to achieve those goals. Based on the literature and the information listed on food hub platforms, Figure 6 shows a wide range of benefits which food hubs are purported to provide (Kurnia et al., 2015b & 2017; Corsi et al., 2018). Interestingly, some authors note that food hubs may align themselves with different objectives at different times and so their activities and orientations can shift (Matson and Thayer, 2013; Levkoe et al., 2018).

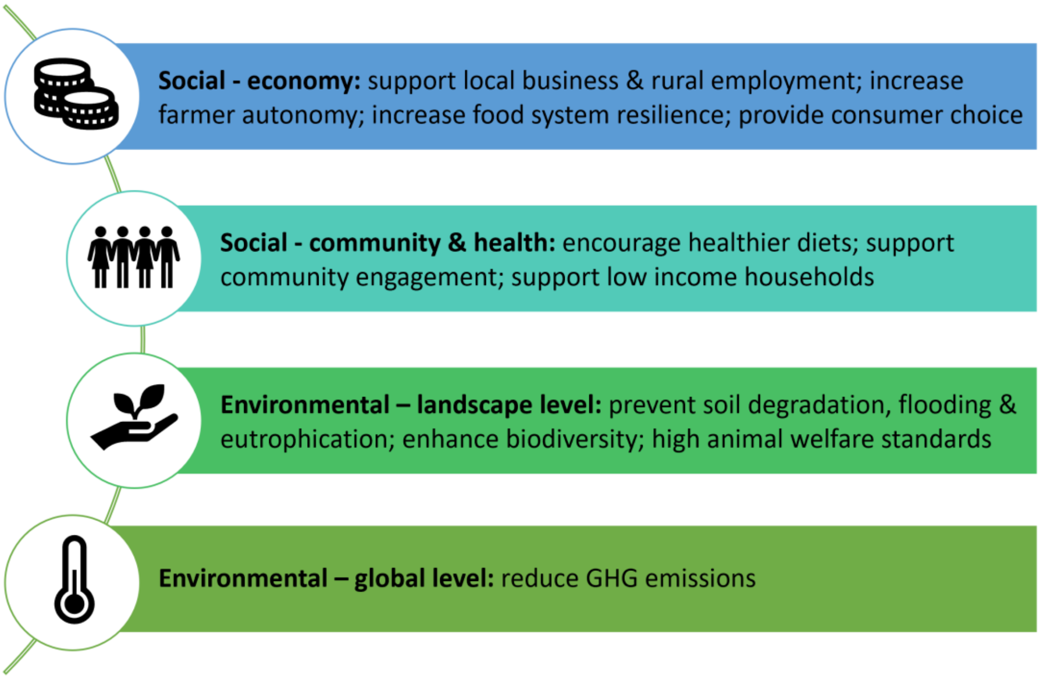


Figure 6, Potential societal benefits of online food hubs

One challenge faced by online food hubs is providing food which is affordable for lower income groups, while ensuring a fair price for small scale local producers (Franklin, Newton, and McEntee, 2011; Kurnia et al., 2015b). There is a tension between the hubs' stated food democracy values and the reality of operating within the existing system of neoliberal market economics (Berti and Mulligan, 2016). Some hubs have engaged with local charities to address food poverty, although this requires adapting their business model and a different set of competencies (Psarikidou et al., 2018 & 2019). It is therefore important to recognise their limitations to overcoming systemic social concerns (Prost et al., 2018; Levkoe et al., 2018).

Benefits for consumers

What is notably missing from the two conceptualisations is private benefits for consumers. Although societal or environmental attributes form part of the value proposition for consumers, they will likely be motivated by expectations of product attributes as well as altruistic reasons. The literature is sparse on food hub product attributes but studies about veg boxes reveal taste, freshness, quality, healthy food and organic production are important to consumers. High cost and a desire to eat out of season food are the main barriers to adoption (Brown, Dury and Holdsworth, 2009; Thom and Conradie, 2013; Kummer and Milestad, 2020). A few articles consider the shopping experience. Kurnia et al. (2015a & 2017) suggest *Open Food Network*'s interface, order customisation and checkout process will be familiar to people accustomed to e-commerce platforms. Joosse and Hracs (2015) observe that time-constrained consumers can feel overwhelmed with the array of product attributes to consider such as fair trade, local, organic and ethically produced. Food hubs and other food apps enable digitally mediated 'curation', where the curators evaluate, sort and ascribe value to specific products. Thus, consumers are presented with a more limited selection which satisfies their social, environmental, or taste criteria.

Consumer-producer relations

Another key aspect is the closer relationship between producers and consumers that direct marketing creates and which differentiates local food enterprises from the conventional food system (Matson and Thayer, 2013). Albrecht and Smithers (2018) found this 'reconnection' fosters mutual trust which enables producers to disengage from mainstream supply chains, although establishing a more ecologically and socially resilient food system was secondary to attaining business autonomy and greater profit margins. Similarly, consumers were not strongly motivated by food system change and cited access to healthy, good quality food as their main reason for participation. In contrast, Randelli (2015) explores how some individuals form buying groups because mainstream retailers do not fulfil their needs with respect to the local economy or environmental standards. However, participation requires changes to purchasing routines and this may not fit with the lifestyles of many consumers. Ulsperger and Ulsperger (2017) found the bonds between consumers and producers using online platforms are not as strong as those formed at physical farmers' markets. Without face to face interaction, the authors question whether online food hubs are able to strengthen communities to the same extent as farmers' markets. Della Gala and Reed (2017) found online communication enabled frequent knowledge sharing between producers and consumers and resulted in some farmers feeling less socially isolated.

2.5.2 Changing food system structures and policies

Some scholars consider the potential of online food hubs and other short supply chain enterprises to transform the mainstream food system or to initiate policy reform. McFarland and Wittmayer (2015) suggest *The Food Assembly* empowers producers, by providing business autonomy, and also consumers because they can intentionally support alternative food networks and products. Although both groups use fairness, social justice and environmental responsibility to question the legitimacy of supermarket dominance, the agricultural, trade and public health policies which are orientated towards the incumbents remain unchallenged and this limits the platform's transformative potential. Similarly, Ankeny (2018) argues that ethical consumerism or 'voting with your fork' only serves to reinforce neoliberal tendencies by transferring responsibilities to individuals as consumers and so overlooks the structural inequalities and unsustainable consumption practices that are perpetuated by the conventional food system. Nicol (2020 & 2021) offers proposals for changing the policy and planning frameworks to scale up agroecological production. She highlights access to secure affordable land, investing in farming livelihood skills and divesting support from unsustainable food systems as necessary measures. Some scholars suggest that *Open Food Network* has transformative power because it provides open source software; the code is publicly available for anyone to use or modify to suit their needs. This 'technological sovereignty' empowers small enterprises, communities and citizens to share food values and knowledge, and participate in a democratic process of reconfiguring food system relations and networks which is entirely independent of hegemonic food or digital technology structures (Ramírez-Portilla, Cagno and Zanatta-Alarcon, 2015; Berti and Mulligan, 2016; Lynch, 2020).

2.5.3 The scaling up predicament

A number of scholars observe that as online food hubs become more established and their customer numbers increase, they are confronted with the decision of whether or not to scale up their operation. Scaling up will likely provide greater profits, support the livelihoods of a larger number of local producers, and have greater impact in realising the purported environmental benefits. However, it requires more organisational capacity and coordination, more attention to ensure consistency of product quality from multiple producers, and potentially sourcing from larger farming enterprises and longer supply chains (Matson, Sullins and Cook, 2013; Kurnia et al., 2015a; Berti and Mulligan, 2016). Some producers will prioritise greater profits, whereas others may believe that lowering entry barriers for small scale farmers is more important than ‘getting big’ (Carolan, 2017). Horizontal collaboration with other nearby food hubs or cooperatives is another option for managing supply, but this introduces uncertainty as to whether all the partners share similar values and production methods (Beckie, Kennedy and Wittman, 2012; Clark and Inwood, 2015).

A further challenge is meeting the manifold expectations of hub users. Local food systems are often expected to provide ‘hybrid benefits’ by offering the price, variety and convenience that consumers associate with mainstream retailers, while maintaining their alternative identity (Mount, 2012). Scaling up or sourcing imported produce may satisfy consumer demand for greater choice but it can blur the distinction between the direct marketing model and conventional supply chains (Kummer and Milestad, 2020). Moreover, it may be perceived as negating core values which are intrinsic to food hubs’ identity such as ensuring traceability and reducing food miles, and this risks undermining legitimacy in the eyes of customers for whom these values carry symbolic meaning (Nost, 2014; Carolan, 2017; Milestad, Kummer and Hirner, 2017). This raises the thorny question - is scaling up even desirable? If food hubs do choose to scale up, the process should be accompanied by an open dialogue with their customers about the decisions taken (Clark and Inwood, 2015).

2.5.4 Impacts of using online food hubs on household food behaviours

Only three articles were discovered which discuss how using online food hubs may influence household food behaviours. Richards and Hamilton (2018) found the use of the *Imperfect Produce* platform in the US resulted in 201836 transactions of ugly/surplus fresh produce diverted from the waste stream over a 60 week period. O’Neill et al. (2022) also identified avoided waste from using *The Food Assembly*, although they do not provide quantifications. De Bernardi, Bertello and Venuti (2019) explored the effect of knowledge sharing on food behaviours, comparing two forms of interaction: using online platforms vs face to face conversations at farmers’ markets. They found online knowledge sharing encourages sustainable purchasing and consumption behaviours, whereas face to face interaction affects purchasing behaviours only. The study does not quantify the effects.

Summary

What we know

The existing literature provides useful insights into how online food hubs operate in the US, France and Italy, although the cultural and contextual conditions may differ from the UK. In addition to supporting local producers, many food hubs incorporate social and environmental values in response to food access or health inequities, asymmetric market relations, or harmful farming practices associated with the conventional food system. The direct marketing model and open source software are seen as mechanisms for challenging the hegemony of mainstream retailers.

What we do not know

Although some articles describe benefits for consumers, none were identified which present empirical evidence of how current or potential users perceive online food hubs or the relative importance of the attributes which characterise consumer appeal[16]. Moreover, there is a clear gap in the literature concerning how the use of food hubs may affect other behaviours relating to diet, waste and shopping preferences.

[16] Kummer and Milestad (2020) compare attributes for veg boxes and so provide a useful point of reference, but their survey was completed by box scheme providers/managers rather than consumers.

3 Methodology

This chapter presents the methodology. It explains the choice of research design and methods, the selection of respondents, and how different types of data were combined to answer the research questions.

This study focuses on the early adopters of online food hubs. By combining empirical data on the adoption and use of online food hubs with existing literature on the carbon intensity of different supply chains and household food behaviours, the study seeks to estimate the potential emission reduction of using online food hubs. The terms 'early adopter', 'food hub user' and 'hub customer' are used interchangeably in this thesis. 'Non-adopter' refers to someone who has never used an online food hub and 'former adopter' refers to someone who has stopped using an online food hub.

3.1 Research questions

Five research questions (RQ) were developed to consider the adoption and use of online food hubs, and the consequent impact on emissions:

RQ 1 - Why do people use online food hubs?

RQ 2 - In what ways does the household food context affect the use of online food hubs?

RQ 3 - In what ways do people use online food hubs?

RQ 4 - Which factors are important in scaling up the adoption of online food hubs?

RQ 5 - How does the use of online food hubs reduce GHG emissions?

3.2 Research Design

This section describes the key research design decisions - the choice of research strategy, the mixed method approach and the DoI theoretical framework.

3.2.1 Deductive research strategy

The deductive research strategy was chosen for this project. This strategy entails prior expectations or theories being imposed on a phenomenon in order to provide an explanation of that phenomenon. Hypotheses or expectations are constructed based on theory and data is then sought to accept or reject those propositions. Alternative causal factors are eliminated to increase confidence in the propositions. Collectively, a set of these corroborated hypotheses can be used to explain a social phenomenon in broader theoretical terms (Blaikie, 2000; Bryman, 2012; Burkholder et al., 2019).

The deductive strategy was chosen for two reasons. First, this project is about the adoption of a low carbon innovation and there are several well-established theoretical frameworks for understanding innovation adoption and diffusion, as discussed in the previous chapter. Considering this abundance of relevant existing theory, using an inductive approach to generate new theory would seem redundant. Of greater value is applying an established theory to a field where it has not been widely used, such as *low carbon* innovation diffusion. Second, the deductive strategy is useful for directing data collection activities towards specific research objectives. This study is concerned with the emission implications of using online food hubs if adopted at scale. Constructing and exploring consistency with expectations narrows the focus of the study on those particular aspects, whereas an inductive approach may capture less germane outcomes of using food hubs but ultimately yield less empirical data about emissions and adoption. Assertions about the emission reduction potential of online food hubs based on sparse or inadequate data would have less validity.

Twenty-one expectations were formulated from the literature review and Rogers' (2003) DoI theoretical framework. Expectations were proposed rather than hypotheses because much of the empirical data collected in this study is qualitative and so formal hypothesis testing using statistical analysis would not be appropriate. Potential causal relationships or associations are explored qualitatively and quantitively to identify whether the empirical findings are consistent with the expectations. The expectations for RQs 1 - 4 were explored using empirical or secondary data collected during this project. The expectations for RQ 5 were explored through a synthesis of LCA literature. A list of the expectations is presented in Table 2 below.

Table 2, List of expectations

RQ 1 - Why do people use online food hubs?

Ex. 1a - *Early adopters are distinctive from non-adopters in their sociodemographic characteristics and food behaviours*

Ex. 1b - *Online food hubs offer novel aspects of appeal compared to supermarkets*

Ex. 1c - *Environmental and societal attributes are important aspects of the perceived appeal of online food hubs*

Ex. 1d - *Early adopters perceive greater appeal of online food hubs than non-adopters*

RQ 2 - In what ways does the household food context affect the use of online food hubs?

Ex. 2a - *The use of online food hubs is affected by broader household food decisions and behaviours*

Ex. 2b - *The use of online food hubs encourages a reduction in household food waste*

Ex. 2c - *The use of online food hubs is affected by practical considerations*

Ex. 2d - *Values are important in the hub users' food decisions*

Ex. 2e - *The use of online food hubs encourages a shift towards lower carbon diets*

RQ 3 - In what ways do people use online food hubs?

Ex. 3a - *Using online food hubs becomes embedded within regular shopping patterns over time, but people vary in how they use the food hub*

Ex. 3b - *Increasing use of online food hubs results in decreasing use of supermarkets for food shopping*

RQ 4 - Which factors are important in scaling up the adoption of online food hubs?

Ex. 4a - *Adoption is constrained by the unavailability of online food hubs in some locales*

Ex. 4b - *Word of mouth is important in the diffusion of information about online food hubs*

Ex. 4c - *Early adopters actively discuss online food hubs in their social networks*

Ex. 4d - *Early adopters communicate with strong and weak ties about online food hubs*

Ex. 4e - *Adoption is constrained by individual circumstances and perceived barriers*

Ex. 4f - *Societal food behaviour, dietary, and ethical consumption trends support a potential scaling up of online food hubs*

Ex. 4g - *The pandemic has resulted in increased use of online food hubs*

RQ 5 - How does the use of online food hubs reduce GHG emissions?

Ex. 5a - *Food distributed through online food hubs will have less production-related GHG emissions compared to conventional supply chains*

Ex. 5b - *Food distributed through online food hubs will have less transportation-related GHG emissions compared to conventional supply chains*

Ex. 5c - *Online food hubs waste less food compared to conventional supply chains*

3.2.2 Mixed method approach to data collection

A mixed method approach was used in this project. The central premise of mixed methods is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than would be possible using either approach alone (Mason, 2006; Johnson, Onwuegbuzie and Turner, 2007; Creswell and Clark, 2017; Schoonenboom and Johnson, 2017).

Four key decisions were made regarding the project design. First, the level of interaction between the qualitative and quantitative research was interactive, rather than independent. Decisions about how different types of data would be collected and integrated were made in the design phase, rather than in the final interpretation, as indicated in the analytical framework (see section 3.7). Second, the research activities were implemented sequentially rather than concurrently. Using an explanatory sequential approach, the quantitative findings which emerged from the survey and the food hub order history were used to refine the analytical focus and determine the participant selection of the qualitative interviews. Third, the qualitative and quantitative data were given equal weight or importance in addressing the research problem and the intention was to exploit their relative strengths. Quantitative data collected from a larger and more diverse sample of respondents is more appropriate for generalising to a system or population level and so scaling up extrapolations have greater external validity. Qualitative data is more suited to investigating people's motivations and behaviours and so causal inferences about household food decisions and shopping preferences have greater internal validity. Finally, this study used existing LCA literature to calculate potential emission reductions, rather than conducting a spatially specific LCA for one online food hub. The novelty or added value is the synthesis of these prior LCA findings in the context of the adoption of a consumer food innovation.

3.2.3 Alternative theoretical frameworks

The choice of theoretical framework is important because it determines the variables of interest, what data should be collected and how it will be analysed. The decision to use DoI as the framework for this study was not straight-forward because there are many other theories that are useful for explaining the adoption, use, diffusion or rejection of new technologies. Sovacool and Hess (2017) suggest these theories can be placed into one of five general categories, depending on their main emphasis: agency, structure, relations, meaning, or norms. Agency-centred theories focus on the decision-making processes of individuals or households, whose actions can be explained by considering their motives, beliefs and intentions. This group includes *Theory of planned behaviour* (Azjen, 1991), *Values Beliefs Norms theory* (Stern et al., 1999) and *DoI* (Rogers, 2003). Structure-centred theories assume that people are influenced in their decisions by external forces beyond their control or even their comprehension, such as societal institutions, infrastructure or political environment. This group includes *Sociotechnical transitions/Multi-level Perspective* (Geels, 2004) and *Large Technical Systems* (Hughes, 1987). Relational theories try to bridge the gap between agency and structure; an individual's decisions are shaped by their values and preferences, but are also influenced by social relations, processes and context. This group includes *Social Practice Theory* (Bourdieu, 2007; Shove, Pantzar and Watson, 2012) and *Actor-Network Theory* (Callon, 1999; Latour, 2005).

Two of the above theories were considered especially relevant for this study. *Sociotechnical transitions* focuses on the 'transition pathway' of a new technology and diffusion occurs through interactions among three levels: the niche, the regime, and the landscape. These interactions imply conflict and reconfiguration, and so diffusion is by no means linear or inevitable (Geels, 2004). The theory has been used to understand household food waste behaviours (Boulet, Hoek and Raven, 2021), the adoption of agroecological farming methods (Anderson et al., 2019), and how alternative food networks become established within existing food system regimes (Belz, 2006; El Bilali, 2019). *Social Practice Theory* tries to explain why people do what they do. It focuses on the actions of people and considers how technologies, materials, competencies and meanings interrelate in repeated performances of the action. Through these performances, human action and social structure are mutually co-constructed (Shove, Pantzar and Watson, 2012). The theory has been used to understand household behaviours such as food acquisition, storage and preparation (Davies, 2014; Dyen et al., 2018), dietary change (Sahakian and Wilhite, 2013; O'Keefe et al., 2016), food waste (Evans, 2014) and growing food (Doberning, Veen and Oosterveer, 2016).

Considering the pertinent themes of the above articles, the adoption of online food hubs could be viewed through either of these two epistemological lenses and both theories would likely provide useful insights. DoI was ultimately chosen for two reasons. First, online food hubs are not common and using one entails making changes to existing shopping routines. Potential customers would therefore have to discover how to access the food hub and perceive some benefit in changing their behaviour, implying a clear element of agency in their decision. Second, because of the author's interest in climate mitigation, an understanding of the process of scaling up adoption as well as the use of the innovation were considered crucial for making inferences about GHG emissions. DoI is well suited to exploring scaling up as well as perceptions of an innovation which may motivate a behaviour change.

3.3 Questionnaire survey

A questionnaire survey is a highly structured data collection tool commonly used to measure variation in a population using a cross-sectional design. They are particularly useful for comparing individuals or groups because this variation can be systematically explored to identify association between different variables/question responses. Strong associations can be used to make causal inferences (although not attributions) about a particular phenomenon. Moreover, because data can be collected from a large number of respondents, generalisations can be made to an analogous population with greater validity (Bryman, 2012; Blair, Czaja and Blair, 2013; de Vaus and de Vaus, 2013).

A questionnaire survey was chosen for this project to identify the most appealing attributes of online food hubs and to establish if food hubs have a broader appeal by comparing early adopter and non-adopter perceptions of these attributes. Additional questions on food habits, shopping behaviour, and sociodemographic and household characteristics were included to test for potential associations of these variables with adoption. Data was collected from 701 respondents in July and August 2019, of which 595 were retained after consistency and error checks. The respondents included early adopters of online food hubs, former adopters (or discontinuers) and non-adopters. This survey is sometimes called the 'attribute survey' to avoid confusion with the UK social surveys referred to in this study (particularly in chapter 7).

3.3.1 Sampling and distribution

The survey targeted three respondent groups: early adopters of online food hubs, non-adopters who demonstrably have an interest in environmental issues, particularly in relation to food, and non-adopters who have no apparent interest in environmental issues. This stratified sample was chosen to reflect Rogers' (2003) adopter categories on the innovation diffusion curve: early adopters, early majority and late majority (see Figure 4). This sampling approach does not presume or predetermine the responses of individuals based on their sampling group. The objective was simply to capture a diversity of opinions about online food hub attributes and to allow comparison between early adopter and non-adopter responses.

Online food hubs are relatively uncommon and so non-probability sampling was used to yield adequate numbers of early adopters to conduct comparative statistical analysis. A quota of 200 early adopters was considered feasible to capture heterogeneity in their sociodemographic characteristics, with sufficient samples in each sub-group. Early adopters were recruited with the assistance of gatekeepers who manage the *Open Food Network UK* platform or one of six food hubs which use this platform, and they distributed the survey through their communication channels. These hubs were: *Mercia Food Hub; Roots, Fruits and Leaves; Cultivate Oxford; Tamar Valley Food Hubs; Glasgow Locavore;* and *New Dawn Traders*. The non-adopters were recruited by posting a link to the survey on various groups of two social media platforms, Facebook and Reddit. The profiles of the social media groups were used to identify those with a clear focus on food and environmental issues (e.g. low carbon, reducing plastic waste, sourcing local produce) and those who do not (e.g. supermarket enthusiast groups, bargains, competitions or prizes). Separate survey links were distributed to identify which of the six food hubs the early adopters use and to ensure the two non-adopter groups reached a quota of >100. Respondents were incentivised to complete the survey by entering into a prize draw. The prizes were 1 x £300 and 3 x £80, in vouchers of their choice. The four winners were randomly selected using Excel.

3.3.2 Survey design and pre-testing

Table 3 provides an overview of the survey structure. Some question blocks were generic and were answered by all respondents, whereas others were answered by specific respondents depending on their experience or knowledge of the innovation. Where applicable, the questions were adapted from UK social surveys or previous academic work and this was done for two reasons. First, these precedent questions have been tested for validity and reliability by other researchers, thus increasing to an extent the validity and reliability of the attribute survey. Second, in relation to blocks Q10-12, the UK social surveys explore public attitudes and behaviours relating to food and so provide useful insights into how distinctive or otherwise both the early adopter and non-adopter respondents are regarding their food practices. The questions about dietary preferences (Q10.2), shopping behaviour (Q10.4, Q13.8) and food habits (Q12.7) were adapted from 'Food and You – Wave 4' (Food Standards Agency, 2017). The food shopping preferences block (Q11.1-Q12.5) was adapted from the 'British Social Attitudes survey 2015' (National Centre for Social Research, 2015). The question on growing your own food (Q10.3) was modified from 'Public attitudes and behaviours towards the environment' (DEFRA, 2009). In block 5, the information sources question (Q5.3) was adapted from Axsen (2017) and the opinion leadership scale (Q5.8) was adapted from Goldsmith and De Witt (2003). Questions about attributes (blocks Q2-Q4) were adapted from Moore (1991), Rogers (2003), Axsen (2017) or were composed to explore specific aspects of online food hubs. Finally, the sociodemographic and household questions are somewhat generic but draw inspiration from Whitmarsh and O'Neill (2010).

Table 3, Overview of the survey structure

Block number	Focus of survey questions	Respondent groups	Type of data collected
Q1	Adoption experience	All	quantitative
Q2, Q3, Q4	Attributes of online food hubs	All	quantitative
Q5	Information and communication about online food hubs Social influence	early adopters former adopters non-adopters (who have previously heard of online food hubs)	quantitative
Q6, Q8	Use of online food hubs in daily life	early adopters former adopters	quantitative
Q7	Customer satisfaction and feedback	early adopters	quantitative and qualitative
Q9	Adoption propensity	former adopters non-adopters	quantitative
Q10, Q11, Q12	Food and shopping behaviour	All	quantitative
Q13	Sociodemographics and household	All	quantitative

The food hub managers were invited to assist in the design and testing of the survey to ensure it met their requirements and they could feel invested in the process and its outcomes. They requested the inclusion of a few specific questions in the customer feedback section (block Q7). Members of the SILCI research team were also involved in pre-testing and the survey was revised several times in May and June 2019. The survey was pilot tested on a sample of 15 early adopters from the *Glasgow Locavore* hub and minor revisions were made before the survey went live on 2 July 2019. The survey was administered using Qualtrics software. An example of the survey template can be found in Appendix 3.1.

Defining online food hubs for non-adopter respondents

Using a digital interface to order locally produced food is a relatively recent innovation and is currently a peripheral food shopping practice. It was therefore necessary to provide a definition for respondents who were unfamiliar with online food hubs:

> **Online food hubs** provide apps or online platforms which allow people to buy food for delivery directly from different local farmers and producers offering a wide a range of products.

Examples include: 'Open Food Network', 'Farmdrop' and 'Neighbourfood'

Please note: This does not include veg boxes from a single producer, nor online sales from supermarkets or other food retailers.

Respondents were then asked about their experience of using online food hubs and those who stated they are not a current or former user were presented with the following hypothetical scenario:

Online Food Hub - Now Open!

Image attributed to Farmdrop; entitled 'How it works'. No modifications were made.

Imagine that a new online food hub has just opened in your area. You see the advert above and are deciding whether to:

a) carry on buying food from your local supermarket, or
b) start buying food from this food hub

The following questions explore some features of online food hubs which might be important in your decision.

The aim of this scenario was to briefly explain how online food hubs work and encourage non-adopters to reflect on whether this might appeal to them, but without providing so much information that would constitute paraphrasing or highlighting the core attributes.

For both early adopters and non-adopters, the attributes were introduced with the prefix ‘Using them…’ (or ‘Using them would…’ for non-adopters). For example:

Q2.3

Using them would provide...

	strongly disagree (1)	disagree (2)	neither agree nor disagree (3)	agree (4)	strongly agree (5)	don't know (6)
... access to better quality food	○	○	○	○	○	○

The intention of this prefix was to encourage respondents to relate the attributes to their daily lives, their food preferences, or their shopping behaviour. For early adopters this is likely to be a relatively easy thought process because they are already using the innovation. Non-adopters, however, are less familiar and it was hoped this framing of the question would make it easier for them to consider potential aspects of appeal in the context of their existing food habits, rather than the survey feeling like an abstract cognitive exercise.

3.3.3 Data preparation and quality checks

The survey data sets contained personal information and so were encrypted with a password and stored securely on the researcher's UEA laptop. Personal information was removed and each respondent was assigned an anonymised identifier (e.g. S371 = survey respondent 371). Thirteen early adopter respondents were recoded as non-adopters due to:

1. A clear misunderstanding of the definition of an online food hub (e.g. they stated 'Tesco' or 'Asda' as the food hub they use in Q1.6/Q1.7) (n=4)
2. They self-corrected their adoption experience when answering the check question later in the survey (Q111-Q117) (n=9)

Their responses to blocks Q6-8, relating to their experience of using the hub, were removed. The responses to block Q5 for those who self-corrected their adoption experience as 'I have never heard of this' (n=5) were also removed. *New Dawn Traders*' responses for Q6.4/Q6.5 ('Which items do you buy from the hub?') were recoded because they sell very different products to the other five food hubs and so are not comparable on this question. Finally, missing values were coded according to whether the question was skipped, the respondent answered 'don't know/prefer not to say' or a response was not required.

Three checks were conducted on the data set to augment data quality. These checks were to investigate: 1. survey completeness (to remove incomplete responses); 2. the time taken to complete the survey (to remove 'speeders'); and 3. non-differentiation in ratings for Likert scale questions (to remove 'straight-line' responses). The process is described below:

1. **Completeness.** If respondents completed most of the survey but did not start the final question block (n=42), these cases were coded as incomplete and remained in the data set

to explore if a particular respondent group chose not to finish the survey. These 42 respondents are distinct from those who completed less than 75% of the survey and were removed entirely from the data set as incomplete surveys (n=95).

2. **Duration**. If early adopter respondents took less than 5½ minutes to complete the survey, or non-adopters less than 4 minutes (non-adopters were required to answer fewer questions than early adopters), they were removed from the data set (n=4). These timings were considered to be the minimum amount of time required to complete the survey, based on the survey pre-testing. Any shorter duration would suggest the respondent had not given each question adequate attention.
3. **Non-differentiation in ratings**. Any cases where the respondent had selected 21 or 22 identical response options for the attribute block (Q2/3/4 - consisting of 22 questions) were removed from the data set (n=7). 'Straight-lining' suggests those respondents had not attempted to answer each question and were simply rushing through the survey. It is possible that other respondents did not fully engage in answering the questions but used a more complex response pattern than straight-lining, but it is very difficult to detect and differentiate these from genuine responses.

The final cleaned dataset comprised 221 early adopters (which includes 25 former adopters) and 374 non-adopters. The data was primarily used to explore consistency with expectations 1a – 1d (see chapter 4) and 4b – 4d (see chapter 7).

3.4 Semi-structured interviews

Qualitative interviews are used to gain in-depth insights into how a respondent views a particular topic, to understand their lived experiences, or their rationale for the decisions they make. Contextualised accounts of people's experiences and decisions can be used for making causal explanations about their behaviour (Whittemore, Chase and Mandle, 2001; Maxwell, 2004). There are different types of qualitative interview and the semi-structured format allows respondents to provide more comprehensive answers and to use their own language to articulate their thoughts. Moreover, this format enables the researcher to pursue revelatory information during the interview and to be responsive to the respondent's concerns or interests (Schmidt, 2004; Denzin and Lincoln, 2011; Kvale, 2012).

Semi-structured interviews were used in this study to explore how using an online food hub is situated in broader household food behaviours. Choosing what food to buy and where to buy it is embedded within various considerations including dietary preference, daily routines, the expectations of family members, previous shopping experiences and, more recently, health concerns due to the pandemic. This complex decision-making context has important implications both for scaling up adoption and for behaviour changes which could reduce emissions. A second objective was to explore the early adopters' communication with others about online food hubs - who they recommend the hubs to, what they say, and in what situations these discussions occur. This information is crucial for understanding social influence processes which could drive diffusion, as described in the DoI framework. Data was collected from 20 online food hub users in December 2020 - March 2021.

3.4.1 Sampling of online food hubs and interview participants

Early adopters were recruited from two hubs: *Tamar Valley Food Hubs* (n=12) and *Glasgow Locavore* (n=8). These particular hubs were chosen for two reasons. First, the early adopter responses to Q6.3-Q6.5 in the questionnaire survey revealed *Tamar* and *Locavore* sell a relatively wide range of products and account for a significant proportion of the weekly shop. These hubs are therefore closer to supermarkets in terms of their capacity to cater for a typical weekly food shop, which supports comparative analysis with the mainstream shopping practice of using supermarkets. Second, *Tamar* serves a predominantly rural clientele, whereas *Locavore* sells primarily to urban customers. This enabled investigation into whether varying availability of food retailers affects how the early adopters use their local hub, or if there are any differences in communication about food hubs in rural and urban settings.

Concerning the sampling of participants, two criteria were applied. The first was to have ordered regularly for at least one year, as these individuals have greater experience of using food hubs and were therefore considered more likely to have concrete opinions about them. The second criterion was for the sample to include a range of expenditure levels, thus reflecting variation in the use of the innovation. This range was based on the mean monthly expenditure percentiles from the food hub purchasing data (see Appendix 6.1). The interview participants were recruited with the assistance of a gatekeeper who manages the *Open Food Network UK* platform. They were incentivised to participate with a £25 voucher.

The gatekeeper invited a total of 80 early adopters who matched the sampling criteria from the two hubs, but this yielded only 15 respondents. Snowball sampling was therefore used to boost the sample size, whereby the respondents were asked if they knew of other hub customers who might like to participate. Ultimately, a range of expenditure levels was achieved in the sample and only one of the participants had been using their local food hub for less than one year, and so the initial sampling criteria was satisfied (see Appendix 3.7). There is a disparity between the number of participants from the two hubs (*Tamar Valley Food Hubs* n=12, *Glasgow Locavore* n=8). This was not intentional, but merely the result of who expressed an interest in taking part. Despite the incentive offered, recruiting respondents proved somewhat difficult and so this disparity was accepted.

3.4.2 Interview design and pre-testing

Table 4 provides an overview of the interview content and structure. A series of open-ended questions and two structured elicitation activities, a card sorting exercise and a ranking exercise, were developed to explore the interview themes. The sections could be easily re-ordered to allow a more conversational flow during the interviews. The interviews were conducted using Microsoft Teams and recorded using the software's integrated function. Five additional questions were included in the second round of interviews (n=11) to explore particular topics of interest which emerged in the first round (n=9). When it became apparent that face to face interviews would not be possible due to Covid lockdown restrictions, the activities were modified to be implemented online. The interview protocol can be found in Appendix 3.4.

Table 4, Overview of the interview structure

Section	Interview themes	Type of data collected
E1	Food shopping behaviour	qualitative and quantitative
E2	Household food behaviours and decision making	qualitative
E3	Dietary choices	qualitative
E4	Communication behaviour and social networks	qualitative and quantitative
E5	Exit survey - sociodemographics and household	quantitative

There were some important considerations when designing the protocol and in conducting the interviews to ensure the requisite data was collected and that it was valid. One of the challenges was to ensure that the open-ended questions were clearly understandable and were not leading. Although the questions regarding shopping habits were relatively straight-forward (section E1), those about food waste, diet or values (sections E2 & E3) were at risk of a potential observerexpectancy effect, whereby the respondent provides answers which they believe will conform to the researcher's expectations. It was stressed to the participants in the pre-amble that the purpose of the interview was simply to explore household food decisions and that there were no right or wrong answers. Moreover, the feedback received during pre- and pilot-testing was very important in improving the clarity and neutrality of the questions. The interview protocol was pre-tested with two members of the SILCI research team and then pilot-tested with two *Riverford* veg box customers in October 2020.

Another challenge was to ensure the emphasis of the interviews was on the use of online food hubs in the context of household food decisions, rather than becoming a discussion about the relative appeal of the innovation. It was anticipated that the early adopters would be enthusiastic about food hubs and would naturally wish to describe what they liked about them, but appealing attributes were previously addressed in the questionnaire survey. Avoiding this situation was managed through careful wording of the questions and by redirecting the focus during the interviews when necessary.

Some respondents struggled with the ranking exercise and the subsequent questions about their communication with others about online food hubs (section E4). The ranking exercise was intended to elicit whether early adopters were primarily speaking to strong or weak ties in their social networks, and whether those ties were already users of food hubs. However, a few respondents were unsure what constitutes a friend and what constitutes an acquaintance and so some clarification was required during the interviews. Another issue was a difficulty in recalling incidental conversations about food hubs and how they occurred, because these discussions were not prominent in the respondent's memory. These participants tended to generalise in their answers rather than provide specific examples. There is no obvious solution to the problem of recall and so this ambiguity was accepted as a weakness of the method.

3.4.3 Transcribing and coding

Each participant was assigned an anonymised identifier (e.g. I12 = interview respondent 12). The interviews were transcribed verbatim and then coded using NVivo 12 Pro. First, relevant themes were categorised using a priori codes predicated on the research aims of the interviews. Inductive coding was then used to identify a small number of unanticipated themes. An iterative process then followed of grouping or merging similar codes, disentangling others into distinct codes, and ascertaining any relationships or hierarchies between the codes or underlying concepts. The final step was in-depth thematic analysis for each code. A list of the final qualitative coding can be found in Appendix 3.5. Descriptive data such as sociodemographic characteristics (see section 5) or where the respondents choose to buy their food (see Appendix 3.6) was used to assess the relative representativeness of the respondent group and discern any features of the sample which may be relevant to their food or shopping behaviour.

The interview data was primarily used to investigate consistency with expectations 2a – 2e (see chapter 5) and 4b – 4e & 4g (see chapter 7).

3.5 Secondary data

Three types of secondary data were used in this project. This section describes these data, how they were obtained and their purpose within the project.

3.5.1 Online food hub users' order history

Purchasing data was collected from 94 anonymised users of two online food hubs (*Glasgow Locavore* and *Tamar Valley Food Hubs*) to ascertain what items the early adopters tend to buy from their local hub. This revealed preference data was used together with the stated preference data from the survey and interviews to build a picture of the typical food hub basket, which could then be compared with the average UK shopping basket. The data points comprised four non-consecutive months: September 2019, February and May 2020 (to capture the initial impact of the pandemic on food hub shopping behaviour), and September 2020. The hub users were chosen according to two criteria: 1) they had ordered from their respective hub at least once in each of these months, allowing for longitudinal investigation of their shopping behaviour; and 2) a range of expenditure levels were included to reflect variation in the use of food hubs. The data set was provided by a gatekeeper who manages the *Open Food Network UK* platform and the sample size was determined by the number of hub users who matched the two criteria. This data was anonymity protected and so did not include sociodemographic or household characteristics.

The data set consists of 1071 orders comprising 9350 items and some data preparation was required prior to analysis. The weight or volumes of various foods and drinks were standardised across the two hubs. For some items, the weight was not specified and so assumptions had to be made using various reference points such as price, the product information from the supplier's website, or the weight of similar items sold by other suppliers (see Appendix 6.4 for more information on the assumptions and the rationales used). DEFRA's *Family Food* survey, the 2018/19 edition (DEFRA, 2020), was used to represent the typical UK basket and so the items in the food hub data set were recoded to match the DEFRA coding.

This dataset was used to explore expectations 3a and 3b, which relate to the food hub users' shopping behaviour (see chapter 6).

3.5.2 Synthesis of LCA studies

Online food hubs are expected to reduce emissions in several ways, shown in Table 5. Some emission reduction mechanisms relate changes in household food behaviours, whereas others are associated with aspects of alternative food supply chains. These expectations were based on literature pertaining to each mechanism, as well as information from the hub platforms concerning their delivery model and the producers' farming practices.

Table 5, Hypothesised emission reduction potential of online food hubs

GHG emission reduction mechanism	Incumbent or mainstream practice (the counterfactual)	Potential impact of using online food hubs
Emission reduction due to consumer behaviour change		
Dietary shift	'Western diet' characterised by a large proportion of red meat and dairy products	Regular deliveries of vegetables encourage a shift to flexitarian and plant-based diets
Eat a more seasonal diet	Year-round availability of all types of fresh produce	Eating fresh produce when it is in season in the UK
Reduce household food waste	Buying excess short-dated food on special offer; low awareness of household consumption patterns and food expiry	Buying less short-dated food; greater awareness of household consumption patterns and food expiry
Emission reduction due to substitution of supply chains		
Reduce transportation emissions	Source food using regional or global supply chains; last mile emissions (driving car to the supermarket)	Source food using local supply chains; home delivery using (electric) van or bicycle
Reduce production emissions	Food produced using carbon-intensive farming practices (agri-inputs, refrigeration, heated greenhouses)	Food produced using less carbon-intensive farming practices (organic; reduced energy use; regenerative agriculture)
Reduce supply chain food waste	Pre-farm gate waste due to quotas and aesthetic specifications	Harvesting to order; no aesthetic specifications

Given the wide range of items sold on the hub platforms and the large number of producers which supply them, conducting a full empirical LCA of a food hub shopping basket was not considered feasible in this project. A comprehensive LCA for just one food product can be very complex and time-intensive (de Backer et al., 2009). This is a problem encountered by other researchers who have investigated food-related emissions at the household or system level, for example dietary choice, shopping behaviours or different farming practices (Koerber et al., 2009; Coley, Howard and Winter, 2013; Clear et al., 2015). This study therefore uses the approach taken by Hoolohan et al. (2013), Clune, Crossin and Verghese (2017), WRAP (2019), Wang, Zhang and Schneider (2021) and others, whereby relevant LCA literature is collated and synthesised to calculate the likely emission implications for multiple food products or supply chain activities. The main drawback of this approach is that it entails a substantial assumption of comparability between this case and those discussed in the LCAs. For example, the emissions saved by a farm using agroecological practices described by Pérez-Neira and Grollmus-Venegas (2018) is assumed to be comparable to a farm which uses similar practices and supplies *Locavore* food hub, although there will undoubtedly be contextual and ecological differences between the two. The main advantage is that a more detailed and accurate description of revealed and stated shopping preferences can be used to make inferences about emission reductions. The entire food hub shopping basket can be considered, rather than a small number of items which does not reflect a typical weekly food shop.

LCA studies were identified which relate to each of the emission reduction mechanisms in Table 5. The following information was extracted and recorded in an Excel matrix:

- the context and scale of the study
- the methodology, including the system boundaries
- the metric used (GHG emissions, waste avoided, energy used)
- the emission reduction estimate (average, high-low, or range)
- any assumptions or aspects which could affect internal or external validity

The empirical data collected in this study concerning the outcomes of using online food hubs (dietary choices, household food behaviours, shopping habits, supply chain substitution) was then placed in the context of these LCA findings. This enabled the potential emission reduction of using an online food hub to be estimated under different scenarios.

The LCA synthesis was used to explore expectations 2b, 2e and 5a - 5c (see chapter 8).

3.5.3 Social surveys, grey literature and census data

Panel or cohort data from four UK social surveys were used to situate the empirical findings of this study within broader societal contexts and trends relating to food and the environment. The data were used in chapter 7 for assessing how these contextual factors could affect the diffusion of online food hubs (expectation 4f). The surveys were: The National Centre for Social Research's *British Social Attitudes*, University of Essex's *Understanding Society*, Food Standards Agency's *Food and You*, and DEFRA's *Food Statistics Pocketbook*. *Statista*, *Mintel, McKinsey, Google trends* and *YouGov* data were also used, together with a limited selection of news articles and grey literature, to identify emerging dietary and food shopping behaviours. Census data from the Office for National Statistics, the National Records of Scotland, and some district councils were used to calculate the populations of the cities and towns which are currently served by an online food hub. This information was used to appraise the potential for scaling up adoption (Expectation 4a).

3.6 Delimitations

Two delimitations were applied to this study:

1. veg box providers were not included
2. this project does not attempt to measure the public benefits of online food hubs, aside from GHG emissions

Veg box providers were excluded to focus on online food hubs. As mentioned in the Introduction chapter, food hubs offer novelty in terms of the open source platform and a wide range of products from multiple producers, both of which support a potential scaling up. Regarding the second delimitation, the public benefits of online food hubs were explored in this project in terms of how they appeal to consumers (the value proposition), rather than quantitatively measuring the impact of online food hubs on a specific outcome (for instance, how much soil degradation is prevented). All of the public benefits are important and ideally a framework could be developed which assesses the contribution of online food hubs for each of them. However, this was considered beyond the scope of this PhD because quantifying GHG emissions is already a complex undertaking.

3.7 Analytical framework

Table 6 is the analytical framework used in this study. Moving across each row from left to right, it shows the research question, the main variables explored, the methods used, and the analytical approaches. Using the mixed method approach, the questionnaire survey and semi-structured interviews were designed to collect data to answer multiple research questions. The green cells indicate the primary focus of a given method, whereas the blue cells indicate a secondary focus. The framework also shows the various secondary data sources that were used to support the empirical data.

Table 6, Analytical framework

Research Questions	Variables explored	Questionnaire survey		Semi-structured interviews		Secondary data	Analytical approach
		Primary or secondary focus	Respondents	Primary or secondary focus	Respondents		
RQ 1 - Why do people use online food hubs?	Appeal of innovation	Primary	early adopters (n=221), non-adopters (n=374)	Secondary	early adopters (n=20)	Online food hub websites	Quantitative: Between group analysis, Logistic regression Qualitative: Content analysis
	Distinctiveness of early adopters	Primary		Secondary		N/A	
RQ 2 - In what ways does the household food context affect the use of online food hubs?	Household food behaviours	Secondary		Primary		N/A	Qualitative: Content analysis
RQ 3 - In what ways do people use online food hubs?	Shopping behaviour	Secondary		Secondary		early adopters' order history (n=94)	Quantitative: Comparison of shopping baskets Qualitative: Content analysis
	Use of innovation	Secondary		Secondary			
RQ 4 - Which factors are important in scaling up the adoption of online food hubs?	Social influence	Secondary		Primary		N/A	Quantitative: Between group analysis Qualitative: Content analysis
	Contextual factors	N/A		Secondary		UK social surveys, Grey literature	
RQ 5 - How does the use of online food hubs reduce GHG emissions?	GHG emissions	Secondary		Primary		early adopters' order history (n=94)	Quantitative: Synthesis of LCA studies

3.8 Research ethics

This research involved human subjects and so two formal ethics review applications were submitted to the UEA ethics committee. Approval was granted for the questionnaire survey on 15 March 2019 (GREC 18-1311) and for the semi-structured interviews on 7 August 2020 (SCI-ENV/1920/R/99). Prior to participation, survey and interview respondents were informed about the purpose of the research, how their data would be stored and used, that their participation is completely voluntary, and they could withdraw at any time. Once they had received this information, respondents were asked to provide their consent before commencing with the questionnaire or interview. All respondent data was stored anonymously and securely using password protection on the author's UEA computer and backed-up on UEA network drives. Respondents were assigned participant codes prior to analysis and cannot be identified in any of the research outputs.

4 Results: Why do people use online food hubs?

This chapter answers the first research question: why do people use online food hubs? Figure 7 is an overview of the chapter and it shows two analytical objectives which relate to this question. The first is to characterise the early adopters and identify ways in which they may differ from the non-adopters. The second is to understand the appeal of online food hubs and ascertain whether early adopters and non-adopters differ in their perception of food hub attributes. This comparative design strengthens internal validity by determining whether early adopters are distinctive from non-adopters and, if so, how this might affect their perception of online food hubs which resulted in adoption of the innovation. Between-group statistical analysis was used to explore these two themes using data from the attribute survey. The early adopters' qualitative responses from the attribute survey and the semi-structured interviews are used to explain particular aspects of appeal, but the main emphasis of this chapter is the quantitative findings.

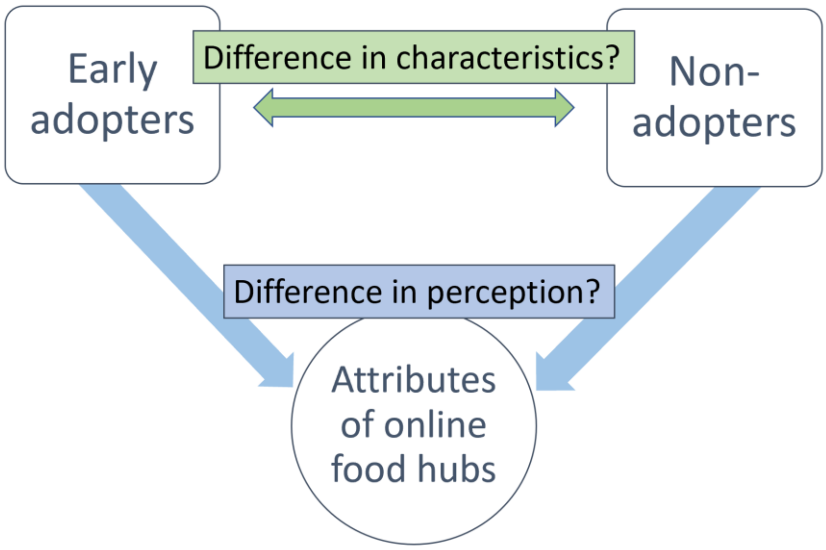


Figure 7, Chapter 4 overview - exploring differences between early adopters and non-adopters to investigate why people use online food hubs

4.1 Who are the early adopters of online food hubs?

Rogers (2003) argues that early adopters can be differentiated from later adopters by various sociodemographic and communication behaviour traits. These characteristics were explored in the attribute survey, along with additional independent variables relating to food shopping, dietary preference, and cooking habits. This section seeks to develop an understanding of who the early adopters are by using these variables to distinguish them from non-adopters. The following expectation was proposed:

> 1a - *Early adopters are distinctive from non-adopters in their sociodemographic characteristics and food behaviours*

4.1.1 Food shopping behaviours

Using an online platform to buy locally produced food direct from farmers is a relatively novel way to shop and so using a food hub should be considered in the context of mainstream food shopping behaviours. Two aspects were investigated: 1) where people buy their food, and 2) their stated preferences when they shop.

Where people shop for food

The survey respondents (n=595) were asked how much of their weekly food shopping they buy from various suppliers (Q10.4). The results show that supermarkets provide the largest proportion for both respondent groups (Figure 8). Early adopters buy only 13% of their weekly shop from online food hubs[17], although some respondents may have conflated food hubs with veg box deliveries.

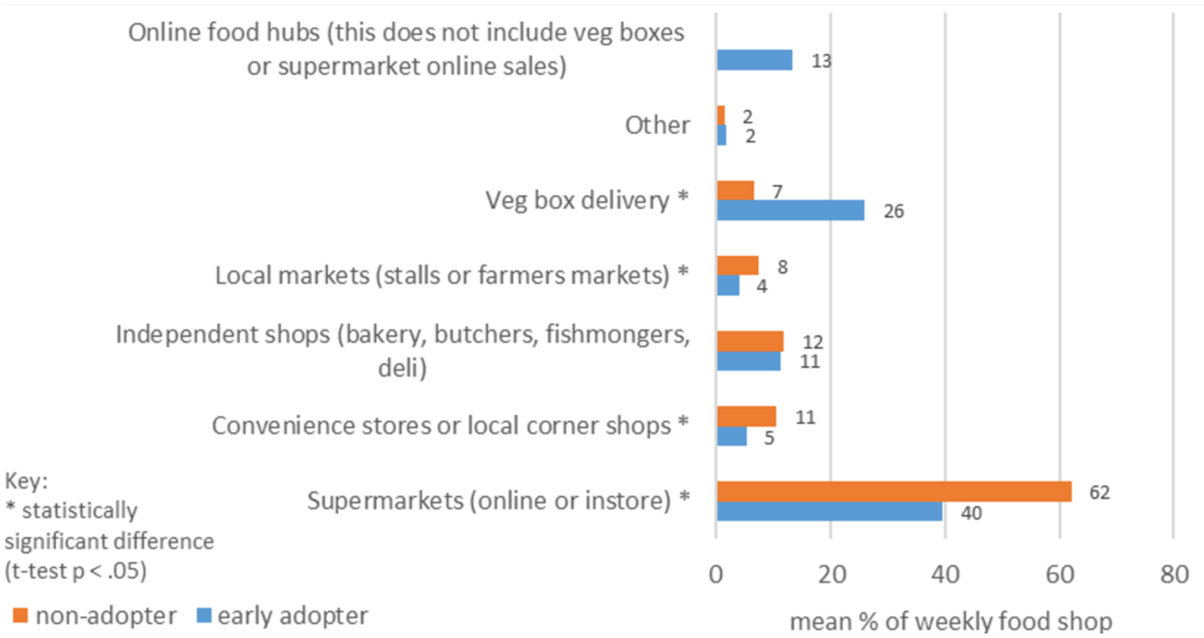


Figure 8, Percentage of weekly food shopping bought from different retailers

[17] Non-adopters were not asked how much they buy from online food hubs as they had already stated they do not use food hubs in the adoption experience question (Q1.5)

Differences in the early adopters' and non-adopters' shopping behaviour were investigated using independent-samples t-tests. Early adopters buy on average 39.7% (± 25.7) of their weekly food shop from supermarkets, compared to 62.0% (± 29.1) for non-adopters, a statistically significant difference of 22.3% (95% CI, 17.6 to 27.2), $t(560) = 9.147$, $p = .001$ (large effect size using Cohen's d). Early adopters buy less food from convenience stores and local market stalls than non-adopters (small effect size), but there was no significant difference between the two groups in their use of the traditional independents such as bakers. The main finding is that early adopters buy considerably less food from supermarkets than the non-adopters.

Food shopping preferences

The survey respondents were asked about the importance of 15 food shopping preferences using a unidirectional scale (Q11.2-12.5). The purpose of these questions was to explore what people look for when they shop for food, irrespective of where they buy it, and they were included for two reasons. First, approximately half of the preferences represent conventional food shopping attributes, whereas the other half relate to aspects of using online food hubs. The relative importance of the two distinct sets of preferences could therefore be investigated for the two respondent groups. Second, six of the preferences were duplicated from the *British Social Attitudes* survey (National Centre for Social Research, 2015). This enabled comparison of the attribute survey responses with a UK population sample (see chapter 7).

A principal components analysis was run on the 15 shopping preferences to identify underlying constructs which could be more easily integrated into a logistic regression model to predict adoption for this respondent sample. The 15-item scale had a good level of internal consistency, as determined by a Cronbach's alpha of 0.74. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin measure was 0.82, a classification of 'meritorious' according to Kaiser (1974), with individual Kaiser-Meyer-Olkin measures all greater than 0.6. Bartlett's test of sphericity was statistically significant ($p < .001$). The interpretability criterion indicated that a three-component solution provided the simplest structure, using a varimax orthogonal rotation and by removing one preference, 'you can try out new recipes'. Collectively the three components explain 58.8% of the total variance. Table 7 shows the factor loadings and communalities for the three components.

The three components can be interpreted from the preferences which load on them:

1. 'ethics and health', which encapsulates an emphasis on the benefits to society, the environment or personal well-being in food shopping decisions
2. 'conventional shopping attributes', which incorporates the more traditional considerations such as cost or the availability of well-known brands
3. 'shopping convenience', which reflects a preference for online shopping and home delivery

Table 7, Rotated component matrix for PCA with orthogonal rotation of 14 food shopping preferences

	Component			
Shopping preference	1. ethics and health	2. conventional shopping attributes	3. Shopping convenience	**Communalities**
The food was grown locally	**0.790**			0.672
The farmer has been paid a fair price	**0.756**			0.590
Minimal plastic packaging is used	**0.735**			0.549
It is clear where all the ingredients have come from	**0.720**			0.536
The highest welfare standards for farm animals were used	**0.717**			0.536
The food is healthy	**0.680**			0.466
The food was grown using organic farming methods	**0.671**			0.568
The food is not highly processed	**0.660**			0.452
You can collect loyalty card points		**0.754**		0.587
Well-known brands are available		**0.728**		0.576
The cost is low		**0.706**		0.531
The food is quick to prepare		**0.667**		0.487
The food can be home-delivered			**0.894**	0.833
The food can be ordered online			**0.891**	0.847
Percentage of variance explained	*32.2%*	*17.5%*	*9.1%*	
Eigenvalue	*4.5*	*2.4*	*1.3*	

Note 1: major loadings for each item are shown in bold
Note 2: factor loadings <0.3 have been removed for clarity, but a complete table of the factor loadings can be found in Appendix 4.1

Differences in the three shopping preference components for the early adopters and non-adopters were investigated using independent-samples t-tests. The results are shown in Table 8 and we can see that the early adopters place greater importance on 'ethics and health' and 'shopping convenience' than non-adopters in their shopping decisions. 'Conventional shopping attributes' are more important for non-adopters than early adopters. The differences between the two groups are somewhat pronounced for all three components, as indicated by the medium effect sizes.

Table 8, Comparing shopping preference components for early adopters and non-adopters using independent samples t-tests

Shopping preference component	Mean early adopter	Mean non-adopter	p-value	Cohen's d	Effect size - Cohen
1. Ethics and health	0.365 (± 0.754)	-0.209 (± 1.062)	**.001**	0.598	medium
2. Conventional shopping attributes	-0.459 (± 0.788)	0.263 (± 1.015)	**.001**	-0.77	medium
3. Shopping convenience	0.312 (± 0.906)	-0.179 (± 1.009)	**.001**	0.504	medium

Note 1: Statistically significant differences are shown in bold
Note 2: Shapiro-Wilk's test showed that none of the shopping preference components are normally distributed
Note 3: Levene's test for equality of variances was used to determine homogeneity of variance between the two groups

Additional between-group analysis was carried out on the 15 shopping preferences and this revealed one important finding (see Appendix 4.2 for complete results). The five highest ranked preferences are the same for both early adopters and non-adopters. These are:

— minimal plastic packaging is used
— the highest welfare standards for farm animals were used
— the farmer has been paid a fair price
— the food is healthy
— it is clear where all the ingredients have come from

These five preferences are all considered to align with attributes of online food hubs.

4.1.2 Household food behaviours

The food shopping preferences and behaviours described above have a clear association with the decision to use an online food hub. There are other food behaviours which are likely to be relevant in this decision. The attribute survey therefore included questions on five different behaviours: dietary preferences, cooking and eating habits, responsibility for food shopping, use of food apps, and growing food. A frequency table can be found in Appendix 3.2.

Dietary preferences

Dietary preferences or requirements are very important in any food purchasing decision. The respondents were asked to describe their dietary preference (Q10.2) and chi-square tests of homogeneity were run to explore differences between the two groups, with an adequate sample size established according to Cochran (1954). The observed frequencies and percentages[18] of different dietary preferences are presented in Table 9. The table shows that the multinomial probability distributions were not equal in the population. A higher proportion of early adopters were flexitarian, vegetarian or vegan, and a higher proportion of non-adopters were omnivore (all small effect size using Cramer's V). There was no statistically significant difference between the groups for pescatarian diet or food intolerances.

Table 9, Crosstabulation of the dietary preferences of early adopters and non-adopters

	Early adopters	Non-adopters	$\chi 2(1)$	*p*
Omnivore	68 (32.9%)	194 (52.7%)	21.082	**.001**
Flexitarian	76 (36.7%)	81 (22.0%)	14.431	**.001**
Vegetarian	46 (22.2%)	50 (13.6%)	7.103	**.008**
Vegan	27 (13.0%)	26 (7.1%)	5.658	**.017**
Pescatarian	16 (7.7%)	20 (5.4%)	1.189	.276
Food intolerance	31 (15.0%)	40 (10.9%)	2.064	.151

Note: statistically significant differences are shown in bold

In view of this difference in dietary preferences, it is reasonable to infer that the early adopters eat a greater amount of vegetables and pulses, and of course less meat, than the non-adopters. For early adopters who eat a flexitarian or plant-based diet, the availability of foods which match their diet is likely to be important factor in their use of online food hubs.

Cooking and eating behaviours

The survey respondents were asked six questions about how often they eat or prepare different types of meals (Q12.7). The intention was to explore whether any of these common food behaviours might be associated with the use of online food hubs. Mann-Whitney U tests were run to determine if there were differences between early adopters and non-adopters in the frequency of these behaviours. Distributions of the frequencies were similar for all six questions, as assessed by visual inspection. The most notable finding was that both groups prepare meals from scratch several times a week, but the median frequency was statistically significantly higher for early adopters (at least

[18] Respondents could select more than one option for this question (for instance, they could be a vegetarian and have a food intolerance) and so the percentages do not sum 100. Thus, the groups' percentages should only be compared within a dietary preference category.

once a day) than for non-adopters (4-6 times week), $U = 45613$, $z = 5.944$, $p = .001$ (small effect size using eta-squared). This greater propensity to cook was supported by two questions which revealed the early adopters eat ready meals and takeaways less often than non-adopters (small effect size). Cooking meals from scratch is consistent with using online food hubs because much of their product range consists of fresh ingredients.

A further finding was that early adopters eat vegetarian meals more often than non-adopters[19] (medium effect size). This reiterates the results of the dietary preference question, that a higher proportion of early adopters choose a flexitarian diet. This triangulation of the data is useful because the definition of a flexitarian diet is somewhat subjective compared to the other dietary preference categories.

Responsibility for food shopping

The respondents were asked about their level of responsibility for food shopping in the household (Q13.8). This question was included to explore whether the two respondent groups had comparable level of influence on food purchasing decisions. Approximately two thirds of early adopters and non-adopters stated they were responsible for 'all or most' of the food shopping. Chi-square tests found no statistically significant difference between them.

Use of food apps

The use of food apps was investigated (Q12.6) to identify whether early adopters are more likely than non-adopters to try digital food innovations, aside from online food hubs. Recipe apps and restaurant review apps were the most commonly used by both early adopters and non-adopters. Chi-square tests found no statistically significant differences between the two groups for four of the five types of app. Early adopters are therefore not considered to have a greater tendency to use digital food innovations.

Food growing

Food growing was included in the survey (Q10.3) because it represents an alternative source of food which could affect how much people buy from online food hubs or indeed other retailers. It is also a strong indicator of an interest in food and where it comes from. A chi-square test identified a statistically significant difference in the multinomial probability distribution; 52% of early adopters grow some of their own food, compared to 42% of non-adopters (small effect size using Cramer's V). Both of these percentages are quite high, which suggests many of the survey respondents share an interest in growing food.

[19] vegetarian and vegan respondents were not asked this question because it would be nonsensical

4.1.3 Sociodemographics and household characteristics

Sociodemographic and household characteristics are another group of independent variables which could indirectly influence the adoption decision (Q13.1-13.9). These characteristics are commonly used to describe survey samples and explain variation in responses. Moreover, Rogers (2003) uses two of them, 'years of formal education' and 'income', to differentiate early adopters from later adopters. Table 10 is a frequency table of the sociodemographic and household characteristics.

Table 10, Attribute survey respondents' sociodemographic and household characteristics

		Early adopter (n=221)		Non-adopter (n=374)	
Characteristic	**Category**	**Frequency**	**Valid %**	**Frequency**	**Valid %**
Gender	*female*	*169*	*84.9*	*305*	*86.4*
	male	*28*	*14.1*	*47*	*13.3*
	other	*2*	*1.0*	*1*	*0.3*
	missing	*19*		*20*	
	prefer not to say	*3*		*1*	
Age	*under 18*	*0*	*0.0*	*2*	*0.6*
	18-24	*10*	*5.0*	*33*	*9.3*
	25-34	*65*	*32.2*	*84*	*23.7*
	35-44	*51*	*25.2*	*86*	*24.3*
	45-54	*29*	*14.4*	*74*	*20.9*
	55-64	*34*	*16.8*	*51*	*14.4*
	65+	*13*	*6.4*	*24*	*6.8*
	missing	*19*		*20*	
	Prefer not to say	*0*		*0*	
Education level	*no qualifications*	*0*	*0.0*	*13*	*3.7*
	GCSE or O-Level	*8*	*4.0*	*57*	*16.4*
	A-Level	*9*	*4.5*	*32*	*9.2*
	other school qualifications	*3*	*1.5*	*15*	*4.3*
	undergraduate degree or higher	*165*	*83.3*	*201*	*57.8*
	vocational qualifications	*13*	*6.6*	*30*	*8.6*
	missing	*20*		*21*	
	prefer not to say	*3*		*5*	
Employment status	*self-employed*	*26*	*13.0*	*36*	*10.3*
	part-time employed	*44*	*22.0*	*59*	*16.9*

Characteristic	Category	Early adopter (n=221) Frequency	Valid %	Non-adopter (n=374) Frequency	Valid %
	full-time employed	*86*	*43.0*	*107*	*30.6*
	unemployed	*3*	*1.5*	*16*	*4.6*
	retired	*17*	*8.5*	*37*	*10.6*
	looking after family or home	*10*	*5.0*	*43*	*12.3*
	student	*11*	*5.5*	*39*	*11.1*
	other	*3*	*1.5*	*13*	*3.7*
	missing	*20*		*21*	
	prefer not to say	*1*		*3*	
Household combined income (before tax)	*less than £15,000*	*17*	*9.4*	*61*	*20.4*
	£15,000 - £19,999	*15*	*8.3*	*43*	*14.4*
	£20,000 - £24,999	*15*	*8.3*	*36*	*12.0*
	£25,000 - £29,999	*14*	*7.8*	*31*	*10.4*
	£30,000 - £34,999	*15*	*8.3*	*25*	*8.4*
	£35,000 - £39,999	*10*	*5.6*	*16*	*5.4*
	£40,000 - £44,999	*14*	*7.8*	*10*	*3.3*
	£45,000 - £54,999	*19*	*10.6*	*18*	*6.0*
	£55,000 or more	*61*	*33.9*	*59*	*19.7*
	Missing	*20*		*22*	
	Prefer not to say	*21*		*53*	
		Mean	**SD**	**Mean**	**SD**
Household size		*2.42*	*1.25*	*2.77*	*1.32*
Household composition	*Children (under the age of 16)*	*0.59*	*0.86*	*0.77*	*1.00*
	Adults over the age of 65	*0.33*	*1.01*	*0.31*	*0.76*

Concerning education, two thirds of the survey respondents have an undergraduate degree or higher and this is well above the national average of 42% (Office for National Statistics, 2017a). A chi-square test revealed that the distributions were not equal in the population. The proportion of early adopters with a degree (83%) was higher than the non-adopters (59%), whereas the proportion of non-adopters with GCSEs or no qualifications (20%) was higher than the early adopters (4%) (small effect size using Cramer's V). Thus, the early adopters of food hubs typically attain a higher level of education than the non-adopters.

Regarding employment and income, 56% of early adopters are either self-employed or work full-time and a further 22% work part-time. The proportion of early adopters in full-time employment was greater than non-adopters (small effect size using Cramer's V) and it would appear this is reflected in income. Early adopters have a median household income of £40,000-44,999, which is higher than the median of non-adopters (£25,000-£29,999) (small effect size using eta-squared) and the national average median of £29,400[20] (Office for National Statistics, 2019a). However, it would be an over-simplification to infer that online food hub users are predominantly affluent. A third of early adopters are in the highest income category, but the remaining two thirds are evenly spread across the full range of income categories. Therefore, lower income households also choose to buy from online food hubs.

Early adopters have an average household size of 2.42 (CI ± 0.18), whereas non-adopters have a slightly larger average household size of 2.77 (CI ± 0.14), a statistically significant difference of 0.35 (small effect size using Cohen's d). No significant difference was found between the two groups for household composition, age or gender. The high proportion of female respondents is interpreted as a greater willingness among women to participate in surveys, rather than a greater interest in online food hubs.

Summary

This section considered whether early adopters and non-adopters can be differentiated using a range of independent variables. Multiple differences were observed and are summarised in Table 11. Expectation 1a - *Early adopters are distinctive from non-adopters in their sociodemographic characteristics and food behaviours* - is therefore supported.

Table 11, Summary of the key differences between food hub early adopters and non-adopters

Characteristic	Key differences
food shopping behaviour	early adopters tend to buy less food from supermarkets than non-adopters and place a greater emphasis on ethics, health and convenience in their food shopping decisions
household food behaviour	early adopters typically eat less meat, cook more meals from scratch, and grow more of their own food than non-adopters
sociodemographics and household	early adopters typically attain a higher level of education, have a higher salary, and live in smaller households than non-adopters

[20] This comparison is presented as a rough guide only, because the Office for National Statistics reports disposable income (after tax deductions), whereas the attribute survey respondents were asked to state their personal income (before tax deductions)

4.2 The most appealing attributes of online food hubs

The focus now shifts to the attributes of online food hubs. Based on the literature review and information presented on the food hub platforms, two prior expectations were proposed:

> 1b - *Online food hubs offer novel aspects of appeal compared to supermarkets*
> 1c - *Environmental and societal attributes are important aspects of the perceived appeal of online food hubs*

The appeal of an innovation is a key determinant in someone's decision to adopt (Rogers, 2003). It is therefore important to establish which aspects of appeal are most important for the early adopters and the potential adopters of an innovation. The survey respondents were asked to state how strongly they agree or disagree with 22 statements about online food hubs, using a 5-point Likert scale (Q2.2-2.12). The purpose of including a relatively large number of attributes was to capture the breadth or nuance of how online foods hubs might appeal. The means of the 22 appeal items were calculated[21] for all of the respondents combined and are shown in Table 12, together with the standard deviations.

[21] The medians were not very useful for differentiating the attributes and so the Likert ordinal data was treated as scale data to produce the ranking. Justification for the choice of parametric over non-parametric approaches is provided in Appendix 4.4

Table 12, Attribute survey respondents' mean ranking of 22 attributes of online food hubs

No.	Attribute of online food hubs	Mean	Std. Deviation
1	provides access to seasonal food	4.52	0.65
2	helps support local businesses	4.51	0.73
3	convenience of home delivery	4.39	0.77
4	convenience of ordering online	4.35	0.73
5	provides access to better quality food	4.28	0.75
6	provides access to fresher fruit and veg because it is harvested to order	4.27	0.80
7	increases transparency in the food supply chain	4.24	0.76
8	fits well with my values and beliefs	4.23	0.82
9	helps protect the environment	4.17	0.84
10	build connections between consumers and producers	4.15	0.87
11	enables me to make informed choices because I know how the food is produced	4.15	0.79
12	helps tackle climate change	4.05	0.87
13	makes me feel positive about myself	3.98	0.85
14	is compatible with my daily life	3.91	0.86
15	convenience of collection from a local pick-up point	3.82	0.93
16	enables me to easily find specific products I want using search filters	3.74	0.86
17	saves time on food shopping	3.64	0.99
18	enables me to connect with like-minded people	3.46	0.95
19	makes a good impression on others	3.36	0.83
20	has helped me address a problem I faced	3.28	0.97
21	does not take more effort than buying my food elsewhere[22]	3.22	1.04
22	saves money on food shopping	2.85	0.98

One observation is that the means are relatively high for majority of the attributes which indicates that most respondents either *agree* or *strongly agree* with the statements. This suggests that their perception of online food hub attributes is generally positive. A second observation is that the standard deviations are smaller towards the top of the list. This implies greater consensus among the respondents regarding the most salient attributes of online food hubs. Some of the attributes further down the list explore symbolic or interpersonal aspects of using food hubs and there is a larger degree of uncertainty about their relative appeal.

[22] This statement is reverse coded from the attribute survey question to maintain consistency with the positive direction of the other attribute statements in Table 12

Food quality attributes

One important dimension of appeal is food quality and choice. Four of the ten highest ranked attributes in Table 12 relate to this theme (No. 1, 5, 6, 7). They can be considered core attributes because they relate directly to the products and where they come from. The seasonality of the food was the highest ranked of all 22 attributes and this is an intrinsic feature of food networks based on short supply chains. Transparency in the food supply chain is another attribute which is more commonly associated with local food networks than supermarkets which tend to rely on regional or global supply chains. To some extent, both of these attributes differentiate online food hubs from mainstream retailers.

Food bought from the hubs is considered to be fresher and better quality than food bought from other suppliers. This was an important theme in the interviews (E1.5: I2, I5, I6, I8-I11, I13-I15, I17, I19, I20) as well as in the attribute survey qualitative feedback (Q7.5-7.6: 45 comments). For example:

> "The quality of vegetables, particularly in the veg bags are excellent. Not only are they far better than my usual supermarket vegetables, but the variety and seasonality has made me experiment with new recipes, which has been great!" (S569)

Quality and freshness are attributes where food hubs are perceived to have relative advantage over supermarkets, but they are not idiosyncratic of food hubs in the same way as seasonality and transparency.

Environmental and societal attributes

Three of the top ten attributes are environmental or societal benefits (No. 2, 9, 10). These attributes can be regarded as non-core because they relate to production methods or the relations between different actors in the food system, rather than the actual products. Supporting local businesses by providing a direct marketing channel is a foundational concept of online food hubs and the high mean of 4.51 implies that consumers recognise this. This was corroborated by the interview data as almost every interview respondent highlighted this attribute (I1-I9, I11-I16, I19, I20). Creating an environmentally sustainable agri-food system is another stated objective of food hubs which differentiates them from supermarkets and is regarded positively by consumers. When describing their motivations for using the hub, the early adopters often bundle these environmental and societal benefits together, or combine them with private benefits:

> "We are happy that we can support local businesses, helping the environment, and eat healthfully in an easy way." (S485)

The opportunity for consumers to build social connections with local producers is another distinctive feature of local food networks and the appeal is succinctly expressed by one early adopter:

> “We really value having a relationship with our food and those that are involved in its production and the food hub goes some way towards this, although it would be lovely if this could be nurtured even more.” (S591)

Supermarkets and convenience stores cannot easily incorporate this social aspect into their business model due to their lengthy, often anonymised, supply chains, although their product labelling increasingly features a short bio of the producer to emulate this dimension of appeal.

The prominence of these non-core attributes in both the quantitative and qualitative results suggests that the appeal of online food hubs is multi-dimensional and extends beyond the established food attributes such as quality or freshness.

Consistency with identity

There is one highly ranked attribute which is associated with personal identity, ‘using online food hubs fits well with my values and beliefs’ (No. 8). This attribute is related to the environmental and societal attributes but is more introspective because it describes whether food shopping decisions are consistent with personal values or how an individual wishes to live. To give an example:

> “I am so happy to have somewhere to buy plastic free. I try and get as much as possible from you [the food hub] when I can.” (S392)

These respondents describe using the food hub in terms of how it makes them feel, rather than conveying an associated benefit to society or the environment. This attribute is therefore considered symbolic rather than functional.

Convenience

The third and fourth highest ranked attributes in Table 12 are associated with convenience. This relates to the consumers’ experience of online food shopping, rather than the products or the farming methods, and these high rankings suggest the convenience associated with this way of buying food appeals to consumers. Supermarkets are proficient in this area and have set the benchmark by developing user-friendly interfaces and allowing their customers to select hourly delivery slots or the option of ‘click and collect’. The efficacy of online food hubs to offer convenience will be viewed by many respondents in the context of their prior experience using supermarkets’ service. Nevertheless, the food hubs appear to meet their users’ expectations. 90% of the early adopters in the attribute survey believe the delivery/collection process works well (Q7.4), although there were 18 requests in the qualitative feedback for more a bespoke delivery service. The convenience afforded by home delivery was also a salient theme in the interviews (I1, I5, I7, I9, I10, I14, I16, I19, I20). Regarding placing orders, 88% of early adopters in the survey agreed or strongly agreed that ‘using the food hub app/online platform is easy’ (Q2.12) and this was supported by the interview data (E2.10) (I1-I3, I5, I7, I8, I10, I11, I14, I16, I17, I20). One survey respondent provided this explanation:

> “Great to be able to get the shopping delivered home, great to have a regular weekly order set up, with specials delivered on specific weeks and the ability to add to the order through the Open Food Network with billing added to account (no need to get credit card details to pay on the Open Food Network).” (S431)

Thus, built-in features such as regular orders and effortless billing allow the food hub platform to compare on a functional level with supermarket platforms (I6, I8, I11).

Cost

The lowest ranked attribute was ‘using them saves money on food shopping’, with a mean of 2.85. The attribute survey qualitative feedback included 37 comments about the food being expensive (Q7.3). The survey findings are aligned with the common perception that locally produced food is more expensive than food bought from supermarkets.

Summary

This section presented the most salient attributes of online food hubs. The hubs compare favourably with supermarkets on established attributes such as food quality and shopping convenience. Less conventional attributes relating to personal identity, supporting the local economy or protecting the environment were also prominent and they differentiate online food hubs from supermarkets. These findings are consistent with both prior expectations:

> 1b - *Online food hubs offer novel aspects of appeal compared to supermarkets*
> 1c - *Environmental and societal attributes are important aspects of the perceived appeal of online food hubs*

4.3 Do early adopters and non-adopters differ in their perception of appeal?

Ascertaining whether online food hubs have a broader appeal beyond the early adopters is essential in assessing the potential of the innovation to become more widely adopted. If online food hubs appeal only to a distinct group characterised by their sociodemographic traits or environmental consumerism, the hubs would have limited potential for a widespread adoption and would likely remain a niche segment of the food system. Therefore, one of the main objectives of the attribute survey was to compare the perception of appeal between early adopters and non-adopters. The early adopters' perceptions are based on their experience of using the innovation, whereas non-adopters' do not have direct experience and so their perceptions reflect their expectations of what the innovation may provide. The following expectation was posited:

1d - *Early adopters perceive greater appeal of online food hubs than non-adopters*

4.3.1 PCA of online food hub attributes to identifying underlying constructs

Prior to conducting the between-group analysis, the 22 attribute scale was reduced to six underlying themes using PCA. Identifying underlying constructs was useful for two reasons. First, it facilitated a positioning of this study within broader theoretical discussions about the diffusion of low carbon innovations, by removing some of the food domain specificity. Second, it reduced the number of variables so that they could be more easily incorporated into a regression model to predict food hub adoption in this sample. This PCA was somewhat exploratory because although some of the attributes were derived from previous studies, others such as 'builds connections between producers and consumers' were novel and were included to explore particular aspects of using online food hubs. Consequently, these 22 items had not been combined before in one scale and so there was no guarantee the attributes would constellate into intelligible components.

Due to the large number of missing responses (skipped questions) across the scale, it was considered necessary to replace these missing values. *Listwise deletion* was not considered viable because this would result in the loss of 175 cases, nearly a third of the dataset. There are different approaches to replacing missing values, each with their relative pros and cons, and the choice of approach depends on the specific characteristics of the dataset (Hawthorne and Elliott, 2004; Schlomer et al., 2010). In most instances the respondents only skipped one or two questions of the 22-attribute scale, which is less than 10% of the data and so single imputation methods are suitable (Scheffer, 2002). *Person mean substitution* was not considered appropriate because the 22-item scale explored several different dimensions of appeal, and so someone's response for one particular attribute may not be a good indicator of their response for another attribute. *Pattern imputation* matches the responses from another respondent who provided similar answers for the other attribute questions, but this approach is unsuitable for this particular dataset, again because of the multi-dimensionality of the scale. *Item mean substitution* was therefore used to replace the missing values. The main drawback of this approach is the loss of variation in the distribution of the data for a given variable, leading to a greater possibility of a type II error. However, the main justification is that greater variation was retained overall because 175 cases were preserved. The mean was not imputed for 'don't know' (n=66) because these were intentional responses and so were considered valid.

The 22-attribute scale had a high level of internal consistency, as determined by a Cronbach's alpha of 0.87. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin measure was 0.89 and all individual Kaiser-Meyer-Olkin measures were greater than 0.6. Bartlett's test of sphericity was statistically significant ($p < .001$). The interpretability criterion indicated that a seven-component solution provided the simplest structure, using oblique rotation. Collectively the seven components explain 66.5% of the total variance. Component three, however, was disregarded because there was no clear interpretation of the construct; it does not make sense to combine 'connects me with like-minded people' with 'easily find specific products using search filters' and 'helps me make informed choices about my food'. Removing 'connects me with like-minded people' from the PCA slightly distorted the loadings[23] for some components and so was not considered a feasible option.

The components and the attributes which load on them are shown in Table 13. One notable observation is the simplicity of the component structure. A 22-item scale is quite large, yet the attributes tend to load strongly on only one component, suggesting this data reduction approach was warranted. Another interesting finding, given the exploratory nature of this analysis, is that the six accepted components are theoretically aligned with either Rogers (2003) or Pettifor et al. (2020). Naming the components is an arbitrary process, but there is a clear sense of relative advantage in the attributes which load on 'food quality' and 'money and time'. All of the attributes which load on 'identity' and 'environmental and societal benefits' have a distinct non-core character. 'Convenience' reflects the relative ease of shopping online compared to going to the supermarket and 'compatibility' relates to the practical implications of using food hubs. These results are discussed further in section 4.5.

[23] The composition of the components did not change – the same attributes loaded on the same components. Removing 'connects me with like-minded people' induced loadings >0.3 for some attributes on multiple components

Table 13, Rotated pattern matrix for PCA with oblique rotation of 22 online food hub attributes

	Component							
Attribute	1. Env. & Soc. benefits	2. Compatibility	3. N/A	4. Identity	5. Food Quality	6. Convenience	7. Money & time	**Communalities**
Helps protect the environment	**0.851**							0.741
Helps tackle climate change	**0.845**							0.732
Builds connections between consumers and producers	**0.786**							0.719
Helps support local businesses	**0.685**							0.515
Takes less effort than buying food elsewhere		**0.740**						0.624
Compatible with my daily life		**0.590**		0.370				0.542
Easily find specific products using search filters			**0.773**					0.686
Connects me with like-minded people			**0.689**					0.575
Helps me make informed choices about my food			**0.604**					0.525
Helps me address a problem I face				**0.807**				0.671
Makes a good impression on others				**0.607**				0.490
Makes me feel positive about myself				**0.525**				0.417
Fits wells with my values and beliefs	0.319			**0.442**				0.394
Provides better quality food					**-0.837**			0.721
Provides fresher produce					**-0.832**			0.776
Provides seasonal produce					**-0.783**			0.654
Increases transparency in the food supply chain					**-0.470**			0.392
Home delivery convenience						**0.751**		0.615
Online ordering convenience						**0.744**		0.606
Collecting from local pick-up convenience						**0.606**		0.475
Saves money on food shopping							**0.879**	0.788
Saves time on food shopping		0.355					**0.676**	0.604
Percentage of variance explained	*30.2%*	*9.3%*	*7.0%*	*6.4%*	*5.0%*	*4.4%*	*4.2%*	
Eigenvalue	*6.6*	*2.0*	*1.5*	*1.4*	*1.1*	*1.0*	*0.9*	

Note 1: major loadings for each item are shown in bold

Note 2: factor loadings <0.3 have been removed for clarity. A complete table of the factor loadings can be found in Appendix 4.3

4.3.2 Between-group analysis of the food hub attribute components

Differences in the food hub attribute components for the early adopters and non-adopters were explored using independent-samples t-tests. The results are shown in Table 14 and we can see that the early adopters rank higher than the non-adopters for four components: 'environmental and societal benefits', 'compatibility', 'identity', and 'convenience'. Non-adopters rank higher on 'food quality'. There was no statistically significant difference between the two groups for the 'money and time' component.

Table 14, Comparing food hub attribute components for early adopters and non-adopters using independent samples t-tests

Food hub attribute components	Mean early adopter	Mean non-adopter	p-value	Cohen's d	Effect size - Cohen
1. Environmental and societal benefits	0.252 (± 0.833)	-0.136 (± 1.055)	**.001**	0.396	small
2. Compatibility	0.576 (± 0.957)	-0.31 (± 0.879)	**.001**	0.977	large
3. N/A					
4. Identity	0.164 (± 0.948)	-0.088 (± 1.017)	**.005**	0.45	small
5. Food quality	-0.141 (± 0.949)	0.076 (± 1.02)	**.017**	-0.218	small
6. Convenience	0.179 (± 0.935)	-0.096 (± 1.022)	**.002**	0.277	small
7. Money and time	-0.073 (± 1.070)	0.039 (± 0.959)	.221	N/A	N/A

Note 1: Statistically significant differences are shown in bold
Note 2: Shapiro-Wilk's test showed that none of the shopping preferences are normally distributed
Note 3: Levene's test for equality of variances was used to determine homogeneity of variance between the two groups

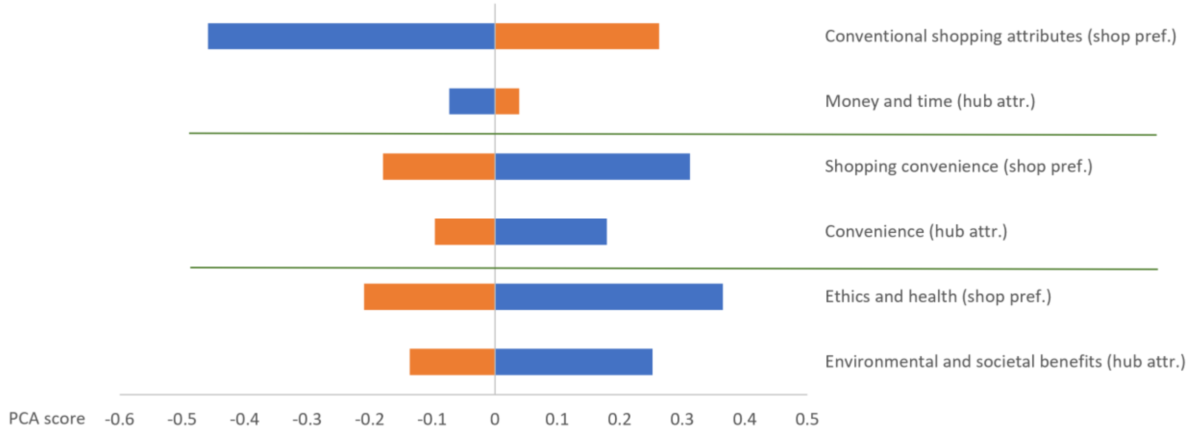
The early adopters' higher ranking for most components is consistent with prior expectations. Indeed, some of the underlying attributes are likely to have been important determinants in the early adopters' decision to start using a food hub. There is no clear pattern for the standard deviations. The early adopter standard deviations were expected to be smaller because of their experience of using food hubs, whereas the non-adopters' lack of experience could conceivably introduce greater variation in their responses. However, the non-adopter standard deviations are smaller for two of the six components.

One important result is the small effect sizes for all but one of the components. Statistically significant differences but small effect sizes indicate that early adopter and non-adopter perceptions are not substantially dissimilar. This finding, together with the relatively high means for most of the attributes (see section 4.2, Table 12), suggests there is potential for a more widespread adoption of online food hubs beyond the current group of early adopters. Additional between-group analysis of the 22 attributes was carried out to corroborate this discovery (see results in Appendix 4.4). To provide an example, early adopters agreed more strongly than non-adopters that using online food hubs fits well with their values and beliefs. Although there is a relatively large mean difference of 0.49 between the two groups, both of the groups' means are above four. An emphasis on ethics is prominent on food hub platforms and so it was anticipated that their customers would prioritise attributes relating to values and identity, and the survey results support this. However, there was no precedent for how the non-adopters would regard these more symbolic attributes. Similarly, the survey results affirm the prior expectation that the early adopters would consider societal benefits, such as supporting local businesses and protecting the environment, to be salient features of online food hubs. Non-adopter perceptions of these two attributes is comparable with the early adopters, albeit with a slightly lower mean. That non-adopters also discern societal or identity benefits from using online food hubs is evidence of their broader appeal.

One clear difference between the groups is their perception of 'compatibility', indicated by the large effect size in Table 14. Between-group analysis of the two attributes which load on the compatibility component revealed that early adopters (4.19 ± 0.81) agreed more strongly than non-adopters (3.73 ± 0.85) that using online food hubs is compatible with their daily lives, a mean difference of 0.46 (95% CI, 0.32 to 0.60), $t(569) = 6.376$, $p < .001$, $d = .55$. In addition, early adopters (3.60 ± 1.02) were more confident than non-adopters (2.98 ± 0.97) that using online food hubs does not take more effort than buying food elsewhere, a mean difference of 0.62 (95% CI, 0.45 to 0.79), $t(565) = 7.244$, $p < .001$, $d = .62$. These two attributes relate to the more practical aspects of using online food hubs; how it fits with daily routines and compares to other modes of food shopping. Early adopters have experience of the practical implications of buying from food hubs, but non-adopters do not and if they perceive using the innovation to require undue effort, these negative considerations could outweigh the positive attributes in their adoption decision.

4.3.3 Correlation between shopping preferences and attributes of online food hubs

Figure 9 combines results from the between-group analyses of the shopping preference components and the food hub attribute components. The figure highlights a correlation in the two groups' responses regarding their general shopping preferences (what is important to them when they shop for food, irrespective of the retailer) and the attributes of online food hubs which they perceive as corresponding with these preferences (what they think about this specific way of food shopping). For example, the early adopters place greater emphasis on ethics and health than non-adopters in their general food shopping decisions. They also consider online food hubs to provide environmental and societal benefits, and this likely constitutes an important dimension of the appeal of food hubs for these individuals. Non-adopters do not prioritise ethics and health to the same extent and so these perceived benefits of food hubs will be less important for them. This correlation supports the prior expectation that early adopters are distinctive not only in their sociodemographic traits but also their food shopping preferences. Their food shopping behaviour (using an online food hub) is associated with these two characteristics.



	Environmental and societal benefits (hub attr.)	Ethics and health (shop pref.)	Convenience (hub attr.)	Shopping convenience (shop pref.)	Money and time (hub attr.)	Conventional shopping attributes (shop pref.)
early adopter	0.252	0.365	0.179	0.312	-0.073	-0.459
non-adopter	-0.136	-0.209	-0.096	-0.179	0.039	0.263

Key: hub attr. = online food hub attribute component, shop pref. = shopping preference component

Figure 9, Correlation between online food hub attribute components and shopping preference components for early adopters and non-adopters

Summary

This section compared the early adopters' and non-adopters' perception of online food hubs. Early adopters tend to perceive greater appeal for the attributes than the non-adopters and this aligns with their stated generic shopping preferences. This finding is consistent with expectation 1d – *Early adopters perceive greater appeal of online food hubs than non-adopters*. However, their perceptions are not substantially dissimilar from the non-adopters and so online food hubs are therefore considered to have a broader appeal which extends beyond the current group of users.

4.4 The most important predictors of adoption

This section synthesises the results presented in the previous sections by identifying the most important predictors of adoption of online food hubs for this sample. A series of binomial logistic regressions were performed to ascertain the likely effects of appeal perception, sociodemographic traits, and various aspects of food and shopping behaviour on adoption. Eighteen independent variables were considered based on statistically significant differences in the between-group analyses. An iterative process of including and removing variables revealed those with the greatest power in predicting the probability of being an early adopter (see Appendix 4.5 for a full description of how the model was developed). Table 15 presents the most parsimonious model, with six independent variables. The first four variables are scale: 'compatibility' (food hub attribute component), % of weekly shop from supermarket, 'conventional shopping attributes' and 'shopping convenience' (two of the shopping preference components). Two categorical dummy variables are included: having an undergraduate degree or not; and cooking a meal from scratch every day or less frequently ('non-adopter' is the reference category in both instances).

The logistic regression model was statistically significant, $\chi^2(6) = 172.408$, $p < .001$. The model explained .432 (Nagelkerke R^2) of the variance in adoption and correctly classified 78.2% of cases. Sensitivity was 61.6%, specificity was 87.0%, positive predictive value was 71.5% and negative predictive value was 81.1%. The area under the ROC curve was .841 (95% CI, .804 to .877), which is an excellent level of discrimination according to Hosmer et al. (2013). All six predictor variables were statistically significant, as shown in Table 15.

Table 15, Logistic regression predicting the likelihood of being an early adopter of an online food hub

Predictor variable	*B*	SE	Wald	*df*	*p*	Odds ratio	95% CI for odds ratio Lower	Upper
Compatibility	.825	.142	33.924	1	**.001**	2.282	1.729	3.012
% of weekly shop from supermarket	-.456	.130	12.384	1	**.001**	.634	.492	.817
Conventional shopping attributes	-.602	.142	18.005	1	**.001**	.548	.415	.723
Shopping convenience	.530	.131	16.429	1	**.001**	1.699	1.315	2.195
Cooking from scratch every day	.883	.247	12.776	1	**.001**	2.417	1.490	3.922
Have a degree	.645	.282	5.255	1	**.022**	1.907	1.098	3.311
Constant	-5.535	1.204	21.127	1	.001	.004		

Table 15 shows that the odds of being an early adopter are 2.4 times greater for someone who cooks a meal from scratch every day and 1.9 times greater if they have an undergraduate degree. Buying a smaller proportion of the weekly food shop from a supermarket is also a strong predictor of being an early adopter. The remaining three variables are PCA components and so the units are less intuitive to interpret, but the model reveals that a preference for the convenience of online shopping and a perception that using food hubs is compatible with daily life both increase the likelihood of being an early adopter. A preference for conventional shopping attributes decreases the likelihood of being an early adopter. Collectively, the six variables in the model increase the probability of predicting adoption by 12.8% above the baseline (constant).

A notable finding from this model is that the six key predictors are not associated with identity or the environmental and societal benefits, despite the importance of these attributes in defining the appeal of online food hubs. Instead, the more practical dimensions of food shopping such as convenience or compatibility are the stronger predictors. The inclusion of cooking frequency is less surprising as this behaviour is consistent with using the fresh ingredients that the food hubs typically sell. Having a degree is also not unexpected as this aligns with Rogers' (2003) characterisation of early adopters.

One practical application of the model would be to orientate food hub marketing towards non-adopters who are broadly similar to the early adopters with respect to these six characteristics. On the basis of this study, they are more likely to be receptive to the idea of using an online food hub than other groups of non-adopters. Target audiences could include recipe exchange/foodie groups on social media, or perhaps busy working families who have limited time to shop in store and so might appreciate the convenience of home delivery. There is, however, a caveat. These six variables represent only some of the characteristics of early adopters. Even when all 18 variables were included in the model, only 83% of cases were correctly classified and so a large amount of variance remains unaccounted for. This model is an indicative tool, but ultimately individuals will make food shopping decisions based on a wide range of considerations and preferences. This decision-making context is explored in the next chapter.

Summary

This section identified the most important predictors of adoption of online food hubs for this sample. These predictor variables can be used to profile the early adopters. Non-adopters who are similar with respect to these six characteristics are considered more likely to adopt an online food hub in the future.

4.5 Discussion

The discussion considers four themes from the empirical findings: the characteristics of the early adopters, evaluating the logit model to predict adoption, compatibility, and the limitations of the quantitative data.

4.5.1 Characterising the early adopters

So who are the early adopters of online food hubs? Rogers (2003) characterises early adopters according to socioeconomic characteristics, personality traits and communication behaviour. Food hub early adopters match Rogers' characterisation in some respects as they have more years of formal education, they earn a higher salary, and they are no different in age to the non-adopters. Personality variables were not included in the attribute survey due to space constraints. Communication behaviour is discussed in chapter 7.

Focusing on the food domain, previous studies have described the customers of short supply chain initiatives as affluent young professionals and families who are environmentally conscious and interested in food (Seyfang, 2008; Brown, Dury and Holdsworth, 2009; Thom and Conradie, 2013; de Bernardi, Bertello and Venuti, 2019). The results from this study support this characterisation to some extent because a relatively high proportion of early adopters work full time, are aged 44 or younger and have children. However, with the exception of employment status, the non-adopters returned similar findings and so this could be a description of the attribute survey sample rather than the early adopters. A large number of lower and middle income households use food hubs and so labelling early adopters as affluent may be erroneous, a finding which corresponds with prior research exploring participation in veg box schemes (Seyfang, 2006; Thom and Conradie, 2013). In terms of food behaviours and preferences, the early adopters typically eat less meat, cook more meals from scratch, grow more of their own food and place a greater emphasis on ethics and health in their shopping decisions than non-adopters. All of these behaviours are associated with environmental awareness or an interest in food (Whitmarsh and O'Neill, 2010; Qasim et al., 2019; Vita et al., 2020). The early adopters tend to buy less food from supermarkets and intuitively this is not a surprise because they receive regular deliveries from the hub. This potential substitution effect aligns with previous studies which found veg box customers buy less fresh produce from supermarkets (Seyfang, 2006; Thom and Conradie, 2013).

4.5.2 Evaluation of the logit model

The logistic regression model was used to determine which characteristics described above are most effective in predicting food hub adoption. One way to evaluate the logit model is to compare it with other studies which used a similar approach. Table 16 summarises the findings of six studies, three of which explored the adoption of a low carbon innovation and the other three the adoption of online grocery shopping. The food hub adoption model correctly classified 78.2% of cases and explained .432 (Nagelkerke R^2) of the variance and so its predictive power is similar to the studies in Table 16. However, each model comprises different independent variables and contexts and so this comparison is presented only as an indication of its efficacy.

Table 16, Logit model results of comparable studies

Authors	Innovation (country)	Variables used in logit models	% correctly classified cases	variance explained (Nagelkerke R^2)
Jansson, Marell and Nordlund (2011)	alternative fuel vehicles (Sweden)	values environmental awareness sociodemographics	71.2% - 78.0%	.071 - .334
Noppers et al. (2016)	smart energy systems (Netherlands)	instrumental attributes environmental attributes symbolic attributes	not stated	.09
Mundaca and Samahitab (2020)	solar PV (Sweden)	government subsidies peer effects environmental awareness sociodemographics	not stated	.408 - .412
van Droogenbroeck and van Hove (2017)	online grocery shopping (Belgium)	sociodemographics household characteristics	73.7% - 75.8%	.265 - .390
Frank and Peschel (2020)	online grocery shopping (Denmark)	social norm complexity comparability relative advantage risk sociodemographics	not stated	.54 - .67
de Magalhaes (2021)	online grocery shopping (Brazil)	delivery lead time delivery cost order fulfilment sociodemographics	74.9%	not stated

Note: some studies presented multiple logit models, hence why ranges are presented for the % correctly classified cases and the variance explained

One question which arises is: how could the model have been improved? In other words, what variables were omitted from the attribute survey that would have increased the predictive power of model, accepting there is a trade-off between including more questions to gather useful data and risking respondent fatigue (Blair, Czaja and Blair, 2013). Table 16 provides an insight into the variables which other researchers considered essential. Sociodemographics are somewhat generic and this underlines the importance of these characteristics in informing our understanding of consumer behaviour. This study aligns with Mundaca and Samahitab (2020) and Frank and Peschel (2020) in using elements of DoI to explore social influence or innovation attributes. A third observation is that functional attributes are prominent in two of the studies which explore online grocery shopping, whereas values and symbolic attributes feature strongly in the studies investigating the adoption of eco-innovations. The attribute survey attempted to incorporate functional *and* symbolic attributes, along with various behavioural dimensions. One legitimate criticism of the survey instrument could be that it included too many questions at the expense of achieving a more thorough understanding of one specific theme. These research design decisions invariably affect what data is available and how it can be applied, including building a valid and reliable logit model to predict innovation adoption.

4.5.3 Compatibility

The model revealed that the practical dimensions of using online food hubs, such as convenience or compatibility, are stronger predictors of adoption than perceptions of product attributes (food quality and freshness) or public good attributes (environmental or societal benefits). These product and public good attributes are central to online food hubs' value proposition, as evidenced by the findings of the attribute survey and their visibility on the food hub platforms. The early adopters and non-adopters tend to agree on the appeal of these attributes, hence their low potential to differentiate the two groups. If online food hubs are considered by both groups to have a relative advantage over other food retailers in many respects, the inevitable question is: why hasn't everyone already adopted an online food hub? Part of the answer is the non-adopters' uncertainty regarding the compatibility of using a food hub with their existing food preferences (low cost, availability of well-known brands), their current practices (frequency of cooking from scratch, shopping at supermarkets), and their daily routines.

The challenge of (in)compatibility or innovation resistance was highlighted by Rogers, who defined compatibility as "the degree to which the innovation is seen as consistent with existing values, previous experiences, and needs of the user" (2003, p.240). Compatibility can therefore be normative or cognitive, relating to people's values or what they think. It can also be practical compatibility with what people do - their past experiences and perceived needs (Tornatzky and Klein, 1982; Rogers, 2003). In light of the non-adopters' high appeal perception of product and public good attributes, it would appear to be the latter, that using an online food hub may not be congruent with existing shopping practices and preferences. Practical compatibility is arguably less of an obstacle than normative compatibility because practices can be changed more easily than values (Steg and Vlek, 2009; Crompton and Kasser, 2009). Moreover, some aspects of practical incompatibility are arguably being eroded as online grocery shopping is becoming increasingly common (Food Standard Agency, 2019; Statista 2021a).

One strategy for overcoming innovation resistance is identifying the consumer segment that is most likely to adopt and positioning the innovation to them through targeted marketing (Ram and Sheth, 1989; Rogers, 2003). The logit model is intended to support this strategy by identifying characteristics which a sub-group of non-adopters may share with the early adopters. Another approach is harnessing the social influence of early adopters by supporting communication mechanisms among consumers, whereby experience sharing may reduce perceived risk (Xiong, Payne and Kinsella, 2016; Jansson, Nordlund, and Westin, 2017). Irrespective of the chosen strategy, the focus should be on enhancing the value proposition with respect to compatibility, not substituting core aspects of appeal such as food quality or the provision of environmental or social benefits.

4.5.4 Limitations of the attribute survey data

One limitation is a possible self-selection bias for the survey respondents. It is likely that early adopters from the six hubs who are especially enthusiastic about online food hubs chose to participate. In terms of the impact on the data, their appeal perception could be more positive compared to hub users who chose not to participate. A self-selection bias for the non-adopters is also possible. Determining their motivations for taking part is more speculative, but likely include the survey incentive and a genuine interest in online food hubs and this study. It is difficult to say how their self-selection could influence the data. A second limitation is the non-probability sample. Convenience sampling yielded adequate numbers of early adopters to conduct comparative statistical analysis with the non-adopters, but neither group should be considered representative of the UK population and this reduces the external validity of these findings. A third limitation is a common drawback of cross-sectional survey data. Inferences can be made about associations between the independent variables (sociodemographic characteristics, food behaviours and preferences) and the dependent variable (adoption), but these should not be construed as causal explanations.

5 Results: In what ways does the household food context affect the use of online food hubs?

This chapter answers the second research question: In what ways does the household food context affect the use of online food hubs? The premise of this question is that various influencing factors and existing food practices form a decision-making context for the adoption and ongoing use of digital food innovations. Early adopters will evaluate and modify their use of the innovation according to whether it meets their needs and expectations, or how it fits alongside their existing practices.

Figure 10 shows the decision-making context for the use of online food hubs. The upper segment includes influencing factors which affect not only the use of food hubs, but household food behaviours in general (discussed in sections 5.1 - 5.4). The middle segment comprises repetitive, interrelated household food activities: cooking meals, planning menus, shopping for food, and so on. The hub user decides how to organise these activities in their daily life. Moreover, the experience of using the hub can affect how they approach these activities, indicated by the feedback arrow on the right of Figure 10. The lower segment presents the potential GHG emission outcomes of these actions. Behavioural outcome findings are discussed in section 5.5. There are also various additional outcomes, shown on the lower right of Figure 10.

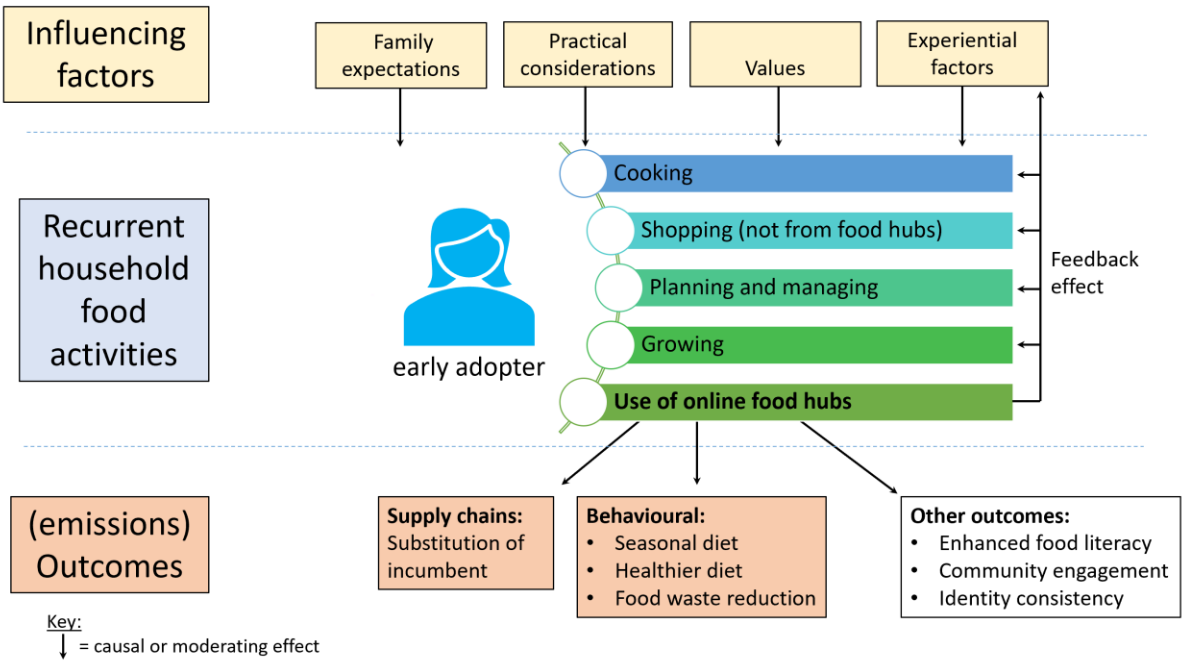


Figure 10, Chapter 5 overview - the decision-making context for using an online food hub

The findings presented in this chapter are based primarily on qualitative data collected in semi-structured interviews with current users of online food hubs (n=20). Content analysis was used to identify important themes in the qualitative data. Where appropriate, questionnaire survey data is used to support the interview findings. Table 17 presents the sociodemographic and household characteristics of the respondents.

Table 17, Interview respondents' sociodemographic and household characteristics

Characteristic	**Category**	**Frequency**	**%**
Gender	*Male*	*4*	*19*
	Female	*17*	*81*
Age	*25-34*	*2*	*10*
	35-44	*4*	*20*
	45-54	*3*	*15*
	55-64	*7*	*35*
	65+	*4*	*20*
Education level	*degree*	*18*	*90*
	vocational	*1*	*5*
	A levels	*1*	*5*
Employment status	*self-employed*	*10*	*50*
	part-time	*2*	*10*
	full-time	*2*	*10*
	retired	*5*	*25*
	other	*1*	*5*
Household combined income (before tax)	*More than £35,000 per year*	*11*	*55*
	£35,000 per year or less	*7*	*35*
	Prefer not to say	*2*	*10*
Dietary preference	*Omnivore*	*6*	*30*
	Flexitarian	*9*	*45*
	Pescatarian	*3*	*15*
	Vegetarian	*1*	*5*
	Vegan	*1*	*5*
Household size	$\bar{x}$ *2.65, SD 1.18*		
Household composition	*1 adult*	*1*	*5*
	2 adults	*12*	*60*
	2 adults, 1 child	*2*	*10*
	2 adults, 2 children	*4*	*20*
	5 adults, 1 children	*1*	*5*

Note: a husband and wife participated in one interview, hence there were 21 respondents but only 20 interviews

5.1 Household food practices and decision-making

This section explores how using a food hub interacts with other recurrent food behaviours: shopping (from other retailers), cooking, storing, and growing food. It also considers how dialogues between family members can shape food decisions. The following expectations were explored:

> 2a - *The use of online food hubs is affected by broader household food decisions and behaviours*
> 2b - *The use of online food hubs encourages a reduction in household food waste*

5.1.1 Shopping, cooking and food waste

Shopping

Most routine food purchasing decisions are taken by the person(s) who does the shopping and the cooking. Approximately half of the respondents share these duties with their partners (I2, I5-I8, I13, I15, I18, I20), whereas for the other half, the respondent tends to take the lead (I1, I3, I9-I12, I14, I17). Irrespective of who carries out these tasks, many families regularly have discussions around food and where to buy it (E1.4, 2.1, 2.2) (I4, I5, I8, I9, I12, I13, I15, I17, I18):

> "My partner hasn't been completely on board with all of this [using the hub] in terms of, a bit resistant…Yeah, I don't think he feels quite so passionate about the freshness and quality as I do. There's so miss-match there, I think, between the two of us. But I think over time he sort of sees how easy it is and he enjoys now not shopping at the weekends." (I5)

This quote highlights that not everyone in a household will want to eat the same food. Family members' expectations invariably play an important role because of different dietary preferences (I15, I16), food intolerances (I4, I20), and tastes (I15, I19). This was especially apparent in catering for children:

> "We have two young kids, they're not that into kale. You know, it's just not like 'oh quick, make the kale dad, that'd be great'. So that becomes a bit of a struggle." (I19)

Kale may not be a popular choice on many children's food wish list, but they do request other items and this has a bearing on where people choose to shop (I11, I15, I19):

> "The kids chow through so much horrible breakfast cereal. So the things we'll get from the supermarket are things like, you know, kind of crappy stuff the kids eat, like loads of biscuits." (I15)

Decisions on where to buy food are therefore influenced by the availability of particular products and by a desire to accommodate family members' food preferences. Aside from their food hub order, the majority of the respondents use supermarkets for at least some of their food shopping (E1.1-1.2) (see Appendix 3.6).

The respondents described food shopping as a routinised activity (I8, I9, I15, I16, I18, I19). Using a food hub necessitates changes to existing shopping habits and for some this requires a conscious effort (E1.5 & 2.11) (I8, I11, I15, I16, I20):

> "I suspect that for most people, it's the usual inertia, you know, this is how I do my shopping. And it requires an effort to start doing things in a different way…it's easy for me now, because I'm in a routine of, you know, I put the order in on a Friday evening and I pick it up the next Friday afternoon." (I8)

Adapting to a weekly order cycle entails having a good awareness of domestic stock levels and identifying which items will need replenishing, rather than impromptu shopping (I4, I8, I11, I14-I16, I20). Others experienced altering their habits as a cognitive challenge because it involves 'changing the mindset' (I11) or 'weaning off' supermarkets (I15). Despite this effort, new habits can quickly be formed (I4, I8, I16):

> "To a certain extent, we've kind of embedded ourselves into it [using the food hub], because you get used to that being the way you do things. So you get used to being able to access those particular things which we can't get from other places. So yeah, kind of like tied ourselves into, you know, it's part of our habits." (I4)

Ordering food through an online platform rather than shopping in store is another potential change, but most respondents did not find this problematic because the *Open Food Network* site is considered easy to use (E2.10) (I1-I3, I5-I8, I10, I11, I14, I16, I17, I20):

> "It takes five minutes. That's one of the Locavore pluses for me, is the simplicity of their ordering system with a limited range of products. So it's quick and easy, and it's almost like I can do it on my phone. It's a very well-designed system." (I5)

Changing routines and suppliers requires an initial investment of effort and a commitment to 'giving it a try'. Once this decision has been made, most hub users adapt to new ways of shopping fairly quickly.

Cooking

Shopping decisions are inseparable from the daily decisions on what to cook and eat. Most interview respondents regularly prepare meals from scratch (I1, I2, I4-I6, I9-I13, I15, I20), reiterating the survey findings, but a further point of enquiry was whether their cooking habits had changed since they started using the food hub (E2.3). One finding is that using the hub reinforces their propensity to cook by encouraging culinary creativity or breaking engrained habits (I3, I6, I7, I11, I15, I19):

> "Sometimes you have vegetables that I wouldn't maybe pick if I was in a supermarket, so it creates a bit of a challenge and then I can find the recipes to use this vegetable. So it sort of gives a bit more the possibility to be more creative." (I7)

> "I quite like that it [using the hub] gets you out of 'right we're having spaghetti bolognaise tonight, that's it'. You know, you can get in that rut with food." (I19)

The opportunity to try out new recipes and, particularly for *Locavore* customers, the element of surprise in discovering unusual vegetables in the weekly box[24] is something several customers said they enjoy (I11, I15, I18, I19).

A second observation is that using the food hub prompts a greater focus on menu planning. Several respondents described how they plan their meals around their food hub delivery (I1, I2, I4, I5, I9, I11, I14, I15, I19, I20):

> "When I first started using Locavore, I was doing a lot more menu planning. I think just because it was quite new, getting fresh foods weekly. So I would have to think about how I was going to use that. I was probably prior to that just, you know, buying bits and bobs here and there." (I1)

Preparing meals to incorporate fresh produce from the hub can also have an educational function (I5, I15):

> "Teaching the kids about cooking differently as well. Our kids are teenagers, so rather than thinking, 'what am I going to cook tonight?' and going and getting everything, it's like, 'what have we got in the house?' and making a meal around that." (I15)

These findings reveal that the weekly hub delivery represents not only a source of food but also a stimulus to learn about food, to reflect on and disrupt existing cooking habits, and to engage with other family members around the topic of food.

Food waste

Household food waste is related to cooking and shopping habits and has significant GHG emission implications. This was an emotive subject and several respondents conveyed strongly that they dislike wasting food (E2.4) (I1, I7, I11, I13-I15, I20):

> "I don't like it, I feel very, it makes me feel a bit [expresses a sad face] about throwing food away, it's just dreadful…especially animal food waste, like that really pees me off, because I think an animal's just died and now you're chucking it away." (I20)

This quote emphasises that many people regard food waste not just as a minor monetary loss or a failure to manage their fridge stock, but as a moral problem. Animal ethics, the climate impacts, and

[24] The *Locavore* business model entails a set weekly veg/fruit box. Customers can then use the *Open Food Network* platform to order additional items from a wide range of food categories, which is delivered together with their veg box. See: Locavore

the farmer’s effort invested in the production were all mentioned. Despite this aversion to wasting food, several respondents have experienced challenges such as differing food habits and preferences within the household (I5, 15, I11, I19):

> “He has changed his habits being married to me because I’ve made him more aware of food politics and also food waste. When I met him, he hated having the same thing twice in a row, he hated leftovers.” (I15)

Another common challenge is managing domestic stock levels alongside busy working lives (I5, I10, I17):

> “There’s definitely some stuff [wasted] on a weekly basis…I’d still consider myself to be a wasteful person. I don’t maintain a strict enough schedule with myself to get where I sort of feel that everything must be used. Yeah, there’s too much other stuff going on.” (I10)

Regarding the impact of joining the food hub, most respondents said their food waste habits had not changed because they were already conscious of avoiding waste (I2-I4, I6-I15, I17, I18). They employ strategies such as eating leftovers the following day (I2, I3, I6, I8, I11, I12, I15, I18, I20), giving surplus to a neighbour (I4, I5), and ‘hiding’ unpopular vegetables in meals (I11). However, three respondents have reduced their waste because they have gained more experience in storing food and buying only what they need (I1, I19, I20), and using the hub has played a role in this:

> “I think I’m wasting a lot less. I guess, I’m also thinking more about how I store my food. So most of what comes from Locavore will go in the fridge…I’m more conscious of how I store it so I make sure I get the best use out of it.” (I1)

Using an online food hub increases people’s awareness of their own consumption patterns and enhances their knowledge of how to store food. A minority have reduced their food waste, although this climate benefit should not be overstated because most hub users already take steps to avoid waste.

5.1.2 Growing food

The attribute survey revealed that early adopters are more likely to grow some of their own food than non-adopters and so food growing was investigated in the interviews to established how this may affect the use of online food hubs (E1.7). Several respondents currently grow some of their own food (I2, I6, I9, I11-I16) or expressed a desire to do so in the near future (I3, I4, I10, I17). Some also keep chickens for eggs (I2, I11, I13) and one is a member of a community orchard (I17). The main impact is that they tend to buy less from the food hub during the summer months (I2, I11, I12):

> "We tend to get more vegetables in the winter from them than we do in the summer when we're growing more things in the garden…they tell you what's in the bag every week and, you know, if it has stuff that we grow, we obviously don't get it." (I12)

This variation can be significant - one respondent described their weekly food hub order ranging from £10 to £90, depending on what they have available in their garden (E1.10) (I2). However, growing food is an investment of time and effort, and this does not work for everyone:

> "Last year was a disaster, the tattie harvest was just really bad and I've decided I'm not going to do it this year. I just don't have time…You've kind of got to decide what's doable and I guess that probably coincided with my decision to go Locavore." (I15)

For this respondent, buying from the hub substituted for growing their own vegetables but remained ethically consistent with how they wanted to eat. In both of these quotes, there is no apparent preference in terms of the produce itself. Instead, other factors such as seasonal availability or competing demands on their time determine where they choose to source their food.

5.1.3 Prosumerism

An unexpected theme to emerge in the interviews, and one which is connected with growing food, is 'prosumerism'. Online food hubs are somewhat unique as a food supplier because an individual can simultaneously be a consumer *and* a producer. Five of the twenty interview respondents participate in their local hub in this way (I8, I11, I16, I17, I19). For instance:

> "I've got a polytunnel, so I grow a lot of veg for ourselves. But if I've got excess, I'll take it there [the food hub] as well which is fabulous. And then when I haven't got anything, I get it back from there, sort of thing. It's a lovely system." (I11)

Selling through the platform can be small-scale and informal, as in the example above, and the food hubs actively facilitate this process by providing equipment and administrative support (I8, I11):

> "I sell my honey through the hub as well. And I extract my honey in a facility that they've set up as part of their wider activity…It was just really easy to become a supplier and stuff that would have gone in the bin otherwise went to good homes. So I got a few pence for them, not very much, but that wasn't the point of it." (I8)

These occasional producers benefit by avoiding waste and receiving a small payment, and they seem to enjoy participating in a different role. For the producers who run a more formal business, three key benefits were identified. The first is income:

> "I, as a producer, understand that [if I] buy direct from the producer, they get more money than if I buy through a middleman." (I16)

The increased profit margin is likely the most important motivation for producers who sell through online food hubs. Another advantage is greater flexibility in their production/harvesting cycle, rather than working to fulfil pre-determined quotas (I9, I17):

> "Another good thing with it is that if you haven't got a product one week, you can just take it off. Because that puts people sometimes under pressure if, you know, they've been asked for eight and they've only really got four. So it's quite a flexible thing." (I17)

The third benefit is having a viable outlet, either for those who operate on a scale which is too small to sell through supermarkets (I3, I8, I9), or because they want to sell ethically produced food. Farmers may wish to use particular production methods and supply local markets in order to be consistent with their own values, and not just to meet consumer demand for certain types of products (I11, I16):

> "My ethos now isn't always just organics, it's the emphasis on local is just as important sometimes. And a lot of growers, they're not necessarily certified organic, but that doesn't mean that they don't grow in that way. It's just as a small producer, you can't afford to have your Soil Association certification. So you grow in tune with nature and you don't use chemicals, but you're not organic." (I16)

Online food hubs provide an alternative mechanism for selling organically grown produce which is based not on certification (which costs £765 per year[25]), but on transparency and trust (I4, I16).

Although the focus of this project has been on the benefits to consumers, these respondents offered valuable insight into the producers' experience of using online food hubs. They identified both functional and symbolic benefits for producers and so parallels can be drawn with how consumers perceive food hubs. Another observation is that the capacity to be a prosumer is relatively rare in the food domain. Only food sharing apps and local gift economies are comparable and, in both of these examples, the producer role is less prominent.

Summary

Existing food habits and family member preferences affect decisions about what food to buy and where buy it. Expectation 2a - *The use of online food hubs is affected by broader household food decisions and behaviours* - is therefore supported. For some hub customers, using online food hubs enhances their food knowledge and skills and they reduce their household food waste. Expectation 2b - *The use of online food hubs encourages a reduction in household food waste* - is partially supported as this applies to some individuals but not all. Thus, shopping decisions can influence food habits and so there is evidence of a two-way interaction or feedback effect (shown in Figure 10).

[25] Soil Association, 2022. Certification fees for food businesses to Soil Association or EU organic standards. See: fees-for-food-businesses-to-sa-or-eu-organic-standards.pdf (soilassociation.org)

5.2 Practical considerations in food shopping decisions

This section considers some important practical considerations or factors which can affect where people choose to shop and what they buy. These are: money, access to shops, product range, time and convenience. This expectation was investigated:

> 2c - *The use of online food hubs is affected by practical considerations*

5.2.1 Money

Locally produced food is often regarded as more expensive than food bought in supermarkets and this perception was explored in the interviews because price is a principal consideration in shopping decisions. The respondents were asked if the food from the hub is expensive and whether this affects how much of their weekly shop they buy from the hub (E2.9). Their responses were varied and revealed a nuanced perception of price. Six respondents stated the hub produce is expensive (I3, I6, I8, I9, I11, I19), but nine others believe the price is variable - some items are expensive, others are not (I2, I4, I5, I7, I10, I13, I15, I17, I20). For example, vegetables (I5, I10, I15), fruit (I13) and milk (I16) are not considered expensive, whereas meat (I15, I16) and fish (I14, I16) are. The respondents tended to provide a justification for the higher price, such as better quality (I2, I5, I6, I9-I11, I16, I18):

> "You think 'oh my god, four pounds fifty [or] five pounds for a tiny jar of something' and then you go 'I'll give it a try'. And inevitably, it's amazing and you go 'okay, well that's another one to add to my list of products that I'll buy again because it's so good." (I5)

> "It's more expensive for sure but if I see a clear correlation between freshness, quality and social responsibility, I am fine with it." (S384)

Other justifications included supporting local businesses (I2, I8, I9, I16-I19), providing environmental benefits (I6, I8, I10, I13, I14, I16, I20), shopping convenience (I5, I6), or the mark-up for organic produce (I7, I9, I19). These justifications parallel the most important attributes of online food hubs identified in the attribute survey (see section 4.2). From the producers' perspective, they try to set a price which they believe is fair and reflects their investment of time and resources:

> "My price point is set in terms of the product, in terms of trying to factor in all the elements that it takes to make it. It's a handmade product and I also have to reach a threshold whereby it's what people would be prepared to pay." (I16)

The hub producers seem to correctly gauge their customers' willingness to pay because 84% of the attribute survey respondents believe the produce is priced fairly (Q7.3).

Many of the interview respondents discussed price with reference to their personal circumstances. Several stated they can afford to pay higher prices for the food they want (I3, I5, I6, I9-I12, I15, I19), whereas others said that price does affect which items, or how much in total, they buy from the hub (I2, I7, I8, I16). Some employ strategies to reduce their overall food shopping expenditure to offset the expense of their hub order, for instance buying in bulk from wholesalers (I2, I4, I15) or avoiding alcohol and expensive processed foods (I20). Others framed the additional outlay as warranted because it provides health benefits or enjoyment for their family (I5, I11, I15):

> "When it comes to food, it's not that money is no object, but money is not a pressure. And I feel like it's such a good investment for our family." (I5)

A third theme focused on the supermarkets' business model or the externalities which the respondents believe are not reflected in their prices (I10, I15, I19, I20, S417):

> "If you go in and look at the meat and stuff [from the food hub], it is expensive but that's just how much food should cost." (I15)

This perspective essentially rejects the assertion that local food is expensive by countering that food sold in supermarkets is often unreasonably cheap.

The qualitative evidence reveals that most hub customers do consider price when they are shopping for food. However, their perception of value for money is strongly influenced by a range of factors such as quality, fairness and environmental benefits.

5.2.2 Access to shops

Another factor which can affect where people choose to shop is ease of access (E2.8). This can relate to their personal situation, for example they may have health issues which prevent them from going to the shops (I3, I5), or they do not own a vehicle (I2, I3, I7):

> "We never used to have a car. So that's a big factor in what you buy in terms of food, whatever would fit in a bicycle pannier. Basically, [the] supermarket thing was complete, yeah, that was something that we didn't do." (I2)

Four respondents stated they sometimes shop by bicycle, thus reducing 'last mile' emissions, but this does require more frequent shopping trips (I2, I10, I15, I19).

The proximity of the shops to their home was another dimension of access mentioned by the respondents. Some have easy access to nearby supermarkets or high street independent shops (I1, I2, I4, I8-I10, I15, I18, I20). For others, particularly those who live in rural areas, the shops are a few miles away and so the journey can be a consideration (I11-I14, I17, I19; S446, S591):

> "If I make a special trip to Waitrose, it's a round trip of about 18 miles. And so that's a bit of a, you know, you don't do that on a whim. So you have to weigh that up against going to a supermarket you're not so keen on, but it's less diesel." (I17)

Two respondents said they prefer using independent shops to supermarkets, but these are becoming increasingly scarce in some areas (I14, I19):

> "Before, I could walk 15 minutes and I could be beside a fish mongers and a butchers and a bakers and candlestick makers. It shows you having these things nearby that haven't died out, it's amazing how much more you use them. But I guess that's just more common in more affluent areas now." (I19)

These quotes reveal that people may have preferences for particular shops but access-related challenges can deter them, or at least cause them to modify their shopping behaviour. For people who do not have easy access to shops, the appeal of a home delivery food service is evident.

5.2.3 Product range

A third consideration is the range of products available from a given retailer. It was anticipated that online food hubs' narrower product range, relative to supermarkets, could limit the size of the weekly hub order because customers would be unable to buy everything they need. Indeed, the survey qualitative feedback contained 38 requests for a greater selection of cupboard stock items and 26 requests for more non-food items (Q7.1). The interview respondents were asked if the hub provides a sufficient choice or product range for their weekly shop (E2.12). Nine respondents stated they are happy with the range (I1, I3-I8, I13, I18), although six said they would like the hub to expand (I1, I3, I4, I7, I12, I19). Some hub users actually prefer a narrower, 'curated' range because it saves time (I5, I17) or facilitates their decision-making when shopping (I5, I13, I15, I20):

> "I kind of find it easier to large extent…if you [are] presented by an array of like ten different varieties of beans, which one do you pick? When really you just want a tin of beans…So there'll be very little differentiation between the different brands [at the hub]. I actually find it simpler." (I13)

Two respondents went further, saying they sometimes feel overwhelmed by the extensive product range in supermarkets (I17, I20). Three respondents pointed out that they would not expect the food hub to have as broad a range as supermarkets (I8, I14, I17).

In terms of the impacts on shopping behaviour, some respondents buy what they can from the food hub first and then supplement this with a supermarket shop to buy the remaining items (I6, I9-I12, I14):

> "Our biggest lament of the present system is using the hub, but using Morrisons to fill in the other half…as the Tamar hub expands what it has available, we would tend to use them where we can." (I6)

A further observation is that the hubs stock some items which are not easily found in other shops (E1.11). The respondents listed various niche products such as specialist bread (I2, I4-I6, I12), artisan cheeses (I2, I8, I12, I14), olive oils or vinegars (I4, I5, I10), spreads and pickles (I5, I14, I17), unusual vegetables (I2, I4, I11), and bio cleaning products (I1, I2, I8). This adds variety to their food shop:

> "Another reason we get fruit and veg from the food hub, actually, as you can get far more interesting stuff. Because there's lots of producers doing interesting perennials like skirret and yacón, and honeyberries, and jostaberries… I mean, there's lots of things on there that you can only, I don't know how else we would get them." (I4)

Although hub users enjoy buying niche items, the availability of these products is not their main reason for using the hub. For most respondents, buying from the hub is part of their regular weekly food shop and speciality items tend to be spontaneous purchases in addition to their regular order (E1.12) (I1, I2, I5, I6, I8, I12, I14):

> "It's more of a fun aspect of it, 'Oh, look what they've got this week, isn't that interesting?' It's not that I couldn't do without them. For example, we order saffron buns, rather than get a cake…so there are some things that are kind of specialty items that we've kind of gotten to like and want to get." (I14)

Other motivations for buying speciality foods are to send to family or friends as gifts/care packages (I4, I10, I16) or for social occasions, such as inviting people around for dinner (I2, I8, I10, I12).

5.2.4 Time and convenience

The respondents were asked if they ever feel time-constrained when shopping for food to establish whether time was a factor in their shopping choices (E2.7). Several respondents stated they did not feel time constrained (I2, I3, I11-13, I15) and some attributed this to their life circumstances, such as being retired (I12) or working from home (I11, I15). For those who do feel time pressured, using the food hub is considered a way of saving time or making life easier and they relate these benefits to their personal circumstances (I1, I5-I8, I10, I12, I19, I20). Examples included having a busy demanding job (I5, S375), not wanting to carry heavy shopping (I8), or wishing to avoid taking young children to the supermarket (I1, I5):

> "I think the onset of the whole thing was about avoiding the slog. I genuinely felt when I signed up for the [Locavore] veg box that it was saving me three or four hours a week…With small kids…it takes an hour to leave the house, it takes an hour to then traipse around the supermarket. You know, you get distracted and go off and buy other stuff. It just freed up a lot of time at the weekends and to me that's worth any additional cost." (I5)

For these respondents, this mode of shopping saves time and effort which they can then dedicate to other priorities, such as spending more time with the family. This is not unique to food hubs, but this evidence suggests online ordering and home delivery provides more leisure time or flexibility in managing domestic tasks.

There are, however, a few time-related challenges associated with using the food hub. Customers who choose to collect their order from the pick-up point sometimes find it difficult to make the collection time because of other commitments (I2, I4, I11-I13):

> “I’m working, quite often, at the time that is the collection time. And the nature of the work that I do, because people book in a bit last minute, sometimes it’s difficult to pin myself down to being free to go and collect.” (I2)

Other challenges include popular items selling out quickly when the order cycle opens (I4), or that the delivery day may not coincide with when they would like to receive their food (I4).

Summary

The relative importance of practical considerations on food shopping decisions is very much dependent on an individual’s household situation and on their perspective. Online food hubs introduce some perceived benefits in relation to these considerations, but also a few drawbacks. Expectation 2c - *The use of online food hubs is affected by practical considerations* - is accepted, with the caveat that the outcomes vary according to the individual.

5.3 The role of values in food decisions

The food hubs and the platform providers promote their core values on their websites and their messaging is directed at both producers and consumers. Their values appear to resonate with consumers because environmental, social and identity benefits were among the most salient attributes of online food hubs identified in the questionnaire survey. However, the closed-ended survey questions did not allow the respondents to articulate their own values or explain why the associated public or symbolic attributes appeal to them. A key objective of the interviews was to develop a deeper understanding of the hub users' values in relation to food and how their values influence their food decisions. The participants were asked if there are any values or ethical considerations which are important in their household's eating or shopping decisions (E2.5). A number of themes emerged: environmental and social values, compromise, identity, and critique of supermarkets. The following expectation was explored:

> 2d - *Values are important in the hub users' food decisions*

5.3.1 Environmental values

A desire to reduce the carbon footprint of the food they consume was a very prominent theme and was mentioned by most of the respondents (I1-I7, I9, I11-I13, I15-I17). They articulated this concern in different ways, such as emphasising the importance of reducing food miles (I1, I5, I12, I13, I16, I17), reducing air freight (I6, I11, I13), or describing the climate crisis/emergency (I2, I7, I9):

> "Carbon footprint is a big one. I mean, a lot of our food choices have been driven by the method of transport for transporting the food." (I2)

> "Just a general awareness about the crisis the planet is in and, you know, that's grown in momentum. I guess we're probably, sort of, more aware of it. Now I look...little bits of broccoli come all the way from Kenya, you know, what are we doing!?" (I9)

In addition to avoiding carbon intensive foods, other actions included reviewing their own footprint using a carbon calculator (I17), prioritising brands that offset their emissions (I13), and advocating for carbon labelling on foods (I3). The respondents were conceivably sensitised to the issue of carbon emissions because it was presented as a rationale for the study in the interview preamble. Nevertheless, they showed a high level of awareness of the climate impacts of food production and transportation and perceive buying locally sourced, seasonal food as a feasible way of reducing their carbon footprint.

Several respondents discussed the importance of sustainability in their food choices (I5, I7, I10, I12-I17, I20). This broad theme could be disaggregated into specific concerns such as pesticide use (I5), land and natural resource use (I7), deforestation associated with palm oil production (I15-I17), and overfishing (I12, I14):

> "I've been careful about the fish I buy to make sure it's sustainable. In fact, I did ask a question of the hub a while ago sort of saying, they get it from a fishmonger in Looe, you know, 'what about the sustainability of the fish?" (I12)

This quote demonstrates that customers sometimes engage in a dialogue with the food hub about the production or harvesting methods of a particular item before deciding whether to buy it (I4, I10, I12, I15). Supermarkets may not have such detailed knowledge of their supply chains to answer these types of questions, beyond referring to products with sustainability certification.

Animal welfare was another key determinant in shopping and dietary decisions (I4-I7, I9, I11, I15-I18, I20). Again, different aspects were identified, for instance respect for the animal as sentient being (I4, I7, I11, I20), apprehension about the rearing conditions (I7, I16), and the potential impact on human health (I4, I5, I7):

> "I wasn't eating chicken [for] more than 10 years, 10 to 15 years, I think, because I knew about the conditions in which chicken were grown...How the animals are kept and what is the effect on their health and also on my health." (I7)

These concerns have led some respondents to source meat and other animal products only from the food hubs or other local suppliers where they can trace the provenance (I4, I16, I17). Many of the respondents stated they prefer buying organic produce (I1-I4, I7, I9, I12, I14-I20), in part because organic certification functions as an umbrella for a range of ethical standards, including animal welfare and sustainable farming practices (I7, I9).

A fourth aspiration was avoiding plastic packaging and the associated pollution (I3-I8, I11, I12, I15-I17, I19, I20). Although some respondents believe the hub producers could go further in reducing their use of plastic (I4, I15), the food hubs are generally considered to perform better than supermarkets in this regard (I5-I7, I11):

> "One of the reasons I like shopping at Locavore is the reduction of the plastic wrapping and packaging in general in relation to the usual supermarkets." (I7)

Other strategies to reduce the amount of plastic entering the household include shopping at refill stores (I18-I20), ordering glass bottled milk deliveries (I15, I18) and buying larger containers of detergents (I12).

These findings reveal that 'environmental values' is a broad category that encompasses multiple specific principles or preferences which relate to how food is produced, transported and packaged. Hub users strive to make food choices that are consistent with their environmental values and buying from online food hubs is one such choice, although the above examples reveal other intentional actions. Some values-based food decisions are infrequent and unequivocal (avoid eating chicken) whereas others occur often and may be less stringently adhered to (check items for the country of origin to avoid air freight). Some decisions are concerned with *where* to buy food (environmental impacts of the supply chain) and others with *what* to buy (environmental impacts of a particular item). Thus, the hub users' food decisions are often complex because they may incorporate multiple values and product-specific information, as well as the practical and household considerations discussed in the previous sections.

5.3.2 Social values

Buying food directly from local producers and supporting the local economy was an important societal benefit for almost all of the respondents (I2-I5, I8, I9, I11-I16, I18-I20). 'Local' is a label commonly used to describe food and has multiple interpretations and so the hub users' understanding of 'local' was further explored. One finding is that local small-scale producers are considered more likely to be better stewards of the land than larger farming enterprises (I4, I8):

> "Using local produce is important to me, keeping small businesses going is important to me. Small businesses because, by and large, the environment, local environment is important to them because their livelihood depends on it." (I8)

Several respondents described their preference for knowing where their food comes from, how it is produced, and by whom (I1, I4, I6, I9, I15, I19). This provides a context or sense of connection with the food they eat:

> "I'm very interested in the story behind things. Whatever I buy, I like to kind of know about the story behind it." (I15)

> "When people look at Locavore and see what they do, and that they have a little bits of farm in Queens Park or some of the parks in Glasgow…they'll be like 'oh, that's really good, that's grown just down the road." (I19)

This sense of connection has an added layer of social meaning for hub users who know the producers personally (I2, I9, I16):

> "You scroll down and you know exactly who the suppliers are. Because they're all very local, quite often you know who they are. Like Tree Hill Farm, which is where they get their meat from, I mean, I know the farmers there." (I9)

The implication in these quotes is that the respondents are used to buying food from other shops which is devoid of context and is simply a product. The food hub platforms reinstate the context by telling the story of each item - who the producers are, what farming methods they use, and why they choose to farm this way.

Five respondents introduced the idea of accountability, that we as consumers have a responsibility to be more aware of how our food is produced and the potential negative impacts (I3, I4, I7, I9, I10). Their point of reference was imported food because of weaker agricultural and employment regulation in many countries[26]. The respondents' concerns included land grabbing (I3), price inflation for those on low incomes in developing countries (I7), and poor working conditions for farm labourers (I10). Online food hubs are viewed as a means of facilitating this accountability:

> "My reasoning is that even if it's not ideal production, I'm seeing more of the consequences, rather than exporting them to some other poor person somewhere else. So I will go for local as much as I possibly can, even if it's not organic, but ideally, small producers and done with a kind of conscience and ethically." (I4)

This quote is interesting because it presents a slightly more critical view of this process of decreasing our current detachment from how our food is produced. In addition to positive experiences like supporting local businesses, hub users may encounter some negative aspects when confronted with the realities of farming on their doorstep. Another potential downside of buying local is that switching supply chains could reduce the income of producers in developing countries (I9, I16).

A third social value was concern for the welfare of the hub staff and two respondents described their local hub as a responsible employer (I10, I11):

> "I appreciate the kind of initiative that they are. They're a fair wage employer…being a good employer matters to me and with being a good employer, I guess, I mean just treating your employees well and fairly and considerately." (I10)

Decent working conditions and a fair wage for the producers, employees and delivery drivers therefore influences where some hub users choose to shop.

The final social value relates to the food hubs' community engagement and their partnerships with local charitable organisations. *Locavore* customers can opt into the 'Good Food Fund', whereby they make a financial donation when placing their order and this provides healthy food for those experiencing food poverty in Glasgow (I1, I10, I19). Some producers who supply *Tamar Valley Food Hubs* have established a similar scheme in Plymouth (I20) and a few of these initiatives now offer training on healthy eating and cooking (I10, I19). Food hubs are seen to actively tackle social issues in their local communities and this fosters loyalty among their customers.

As with the environmental values, the hub users tend to view buying from online food hubs as a way of ensuring consistency with their social values. Social public benefits are more visible than environmental public benefits and the respondents demonstrated a good awareness of the hubs' role in providing them.

[26] Online food hubs do sell a limited range of imported products but these items tend to have 'Fairtrade' certification (I11, I14)

5.3.3 Compromise

Adhering to values, in particular the environmental ones, can restrict choice in terms of what foods are permissible because of the ingredients commonly used in processed foods, or the climatic limitations of what can be grown in the UK (I15, I16):

> "For a while I stopped buying biscuits that had palm oil in it and then it was like you could basically only get one type of biscuit…I was baking all my own biscuits and I'm like, you know, that's not sustainable." [in terms of time and effort] (I15)

> "You have to be accepting that there's certain things if you want to eat, they're not grown in this country. So you've got to buy them from elsewhere." (I16)

One respondent's solution to this challenge is to accept a degree of compromise between the ideal and what they perceive as realistic:

> "It's easy to just feel so overwhelmed by all the conflicting food advice that you almost get kind of frozen into not bothering...I'm leading the way to just try and make some changes that are sustainable for us as a family…and not feel guilty about the fact we could do even better because, at the moment, this is good enough." (I15)

Accepting compromise reduces the risk of decision fatigue or a sense of failure in not living in accordance with your values. It may also avert tension within the household if family members have different food preferences.

5.3.4 Identity

People attach symbolic meaning to their lifestyle choices and this creates a sense of self- or shared identity. For some hub users, their identity perception is inherently related to their values and is expressed in terms of how their food choices make them feel about themselves, or how they wish others to regard them (E2.6). For example, three respondents said they feel positive when they use the food hub because they believe it is a morally good thing to do (I10-I12):

> "I feel that I'm doing the right thing, the ethical thing, by getting stuff from them." (I12)

Others described using the food hub as being part of a community or movement (I5, I14, I15, I17, I19). Buying from the hub can even be a form of political expression (I10, I15):

> "I used to do a veg box years ago and then I stopped…I think I'd read something about food politics again, you know, and it just reminded me that it's a radical thing…It's so important to use your pound as a vote." (I15)

This hub user understands spending money as more than a transaction to obtain something they want or need. By aligning their purchasing decisions with their values, they are articulating their support for the kind of food system they would like to see. Using their pound as a vote signals their views to other actors in the food system such as supermarkets or policy makers.

For one respondent, the relationship between their food choices and their identity extends beyond the personal and into the professional sphere:

> "I'm active in our parish council. We were one of the first in [place name removed], maybe the first parish council to declare a climate emergency. And I'm heading up a tree growing project with the parish council raising money through crowdfunding. So I'm becoming much more active in environment issues. You can see that our diet kind of matches the broader, you know, political dimension I operate in." (I9)

This respondent recognised a need to ensure their dietary choices are consistent not only with their personal concerns about climate change, but also their public role in driving local climate action. Although dietary choices are inherently personal, eating a meat intensive diet (or indeed any other carbon intensive behaviour) could risk undermining their credibility as an environmental advocate.

In these examples, food behaviours which tend to occur in the household, such as dietary choice or buying local produce, are invested with symbolic meaning. Thus, for some individuals, these behaviours represent yardsticks in their efforts to be consistent with their values. This is a self-reflective process, but there may also be an expectation that their actions will be appraised by others.

5.3.5 Critique of supermarkets

The interview respondents often discussed the perceived benefits of using online food hubs in the context of using supermarkets. The respondents were at times very critical of supermarkets and this can be largely attributed to a perceived incompatibility with their values. In some cases, this was because of their personal experience, for example the unavailability of ethical products (I3, I17, I20) or a dislike of the shopping environment and their marketing approach (I5, I11, I13, I15 I17):

> "I hate supermarkets, even before the pandemic…I just don't like the lighting, I don't like the layout, don't like being conned. Don't like the 'BOGOFs', don't like the fact that they think we're stupid and we'll buy it because it's got something on it." (I11)

In other instances, the hub users' critique centred on broader social or environmental issues. Their grievances included how supermarkets treat their staff (I3, I10, I17), the social disconnection associated with self-service check-outs (I3), or the perceived manipulation of producers to attain greater profit margins (I3, I8, I11, I12):

> "I think especially dairy farmers get a really raw deal off supermarkets. They just decide a price and either sell to us or don't sell." (I3)

These concerns were directed at supermarkets and how they choose to run their businesses. However, some respondents view supermarkets as a part of wider systemic problems with how we source our food and run our economy. One example is their market dominance which enables them to undercut their competitors (I10, I15, I20):

> “Simply because of size, they’re able to undercut and offer things at values that other places can’t. But I think in the long run, we pay the price for the discounts…I don’t think big supermarkets are evil, but I think capitalism is a problem and any dent I can make in it, I’m happy to…I see that bigger stores also offer jobs and things like that which are important. But the subsidies that they receive and the products that they have, I think, are to the detriment of our society.” (I10)

Another concern was the health implications of dietary choices, particularly as cheaper foods tend to be less healthy and this disproportionately affects lower income groups (I5, I17):

> “We can keep building enormous, more enormous hospitals, but we need to look at why people are in there in the first place. There’s a big problem with food in Glasgow, I think, in terms of working people who are on a very poor diet…you see people in Lidl and what they’re buying…high sugary foods and, you know, square sausages…really full of fat. So the whole obesity thing, the obesity epidemic.” (I5)

A third example is the supermarkets’ reliance on complex supply chains and the environmental impacts this entails:

> “There was a Scottish company and they do frozen fish. And those fish, once they were dead, travelled far further than they ever did in the ocean. Because they were caught here, sent somewhere else for processing, sent to the Far East for packaging, brought back to get sold in the shops here. The carbon footprint is just horrendous. And you think, well, it’s not actually that fresh by the time you’re getting it. It’s been dead a long time.” (I3)

In these last three quotes, the respondents describe three widely acknowledged problems with the current food system: supermarket monopoly, rising levels of diet-related illness, and the absence of any environmental accounting or accountability for food supply chains. Although supermarkets contribute to these problems, they cannot be held entirely responsible for them and this raises questions about the need for appropriate governance. Some respondents recommended policy measures such as increased taxation of supermarkets (I10), a holistic approach to legislation through the Good Food Nation bill in Scotland (I3), or subsidising healthy food (I5, I15):

> “I personally feel cost is an undervalued factor in terms of trying to bring about change. Why don’t they just make fruit and vegetables free? Why don’t they? Would that change [the] behaviour of our local population? Of course it would, and it wouldn’t be that expensive.” (I5)

Their proposals echo some of the ideas that have been discussed in other forums such as England's National Food Strategy (2021). Moreover, there are recent examples of successful policy interventions in the food domain when a problem was perceived as intractable, such as the levy imposed on plastic shopping bags. However, addressing these three problems would involve a much greater level of market interference than the four UK parliaments/assemblies have historically been prepared to consider.

Summary

Values play a crucial role in most hub users' food decisions. Buying from online food hubs is one important way of ensuring their food choices are consistent with their values, although they reported several other strategies. Supermarkets are often perceived as incompatible with their values, although they remain an important food supplier for many hub users. These findings are consistent with expectation 2d - *Values are important in the hub users' food decisions*.

5.4 Experiential factors and the use of food hubs

This section considers the experience of using the food hub and how this can shape the customers' view of the innovation or how they choose to use it. Four experiential factors are discussed: trust and relations, motivation shift, social activities and community, and dissatisfaction. Most of the findings presented in this section were inductive and so there was no associated prior expectation.

5.4.1 Trust and hub-customer relations

Trust was a notable theme to emerge in the interviews and two dimensions were identified. The first is the customers' trust in the hub to provide foods which meet their expectations regarding certain attributes and so they do not feel the need to spend time checking how and where their food is produced (I4, I5, I10, I15). The expectations they mentioned in the context of trust were food quality (I5, I9), ethical farming (I7, I19), produce which is seasonal (I1, I7) or sourced locally (I15, I19):

> "I trust them for the veg and they've got really good communication. So for example, they've said, 'that's it for Scottish onions' or 'there's a garlic shortage, we're having to get it from Europe', you know, that's good enough for me." (I15)

This transparency in the hubs' supply chains and business decisions is very important to some customers because it enables them to feel confident that their food choices are aligned with their values.

The second dimension of trust relates to their experience of customer service. Although hub users do occasionally experience problems with their orders, they appreciate the hubs' open approach to communication as well as their willingness to resolve issues (I4-I6, I8, I9, I11, I17):

> "The responsiveness of the business means that when there have been problems over the years, you feed it back, and they sort it. So that's interesting as well because you feel a bit valued. Although I don't hang out with the folk in there, you build up this trust and you're part of it. So you're a Locavore supporter, which feels very positive…It's probably about human connection, there is a connection there. It's not like the anonymity of a supermarket." (I5)

In general, the hub users feel listened to when they are dissatisfied with an aspect of the hub's service and they recognise the efforts of the people who run the hub to improve how it operates. This constructive, at times even collaborative, process fosters a sense of loyalty and connection with the hub staff, something which is lacking in their experience of using supermarkets (I5, I11). In defining themselves not just as a customer but as a 'supporter', this respondent expresses a shared identity with the food hub and this is a fundamentally different relationship to the one they have with supermarkets.

5.4.2 Motivation shift

The attributes of an innovation as well as recommendations from peers may be instrumental in the initial decision to adopt (see sections 4.2 & 7.2). However, the rationale for using the innovation can change over time as the early adopter gains personal experience (Rogers, 2003). Most of the interview respondents are long-term hub customers (see Appendix 3.7) and they were asked if their reasons for using the hub have changed over time (E1.8 & 2.13). For the majority, their motivations had not significantly changed (I2-I4, I6-I10, I13-I15, I17, I18). Their foremost reasons remain a combination of environmental benefits (I1, I3, I6, I10, I12, I17), supporting local producers (I3, I12, I13, I15), food quality (I10, I13, I15) and shopping convenience (I10, I15). A few respondents stated that new motivations had arisen in addition to their initial reasons for joining. These include particular foods they enjoy which the hub sells (I14), concerns about disruption to supermarket supply chains after Brexit (I7), and being involved in their community.

5.4.3 Social activities and community

The hubs organise or participate in various public events and so have an important social function in their local communities. The respondents mentioned several structured activities such as bicycle repair workshops, apple pressing days, and community orchards (I8, I10-I12, I17), as well as regular informal gatherings in the hub café (E4.12) (I1, I2, I6, I7, I11, I13, I20). These activities help to connect people:

> "They were running beekeeping courses so I went on that because they happened to have a last-minute spare place…I hadn't anticipated quite so much the sort of sense of community that has come out from it, helping me to feel a part of what's going on within the local area. That I hadn't anticipated and that's been nice." (I8)

This sense of community and the opportunity to meet with people became particularly important during the pandemic lockdowns. The outdoor collection points inadvertently became one of the few remaining social spaces where hub customers could stop and talk to each other (E1.15) (I2, I8, I11, I13, I14):

> "In the pandemic, because I never went anywhere…my little trip to pick up my, I don't have it delivered, to pick up my shopping from the food hub was an absolute highlight of the week." (I11)

Some food hubs also facilitate online interaction using social media platforms. *Locavore*, for instance, encourages recipe sharing for unusual vegetables and organises a monthly competition for the best meal prepared using hub produce (I1, I7, I15). Food hubs therefore engage with their customers in various in-person and online settings and bring people together around a shared interest in food.

5.4.4 Dissatisfaction and discontinuance

A scaling up of online food hubs is contingent not only attracting new customers, but also on retaining existing customers. The interview respondents were therefore asked if there was anything they did not like about buying from the food hub (E2.14). Although the respondents were generally satisfied with the hub's service, they did mention some aspects which they believe could be improved. The most common were 'vague product description' and 'large variation in the size of the vegetables', both of which make it difficult to plan how much food to buy (I4, I12-I14, I17):

> "It's hugely variable and sometimes really hard to know. Because it will be like 'one bunch of this, 200 grams of this, one thing-amy of this' and you're just like, 'I have no idea, actually, what the comparison is between these." (I4)

Other issues mentioned were unnecessary packaging (I4), too much soil on the vegetables (I5, I7), occasional issues with product quality (I1, I4, I9), and a short window for placing orders (I11, I14). However, the respondents were keen to emphasise that none of these problems had deterred them from continuing to use the hub (I1, I5, I9, I11, I14, I17).

For some hub users, however, these problems are sufficient to deter them. Former hub users were not interviewed, in part because they are difficult to identify and therefore invite, but some information is available from the former users who participated in the survey (n=25). Most former users decided to discontinue within one year of adopting. Their reasons varied but the most common were insufficient product range (S136, S485, S581), a preference for shopping in store (S369, S373, S518) and being unable to use up all of the food before it spoiled (S352, S357, S360) (Q8.6). They were comparable with the current users in terms of their hub shopping behaviour and their sociodemographic characteristics (Q8.2-8.3; Q13.1-13.9). On the basis of this limited evidence, discontinuance is driven by personal shopping preferences or their experience of using the hub not matching their prior expectations.

Summary

This section considered the customers' experience of using online food hubs. Some hub users develop a sense of loyalty which they attribute to positive interactions with the staff or the hub's active engagement in the local community. However, online food hubs are not for everyone and some decide to discontinue.

5.5 Food hubs and dietary choices

This section considers some of the behavioural outcomes of the adoption decision - how using online food hubs affects dietary choices. Three aspects were explored: dietary preference, seasonality, and health. The following expectation was investigated:

> 2e - *The use of online food hubs encourages a shift towards lower carbon diets*

5.5.1 Dietary preference

There is enormous variety in what people choose to eat but 'dietary preference', as a set of established dietary categories, is a good indicator of the carbon intensity of someone's food choices. The attribute survey revealed that early adopters are more likely than non-adopters to eat a flexitarian, vegetarian or vegan diet (see section 4.1.2). Based on this finding, one aim of the interviews was to explore whether using an online food hub has any demonstrable effect on dietary preference. The respondents were asked if they eat more or less of any particular foods since they started using the hub (E3.4). This question was deliberately phrased without any reference to meat consumption in order to reduce the potential for a social desirability response bias. Several respondents had switched to a flexitarian or plant-based diet in recent years and the most important motivations were personal health (I5, I9), concerns about animal welfare (I16, I18, I20), and the environmental impacts of meat production (I2, I6, I7, I9, I15-I17). For example:

> "I am trying to reduce the amount of meat we eat. But that's not because of the hubs, really, that's just because it's not good for the planet and it's probably not good for me." (I9)

Some respondents mentioned the influence of contemporary environmental movements or a possible peer effect in their dietary decisions (I2, I7):

> "Probably a couple of years ago now, [I] just made a big effort to go back to vegetarianism. Yeah, as part of the kind of extinction rebellion stuff…I started to talk to people about all of that and thinking, 'really, I need to have a look at my own diet too.' So yeah, a reawakening of environmentalism." (I2)

For others, the shift towards a more plant-based diet is not always a conscious action:

> "I think we just always tend to have meat or fish as a special time, you know, a moment or something. And it [their diet] tends to be vegetarian, but I don't actually think 'let's cook something vegetarian', it just is." (I18)

These examples illustrate that someone's dietary preference may involve multiple considerations but these are distinct from their decision to use an online food hub. Indeed, none of the respondents attributed a change in their dietary preference as a consequence of using their local hub. There was, however, evidence that using food hubs is compatible with different dietary preferences (E3.5) (I1, I2, I4):

> "I think we could have met [our dietary] requirements easily without Locavore…. normally they'll put something quite random in there and you have to learn what it is and how to cook it. So it makes things more interesting and varied but not necessarily easier to be vegan." (I1)

Hub users that eat meat and are interested in provenance and animal welfare standards also found that the food hub meets their requirements (I15-I19):

> "Most of us are into the ethos where we'd rather eat a small amount of meat, maybe only once a month, but have good meat. We don't want to go and buy from the supermarket just for the sake of it. So we're quite fussy about where the meats come from. Yeah, I do have a bit of meat from the hub." (I17)

Online food hubs therefore sell an adequate range of products to cater for most dietary preferences. The food hubs are neutral on diet and do not try to influence people's dietary choices.

5.5.2 Seasonality

Seasonality is another element of dietary choice which has implications for reducing emissions. Seasonality as characteristic of food is not always apparent when shopping in supermarkets (I1, I16, I17), but it defines local food networks and was identified in the survey as one of the most salient attributes of online food hubs. Thirteen of the twenty interview respondents stated that using their local hub has contributed to them eating a more seasonal diet (E3.8) (I1, I5, I7, I10-I12, I14-I20):

> "One of the things with the hub is, it sticks stuff under your nose seasonally. We shouldn't expect everything, you know, strawberries in December, it's nuts." (I17)

A seasonal diet may be an incidental outcome for early adopters who use the hub for different reasons, but some respondents perceive clear benefits of seasonality such as better taste (I16, I20), a longer shelf life (I20), or reduced environmental impacts (I7, I16). Some look forward to a particular vegetable, fruit or season (I5, I10, I11, I17, I18, I20):

> "It's lovely to start to begin to recognise, 'Oh, it's the time for asparagus'…at a certain time of year you have asparagus and at this time of year you have grünkohl which is a kale dish with pork fat and sausages. And there's a lovely yearly pattern, so we very much enjoy that now." (I5)

A yearly pattern eating in harmony with nature's cycles may sound appealing, but it comes with a challenge, namely the lack of choice of fresh produce during the 'hungry gap' in the spring (I4, I5, I7, I8, I15, I16, I18, I19). Food hub users have different strategies to manage the limited variety during this period. Some choose to supplement their hub delivery with non-seasonal food from the supermarket (I10, I12, I15):

> "We do top it up with some unseasonal stuff like, you know, peppers or tomatoes and things. And again, it's just like, it's a bit of compromise." (I15)

> "I'm much more conscious if I'm eating something and it's not seasonal, which doesn't mean I don't buy it, but it just means I do think about it more." (I10)

In both of these quotes there is an implicit acknowledgement that imported or non-seasonal food has a higher environmental impact, but they accept this to avert monotony in their diets. It is a conscious decision rather than a spontaneous purchase. Other strategies include culinary creativity using the same vegetables (I5, I15, I18, I19) or storing produce in a home freezer to use it out of season (I13).

Aside from the hungry gap, there was a consensus among the respondents that seasonal food was something they enjoy, but some articulated seasonal eating as something we *should* do (I5, I7, I8, I16, I17). For instance, this hub user views it as a shared responsibility, even if they do find it repetitive:

> "I'm keen on the concept of, 'let's try and use what's available'. So I basically feel you're signing up for this group effort here and let's just go for it and take what they're giving and not be fussy and try and make do with it. But we do get too many squash." (I5)

This idea of a group effort or social contract to eat seasonally sits in contrast with the current food shopping paradigm of 'everything available, all year round'. However, one respondent could recall when seasonal diets were the norm:

> "I remember as a child going and picking runner beans, digging up carrots, picking strawberries. It was all part of the way we grew up. Then with the advent of supermarkets and people being able to buy non-seasonal food all year round, people eat differently." (I16)

That some people can remember eating differently prior to supermarkets reminds us that the mainstream model of food provision emerged relatively recently, despite its ubiquity. Food habits can change fairly rapidly, even at the societal level.

5.5.3 Healthy diets

The third theme to emerge was healthy diets. Over half of the respondents believe their diet has become healthier since they started using their local hub (E3.7) (I1, I4-I8, I10, I11, I14, I17, I20). For some, their decision to eat healthier was independent of their adoption decision and using the food hub simply enables this dietary choice (I1, I4, I5). For others, however, using the food hub actually provides the impetus (I6-I8, I10, I11, I20):

> "I'd say it's probably a little bit healthier….just because generally there's a regular delivery of fresh fruit and veg coming in and it needs eating." (I10)

The regularity of fresh fruit and vegetables entering the household, combined with the desire not to waste any food, appears to subtly encourage healthier eating habits. Moreover, one respondent described how they use the hub delivery as a way of educating their children about healthy food and where it comes from (I5). These are important positive aspects of buying from online food hubs, particularly in the context of rising diet-related illness. Although this project focuses on the climate impacts, these findings demonstrate that food hubs provide multiple co-benefits.

Returning to the question of emissions, a healthy diet does not *necessarily* equate to a low carbon diet. However, it is plausible that increasing the proportion of vegetables in people's diets may result in less frequent consumption of meat and dairy products, even if this is not a conscious decision or they are unaware of a dietary shift.

Summary

This section considered the dietary implications of buying from online food hubs. There was compelling qualitative evidence that using food hubs encourages a healthier, more seasonal diet. The evidence was inconclusive concerning the impact on dietary preference, although using food hubs can complement existing low carbon dietary choices. Expectation 2e – *The use of online food hubs encourages a shift towards lower carbon diets* – is therefore partially accepted, on the basis of supporting healthier, seasonal eating.

5.6 Discussion

The discussion considers four key themes from the empirical findings: the innovation-decision process, the context of using online food hubs, some of the behavioural outcomes, and the limitations of the qualitative data.

5.6.1 The innovation-decision process

Rogers (2003) presents a model of the innovation-decision process consisting of five stages (see Figure 11). The knowledge and persuasion stages were considered in chapter 4 by exploring the characteristics of the early adopters and their perception of innovation attributes, both of which are associated with the decision to adopt. The qualitative data presented in this chapter informs our understanding of the latter part of this process – the implementation and confirmation stages. This is where an innovation is used on a regular basis (implementation), evaluated in terms of its compatibility with previous practices or perceived needs (based on actual experience post-adoption, rather than anticipated benefits pre-adoption), and ultimately integrated into ongoing routines (confirmation) or otherwise discontinued. Seventeen of the twenty interview respondents have been using their local food hub for two years or more (see Appendix 3.7) and so most are in the confirmation stage.

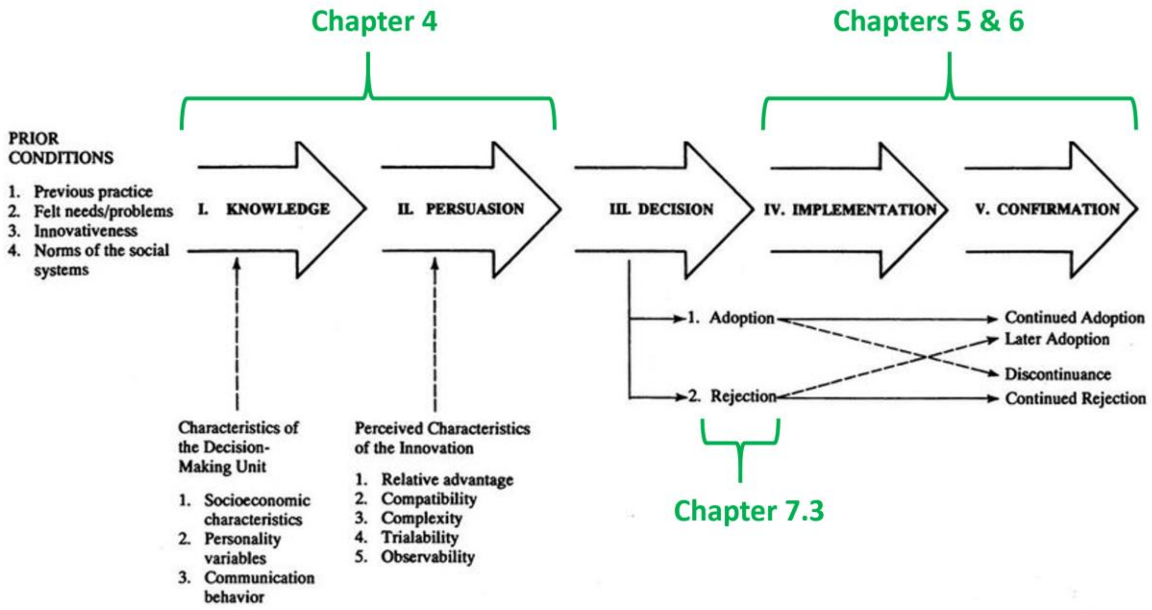


Figure 11, The Innovation-Decision Process, adapted from Rogers (2003, p.170)

The implementation and confirmation stages have received much less attention in diffusion literature than the preceding stages of knowledge, persuasion and decision (Tornatzky and Klein, 1982; Kapoor, Dwivedi, and Williams, 2014). However, digital service-based innovations are becoming increasingly common and so scholarly interest in the use phase is growing (Vrain, Wilson and Andrews, *in press*). For low carbon innovations, exploring variability in the use phase is especially important because the intensity of use has implications for GHG emissions through reduction or substitution mechanisms. Online food hubs are both service-based and potentially low carbon and so a strong research emphasis on the use phase was crucial in this study. Combining the interview data and the food hub order history (see chapter 6) builds a comprehensive picture of how food hubs are used and why the early adopters choose to use them in this way. Due to the minimal consideration of the use phase in DoI, other bodies of literature were consulted to understand these aspects. There are several related terms which are relevant for understanding the use phase: a 'behaviour' simply describes an action or something that people do, whereas 'habit' or 'routine' describes the repetition of familiar actions in daily life that are activated by context (Kurz et al., 2015). A 'practice' describes a particular way of doing something.

5.6.2 The household food context

The literature focuses on online food hubs as a socio-technical innovation which creates new market linkages and potentially supports community or environmental objectives. There has been little attention regarding how consumers choose to use the innovation and how it may affect their consumption behaviour. The aim of the interviews was to place the adoption and ongoing use of online food hubs in context, and to the determine the behavioural outcomes of adoption.

Day to day food practices – cooking, shopping, eating, planning – are highly routinised and therefore resistant to change (Macdiarmid, 2014; Dyen et al., 2018). Habitual behaviours develop through the repetition of actions in a stable context which produce successful outcomes (Verplanken et al., 1998; Nash, Whittle and Whitmarsh, 2020). For example, the weekly shop at the supermarket successfully refills the cupboards or preparing the kids' favourite meal is assured of a favourable response. Once established, any disruption to these habits entails an investment of time and cognitive effort. Moreover, there is a risk of disapproval from family members if their expectations are not met (Olsen and Grunert, 2010). This was indeed the experience of some of the respondents in this study. A further challenge is the potential for a 'practice conflict' or incompatibility, where the new activity does not align with existing practices or daily routines (Wood, Tam and Witt, 2005; Fuentes et al., 2021). For instance, food hub users who collect their order did not always find the pick-up time or location convenient because of other unrelated commitments in their daily life. The habitual nature of food behaviours and the interconnectedness of food practices are cited as obstacles to achieving more sustainable consumption patterns (Macdiarmid, 2014; Evans, 2014; Devaney and Davies, 2016). However, therein lies an opportunity because if one habit can successfully be changed, this can potentially affect multiple related food practices.

A key finding from the interviews is that the adoption and ongoing use of an online food hub represents an 'intervention' which can disrupt several food behaviours. A change in food shopping habits is unsurprising, but the qualitative evidence suggests this disruption can extend to meal planning, cooking, storing, or even producing food and selling surplus. New habits are formed and then reinforced by positive experiences, some of which directly relate to food hub attributes, such as a particular food the customer enjoys. Other positive experiences relate to the lifestyle options or broader social context that using a food hub may support, such as having more free time at weekends by avoiding the 'big shop' or feeling more involved in the local community through participation in workshops. These experiential aspects, whether food related or otherwise, are important in the consolidation of reconfigured food habits:

> "The more links a practice shares with other practices, the more stabilized these become. Therefore, to exist, to be reproduced and temporarily stabilized, a new (sustainable food shopping) practice needs to find its place among other practices." (Fuentes et al., 2021, p.8)

A further observation is the key role of the household 'food champion' who takes the initial decision to adopt and is then willing to navigate the bumpy road of changing embedded habits. Evidence from this study and others is that altering habits is not a passive process and requires agency, reflexivity, and perhaps even advocacy to persuade household members who are less enthusiastic (Devaney and Davies, 2016; Dyen et al., 2018).

5.6.3 Behavioural outcomes of using online food hubs

One outcome of using an online food hub is greater food literacy, which encompasses not just preparing meals but also an improved knowledge of nutrition, meal planning, ingredient shelf life, and how to store food (Vidgen, 2016; Burton et al., 2017). This knowledge is acquired ad-hoc as hub users adapt to new provisioning routines or unfamiliar foods. A related outcome, at least for some individuals, is a reduction in household food waste. Both this study and that of O'Neill et al. (2022) found that hub users' enhanced food literacy is accompanied by the adoption of new habits (systematic auditing of food stocks) and flexibility in meal choice (meals are determined by what needs using up). This willingness to alter household food behaviours is driven by an underlying value that food waste is morally wrong:

> "While wastefulness was a source of guilt, the gravity of the waste offence varied depending on the product and place of purchase…food acquired from non-mainstream sources appears to have elevated status and thus the wasting of this is more significant." (O'Neill et al., 2022, p.7)

Thus, greater value is ascribed to food hub produce because of its environmental, local or quality attributes. Moreover, the sense of guilt may be amplified because many hub users have a personal connection with the producers who have invested their time and energy (ibid). If guilt aversion provides the moral incentive, the ongoing use of food hubs fosters the competencies and modified food routines which facilitate the waste reduction. Previous research has shown that habitual over-provisioning and a lack of food knowledge are contributing factors to food waste (Evans, 2014; Aschemann-Witzel, 2016). Using an online food hub moderates both of these factors.

Another outcome is eating a healthier, more seasonal diet. This finding is consistent with other studies which found the quantity and diversity of fresh fruits and vegetables increased following adoption of an alternative food supplier (AbuSabha, 2016; Verame et al., 2018). In her longitudinal study of veg box customers, Huyard describes a veg box subscription as a:

> "single long-term choice [which] helps consumers choose more sustainable products while competence building maintains their ability to use and value them." (2020, p.8)

Although using an online food hub is not usually subscription based, it is similarly perceived by hub customers as a long-term decision regarding their food provision. Placing the order each week simply enacts this initial decision. This ongoing commitment ensures one essential component of a healthy diet, the produce itself, is structurally embedded within regular food shopping practices, which in turn reinforces a routine of cooking from scratch. The quote above refers to another component, the competencies required to convert unprocessed or unfamiliar vegetables into meals. This food literacy develops over time and, in some instances, arises out of necessity. Moreover, many hub users view this learning and creating experience positively, rather than healthy eating as a reluctant good intention (ibid). These findings highlight that using an online food hub provides the material, cognitive and behavioural elements which, collectively, constitute one route to healthier dietary outcomes.

5.6.4 Avoiding discontinuance

As indicated in Figure 11, one possible outcome of the adoption-decision process is 'discontinuance', whereby an adopter decides to stop using an innovation following an unfavourable evaluation of its attributes or performance (Talke and Heidenreich, 2013). This is distinct from 'innovation rejection', whereby a potential adopter decides not to adopt at the persuasion stage because of a perceived incompatibility with prior needs or conditions (discussed in section 7.3). Discontinuance inhibits diffusion and, for low carbon innovations, it represents a missed opportunity to reduce emissions. Moreover, discontinuers may communicate their dissatisfaction amongst their social networks, creating a 'negative interaction effect' which can hinder adoption (Vrain, Wilson and Andrews, *in press*). A focus only on the motivations and context of adoption risks overlooking the dynamics and consequences of discontinuance.

The main drivers of discontinuance identified in this research were inadequate product description (weight/quantity, farming methods), particular food attributes (short shelf life, limited product range), and personal shopping preferences (in-store rather than online). Food hub staff and producers are able to address some of these, for instance improving the product description or identifying gaps in the range, and the customer feedback collected in this study may be useful for this purpose. Another suggestion would be to create a digital feedback mechanism, either embedded on the hub platform or using a social media platform, through which customers could easily express any concerns to the hub, thus facilitating different modes of dialogue. This study has found that engaging in a dialogue fosters loyalty and increases customers' understanding of the constraints faced by the hubs. In some cases, transparent communication may be sufficient to avert discontinuance even if an immediate solution to their concern is not available.

5.6.5 Limitations of the qualitative data

There are some potential biases which should be acknowledged even if they cannot be eliminated. As with the attribute survey respondents, there is a possible self-selection bias. The strategy of recruiting from three different expenditure levels did preclude a sample weighted heavily towards those who spend the most at the food hub (see Appendix 3.7). Nevertheless, it is likely that hub users within each expenditure level who are especially enthusiastic about online food hubs chose to participate. In terms of the impact on the data, these respondents could conceivably place more emphasis on the positive aspects such as their shared identity with the hub and less importance on the negative aspects such as high cost, relative to other hub users.

The choice of food hubs has two implications for the data. First, *Tamar* and *Locavore* are large, well established hubs with a wider range of products than smaller, less established hubs. The interview respondents are therefore more likely to consider their local hub as a viable alternative to the supermarket for a larger proportion of their weekly food shop than the customers of smaller hubs. Indeed, the respondents were predominantly positive about the product range and this perception, along with a potentially larger weekly order, may lack external validity for describing other food hubs. Second, *Tamar* and *Locavore* are the same two hubs that were selected for the food hub order history and so there is consistency between the two data sets (see chapter 6). The interview respondents therefore referred to identical products and prices as what is represented in the observed shopping preference data. Qualitative descriptions of items such as 'expensive' could be cross-referenced with quantitative information on the actual prices, increasing internal validity.

6 Results: In what ways do people use online food hubs?

This chapter considers how the early adopters use online food hubs in a practical sense. Several shopping behaviours were explored: the types and quantities of the food they buy, how often they place an order, and whether using the hub likely affects how much food they buy from other retailers. These behaviours have implications for reducing emissions because of a potential dietary shift or a substitution of supply chains (discussed in chapter 8). Moreover, they provide insights into some outcomes of the adoption decision process. Figure 12 provides an overview of this chapter - the aspects of food hub shopping behaviour that were investigated and a comparison of weekly shopping baskets from two distinct supply chains.

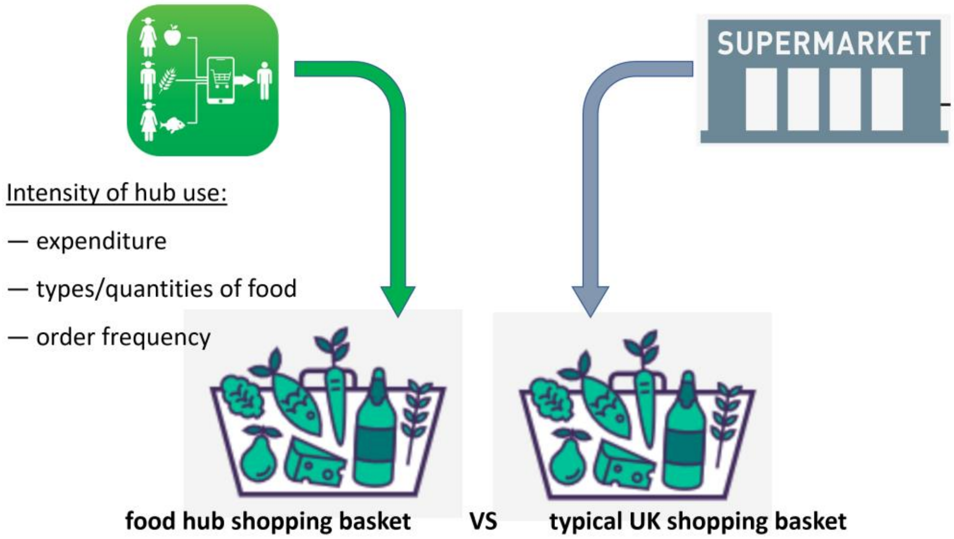


Figure 12, Chapter 6 overview - comparing shopping baskets from two food supply chains

Survey and interview data were used to inform the analysis, but the main data source for this chapter is the *Open Food Network* purchasing history. Mean, standard deviation and percentage change were used to investigate trends in expenditure, order frequency and shopping basket composition for the customers of two food hubs: *Tamar Valley Food Hubs* (n=43) and *Locavore* (n=51).

6.1 Early adopters' intensity of food hub use

There are three main indicators of the early adopters' intensity of food hub use: 1) average monthly expenditure, 2) the types and quantities of the food they buy from the hub, and 3) order frequency. All three metrics of food shopping behaviour are discussed below. Based on the literature, the following expectation was posited:

> 3a - *Using online food hubs becomes embedded within regular shopping patterns over time, but people vary in how they use the food hub*

6.1.1 Expenditure

Table 18 shows the mean monthly expenditure across four non-consecutive months and several observations can be made. First, these expenditures represent only a portion of the hub users' monthly spending on food. The average monthly expenditure of a UK household on food and non-alcoholic drink was £276.03 in the year ending March-20 (Office for National Statistics, 2021a) and the figures in Table 18 are, for the most part, well below the UK average. Second, there is a clear spike in expenditure in May-20, reflecting the impact of the pandemic (discussed in section 7.5). Third, *Tamar* customers spend approximately 3.75 times more than *Locavore* customers each month. This can be partially explained by *Tamar*'s wider product range, but also by the two hubs' different business models. *Locavore* run a veg box scheme separately and the associated costs are not shown in this data set. *Locavore* expenditure therefore represents purchases *in addition to* a set veg/fruit box, whereas the *Tamar* expenditure is for all purchases.

Table 18, Mean monthly expenditure (£) for Tamar and Locavore customers

	Sep-19	Feb-20	May-20	Sep-20
Locavore	23.21 (SD 19.72)	24.27 (SD 23.77)	58.09 (SD 49.10)	37.18 (SD 32.99)
Tamar	110.03 (SD 79.82)	79.98 (SD 66.33)	199.45 (SD 152.06)	145.36 (SD 103.44)

Another observation from Table 18 is that the standard deviations are very large which would suggest there is variation in the early adopters' intensity of food hub use. Further evidence of this variability was identified in the survey data. The early adopters were asked how much of their weekly food shopping they buy from the food hub (Q6.3) and Figure 13 shows a distribution across all of the response categories. Nearly half of the respondents buy 20% or less of their food from their local hub (yellow bars), but nearly a quarter buy over 40% of their food from the hub (green bars).

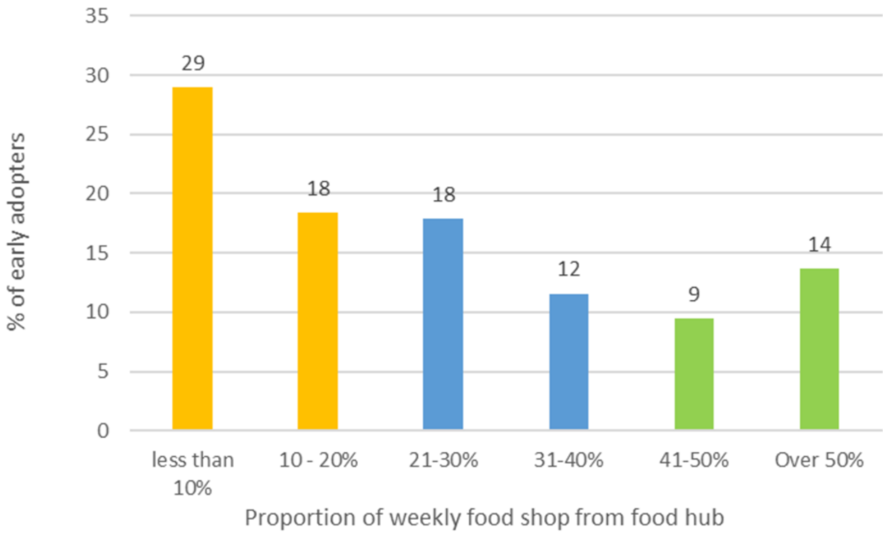
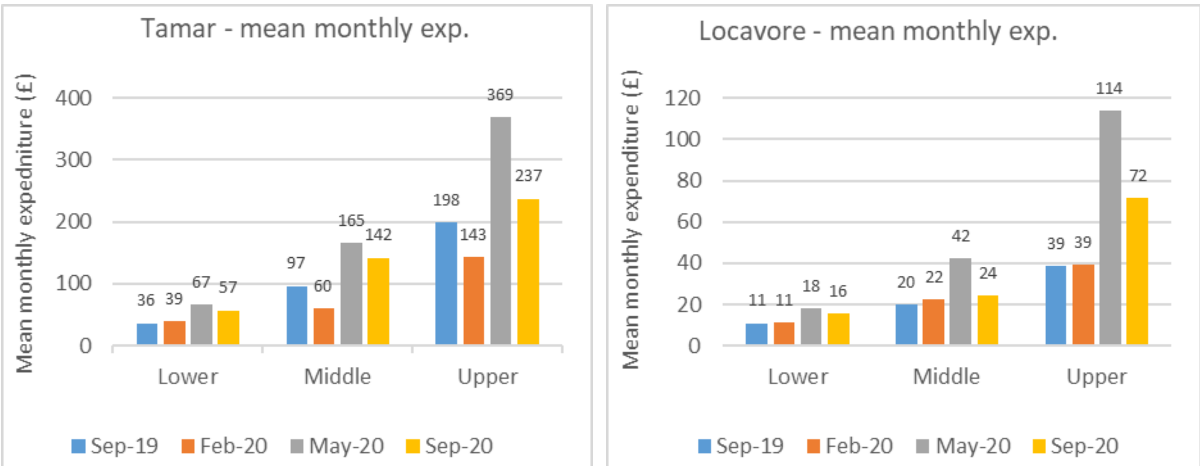


Figure 13, Proportion of the weekly food shop bought from online food hubs

One important inference from these results is that early adopters should not be considered one uniform group with respect to their shopping behaviour. Average monthly expenditure was therefore used to segment the early adopters into lower, middle and upper expenditure groups to identify whether the groups differ in terms of the types of products they buy and their order frequency (see further explanation in Appendix 6.1). The three groups' mean monthly expenditures for the four months are shown in Figure 14:



Note – different scales on the y axis

Figure 14, Mean monthly expenditure (£) for lower, middle and upper expenditure customers

Figure 14 shows a trend of increasing expenditure for all groups, notwithstanding the May-20 spike. Thus, for these 94 customers, the hubs gradually supply more of their food over time and this would suggest that using a food hub becomes embedded within their regular shopping behaviour. A further observation is that as expenditure increases, the variation in shopping basket size also increases (see Appendix 6.1). Some customers spend a lot more, whereas others only spend a bit more.

6.1.2 The types and quantities of foods

The second key indicator of the early adopters' intensity of use is the composition of the food hub shopping basket. Profiling the shopping basket is important not only to identify potential dietary trends, but also because it informs how early adopters use the hub relative to other food retailers. Although the product range of online food hubs is not comparable with supermarkets, some of the more established hubs do sell a relatively wide range of foods. Early adopters were asked in the survey what foods they buy from their local hub (Q6.4) and the results are shown in Figure 15. Fresh fruit and vegetables is a mainstay of food hubs and 80% of the respondents buy these items. However, other product categories are also important, with over half of the respondents using the hub for dairy and eggs and cupboard stock.

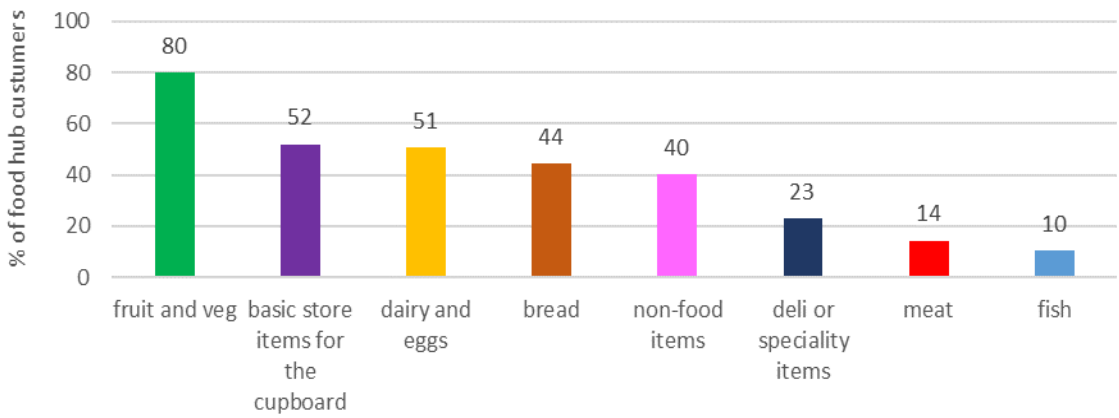


Figure 15, Percentage of customers buying particular items from online food hubs

The survey respondents were then asked to rank these food categories in terms of how frequently they buy them from the hub (Q6.5): fruit and veg was purchased most often, followed by (in descending order) dairy and eggs, bread, basic store items for the cupboard, meat, deli or speciality items, fish, non-food items. The interview data supports these findings regarding the most important food categories and also the wide range of products bought from hubs (E1.1 & E1.2; see Appendix 3.6).

Variation in basket composition

The relative composition of the three expenditure groups' shopping baskets was explored using 'number of items bought' as a metric for nine broad food categories. The upper expenditure group buys as much as the other two groups combined for most food categories (see Appendix 6.2). This suggests the food hub is a key supplier across multiple food categories for a dedicated set of customers. Figure 16 shows the importance of fresh produce - fruit & vegetables (dark blue segments) and dairy & eggs (orange segments) – for *Tamar* customers[27]. A further finding is that fresh produce makes up 63% of the *Tamar* lower groups' basket, compared to 59% and 53% for the middle and upper groups respectively.

The results presented in Figure 16 and Appendix 6.2 provide some insight into the adoption decision process. The lower expenditure group primarily buys fresh produce and these items are prominent on the hub platforms and the product range is the most comprehensive, relative to the other food categories. Fresh produce therefore represents an entry point into shopping from online food hubs. Fresh produce typically has a short shelf life and there is a limit to how much a household will consume in a week. Expenditure increases as some customers decide to try other items in addition to fresh produce, such as cupboard stock, non-food items, or treats such as snacks and baked goods. These items comprise a larger proportion of the food hub basket for the middle and upper expenditure groups.

[27] The *Locavore* baskets look quite different and this is because their fruit and veg boxes are not represented in this data set, although a similar pattern of a decreasing proportion of fresh produce (e.g. fruit and veg 'optional extras') as expenditure increases can be observed in Figure 16.

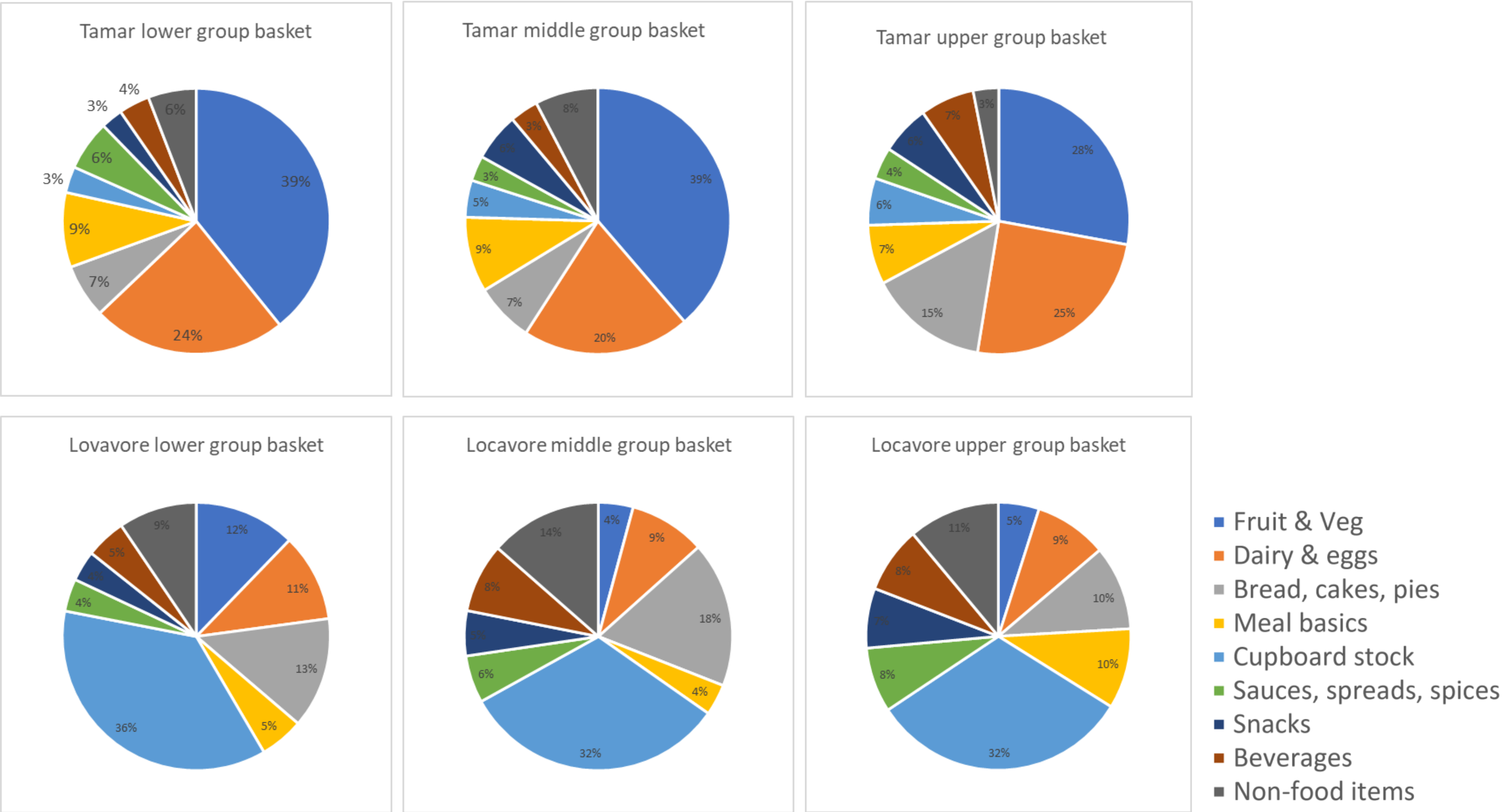


Figure 16, Basket composition for Tamar and Locavore customers – lower, medium and upper expenditure groups

Dietary trends

Dietary trends were explored by considering foods commonly associated with particular diets. Figure 17 shows a gradual increase in the sales of vegetables for all three expenditure groups at *Tamar* over the four months, which could signal a shift towards more flexitarian or plant-based diets. However, this finding is countered by a similar trend of increasing meat purchases. Sales of dairy products increased for both hubs, whereas tofu and tempeh sales increased for *Locavore* but not for *Tamar* (see Appendix 6.3).

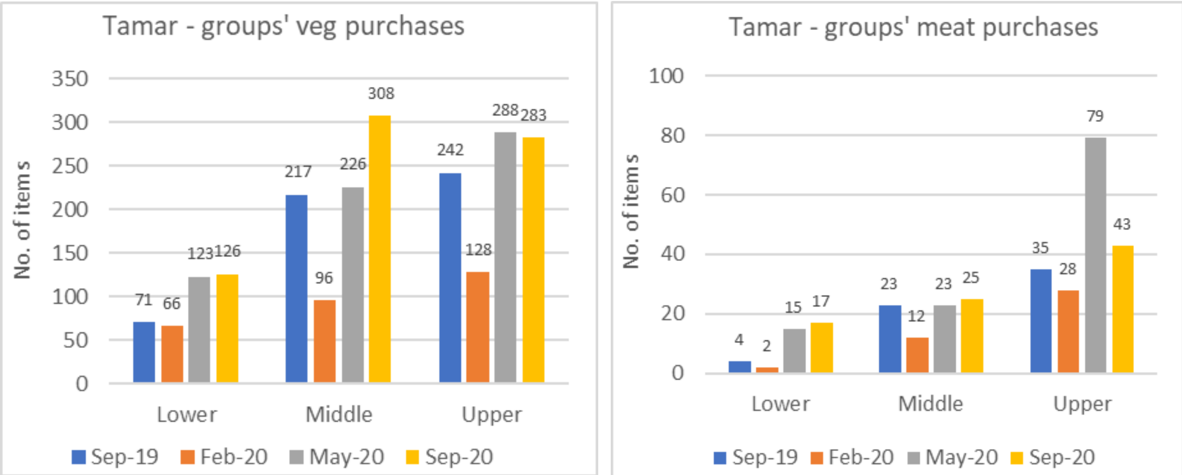


Figure 17, Number of vegetable and meat items bought each month by lower, middle, and upper expenditure customers at Tamar

The evidence of a potential dietary shift is therefore inconclusive because sales increased for foods associated with plant-based *and* omnivore diets. These increases could simply reflect an incremental substitution of weekly food shopping from supermarkets to food hubs, with no overall change in the amount consumed of a particular food. Furthermore, the dietary preferences of the 94 hub customers in this data set are unknown and so drawing firm conclusions difficult. The potential impact of hub use on the dietary preferences of the survey respondents was explored, comparing recent adopters (< 1 year) with long term customers (1 year or more) but there was no statistically significant difference between the two groups.

6.1.3 Order frequency and longevity of hub use

Order frequency is related to expenditure and is a useful metric for assessing whether using food hubs can be considered a routine activity. The survey revealed that 39% of early adopters order from their local hub every week and a further 27% order once a fortnight (Q6.2). Order frequency was even higher among the interview participants, with 19 of the 20 respondents placing an order every week (E1.9; see Appendix 3.7). Trends in order frequency over the four months were explored using the purchasing data. Figure 18 shows that both hubs experienced a spike in May-20 which can be partially attributed to five order cycles rather than four in this month, but also changing shopping patterns during the pandemic. Unsurprisingly, upper expenditure customers tend to order most frequently and lower expenditure customers order least frequently. All three data points indicate that using hubs has become an integral part of the early adopters' food shopping routine, as opposed to occasional or sporadic use.

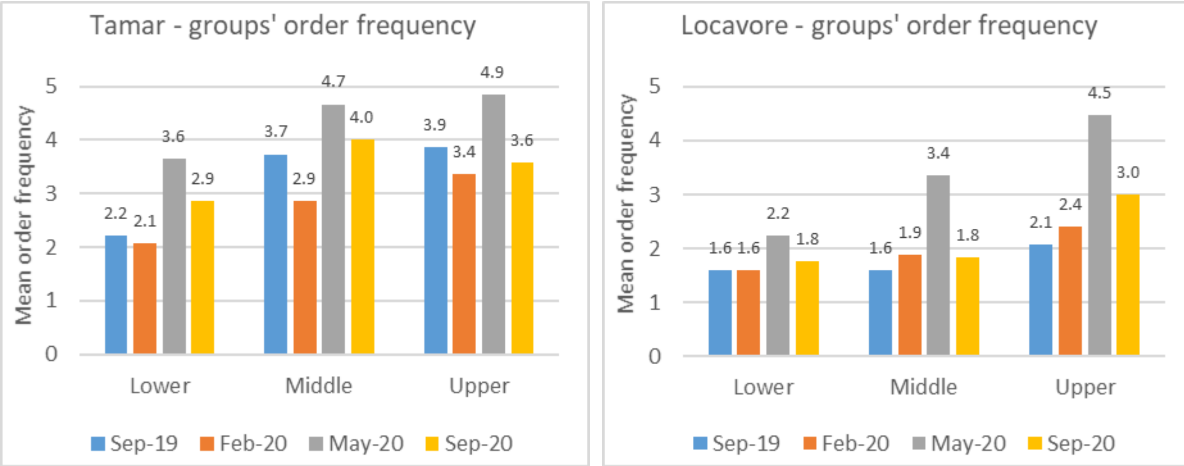


Figure 18, Mean monthly order frequency for lower, middle and upper expenditure customers

Another clear indicator of habit-forming is the sustained use of the innovation over a period of time. The early adopters were therefore asked how long they have been using their local food hub. In the survey, nearly half of the respondents had been using the hub for a year or more (Q.6.1). One of the sampling criteria for the interviews was to have been a hub customer for at least one year, but most had been using a food hub for somewhat longer: 8 respondents had been customers for 2 to 3 years and another 9 respondents for 4 years or more (E1.8; see Appendix 3.7). As discussed earlier, the samples may reflect the more committed hub users, but nevertheless these results suggest using food hubs has become a habitual activity for early adopters in both samples.

Summary

This section explored the early adopters' intensity of food hub use. The early adopters vary in the quantities and types of food they buy, but they are alike insofar as using food hubs becomes a routinised activity. Observed trends in expenditure and basket composition suggest that how they use food hubs is not fixed and can change over time. These findings are consistent with expectation 3a - *Using online food hubs becomes embedded within regular shopping patterns over time, but people vary in how they use the food hub*.

6.2 Substitution of supermarket supply chains

Based on the LCA literature, it was anticipated that food bought from online food hubs would have less GHG emissions than the counterfactual, buying the same items from supermarkets. Any reduction in emissions would nevertheless depend on a substitution of the counterfactual. In other words, the early adopters avoided buying food from supermarkets, rather than their use of food hubs replacing a different low carbon activity, for instance growing their own food on a local allotment. In the survey, early adopters were asked whether the amount of food they buy from supermarkets has changed since they started using the hub (Q6.6). The results are shown in Figure 19 and we can see that 85% of early adopters now buy less from supermarkets (the green bars).

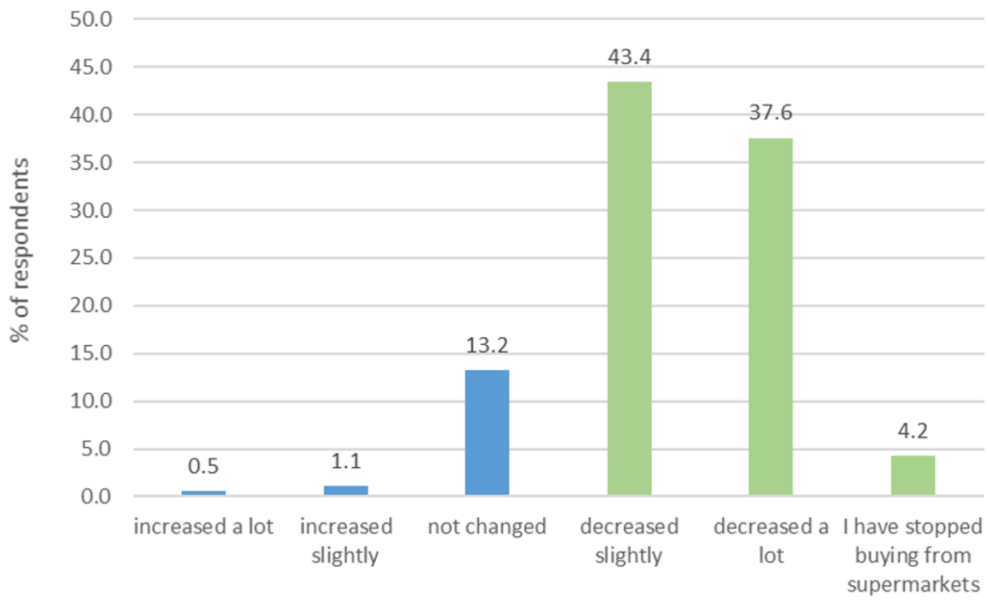


Figure 19, Changes in the amount of food bought from supermarkets following the adoption of a food hub

These results are supported by the interview findings. The respondents were asked where they used to buy the items that they now buy from the online food hub, and the majority answered 'from supermarkets' (E1.3) (I1, I5, I7-I11, I15, I17, I20). A smaller number of respondents stated that they previously bought these items from either a supermarket or a local independent shop (I2, I3, I6, I13, I14, I19). Thus, there is a degree of substitution of supermarkets for both respondent groups. Three respondents mentioned switching from a veg box provider to an online food hub (I4, I5, I16).

Summary

This section explored whether the early adopters' use of food hubs affects how much food they buy from supermarkets. The survey and interview data indicate that a substitution does occur, although there is variation in the extent. Expectation 3b - *Increasing use of online food hubs results in decreasing use of supermarkets for food shopping* - is supported.

6.3 Comparing the weekly food hub basket with the UK shopping basket

This section compares the average *Open Food Network* shopping basket with the average UK shopping basket. This comparison informs the calculations of GHG emission reductions which can be attributed to a substitution of supermarket supply chains (see chapter 8). The *Open Food Network* purchasing data was used to calculate the average food hub shopping basket. The *Family Food* survey, the 2018/19 edition (DEFRA, 2020), was used to represent the typical UK shopping basket. The metric used for this comparison was weight or volume, rather than number of items bought, to ensure consistency with the *Family Food* dataset.

Table 19 shows the weights/volumes of household purchases of food and drink, per person per week, for 49 of the categories used in *Family Food* 2018/19 (see 'UK av. weight/volume' column). The weights/volumes of comparable items bought from online food hubs are shown in the 'OFN av. weight/volume' column. The 'OFN as a % of UK average' column provides an indication of how much of a particular food the users buy from their local hub by showing the *Open Food Network* purchase as a percentage of the average UK purchase. The blue cells indicate a medium proportion bought from food hubs (25-49% of the average UK purchase), the green cells indicate a large proportion (50-100%) and the orange cells indicate hub purchases which surpass the average UK weekly purchase (greater than 100%). The 'OFN as a % of UK average' was calculated as the average of the *Tamar* and *Locavore* customers combined.

Assumptions used in the calculations

The weight was not stated for some items in the *Open Food Network* data. If this information was not available on the *Open Food Network* platform or the supplier's website, the weight was estimated using similar items sold by other retailers as points of reference. A full list of these assumptions and references used can be found in Appendix 6.4.

The 'Assumption level' column in Table 19 refers to the magnitude of these assumptions: ^ = the weight was estimated for one or two items only within the category; ^^ = the weight was estimated for multiple items; ^^^ = the weight was estimated for multiple items and the product description did not clearly define the contents or quantity, such as 'a fruit *bag*' or 'a *bunch* of golden beetroot'. Thus, the greater the number of ^, the greater the level of uncertainty in estimating the weight. Assumptions were required for 11 of the 49 food categories.

Another important assumption is that the hub users represented in the *Open Food Network* data live in households consisting of 2.42 people. This figure, 2.42 (CI ± 0.18), is the average number of people in early adopter households from the attribute survey (Q13.6) and is consistent with the UK average household size of 2.39 (CI ± 0.01) (Office for National Statistics, 2021b). This assumption was necessary to enable comparison between the anonymised *Open Food Network* data, which is at the household level, with *Family Food* data which is at the person level.

Table 19, Comparing weights/volumes of food in the OFN average weekly shop vs the UK average weekly shop

Type of food	Specific food categories	Unit of measur-ement	OFN av. weight/ volume	UK av. weight/ volume	OFN as a % of UK average	Tamar % of UK average	Locavore % of UK av.	Assum-ption level
Fr. fruit & veg	Fresh veg	g	1053.0	1129.5	93.2	81.4	95.3	^^^
	Fresh fruit	g	191.5	787.0	24.3	18.1	29.6	^^^
Dairy & eggs	Butter	g	23.3	33.5	69.5	126.5	21.3	
	Non-dairy milk substit.	ml	43.4	68.9	63.0	31.0	90.1	
	Milk & cream	ml	480.7	1416.5	33.9	33.9	N/A	
	Cheese	g	30.5	108.4	28.2	52.5	7.7	
	Eggs	no.	0.5	2.1	21.9	37.2	9.1	
	Yoghurt	ml	20.0	187.6	10.6	17.2	5.1	
Bread, cakes, pies	Quiches	g	5.7	9.9	57.3	57.3	N/A	^^
	Bread	g	108.5	521.0	20.8	31.8	11.6	^^
	Pies & pasties	g	23.8	155.6	15.3	15.3	N/A	^^
	Cakes, buns, pastries	g	17.5	150.8	11.6	15.5	8.4	^^
Meal basics	Soya & novel proteins	g	15.1	9.1	166.5	108.3	215.6	
	Fish	g	25.7	75.6	34.0	69.7	3.9	^^^
	Meat	g	77.7	515.2	15.1	15.1	N/A	^
	Veg ready meals	g	7.1	76.2	9.3	9.3	N/A	^^
Cupbo-ard stock	Vegetable purees	g	6.9	4.5	152.6	43.2	244.9	
	Dried veg	g	0.3	0.4	77.2	77.2	N/A	
	Flour	g	27.9	47.8	58.4	104.1	19.9	
	Stock & yeast	g	2.4	4.5	52.7	48.6	56.1	
	Oatmeal/oat products	g	13.5	25.7	52.4	70.7	37.0	
	Canned tomatoes	g	39.6	77.6	51.0	29.7	69.0	
	Cocoa	g	2.0	4.2	46.3	46.3	N/A	
	Canned pulses	g	48.6	106.0	45.8	20.6	67.1	
	Dried pulses	g	3.2	9.0	36.1	69.4	8.0	
	Salt	g	2.4	7.4	32.8	32.8	N/A	
	Canned veg	g	9.8	31.3	31.2	22.4	38.7	
	Other cereals	g	1.4	8.5	16.7	16.7	N/A	
	Pasta	g	12.2	77.7	15.7	14.3	16.9	
	Rice	g	9.8	69.8	14.1	23.1	6.5	
	Breakfast cereals	g	11.0	121.9	9.1	8.8	9.3	
	Sugar	g	4.9	63.2	7.8	11.6	4.5	
Sauces, spreads, oils	Peanut butter	g	3.5	6.2	56.8	82.7	34.9	
	Honey	g	2.8	7.9	35.5	26.7	42.9	
	Pickles	g	4.0	14.4	27.7	55.7	4.1	
	Jams	g	4.5	21.5	20.9	34.1	9.8	
	Vegetable & salad oils	ml	11.4	59.9	19.0	13.6	23.5	
	Other spreads	g	1.0	11.2	9.1	9.1	N/A	
	Sauces	g	3.0	112.9	2.7	5.5	0.3	
Snacks	Savoury snacks	g	8.1	23.5	34.2	34.2	N/A	
	Unsweetened biscuits	g	4.1	15.3	26.7	26.7	N/A	
	Nuts, seeds, dried fruit	g	6.1	49.0	12.5	19.4	6.7	
	Chocolate	g	3.9	38.4	10.0	13.1	7.5	
	Sweet biscuits	g	4.7	80.8	5.8	6.6	5.1	^
Bevera-ges	Coffee	g	5.5	24.5	22.4	36.5	10.6	
	Tea	g	4.1	20.3	20.0	34.1	8.1	^
	Pure fruit juices	ml	30.2	227.0	13.3	22.0	6.0	
	Mineral/spring waters	ml	34.3	503.9	6.8	6.8	N/A	
	Soft drinks	ml	27.4	840.3	3.3	3.3	N/A	

Key: Assumption level: ^ low, ^^ medium, ^^^ high ; Proportion of UK av. weekly shop: medium % large % v. large %

We can see from Table 19 that hub users buy a large proportion (more than 50% of the UK average weekly purchase) of the following foods from their local hub: fresh vegetables, butter, non-dairy milk substitutes, canned tomatoes, flour, oats and oat products, nut butter, soya & novel proteins, quiche, dried vegetables, stock & yeast, vegetable purees. In addition, they buy a medium proportion (25-49% of the UK average weekly purchase) of the following foods from their local hub: milk & cream, cheese, fish, canned pulses, canned vegetables, honey, cocoa, dried pulses, pickles, salt, savoury snacks, unsweetened biscuits.

Summary

This section compared the average food hub shopping basket with the average UK shopping basket. Food hub users buy a significant proportion (>25% of the UK average) of 24 types of food from the hub. This affirms that, for hub users, online food hubs are an important supplier of a relatively wide range of products, but they are by no means the only supplier.

6.4 Discussion

The discussion considers two themes: the use or implementation phase of the adoption process, and the limitations of the food hub purchasing data.

6.4.1 The use phase of the adoption process

The findings in this chapter inform our understanding of the use phase of online food hub adoption. The regular order frequency and gradually increasing expenditure is evidence of habit forming and the integration of hub use into weekly shopping routines, thus supporting the qualitative results presented in chapter 5. The changing composition of the food hub basket as expenditure increases is another observable effect which occurs during the use phase. The substitution of supermarkets is a third tangible outcome of adoption and this has emission implications. The purchasing data also revealed the essential fresh produce items that hub users order frequently, as well as some niche products which are bought occasionally. Collectively, these results suggest food hub users gradually reconfigure their existing shopping behaviours as they identify which items they prefer to buy from food hubs and how often.

The purchasing data enabled longitudinal investigation of the hub users' shopping behaviour, but without the time commitment required from participants to complete a food diary or participate in a living lab study. However, some of the anticipated research findings did not materialise, notably the lack of conclusive quantitative evidence of a dietary shift which might be attributed to the ongoing use of food hubs. Nevertheless, this analysis did yield longitudinal data for characterising the use phase and for identifying the impact of the pandemic on shopping behaviours (discussed in section 7.5), thus providing valuable insights in addition to those from the cross-sectional methods. Moreover, the purchasing data constitutes a direct measure of shopping preferences and is therefore more robust and more detailed than the stated shopping preference data from the attribute survey and the interviews.

6.4.2 Limitations of the food hub purchasing data

There are some limitations regarding how this data can be used. First, the data is anonymised and this precludes any heterogeneity analysis. It would be especially useful to know whether these particular hub users are similar to the survey and interview respondents in terms of their sociodemographic characteristics, or whether their shopping behaviour may reflect their dietary preferences. Second, estimating the weights for some food items enabled comparison with the *Family Food* data, but introduced uncertainty with respect to the accuracy of these assumptions. The only other option would be to remove these items from the analysis and this would diminish the utility of the revealed shopping preferences for several important food categories. Finally, we do not know what foods the hub users buy from other retailers and this limits emission quantifications to the items in this data set, rather than considering their entire household food consumption.

7 Results: Which factors are important in scaling up the adoption of online food hubs?

This chapter considers the potential for online food hubs to become more widely adopted and so answers the fourth research question: 'Which factors are important in scaling up adoption of online food hubs?' Figure 20 is an overview of these factors. The factors on the left are likely to encourage adoption and support the process of scaling up, whereas the factors on the right may constrain adoption and so flatten the adoption curve. Some factors directly relate to online food hubs, for example the non-adopters' perceptions of the innovation or the early adopters' communication about their local hub in their social networks. Other factors relate to the broader societal context in which adoption occurs and are independent of online food hubs but are nevertheless considered likely to affect the rate of uptake.

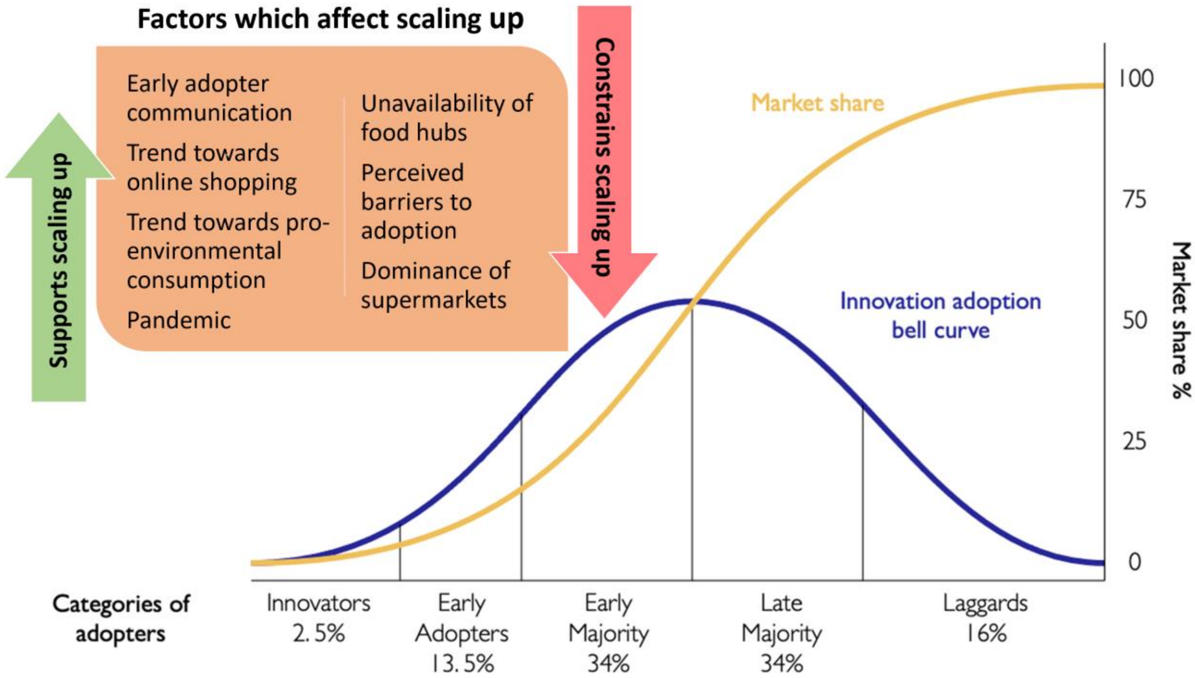


Figure 20, Chapter 7 overview - Factors which could support or constrain the scaling up of online food hubs. Adapted from Rogers (2003, p.281)

Content analysis of qualitative data from the semi-structured interviews with hub users (n=20) was used to inform about the early adopters' communication behaviour, the perceived barriers to adoption, and the impact of the pandemic. Quantitative data was collated from various secondary sources to consider the potential impacts of societal trends on adoption.

7.1 (Un)availability of online food hubs in the UK

A logical starting point for considering the scaling up of adoption is to ascertain the current market share and accessibility. The following expectation was proposed:

4a - *Adoption is constrained by the unavailability of online food hubs in some locales*

There are three open source platforms in the UK which food hubs can use: *Open Food Network UK* (49 hubs), *Neighbourfood* (22 hubs), and *The Great British Food Hub* (8 hubs). In addition, a small number of food hubs have developed their own platform such as *Goodery* in Norwich or *Dean Forest Food Hub* in Gloucester. A further three platforms (*Big Barn*, *Harvest Bundle*, *Real Food Hub*) facilitate direct sales nationwide using a courier service, but they were not included in this analysis as their business model and the types of food they sell are quite distinct from online food hubs which deliver within a defined area. There are at least nine large businesses which sell similar products to food hubs but do not use open source platforms, notably *Riverford* and *Abel and Cole*. As discussed in Chapter 1, veg box providers were excluded from this analysis.

The availability of online food hubs is by no means static. One platform, *The Food Assembly*, ceased operating in the UK in 2019[28] and this led to the creation of *The Great British Food Hub* and the expansion of *Open Food Network UK.* Two other platforms, *Grub Trade* and *Maker2u*, were trialled but did not become established. The reasons why these three platforms did not succeed are not clear. At the time of writing (March 2022), three additional hubs were being developed on *The Great British Food Hub* and one more on *Neighbourfood*.

The locations of online food hubs in the UK are shown in Figure 21. The populations of these cities and towns were summated to provide an estimate of how many people in the UK could adopt an online food hub if they chose to (see Appendix 7.1). This provides a number of *potential* UK food hub users: 17,670,380, or 26% of the UK population (Office for National Statistics, 2021b). This is a hypothetical scenario; if all of the people living in those areas did decide to adopt, the food hubs would have to scale up their operations considerably to cater for this increased demand. The potential UK food hub population is presented to demonstrate that 74% of the UK population could not, at present, become a food hub user even if they wanted to. The unavailability of online food hubs in many areas is evidently a constraint to scaling up adoption.

[28] *The Food Assembly* is still active in several other countries, especially France

Figure 21, Locations of online food hubs using (1) Neighbourfood, (2) The Great British Food Hub (and independent hubs), and (3) Open Food Network UK

The maps provide an overview of where particular hub platforms are active, as well as the areas in the UK where online food hubs are currently unavailable (the three maps are presented separately to offer greater clarity).

Ascertaining the current total number of hub users in UK is difficult because most food hubs operate independently and there are many of them. The only information available for indicating the current population level is the total number of orders for the *Open Food Network UK* platform. Figure 22 shows a clear trend of increasing orders over time, excepting the slight decrease in 2021 from the 2020 level (the impact of the pandemic is discussed in section 7.5). The total number of orders suggests the current market share of online foods hubs is likely to be very small, relative to mainstream retailers.

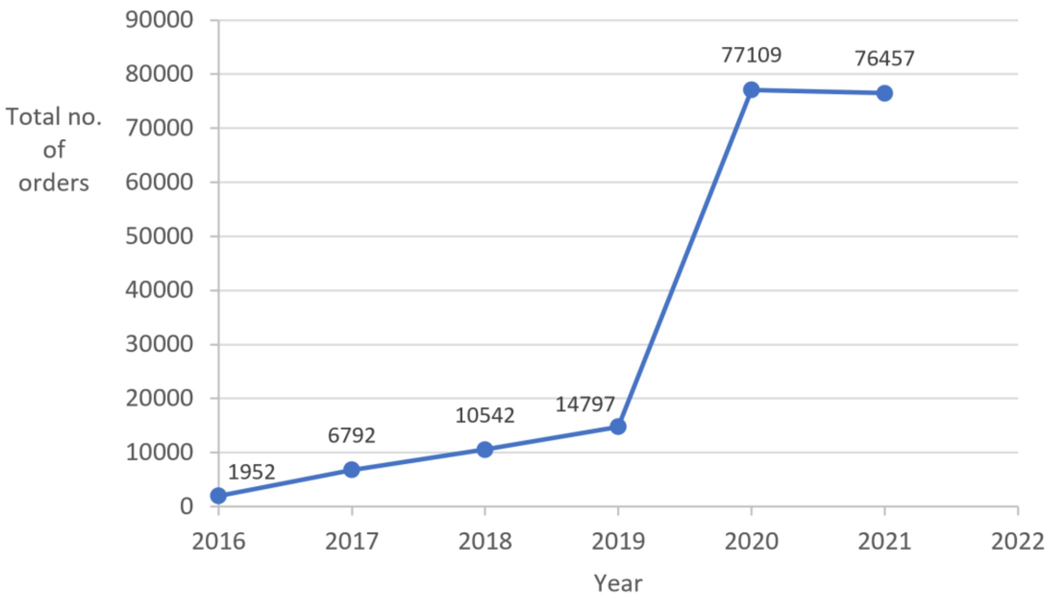


Figure 22, Total no. of orders from Open Food Network UK, 2016-2021

Summary

This section considered the current availability of online food hubs in the UK. The increasing number of orders and the establishment of new hubs indicates a gradual upscaling of online food hubs. However, the unavailability in many areas is a clear limitation. Expectation 4a - *Adoption is constrained by the unavailability of online food hubs in some locales* - is therefore supported.

7.2 Social influence and the diffusion of information

Rogers (2003) argues that diffusion is a social process and that the early adopters play a crucial role in spreading information about a new innovation. Three expectations were therefore posited regarding the communication behaviour of online food hub early adopters:

> 4b - *Word of mouth is important in the diffusion of information about online food hubs*
> 4c - *Early adopters actively discuss online food hubs in their social networks*
> 4d - *Early adopters communicate with strong and weak ties about online food hubs*

This section explores different aspects of the early adopters' communication behaviour: who they recommend food hubs to, what they say, and what impact this may have on potential adopters. [29]

7.2.1 Innovation discovery

How people discover an innovation is clearly an important determinant of how that innovation might be scaled up. In the attribute survey, the early adopters (n=221) and the non-adopters who had previously heard of online food hubs (n=112) were asked how they first found out about the innovation (Q5.2). The results are shown in Figure 23:

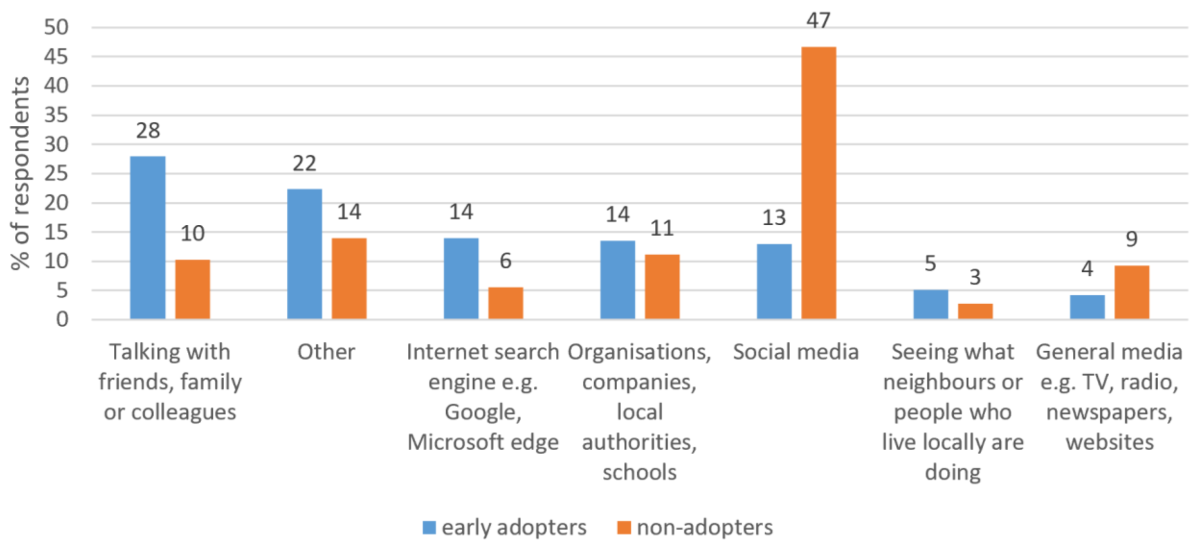


Figure 23, Early adopters' and non-adopters' discovery of online food hubs

Figure 23 shows that for early adopters, talking with friends, family or colleagues was the most common way of discovering the innovation, although food hub marketing such as handing out flyers

[29] Some of the empirical data presented in this section (7.2) was published in the article below. I am a co-author but did not lead on any of the writing and so there is no duplication of text between my PhD thesis and this article. See: Vrain, E., Wilson, C., Kerr, L. and Wilson, M., 2022. Social influence in the adoption of digital consumer innovations for climate change. *Energy Policy*, 162. DOI: https://doi.org/10.1016/j.enpol.2022.112800

or placing notices on information boards is also effective[30]. For non-adopters, social media played an especially important role. A chi-square test of homogeneity found statistically significant differences between the two groups regarding these two ways of finding out about food hubs, but not for the other five ways (see results in Appendix 7.2). The interview respondents were also asked how they first found out about their local hub (E4.1). Table 20 shows that word of mouth was the most common and this supports the survey findings.

Table 20, Interview respondents' discovery of online food hubs

Information source	No. of interview respondents
Word of mouth	*10*
eWord of mouth (social media)	*1*
Hub marketing or an outreach event	*2*
Local news media	*1*
Neighbourhood effect (observed local hub activity)	*1*
Actively looked for a local food hub	*2*
Can't remember	*2*
N/A (question not asked/answered)	*1*

Aside from making people aware of an innovation, these information sources can also play a role in influencing someone's opinion about it, for instance if they are considering adopting and want to know more about the innovation. The attribute survey participants were asked how important the information sources were in shaping their opinion of online food hubs (Q5.3). Social media and talking with friends, family and colleagues emerged as the most important for both early adopters and non-adopters (see Appendix 7.2).

Two conclusions can be drawn from these findings. First, the prominence of word of mouth communication for the early adopters would suggest that the information they receive in these conversations is effective in encouraging adoption. Second, social media is important in providing information to non-adopters, many of whom may not know an early adopter and would therefore be unlikely to receive peer recommendations through word of mouth. Considering the small market share of online food hubs, eWord of mouth could be essential for the diffusion of information among unconnected social groups. Expectation 4b - *Word of mouth is important in the diffusion of information about online food hubs* - is supported, but with an acknowledgement of the role of eWord of mouth in disseminating information among potential adopters.

[30] Respondents who selected 'other' were invited to provide further information about their innovation discovery using an open text option. Flyers and notices were most commonly mentioned.

7.2.2 Early adopter communication

Several aspects of the early adopters' communication behaviour were investigated in this study: 1) the frequency, form, and content of their discussions, 2) their level of opinion leadership, and 3) their social network structure. These are discussed in turn.

The early adopters were asked in the survey how many people they have spoken to about online food hubs in the past 6 months (Q5.4) and the average was 9.5 people (± 15.2) (see Appendix 7.2). 13% of early adopters are especially active in their communication, having spoken to 20 - 100 people. The interview respondents were also asked about the frequency of their discussions about food hubs (E4.5). Table 21 shows that at least half of the respondents discuss food hubs with someone outside their household once a month or more often. Collectively, these findings reveal that early adopters are active in spreading information about online food hubs.

Table 21, Interview respondents' frequency of communication about online food hubs

Frequency of communication	No. of interview respondents
Once a week	*3*
Once a fortnight	*2*
Once a month	*5*
Once every 2 months	*2*
Frequently/constantly	*2*
Not that often/occasionally	*3*
N/A (question not asked/answered)	*3*

A second aspect is the form of the communication and so the interview respondents were asked whether these conversations tend to occur face to face or through social media. Table 22 shows that face to face conversations are more common, although five respondents did mention social media (E4.6).

Table 22, Interview respondents' form of communication about online food hubs

Form of communication	No. of interview respondents
Face to face (Word of mouth)	*14*
Through social media (eWord of mouth)	*3*
Both face to face and through social media	*2*
N/A (question not asked/answered)	*1*

Face to face communication about food hubs occurs in a variety of settings such as on the school run (I16), having friends around for dinner (I9, I11), bumping into neighbours or people passing by the hub pick-up point (I5, I6, I14, I16), or during conversations about food and shopping (I1, I2, I4, I7, I8, I13-I15, I17).

How online food hubs are presented to potential adopters will invariably affect their likelihood of adopting and so the interview respondents were asked what they say in these discussions (E4.3-4.4). Typically, they highlight the core attributes such as the freshness and quality of the food (I5, I11, I17, I20), the convenience (I4, I5, I10, I11, I17, I19, I20) or supporting local producers (I11, I20). In addition to these generic reasons for using food hubs, one notable finding is that some early adopters identify individuals who they think might be receptive to the idea and adapt their message according to this person's needs or aspirations (I4, I5, I10, I14, I16). For instance, this could be a potential adopter's values or intended consumption behaviour:

> "I'd say the first context would be people who are actively maybe looking for what Locavore does. The second one would be people who are interested in ethical shopping, and then I'd say 'here's the service I use, you might like it'." (I10)

Another example of this bespoke messaging relates to dietary preference or health requirements:

> "Anybody who's veggie, I tend to mention it to…I'm a healthcare worker and I sometimes talk to people at work about the benefits of getting veg boxes, which feels a bit random, but I guess you're trying to get people to think laterally about, you know, bringing about change in their lives." (I5)

A third example has arisen during the pandemic. Early adopters have recommended their local hub to their neighbours as a way of buying food which avoids going to the shops (I4, I7, I14, I16, I17):

> "We've been trying to advertise the possibility of ordering through the hub if they were shielding, or if they were unable [to shop at a supermarket] because they had small kids, that they could order from the food hub online and they could have the food delivered to them." (I14)

This adaptive messaging highlights that early adopters carefully consider their intended audience and the reasons for using food hubs that they communicate to others may not be the same reasons which motivated their own decision to adopt. Moreover, they use a combination of rationales to encourage adoption, whereby hubs are presented as matching individual circumstances or dietary preferences as well as achieving broader societal goals such as sustaining the local economy.

7.2.3 Opinion leadership

Early adopters play a key role in diffusion because they are regarded as trusted knowledge providers and so are able to influence the views of others with respect to the innovation (Rogers, 2003). Food hub users' opinion leadership was explored in the survey using a well-established opinion leadership scale (Q5.8). The 6-item scale was reduced to two underlying constructs, *having influence* and *giving advice*, using PCA (see results in Appendix 7.3). An independent-samples t-test was then carried out. Early adopters (0.17 ± 0.95) perceive themselves to have a greater degree of influence on others regarding online food hubs than non-adopters (-0.34 ± 1.02), a statistically significant difference of 0.51 (95% CI, 0.28 to 0.74), $t(314) = 4.39$, $p < .001$ (medium effect size using Cohen's *d*). There was no statistically significant difference between the two groups for the *giving advice* construct. Intuitively we would expect early adopters to have more influence about online food hubs than non-adopters, given their experience of using the innovation.

Another measure of opinion leadership is whether the early adopters' communication likely swayed someone in their decision to become a food hub user. The interview respondents were therefore asked if anyone they had recommended their local hub to had then started using the hub (E4.8). Table 23 is a summary of their responses and we can see that 13 respondents know at least one new user who had previously received a recommendation from them (the second column). Those 13 respondents were then asked how many new users they had recommended the hub to. The table shows that four respondents have suggested online food hubs to multiple new users (the fourth column).

Table 23, New food hub users following an early adopter recommendation

	No. of interview respondents	Number of new users	No. of interview respondents
New users following a recommendation	*13*	*1 new user*	*4*
No new users following a recommendation	*2*	*2 – 4 new users*	*2*
Not recommended food hubs to anyone	*2*	*5 or more new users*	*2*
Don't know	*1*	*Don't know*	*1*
N/A (question not asked or answered)	*2*	*N/A (question not asked or answered)*	*4*

These findings indicate that the early adopters' social influence is playing a role in the adoption decision. However, without speaking to these specific new users, it is difficult to say to what extent the peer recommendation affected their decision. With respect to the interview respondents' adoption decision, a causal relationship can be asserted with greater confidence because they expressly stated that the opinions of their early adopter peers influenced them (E4.1) (I10, I14, I15, I17, I18):

> "I asked on social media, before I joined Locavore, I asked for recommendations and Locavore, you know, a few people that I trusted said they love Locavore and the quality's great." (I15)

This quote reveals that food hub users are perceived by others as trusted sources of information and people will actively seek their opinion. Food hub early adopters are especially important in driving adoption because, unlike some other innovations, there are relatively few alternative sources of information. Almost all of the interview respondents said they had never heard online food hubs mentioned in the general media (I2-I5, I7-I10, I13, I14, I17, I18) and only two respondents recalled seeing any coverage in local media (E4.11) (I1, I20).

The quantitative and qualitative findings on the early adopters' communication behaviour presented above are consistent with expectation 4c - *Early adopters actively discuss online food hubs in their social networks*.

7.2.4 Early adopter social networks

The final aspect of communication behaviour is the early adopters' social network structure, or who they talk to about online food hubs. The attribute survey revealed that two thirds of the people the early adopters speak to are close friends or 'strong ties' and so one third are acquaintances or 'weak ties' (Q5.6-5.7 - see Appendix 7.2). Social networks were also explored in the interviews (E4.2). The respondents were asked to rank four groups of people that they talk to about online food hubs, with the group comprising the largest number of people ranked 1st. A simple weighting was then applied to their responses: the largest group was assigned four points, the second largest group three points, and so on (Pugh, 1981). Table 24 reveals that the interview respondents communicate with a greater number of non-adopters than other early adopters. A second finding is that the number of strong ties and weak ties are fairly equal. These results are in line with expectation 4d - *Early adopters communicate with strong and weak ties about online food hubs.*

Table 24, Weighted ranking of interview respondents' communication with different social groups

People spoken to about online food hubs	Weighted ranking
Non-adopter - weak tie (acquaintances or other people you know)	*39*
Non-adopter - strong tie (friends and family)	*36*
Early adopter - strong tie (friends and family)	*31*
Early adopter - weak tie (acquaintances or other people you know)	*18*

Early adopter communication with non-adopters supports diffusion because it introduces the innovation to those who have not heard of it, or it can reduce uncertainty for those who have (Rogers, 2003). That a significant proportion of food hub non-adopters are also weak ties further supports diffusion because this information is more likely to reach individuals beyond the early adopters' immediate social networks (ibid). Homophilous communication is generally associated with strong ties and is more likely to result in adoption (Rogers, 2003), but there is a downside:

> "Quite a lot of people I know that are in our circle do already get a veg box anyway, you know, so we'd be a bit preaching to the converted in our friendship group." (I15)

This quote highlights that homophilous communication often occurs in 'echo chambers' where everyone in the social group is already aware of the innovation and many would have already made the decision whether or not to adopt.

Social norms

Another form of social influence is social norms, where people observe what others do and interpret what they think might be expected of them (Cialdini and Trost, 1998; Sanders and Hume, 2019). One interview respondent indicated that social norms played a role in their adoption decision:

> "Because I know them [food hub users]. Yeah, I made the decision that, even though I was only two miles away, just moving into kind of their village and I'm just opposite the community orchard. So I thought it would be good to, you know, put my money where my mouth is and get back in the fold a bit." (I17)

This respondent clearly felt that using the food hub would be viewed favourably by others in her social circle and that it would be consistent with her own sense of identity. Social norms were more noticeable in the rural hub than the urban hub, perhaps reflecting a stronger sense of community in a village setting where people tend to know each other. Another explanation is the visibility of the pick-up point in a prominent location in the village, where hub users often stop to chat when they collect their order (I2, I13, I14). The urban hub operates a home delivery model and this does not have the same level of visibility as a central pick-up point.

Summary

This section explored the communication behaviour of the early adopters of online food hubs. Word of mouth was identified as the main source of information about food hubs, although social media is also important. Early adopters were found to actively encourage adoption in various social contexts and this supports a potential scaling up. These findings are consistent with all three prior expectations concerning communication behaviour and social influence (4b, 4c, 4d).

7.3 Perceived barriers to adoption

It was anticipated that some people would identify aspects of using online food hubs which are incompatible with their personal situation, even if the idea appeals to them or they received a recommendation from a friend. This outcome is rejection of the innovation at the decision stage of the innovation-decision process (see Figure 11). The following expectation was proposed:

> 4e - *Adoption is constrained by individual circumstances and perceived barriers*

Identifying the reasons why people choose not to adopt is crucial in understanding how a scaling up could occur. The most appropriate people to ask would be those who had previously rejected but, as with the discontinuers, these individuals are difficult to identify. Thus, the interview respondents who had spoken with potential adopters were asked if they know of any barriers which might prevent people adopting (E4.9). The most important barriers they suggested were high price, changing shopping habits, and competency in cooking or using digital technology. There is some thematic overlap between these perceived barriers and the practical considerations in food shopping decisions (discussed in section 5.2).

High price

The most important perceived barrier is high price and this was mentioned by 11 respondents (I3, I5, I9-I12, I14, I15, I17-I19):

> "If you're strapped for cash, then using these places, there is a financial consideration I reckon…in fact my partner's daughter, she said 'ah mum, I'd love to get this stuff, laughing, you know, I can't afford to do it'. So price, I think, might be [a barrier]." (I9)

As discussed in chapter 5, the hub users' perception of cost is nuanced and they factor in other considerations such as food quality or supporting local farmers. However, some potential adopters will be deterred because of their economic circumstances, like the family member mentioned above. Others may be unsure and so carry out a price comparison (I5, I19):

> "I looked at it at the start of how much it was, and it was definitely more expensive. I can't really remember how much more expensive than in the shop. It obviously it depends what you buy in the shop, because it's all organic, if you're comparing it. I don't know, maybe say it's 20% more expensive." (I19)

This respondent estimated a 20% mark-up but chose to adopt anyway. These findings suggest there are two underlying questions relating to cost in the adoption decision: 'Can I afford it?' and 'Is it worth paying extra?' The first question is inherently dependent on the individual and their personal situation. The food hubs already focus their marketing strategy on the second question by highlighting the quality and environmental or social attributes. No novel recommendations emerged from this study, except perhaps presenting price comparisons for items which are broadly similar to supermarkets to remove some preconceptions around price.

Changing shopping habits

A second perceived barrier is changing existing shopping habits and preferences. Using a food hub entails adapting to a more limited product range and in most cases buying food from more than one supplier. While many hub users did not see this as a problem (see sections 5.1 & 5.2), this may not work for everyone (I7, I8, I13, I15-I17, I19, I20):

> "I think some people are very used to the complete one stop shop approach, where they can just go when they want…to a single location, park, shop and leave. Although the variety of foods that they [the food hub] sell is very broad…they don't sell baby food or nappies. So if you're a young mother and you want to be doing all of your shopping in one place, then that's going to drive how you do that." (I13)

The unavailability of one or two essential items may be a deal-breaker, particularly for anyone who feels time-constrained such as a busy parent. Moreover, the 'one stop shop' approach is a proven business model which many consumers prefer and this has contributed to the success of supermarkets. These consumers are less likely to view online food hubs as a viable option.

Competence with digital technology

The third potential barrier, identified by four respondents, was a lack of confidence in using computers or the internet (I11, I12, I17, I20):

> "I have a very good friend who is very, sort of, environmentally minded. And she's always saying, 'oh, they deliver up near me, I must do an order' and I say to her, 'have you done an order?' And I know what it is, she won't admit to me that she's rubbish with technology…she struggles just, you know, getting the damn thing turned on really." (I11)

Thus, some potential adopters may like the idea of using a food hub but their inexperience in using online ordering systems prevents them from adopting. These individuals may not wish to acknowledge or discuss their low level of digital competence for fear of being judged. Food hub staff may be willing to support them by taking orders over the phone, but this does not resolve the challenge of how to establish the initial contact or how to manage any sensitivity in offering to accommodate their needs.

This example highlights that although computers and smartphones are a ubiquitous feature of daily lives for many people, there are others, particularly the older demographic, who are averse to using digital technology. In 2018 there were 5.3 million adults in the UK, or 10% of the adult population, who had never used the internet or had not used it in the past three months (Office for National Statistics, 2019b). The UK government has implemented strategies to address digital exclusion and so the number of people lacking basic digital skills is declining (ibid), but for food hub adoption this remains a barrier, at least in the short to medium term.

Culinary knowledge and food expectations

The final barrier relates to people's cooking experience or their expectations of food aesthetics and choice. Using a food hub is associated with preparing meals from scratch and some potential adopters may believe they lack the requisite cooking skills (I1, I5, I11, I19):

> "They don't cook that often. I think a lot of the food hub is, you've got to be able to cook it. You know, even in the simplest of forms, you got to know something about cooking. So probably, even if they've tried it once, then they don't seem to try it again, which I find a bit disappointing." (I11)

A lack of confidence in the kitchen could be exacerbated by discovering unfamiliar vegetables (in the set veg box):

> "If you've never actually had a cooked artichoke, it looks like some kind of alien, 'what am I meant to do with that?' The same with celeriac, I mean, it's a pretty ugly looking thing, why would I buy that, you know?" (I19)

Although many early adopters relish the challenge of creating a meal from an unusual vegetable (see section 5.1), some potential adopters may be discouraged by this. Another concern is that they will receive a glut of veg that they will be unable to use (I1, I15, I18), engendering a sense of guilt commonly associated with food waste. Others may be deterred by not being able to choose exactly which vegetables they want (I7, I13, I17, I19, I20) or by the appearance of the vegetables (I5, I19):

> "My mother in law, I'd said to her about it [the food hub] but she didn't like the idea that it's all covered in mud because she's so used to the, sort of, sanitised bag…she didn't like the idea that you'd have to wash it all before you put it in the fridge because otherwise the fridge would get all dirty." (I19)

Potential adopters will be accustomed to how food is presented in supermarkets, both in terms of choice and aesthetics. If food hub produce does not meet their expectations, or they perceive undue effort in storing and preparing the food, they may decide food hubs are not for them.

Summary

This section considered four barriers to the adoption of online food hubs. Perceptions of these barriers vary and this relates to an individual's situation, abilities, or expectations. For some people, these barriers are sufficient to reject the innovation from the outset and this is consistent with expectation 4e - *Adoption is constrained by individual circumstances and perceived barriers.*

7.4 Trends in societal attitudes and food behaviours

This section uses UK social survey data and grey literature to position some of the empirical findings of this project within broader societal trends or contexts relating to food and the environment. Most of the trends are unrelated to online food hubs and are presented with the caveat that their potential impacts on the adoption trajectory of food hubs are speculative as there is no prior research on this topic. The impacts are considered unidirectional - food hub adoption could be affected by the trends or contexts, but the inverse is highly improbable given the small market share of online food hubs at the present time. The following expectation was posited:

> 4f - *Societal food behaviour, dietary, and ethical consumption trends support a potential scaling up of online food hubs*

7.4.1 UK food shopping preferences

Three food shopping contexts were explored: the market share of food hubs relative to supermarkets, the shift to online shopping, and the shopping preferences of different adopter groups compared to a UK population sample.

Dominance of supermarkets

Assessing the potential for a more widespread adoption of online food hubs should be considered in the context of the mainstream shopping practices and preferences. Figure 24 is from the Food Standards Agency's *Food and You* survey (2019) and it shows where UK households shop for food. The dominance of supermarkets is evident in Figure 24 and this was also a clear finding from the attribute survey (Q10.4). Shopping from online food hubs is represented within 'Home delivery – not from a supermarket', which also includes recipe box deliveries such as *Hello Fresh*.

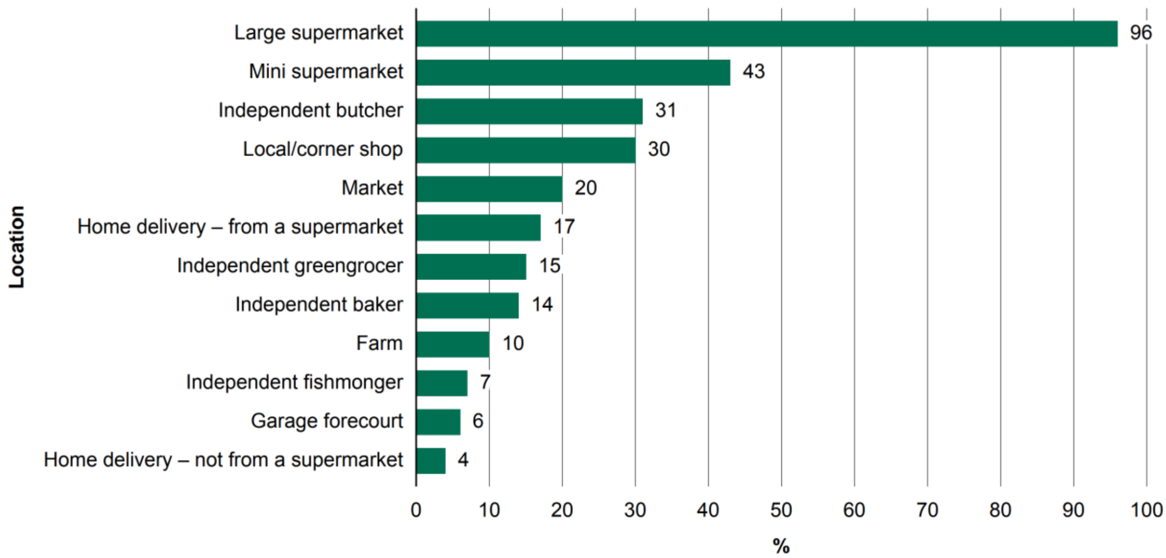


Figure 24, Where households shop for food (Food Standards Agency, 2019)

The challenge facing online food hubs to capture a greater market share in the UK, particularly from their current marginal position of (much) less than 4% of households, cannot be overstated. Grocery shopping in supermarkets is the default option, both practically due to their availability and close proximity in most areas, but also cognitively as a routinised habit (Machin et al., 2020).

Trend towards online shopping

There is one emerging trend which could to some extent disrupt this embedded behaviour and that is the shift to online shopping and home delivery, which was occurring even before the pandemic. Figure 25 shows that from 2012 to 2018, the proportion of households using supermarket home delivery increased from 10% to 17% and the use of other home delivery services doubled over this period. Statista (2021a) conducted similar research and found that 30% of individuals had shopped for groceries online in 2019.

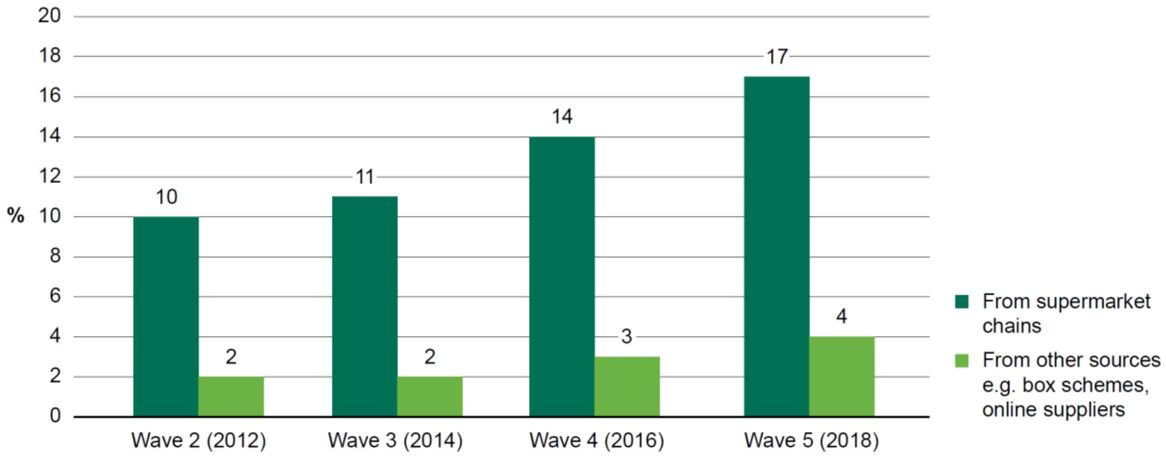


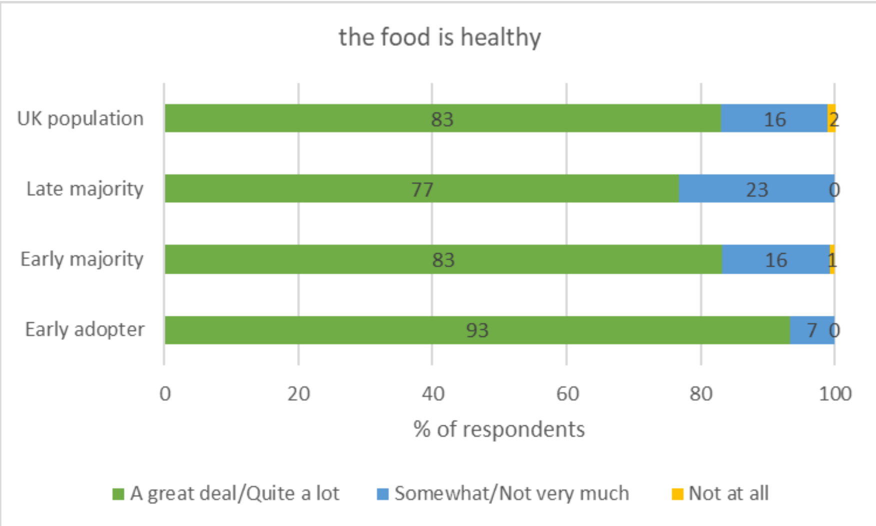
Figure 25, Trends in the use of home delivery services by survey wave (Food Standards Agency, 2019)

It is likely that a sizeable proportion of the 17% of households who use supermarket home delivery value the convenience and the compatibility with busy daily routines associated with this way of shopping. Convenience was identified as an important attribute of online food hubs in this study and this presents an opportunity for the hubs to position themselves within a growing market segment, albeit with competition from supermarkets and other online retailers. Food hubs could consider a greater emphasis on convenience in their marketing strategy, together with the food quality, environmental and social attributes they already convey.

Comparing food shopping preferences

So far as the author is aware, this study is the first to explore non-adopter perceptions of online food hubs. The attribute survey sample is not representative of the UK adult population in terms of sociodemographic characteristics and this reduces its external validity for proposing scaling up projections. There is, however, a limited amount of UK social survey data on food shopping preferences and some of these are analogous to food hub attributes. Six of the fifteen shopping preferences explored in the attribute survey (see section 4.1.1) were replicated from NatCen's (2015) *British Social Attitudes – Wave 33* and this enabled comparison between the attribute survey respondents and a UK population sample.

In Figure 26, the NatCen respondents are indicated by 'UK population' and the remaining three groups are respondents of the attribute survey. Using Rogers' (2003) adopter categories (see Figure 4), the attribute survey non-adopters were segmented into hypothetical early and late majority groups based on their stated adoption propensity (see further explanation in Appendix 7.4). Figure 26 shows that the high propensity or 'early majority' group is comparable with the UK population sample for the importance of healthy food and low cost. Thus, 83% of both the UK population sample and the early majority non-adopters consider healthy eating to matter 'a great deal' or 'quite a lot' (green bars). Low cost is an important consideration for less than half of the UK population sample and the early majority non-adopters (green bars). The remaining four preferences are discussed in Appendix 7.4.



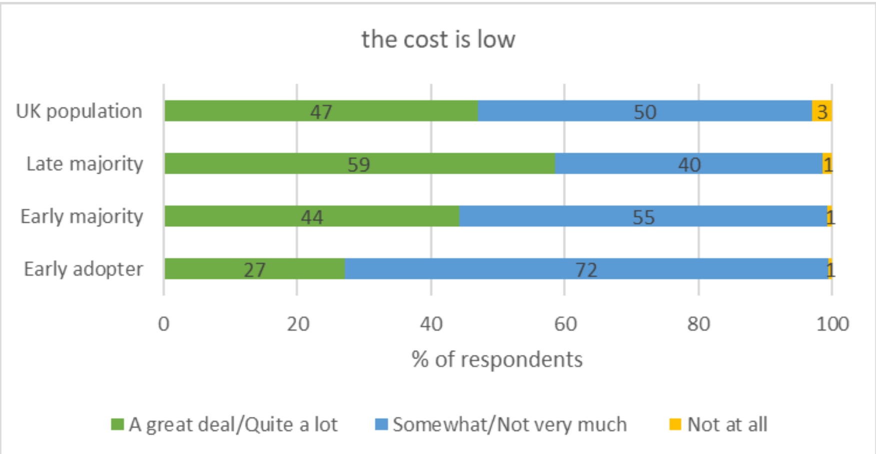


Figure 26, Comparing three adopter groups' shopping preferences with a UK population sample

If the UK population sample aligns with the high propensity non-adopter group rather than the low propensity group for some important shopping preferences, this increases the likelihood they would be broadly aligned with the high propensity group in their perception of food hub attributes. A second inference is that using an online food hub would be appealing for UK consumers who prefer to eat healthily and low cost is not their overriding concern.

7.4.2 Pro-environmental consumption

One notable finding from this study is the importance of social and environmental values in the hub users' food shopping decisions. The question then arises: are food hub early adopters a niche, highly motivated group of ethical consumers, or do values also feature in the consumption decisions of a broader segment of UK consumers? Evidence of pro-environmental consumption behaviour at the UK population level was explored to determine whether a scaling up of values-based food networks is consistent with current shopping patterns.

Sales of ethical products

The most demonstrable indicator of pro-environmental consumerism is sales of ethical products. Figure 27 shows that sales in ethical food and drink in the UK doubled between 2010 to 2018, rising to £12 billion or 11% of all household food sales (DEFRA, 2018a).

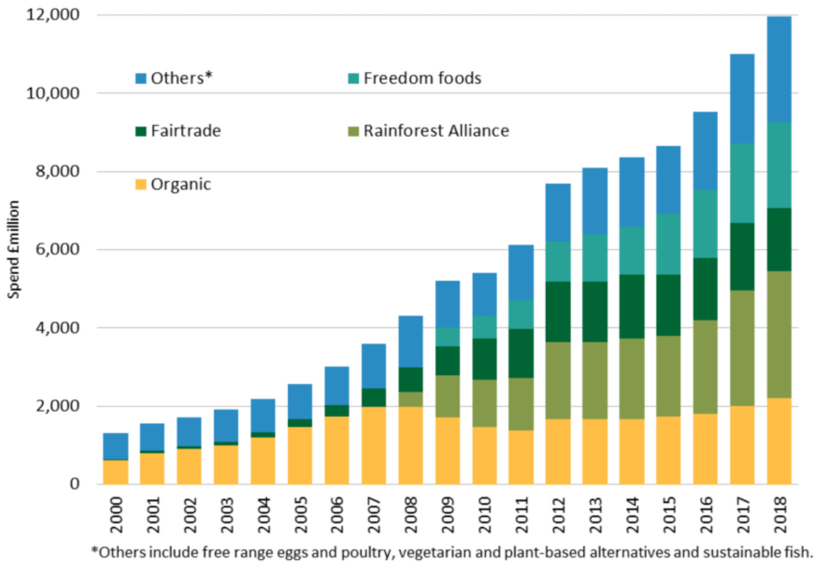


Figure 27, UK trend in sales of ethical produce (DEFRA, 2018a)

This steady increase bodes well for a more widespread adoption of online food hubs because ethical products represent their core offering. Figure 27 shows sales of organic, freedom foods and the products included in 'others' are rising. Food hubs compare well with supermarkets in terms of their product range for each of these categories, with the exception of plant-based alternatives. Furthermore, 'increasing transparency in the food supply chain' was one of the highest ranked attributes of online food hubs (see section 4.2). Greater transparency in animal rearing and welfare standards would especially appeal to consumers who prefer to buy freedom foods/RSPCA assured.

Ethical products are typically more expensive and perceived high cost was identified as a barrier to food hub adoption. Respondents of the *Understanding Society* survey were asked the extent to which they agree with the statement 'I would be prepared to pay more for environmentally-friendly products.' Their responses are shown in Figure 28 and we can see a marked increase from 2013 to 2019 in their willingness to pay more.

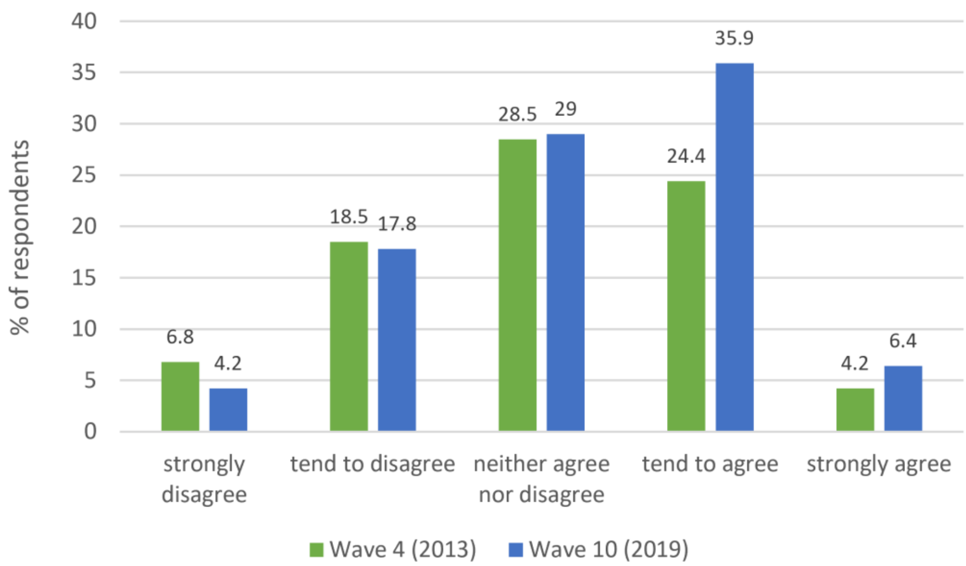


Figure 28, Willingness to pay more for environmentally-friendly products (Understanding Society, 2013 & 2019)

In 2019, 46.3% of respondents agreed or strongly agreed that they are prepared to pay more for these products and this represents a substantial proportion of the UK population. High cost will undoubtedly be a barrier for many potential adopters, but the increasing number of consumers who are willing to pay a mark-up for environmental attributes suggests the potential market for online food hubs extends beyond the current group of early adopters.

Plastic pollution

Plastic pollution is a prominent contemporary environmental concern and this was reflected in attribute survey with 'minimal plastic packaging is used' ranked as the most important shopping preference by both early adopters and non-adopters (see Appendix 4.2). Research conducted by YouGov (2019b) found that 82% of respondents are actively trying to reduce the amount of plastic they throw away and 51% would be willing pay more for products with eco-friendly packaging. Figure 29 shows that 'fresh fruit and vegetables' is one area in particular where consumers are trying to reduce single use plastic packaging.

Figure 29, Types of products where consumers are actively trying to reduce plastic packaging (YouGov, 2019b)

The desire to avoid plastic packaging has led to a resurgence of refill stores on the high street as well as several supermarkets trialling 'refill zones'[31]. Moreover, apps are now available which enable consumers to locate places to eat, drink and shop with less packaging waste[32]. That consumers are prepared to try alternative stores or ways of shopping to avoid unnecessary plastic supports a potential scaling up of online food hubs. Hub producers typically use less plastic packaging, particularly for fresh fruit and vegetables (see Appendix 7.5). Food hubs would therefore be seen as a viable option by consumers who are actively seeking more environmentally conscious ways to shop.

Climate change

Climate change has been an important environmental issue for some time but in recent years it has gained traction in terms of broad public interest, media coverage and political engagement. The potential to reduce GHG emissions was a salient attribute of online food hubs identified in both the attribute survey and the interviews (see sections 4.2 & 5.3.1). In 2015, NatCen's *British Social Attitudes* survey revealed that people were, on average, only 'somewhat worried' about climate change. However, a recent wave of *Understanding Society* (2018-19) included a range of metrics which indicate this concern is growing. Mass participation in climate protests across the world in 2019[33] provides further evidence of this societal trend, as does research conducted by BEIS in 2020 shown in Figure 30.

[31] BBC, 2019. Going plastic-free: The rise of zero-waste shops - BBC News
BBC, 2020. Asda trials refills at 'sustainability store' - BBC News
The Grocer, 2021. Morrisons brings back refill container scheme as Covid cases fall | News | The Grocer
Retail Gazette, 2019. Almost 3/4 of shoppers willing to use food refill services - Retail Gazette
[32] Refill.org, 2021. Home | Refill | find more than 190,000 Refill Stations globally
[33] The Guardian, 2019. 'Enough is enough': biggest-ever climate protest sweeps UK | Climate change | The Guardian

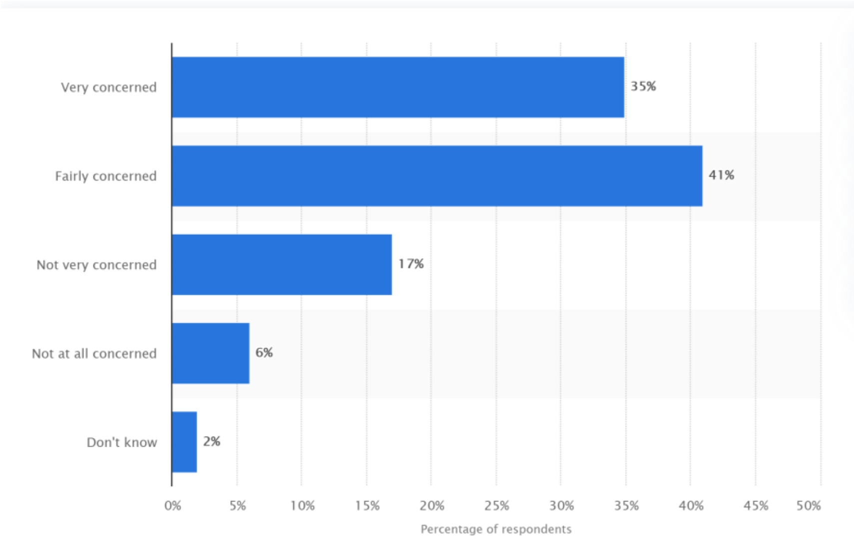


Figure 30, Levels of concern about climate change in the United Kingdom 2020 (Statista, 2020)

Concern for the environment does not always translate into tangible behaviour change and the *Understanding Society* survey (University of Essex, 2018) revealed evidence of a value-action gap, where people's self-perception of their green lifestyle did not necessarily match the number of green actions they took. However, a heightened concern about climate change will result in some people making pro-environmental lifestyle choices to match their values and this may include considering where their food comes from. For those who are looking for ways to reduce their carbon footprint with respect to food, sourcing seasonal local produce would be one clear action, along with shifting their diet.

7.4.3 Cooking habits and dietary preferences

Chapter 5 revealed how using an online food hub can affect various household food behaviours. Cooking habits and dietary trends at the UK population level were investigated to establish whether using a food hub is congruent with prevalent food behaviours.

Cooking habits

The interviews revealed that cooking meals from scratch is associated with using online food hubs. Food Standards Agency's *Food and You* survey explores a range of food behaviours and found the frequency of cooking meals has remained consistent in recent years. Between 2010-2018, 57-60% of UK adults reported cooking a meal at least once a day and a further 8-10% cook 5-6 times a week (Food Standards Agency, 2019). Thus, two thirds of UK adults cook frequently and this is a similar proportion to the 63% of food hub early adopters who cook at least once a day (Q12.7). Moreover, 67% of *Food and You* respondents agreed with the statement 'I enjoy cooking and preparing food' (ibid). This was not measured in the attribute survey, but an enjoyment of cooking was a clear theme in the interview data (E2.3). Early adopters are therefore comparable with the UK population sample in terms of their cooking frequency and enjoyment. A lack of cooking skills was identified by the interview respondents as a possible barrier to adoption. On the basis of the *Food* *and You* data, it can be inferred that this barrier would apply to, as a high estimate, a third of the UK population.

Dietary shift

There has been a growing awareness in recent years of the health and climate implications of eating a meat-intensive diet[34] (Chatham House, 2021). However, at present only 3% of the UK population are vegetarian and 1% are vegan and these figures have remained constant since 2012 (Food Standards Agency, 2019). What has changed is the increasing number of people who intentionally reduce their meat consumption; 10 - 14% of households now have at least one person who eats a flexitarian diet (Kantar Worldpanel, 2019; YouGov, 2019a). This change is reflected in the *Food and You* survey which found a decrease in meat consumption from 2012-2018, shown in Figure 31, although there was a slight increase in convenience meats such as burgers and sausages (Food Standards Agency, 2019). This dietary shift has driven sales of meat-free foods, which have grown 40% from £582 million in 2014 to an estimated £816 million in 2019[35].

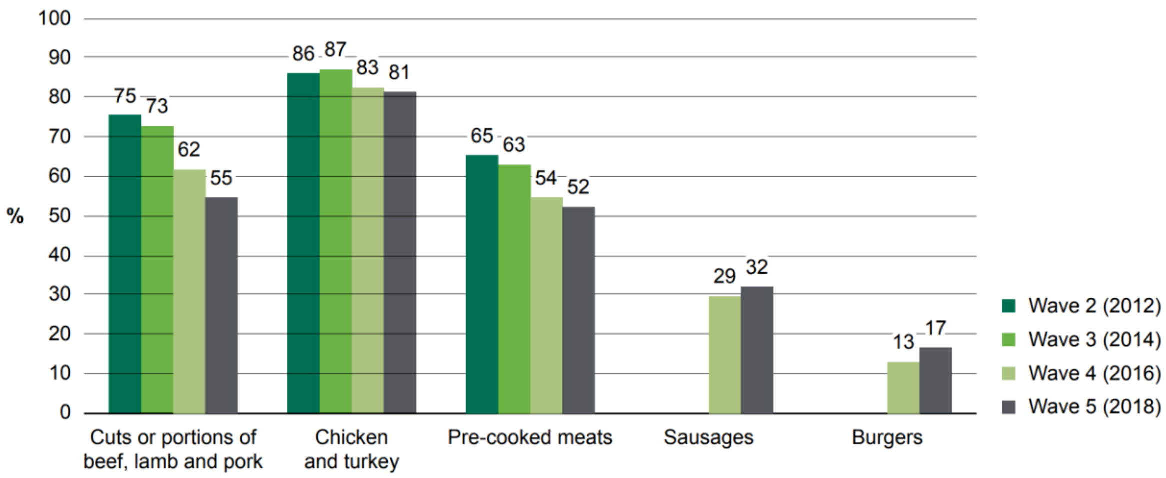


Figure 31, Proportion of respondents eating different types of meat at least once a week, by survey wave (Food Standards Agency, 2019)

The shift towards a flexitarian diet was also observed in the attribute survey data (see section 4.1.2) and several interview respondents described how they buy foods from the hub which match their flexitarian diet. This includes a wide variety of vegetables but also meats produced to high animal welfare standards (see section 5.5.1). Furthermore, the prospect of cooking from scratch is unlikely to deter potential adopters who are flexitarian. *Food and You* revealed that the proportion of people who cook every day was 9% higher among those who eat a vegetarian, vegan or flexitarian diet (Food Standards Agency, 2019). In the attribute survey, the proportion was 17% higher (Q12.7).

[34] The Guardian, 2018. Avoiding meat and dairy is 'single biggest way' to reduce your impact on Earth | Farming | The Guardian

[35] BBC, 2020. Tesco targets 300% rise in vegan meat sales - BBC News

Mintel, 2020. Plant-based push: UK sales of meat-free foods shoot up | Mintel.com

Online food hubs are therefore a viable option for people who eat a flexitarian diet, both in terms of product range and cooking habits. The societal trend towards reduced meat consumption could, in principle, support a more widespread adoption of food hubs.

Summary

This section considered a range of societal trends and consumer preferences which could affect the adoption of online food hubs in the UK. Some attributes of online food hubs align with emerging preferences and environmental concerns. If these trends continue on their current trajectories, online food hubs would conceivably appeal to an increasing proportion of the UK population. Expectation 4f - *Societal food behaviour, dietary, and ethical consumption trends support a potential scaling up of online food hubs* - is therefore supported.

7.5 Impact of the pandemic on food shopping behaviour

This section explores the impact of the COVID-19 pandemic on food shopping habits. On the premise of the food hubs' home delivery model and various discussions in the *Food for Cities* research network[36], the following expectation was put forward:

> 4g - *The pandemic has resulted in increased use of online food hubs*

The effects of the pandemic were investigated using the food hub order history and qualitative data collected in the interviews. Market research data and grey literature was used to contextualise these findings.

7.5.1 Food insecurity and disrupting shopping behaviours

One of the first impacts of the pandemic was a widespread apprehension about potential disruption to food supply chains. Almost overnight, food insecurity became a genuine concern. Empty shelves led to supermarkets rationing some items[37]. Once the initial panic buying had abated, many people soon adapted to new shopping behaviours (E1.15). One of these was shopping less frequently, either because supermarket delivery slots were oversubscribed (I6, I14, I17) or because people chose to go to the supermarket less often to reduce possible exposure to the virus (I5, I8, I9, I1-I19):

> "Rather than getting the shop every week sometimes you have to wait 10 or 12 days so you're having to do a bigger shop. But then that made me think a lot harder about 'right we need to get to that point, because we're not going to be able to [shop]' and we were trying not to go to the shops if we could possibly help it." (I19)

Thus, food shopping became less of an on-demand activity and now required more advance planning in terms of meals and estimating domestic stock levels. This entailed buying food in bulk and, for some people at least, learning how to store it so it would last longer (I2, I5, I8, I11, I14, I17, I19).

A second consequence was a dramatic increase in online grocery shopping. Several food hub users, particularly the older demographic, immediately switched to using supermarket home delivery (I6, I7, I12, I14, I17) and this shift was reflected at the national level. Figure 32 shows the percentage change in the value of monthly internet food sales from 2017 to 2021. Sales were relatively steady in the months preceding the pandemic before a sharp rise in March 2020. In March 2021, monthly online sales remained 100% above pre-pandemic levels. The pandemic is ongoing and so it is too early for definitive statements regarding the longevity of this shift, but market research provides some indication. In a recent survey of 2,000 UK consumers, 57% said they will continue to buy at least some of their groceries online even after the restrictions end (The Grocer, 2021). McKinsey (2020) and Accenture (2021) conducted similar research and came to the same conclusion.

[36] This network comprises researchers interested in alternative food networks. The impact of the pandemic on stakeholders and food supply chains was, not surprisingly, a prominent discussion topic in the spring of 2020
[37] BBC, 2020. Coronavirus: Supermarkets ask shoppers to be 'considerate' and stop stockpiling - BBC News

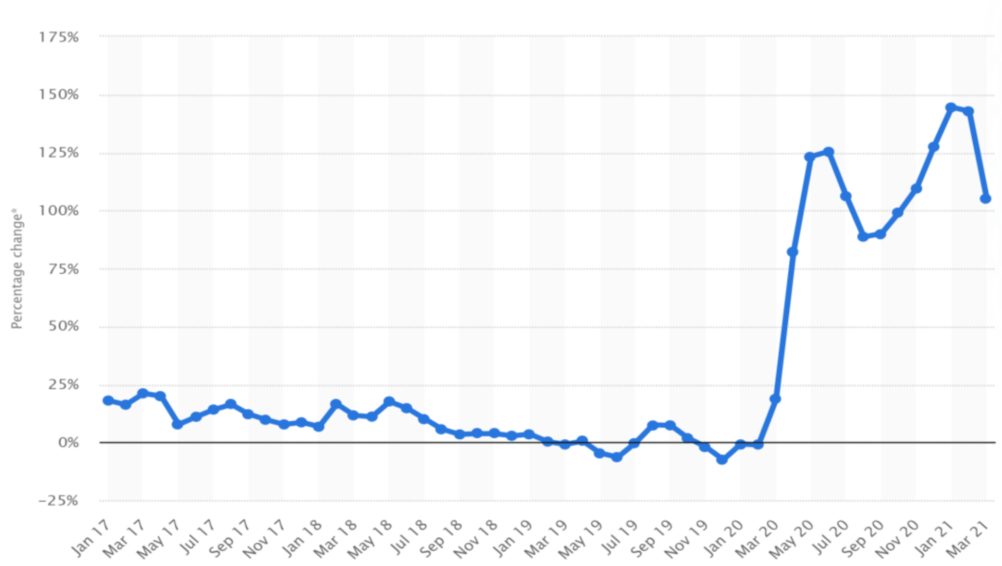


Figure 32, Percentage change in monthly internet food sales value in the UK from January 2017 to March 2021 (Statista, 2021b)

A third impact is that many people reconsidered where they buy their food. Several hub users stated that they rely more on their local hub since the pandemic started (I3, I5, I6, I8, I17):

> "We used it [the food hub] as a sort of, you know, as an add on, we didn't use it that seriously. Yeah, we now use it. I would say a good half of our food probably comes from Tamar Grow Local." (I6)

For this respondent, the food hub changed from a periphery to a key supplier and they are not unique in this regard. Figure 33 shows the percentage change in the monthly expenditure of 94 hub customers and there is a clear upturn in May 2020, relative to September 2019. Expenditure in September 2020 decreased from the May 2020 peak but remained well above pre-pandemic levels.

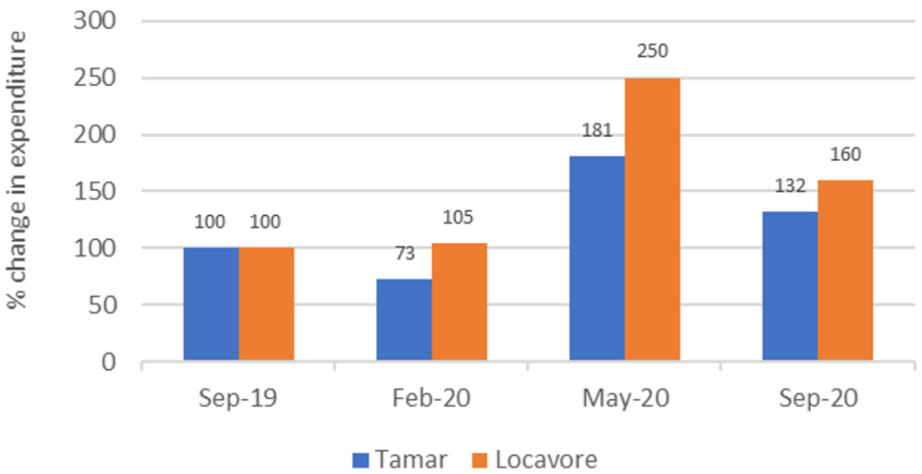


Figure 33, Percentage change in mean monthly expenditure for Tamar and Locavore customers

Open Food Network (2020) reported a 900% increase in demand in the first months of the pandemic and this was partly driven by the existing customers spending more, as indicated in Figure 33, but also by an influx of new customers. For example, *Locavore* gained 400 new customers during the first lockdown (Food, Farming and Countryside Commission, 2020). Further evidence of this intensified interest in food home delivery services is reflected in the surge in Google searches for 'online farmers' market', 'veg box' and other related terms during this period (see Appendix 7.6).

A greater reliance on food hubs was not the only strategy employed by hub customers to allay their concerns of food insecurity. Some tried different suppliers such as wholesalers, farm shops or informal 'pop-up' stalls selling surplus from people's allotments (I2, I9, I16, I17). Others explored ways to increase their food self-sufficiency, for instance upscaling their own food-growing (I2, I11), buying chickens (I11), or establishing a community-run shop to sell basic items (I2, I9, I14).

Food shopping is regarded as a routinised activity which is resistant to change. The pandemic disrupted these habits, causing people to re-evaluate how and where they shop. Whether these new habits endure beyond the pandemic is unknown, but several hub users believe they will (E1.16) (I6, I8, I9, I17, I18).

7.5.2 Online food hubs' response to pandemic

The pandemic also had significant ramifications for the hub staff and the producers. Community food initiatives of every description were suddenly required to rapidly upscale their operations in order to meet the surge in demand (*Food for Cities* network, 2020). The hub staff responded in two important ways. First, they contacted producers who normally serve the now closed hospitality sector and redirected food that otherwise would have been wasted. Not only did this increase supply for their customers, but also supported the livelihoods of local farmers at a critical time (I16). Second, the hubs implemented measures to ensure their existing customers, or people who were self-isolating, could still place an order (E1.15) (I4, I6, I13, I14, I16):

> "The food hub really upped their game, because they had a massive demand, they really stepped up and the growers really tried to step up…They made priority customers during the pandemic, vulnerable people but also people that had been long term regular customers….that probably did kind of err us towards always doing an order really often because...it's nice, you feel like 'ooh I'm a priority customer'. Yes, so it's that kind of, like, loyalty." (I4)

Priority status demonstrated the food hubs' commitment to their customers and this loyalty was then reciprocated. Moreover, by contacting vulnerable people and offering to deliver food at a time when supermarket delivery slots were scarce, the hubs played an important role in alleviating food insecurity concerns in their local communities. They also focused on the well-being of their staff:

> "I was really impressed with how Locavore handled things in Covid, both in keeping their services running, but also keeping their employees safe…I feel that they're a fair enterprise also for the people who make it possible and that's really important for me." (I10)

The food hubs' response to the pandemic reaffirmed customer loyalty and trust. Their customers could see how hard the staff, producers and delivery drivers were working in challenging circumstances and they believe the hubs responded well (I4, I8, I10, I11, I17, I20).

Summary

The pandemic disrupted food shopping behaviours, prompting some people to try new suppliers and accelerating the shift to online grocery shopping. The food hubs experienced a surge in demand which can be attributed to existing customers buying more as well as an influx of new customers. These findings are consistent with expectation 4g - *The pandemic has resulted in increased use of online food hubs*. As the pandemic is ongoing, it is difficult to comment on the permanency of these changes.

7.6 Discussion

The discussion revisits two factors which are considered important in determining how online food hubs might be scaled up: the societal context and trends, and the pandemic. Another important factor, the food hub users' interpersonal communication, is discussed in chapter 9. The limitations of using secondary data are also presented.

7.6.1 Societal trends and consumer segmentation

Social segmentation is a widely used approach to identify groups of people who share sociodemographic, cultural, lifestyle, attitude or behavioural traits. It is commonly used to orientate marketing strategies or information campaigns towards target groups, as well as to identify societal trends which can inform environmental or public health policy interventions (Verplanken, 2018; Agnew, Pettifor and Wilson, 2020). This study uses a segmentation approach in two ways: 1) *descriptively*, to suggest how marketing could be tailored to individuals with routines, preferences or social identities that may correspond with using online food hubs; and 2) *analytically*, to compare the participants of this research with broader societal groups in order to make scaling up projections.

The findings in section 7.4 position food hub early adopters and high propensity non-adopters within relatively large segments of the UK population according to particular shopping preferences, household food behaviours and environmental values. Most of the societal trends indicate that membership of these segments is growing and so there are increasing numbers of potential adopters who are aligned with food hub users on one or more of these traits. If some of these individuals perceive online food hubs as being consistent with existing behavioural intentions such as choosing a flexitarian diet, or broader social norms such as reducing plastic waste, they may choose to adopt, particularly if they receive a peer recommendation. This is the premise for arguing that the societal trends presented in this chapter largely support a scaling up of online food hubs. There is, however, no claim of a deterministic outcome; there are many behavioural responses to a concern about climate change aside from adopting a food hub.

To provide an illustrative example of the analytical application of social segmentation – high propensity non-adopters are comparable with the 83% of the UK population sample for the importance of healthy food in their shopping preferences (NatCen, 2015). This represents a sizeable potential market for online food hubs to access if they can successfully promote the relative health benefits of the food they sell. Health is considered a stronger motivation for consumers to shift towards more sustainable diets than environmental concern and this has implications not only for food hub marketing but also for public health policy interventions (Darnton et al., 2011; Gilliland et al., 2015; Scheelbeek et al., 2020). A related example is dietary preference. 27% of high propensity non-adopters eat a flexitarian diet, which is markedly higher than the 10 - 14% of the UK population sample, although this is still a moderately large proportion of the UK population and the trend for this dietary choice shows a clear increase (Kantar Worldpanel, 2019; YouGov, 2019a). The most important reasons for shifting diet include personal health, concern for animal welfare and protecting the environment (ibid). Online food hubs are perceived as compatible with a flexitarian diet for each of these motivations. The next chapter situates the empirical findings of this study using a segmentation approach and infers what this means for adoption and reducing GHG emissions.

7.6.2 Adaptive behaviours in response to the pandemic

The results of this study regarding how food behaviours changed during the pandemic are similar to the findings of other articles on this topic. They include a heightened focus on meal planning and food management, less frequent shopping trips, trying alternative retailers and a shift to online and home delivery. Two articles used a 'psychological resilience' framing to explain these behaviour changes (Cavallo, Sacchi and Carfora, 2020; Benker, 2021). Psychological resilience is the capacity of individuals to adapt to the circumstances they encounter to mitigate adversity (Fletcher and Sarkar, 2013). Actions such as the extra procurement of storable items, establishing a village shop and growing your own produce can be understood as adaptive mechanisms to ensure continued access to food in a situation of uncertainty. These actions diversified food supply options and likely enhanced the food hub users' psychological wellbeing by creating a degree of self-determination.

Another useful lens which could be applied is 'community resilience', specifically for considering the response of online food hubs, veg box providers and small neighbourhood stores to the pandemic. Community resilience is the existence and engagement of local resources by community members to respond positively in an environment characterised by change and unpredictability (Magis, 2010; Berkes and Ross, 2013). These small businesses used their agency, self-organisation and place-based knowledge to adapt how they operate in order to prioritise vulnerable individuals in their local community (Wheeler, 2020; Cavallo, Sacchi and Carfora, 2020). For a brief period when supermarkets were struggling to meet demand for home delivery, alternative food networks and local independent stores scaled up their operations to close the gap in supply. This adaptive capacity demonstrates how online food hubs and other community-embedded retailers augment resilience in the food system. The food hubs' ongoing partnerships with local organisations to tackle social issues (see section 5.3.2) is further evidence of their role in supporting community resilience.

The data relating to the pandemic was collected during the UK lockdowns (spring 2020 and winter 2020/21). The same question therefore arises as with the other studies; how relevant are these results to describe the current situation or the longer term impacts in a post-pandemic context? In other words, will these altered food behaviours persist? Nash, Whittle and Whitmarsh argue that habitual food behaviours "may be susceptible to disruption from 'moments of change' (significant or sudden changes in circumstances or context), which result in the regular behaviour no longer being possible or desirable" (2020, p.3). An exogenous event such as a pandemic is evidently a moment of change. One finding from this study and others is that the practical and cognitive barriers to online grocery shopping were removed by necessity, particularly for older people who had less prior experience using digital platforms (Cavallo, Sacchi and Carfora, 2020). It takes an average of two months to form a new habit, which will become embedded only if reinforced through routines or rewards (Günday et al., 2020). The UK lockdown durations were longer than two months and so there was sufficient time for new shopping, food management or dietary habits to form. The permanency of these new habits will depend on how favourably they are viewed relative to previous habits as the moment of change passes. A proportion of food hub users in this study, as well as those who participated in research conducted by Butu et al. (2020), stated they prefer their new shopping habits and so will continue beyond the pandemic.

Returning to the research question, the pandemic triggered a scaling up of online food hubs and other e-commerce retailers, both in terms of an influx of new customers and an increase in demand from existing customers. This is only contextual factor where a causal relationship can be affirmed with high confidence (see 'limitations' below) because multiple empirical and secondary data converge showing altered shopping habits and increased numbers of adopters. While some hub customers may revert to previous shopping behaviours and retailers, it is also plausible that others will continue to buy from online food hubs for reasons other than necessity, now they have direct experience of using them. Attributes such as convenience, food quality, or even a revised perception of compatibility with their daily lives, may be sufficient to consolidate their adoption decision.

7.6.3 Limitations of the secondary data

A wide range of data sources were used in this chapter to provide information about the numerous factors which could affect the scaling up of online food hubs. The limitations of the survey and interview data were discussed in previous chapters and so the focus here is on the limitations of the secondary data. This data was used to describe the potential impacts of societal contexts and trends on food hub adoption, as prior empirical research on this specific topic was not available. The inclusion of this analysis was to overcome one valid criticism of DoI, that the external context of adoption is largely omitted from the framework (Shove, 1998; Lyytinen and Damsgaard, 2001). Indeed, other theoretical frameworks such as *Sociotechnical transitions* (Geels, 2004) have a much stronger emphasis on the effect of contextual factors in determining whether an innovation becomes mainstream. Without detracting from the relative strengths of DoI, these contextual factors were considered relevant for making scaling up projections. The selected secondary data are considered reliable and of high quality as they originate from respected research institutes (NatCen, UK government data, reputable market research companies). The issue is the validity in applying it to this study because the initial research was conducted for unrelated purposes and so making causal inferences is more tenuous (Smith, 2008; Johnston, 2017). However, this limitation was considered preferable to disregarding the potential impact of factors such as socio-cultural norms (dietary shift, pro-environmental awareness) or the market hegemony of large retailers on food hub adoption.

8 Results: How does the use of online food hubs reduce GHG emissions?

This chapter explores the emission implications of using online food hubs. Figure 34 is duplicated from Chapter 1 and shows the three main ways consumers can reduce their food carbon footprint. The blue text refers to six emission reduction mechanisms based on empirical data from this study and key aspects of the online food hub business model. The chapter is structured according to these reduction mechanisms.

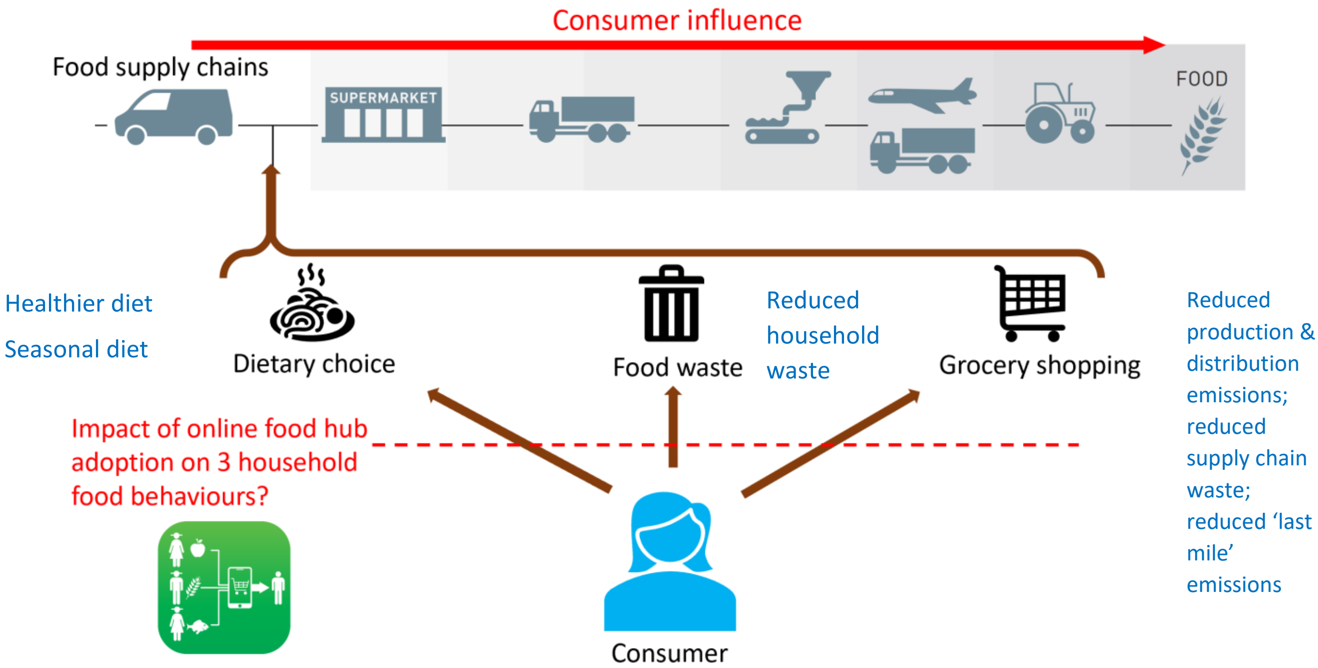


Figure 34, Consumer influence on food supply chains and the emission reduction mechanisms

Figure 35 shows emission reduction explored at three levels:

1. Sample - based on the food hub users who participated in this study and calculated at the household level
2. Population - the estimated total number of food hub users in the UK (n=3483). Assumptions were used to calculate this figure (see Appendix 8.1)
3. Potential future population - a scenario of a more widespread adoption of online food hubs (see section 8.1, below)

The household level relates directly to the consumer food behaviours shown in Figure 34 and it identifies which of these behaviours represents the greatest emission reduction potential. Exploring reductions at the 'population' and 'potential future population' levels provides insights into the possible contribution of online food hubs to mitigate UK food system emissions.

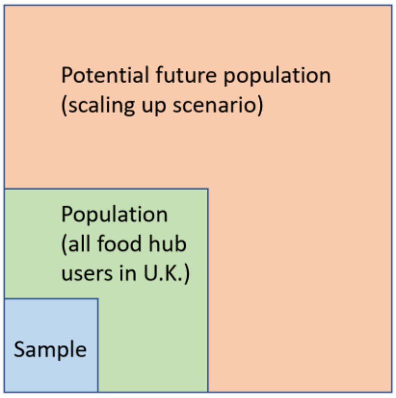


Figure 35, Emission reduction explored at three levels

Quantifying emissions and proposing scaling up scenarios entails multiple types of uncertainty: response variation; the relative strength of causal associations based on empirical data; variation in how different food hubs and producers operate; differing emission estimates in the LCA studies (depending on the context, or the methodology, functional units and system boundaries applied); and the assumptions used to extrapolate from the comparatively small respondent sample in this study to larger market segments. The emission quantifications are therefore situated within various uncertainty spaces, rather than providing a definitive emission reduction finding.

8.1 Potential adopter segments and scaling up

The previous chapters presented empirical findings that are consistent with Rogers' (2003) conceptualisation of innovation diffusion. Non-adopters' perceptions of online food hub attributes are generally positive and hub users actively encourage adoption in their social networks (see sections 4.3 & 7.2). Some non-adopters are similar in some ways to existing users and these individuals are considered more likely to be receptive to the idea of adopting (see sections 4.1 & 7.4). Following the DoI framework, if the above elements of innovation diffusion combine, a more widespread adoption of online food hubs would be the outcome.

Figure 36 shows five population segments that are indicative of larger potential markets for online food hubs. These 'potential adopter segments' were formulated on the basis of shared characteristics with existing hub users, while taking into account two contextual limitations to adoption identified in this study (see explanation in Appendix 8.2). The segments are considered the maximum possible scope for adoption, whereby all individuals within a social system choose to adopt. For example, people who consider healthy food to be important *and* have an online food hub operating in their area *and* have digital competences comprise 19% of the total UK population. The figure illustrates there are multiple ways in which potential adopters may be comparable with existing food hub users. Moreover, there are multiple ways online food hubs appeal to consumers (see section 4.2), some of which align with the characteristics presented in Figure 36.

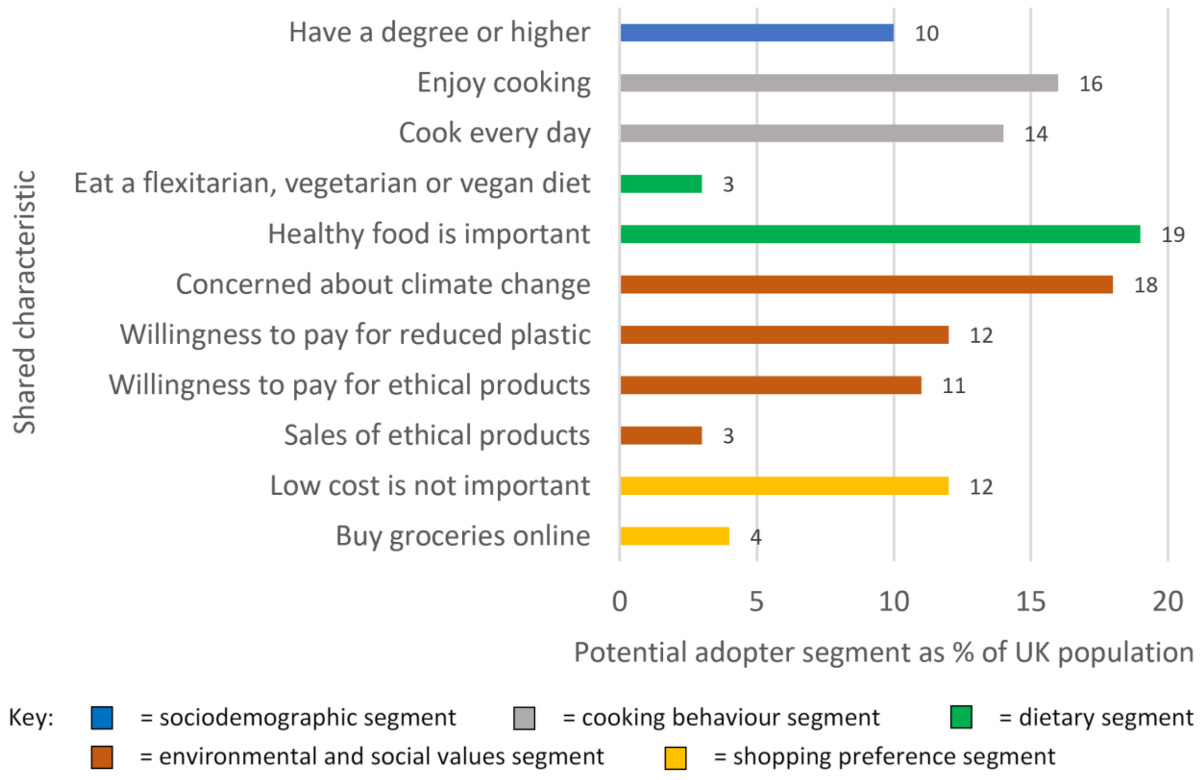


Figure 36, Potential adopter segments based on shared characteristics with food hub users

There is one further limitation which has not yet been discussed. Scaling up adoption in these potential adopter segments assumes elasticity of supply to meet the increase in demand. Although online food hubs scaled up considerably during the pandemic, their market share remains marginal and so this elasticity is a particularly ambitious assumption. There is, however, some evidence to suggest that supply is not necessarily static. First, the UK currently produces 55% of the food consumed domestically (DEFRA, 2020). It is conceivable that some farmers could switch supply chains if they perceived an advantage in doing so. Second, the UK government is in the process of reforming agricultural subsidies under the new 'Environmental Land Management schemes' (ELMs) (DEFRA, 2021a). If farmers adopt more environmentally friendly practices to meet these requirements, they may see an opportunity for greater profit margins through product differentiation and direct marketing. The third factor is the prominence of local food systems in other countries. Short supply chains represent 8% of the French food market (Herbert, Robert and Saucède, 2018). In the US, 7.8% of farms are engaged in some form of direct marketing, equating to 2.2% of overall agricultural sales (Low et al., 2015; Martinez and Park, 2021). In Switzerland, 26% of farms sold to consumers in 2020, up from 12% in 2010 (Agristat, 2021). Although it cannot be claimed that local food systems are challenging the hegemony of supermarkets in these countries, the 'local' market share is considerably larger than in the UK and so these countries provide a useful reference point.

8.2 Healthier diet emissions

The interviews revealed that over half of the respondents believe their diet has become healthier since they started using the hub and some attributed this to the regularity of fresh fruit and vegetables entering the household (see section 5.5.3). This finding is consistent with other studies which investigated how participation in alternative food networks can change people's dietary patterns (AbuSabha, 2016; Verame et al., 2018; Huyard, 2020).

Figure 37 compares the potential emission saving from eating a healthy diet relative to the UK-average diet, using existing LCA studies (see summary tables in Appendices 8.3 & 8.4). The healthy diets described in these studies are based on national nutritional guidelines, such as the UK 'Eatwell Guide', or diets which are advocated in public health literature such as the 'Atlantic' or the 'Mediterranean'. The LCA articles present different emission estimates and this is reflected in the wide range for both diets. The minimum and maximum estimates for the UK-average diet are 3.34 and 8.81 kg CO_2-eq. person^{-1} day^{-1} (Aston, Smith and Powles, 2012; Hoolohan et al., 2013). Regarding a healthy diet, the minimum estimate is 2.10 kg CO_2-eq. person^{-1} day^{-1}, whereas the maximum is 4.93 kg CO_2-eq. person^{-1} day^{-1} (van de Kamp et al., 2018; Meier and Christen, 2013). In the maximum range emission reduction scenario (e.g. the max. UK-average diet estimate – the min. healthy diet estimate), eating a healthy diet could save up to 5,853 kg CO_2-eq. household^{-1} year^{-1}. However, due to the overlap in the ranges, a healthy diet could actually increase emissions by 1,388 kg CO_2-eq. household^{-1} year^{-1} (the min. UK-average diet estimate – the max. healthy diet estimate).

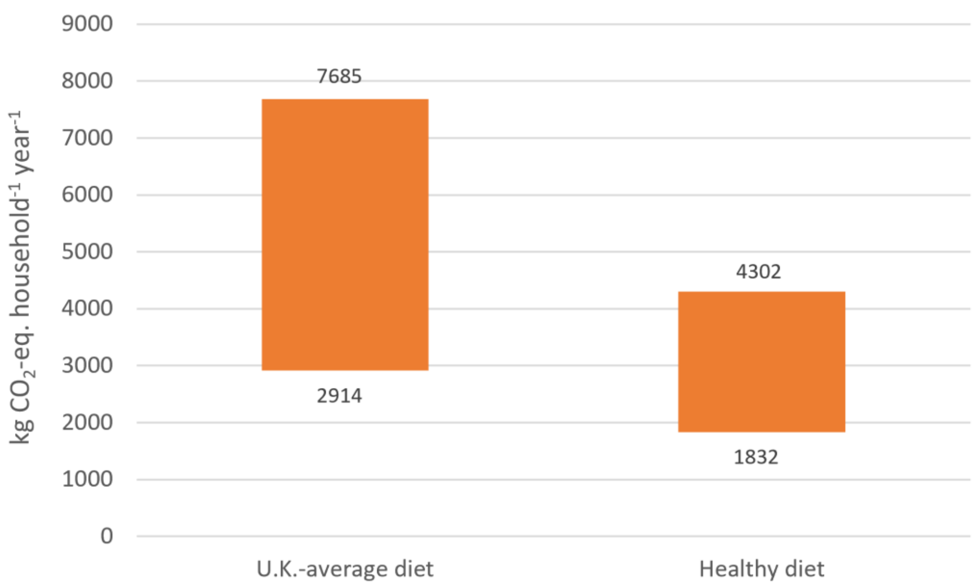


Figure 37, Emissions associated with the UK-average diet vs a healthy diet

If the healthier eating outcome is applied to all current users of online food hubs in the UK (n=3483), the maximum reduction scenario would result in emission savings of 20.4 kt CO_2-eq. year^{-1} (population level). The 'healthy food is important' is the largest potential adopter segment (see Figure 36). Extrapolating from the high estimate, if all of the households in this segment decided to adopt an online food hub and subsequently ate a healthier diet, the resulting emission reduction would be 30.9 Mt CO_2-eq. $year^{-1}$ (potential future population level, see Appendix 8.5 for calculation). To put this into context, the entire UK food system emissions in 2019 were estimated to be 158 Mt CO_2-eq. (WRAP, 2021b)[38].

This potential emission saving is huge, but then so is the challenge of upscaling to the entire healthy eating potential adopter segment (e.g. 19% of UK households). There is, however, one clear leverage point. Healthy eating is a prominent public health approach to tackle various dietary related illnesses and features strongly in the 'National Food Strategy' (2021). Sourcing from online food hubs could conceivably play a role in meeting three of the strategy's key recommendations. This is discussed further in chapter 9.

8.3 Household food waste emissions

The interviews revealed that a minority of hub users have reduced their household food waste as one outcome of using an online food hub (see section 5.1.1), a finding that is consistent with a study conducted by O'Neill et al. (2022). However, neither this study nor O'Neill et al. quantify the waste reduction.

Avoidable household food waste was calculated as 180 kg $household^{-1}$ $year^{-1}$ in the UK. The maximum emission estimate for household food waste identified in the LCA literature was 2500 kg CO_2-eq. t^{-1} waste, whereas the minimum was 490 kg CO_2-eq. t^{-1} waste (Tonini, Albizzati and Astrup, 2018; Salemdeeb et al., 2017). Based on these LCA findings, Figure 38 shows the associated emission reduction ranges from 88 to 449 kg CO_2-eq. $household^{-1}$ $year^{-1}$ (see Appendix 8.6 for articles and calculations). The emission reduction associated with food waste prevention, as a result of using an online food hub, is assumed to fall within this range or uncertainty space.

[38] The maximum potential emission saving of 30.9 Mt CO_2-eq. $year^{-1}$ may seem high, relative to the entire UK food system emissions of 158 Mt CO_2-eq. $year^{-1}$. This is partly because the maximum UK-average diet estimate in the LCA literature (Hoolohan et al., 2013; 7685 kg CO_2-eq. $household^{-1}$ $year^{-1}$) is somewhat higher than the estimate by WRAP (2021b; 5700 kg CO_2-eq. $household^{-1}$ $year^{-1}$). Using WRAP's UK-average diet estimate, the maximum emission saving would equate to 20.4 Mt CO_2-eq. $year^{-1}$.

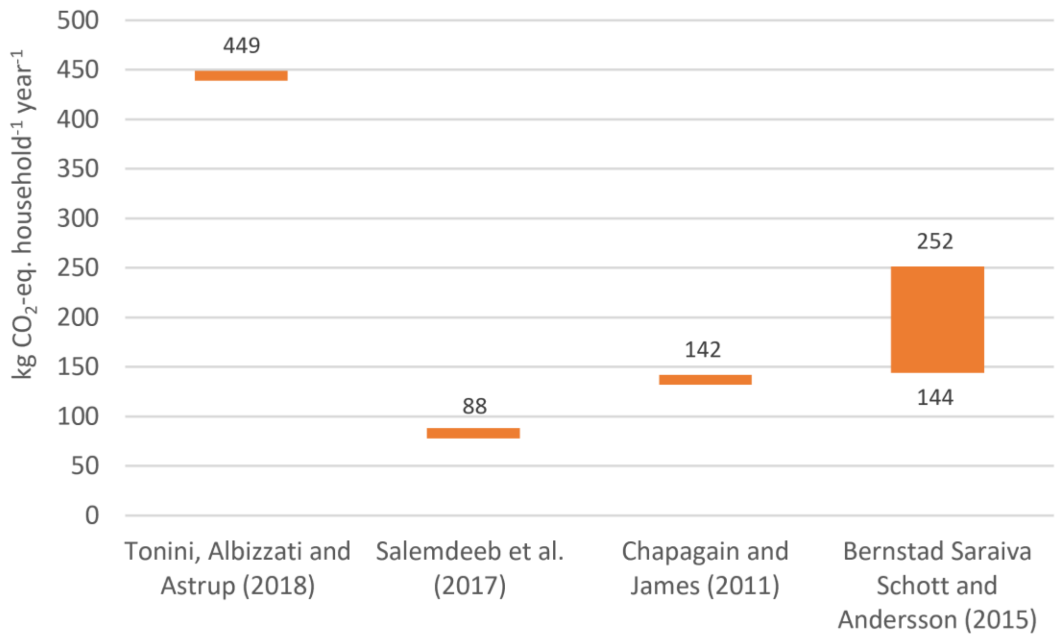


Figure 38, Potential emission reduction from preventing household food waste

Most interview respondents were already conscious of avoiding food waste prior to adoption. If we therefore assume a minority comprising 20% of current users at the population level (n=697) reduced their overall household food waste by half, the resulting emission reduction would be between 30.7 - 156.5 t CO_2-eq. year^{-1}. If all of the households in the 'cook every day' potential adopter segment started using an online food hub and 20% of those households (n=778,400) consequently reduced their food waste by half, the resulting emission reduction would be between 68.5 - 349.7 kt CO_2-eq. year^{-1} (potential future population level, see Appendix 8.6).

8.4 Supply chain emissions

This section considers the third way consumers can reduce their food carbon footprint - buying food which has less embodied emissions in its production, harvesting or transportation. 85% of food hub users buy less from supermarkets since joining the hub (see section 6.2). If online food hub supply chains are intrinsically less emission intensive than conventional supply chains due to one or more of the above activities, this substitution of food retailers infers an emission reduction.

8.4.1 Seasonal diet

The interviews revealed that most hub users associate using an online food hub with eating a more seasonal diet (see section 5.5.2). As discussed in the literature review, eating a seasonal diet may save emissions but it is contingent on the time of year, the production method and, if imported, the mode of transport. Figure 39 shows the potential emission reduction from eating a 'local seasonal' diet ranges from 5% to 60%, relative to the national average diet[39], although the upper estimate would entail a very restrictive diet for much of the year and so is not considered a realistic consumer choice.

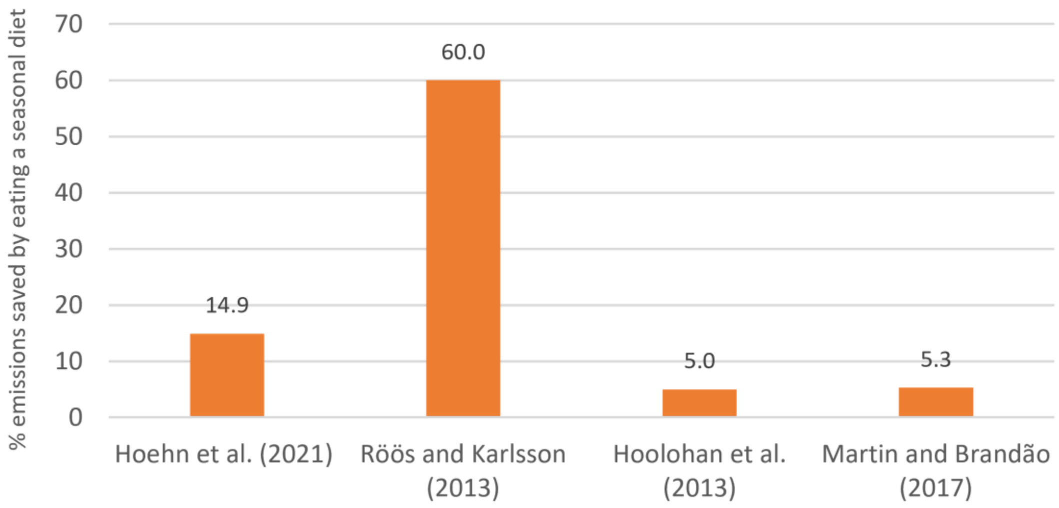


Figure 39, Percentage emission reduction by eating a seasonal diet

There are two main approaches to increasing the variety of fresh produce outside of the domestic summer growing season: 1) the use of heated greenhouses to extend the domestic season, and 2) importing food (e.g. 'global seasonal').

Field or passive greenhouse production vs heated greenhouse production

The lower section of Figure 40 shows domestically produced (in this case, Switzerland) zucchini has lower emissions from May - September (0.6 kg CO_2-eq. kg^{-1} produce, indicated in green), whereas importing from Spain, Italy or Morocco and transported by lorry has lower emissions from October - April (0.7 - 1.0 kg CO_2-eq. kg^{-1}, also indicated in green). Heated greenhouse production in Switzerland in March, April, October and November is the most emission intensive option (3.9 kg CO_2-eq. kg^{-1}, indicated in red). Considering a wider range of crops, field grown or passive greenhouse production ranges from 0.06 - 1.38 kg CO_2-eq. kg^{-1}, whereas heated greenhouse production ranges from 0.6 - 10.1 kg CO_2-eq. kg^{-1} (see Appendix 8.7 for the LCA studies used to formulate these max-min ranges).

Online food hubs do not typically use heated greenhouses but they do occasionally import by road from southern Europe during the UK 'hungry gap' (see producer 'shop fronts' on the food hub platforms; also, hub e-newsletters to their customers, interviews I5 & I15). The emissions of food hub produce are therefore assumed to fall within the lower range of 0.06 - 1.38 kg CO_2-eq. kg^{-1} produce.

[39] The reference points are the national average diet in the UK (Hoolohan et al., 2013), Spain (Hoehn et al., 2021) and Sweden (Röös and Karlsson, 2013; Martin and Brandão, 2017)

kg CO2-eq per kg vegetable		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Green asparagus	CH-Lorry	n.a.	n.a.	n.a.	1.9	1.9	1.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	ES-Lorry	n.a.	n.a.	n.a.	2.1	2.1	2.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	MX-Air	22.7	22.7	22.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	PE-Air	24.9	24.9	n.a.	n.a.	n.a.	n.a.	24.9	24.9	24.9	24.9	24.9	24.9
	US-Air	n.a.	18.7	18.7	18.7	18.7	18.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Zucchini	CH-Lorry	n.a.	n.a.	3.9	3.9	0.6	0.6	0.6	0.6	0.6	3.9	3.9	n.a.
	ES-Lorry	0.9	0.9	0.9	0.9	n.a.	n.a.	n.a.	n.a.	n.a.	0.9	0.9	0.9
	IT-Lorry	0.7	0.7	0.7	0.7	n.a.	n.a.	n.a.	n.a.	n.a.	0.7	0.7	0.7
	MA-Lorry	1.0	1.0	1.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1.0	1.0
Zucchini TK	FR-Lorry	1.8	2.0	2.2	2.3	1.1	1.1	1.1	1.1	1.1	1.3	1.5	1.6
Zucchini TK	CH-Lorry	0.7	0.7	0.7	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7

Figure 40, Global warming potential per kilogram of zucchini and green asparagus as an example for the creation of the season table. Duplicated from: Jungbluth, Keller and König (2015, p.651)

Avoiding air freight

The upper section of Figure 40 indicates the impact of the mode of transport. Eating asparagus in the domestic season (April - June, indicated in green) or importing by lorry from Spain results in 1.9 - 2.1 kg CO_2-eq. kg^{-1} asparagus, whereas importing by air freight during the rest of the year results in 18.7 - 24.9 kg CO_2-eq. kg^{-1} (indicated in red). Considering a wider range of crops, UK production or importing by lorry from southern Europe ranges from 0.6 - 2.1 kg CO_2-eq. kg^{-1} produce, whereas air freighting the same fruits or vegetables ranges from 7.4 - 24.9 kg CO_2-eq. kg^{-1} (see Appendix 8.8 for the LCA studies used to formulate these max-min ranges).

Online food hubs do not import by air freight and so the emissions of food hub produce is therefore assumed to fall within the lower range of 0.6 - 2.1 kg CO_2-eq. kg^{-1} produce.

Seasonal diet emission reduction

Hub users spoke of delegating responsibility to the food hub to make environmentally responsible decisions regarding the sourcing of their food (see section 5.4.1). On the evidence of this study, online food hubs encourage a local seasonal diet where possible, import by road when necessary, and avoid two of the most emission intensive practices. Combining the two lower ranges described above produces an overall range of 0.06 - 2.1 kg CO_2-eq. kg^{-1} produce for ten illustrative crops: tomatoes, cucumber, peas, asparagus, zucchini, garlic, winter veg, cherries, apples and strawberries. This emission range is comparable with the range identified by Clune, Crossin and Verghese (2017; see Appendix 8.7). The emissions of *all* fruits and vegetables bought from online food hubs are assumed to fall within this combined lower range.

Based on the average weekly consumption of food hub fresh produce (see section 6.3), the emissions of eating a local seasonal diet as an outcome of using an online food hub are between 7.9 - 274.8 kg CO_2-eq. $household^{-1}$ $year^{-1}$ for vegetables and between 1.4 - 50.0 kg CO_2-eq. $household^{-1}$

year^{-1} for fruit. In terms of the emission reduction, the 'avoided heated greenhouse' scenario prevents 3.2 - 47.6 kg CO_2-eq. household^{-1} year^{-1} for fruit and vegetables combined. The 'avoided air freight' scenario prevents a further 102.2 - 317.4 kg CO_2-eq. household^{-1} year^{-1} for fruit and vegetables combined. Scaling up to the total estimated number of food hub users in the UK, the resulting emission reduction would be between 367.1 - 1271.3 t CO_2-eq. year^{-1} (population level). If all households in the 'concerned about climate change' potential adopter segment decided to adopt, the resulting emission reduction would be between 527.4 - 1,826.5 kt CO_2-eq. year^{-1} (potential future population level, see Appendix 8.9 for calculations).

8.4.2 Production methods

Online food hubs place an emphasis on environmentally friendly or low carbon farming practices[40] as part of their value proposition. Organic is the most prominent farming method mentioned on the platforms and so forms the reference point, although this entails some uncertainty because not all online food hubs sell only organic produce.

Fruit and vegetables, bread and dairy products comprise approximately two thirds of the typical food hub shopping basket (see section 6.1.2). Figure 41 shows the emission ranges of two production systems for these three food categories. The emission ranges for organic production are, for the most part, lower than the ranges for conventional production per kilogram of product, although there is a large degree of overlap. The relatively wide ranges reflect two types of variability: 1) differing LCA estimates of the emission intensity of the two respective farming systems, and 2) the 'veg' and 'cereal' categories comprise multiple crops (see Appendices 8.10 - 8.12 for the LCA studies used to formulate the max-min ranges in Figure 41).

[40] This refers to farming methods aside from avoiding the use of heated greenhouses. Organic (or working towards organic certification) is the most common, although other practices such as no-till and regenerative agriculture are also mentioned. See: *Cultivate Oxford* About Us - Cultivate (cultivateoxford.org) ; *Glasgow Locavore* About our Farm – Locavore ; *Tamar Valley Food Hubs* Your Online Farmers' Market | Tamar Valley Food Hubs | Cornwall

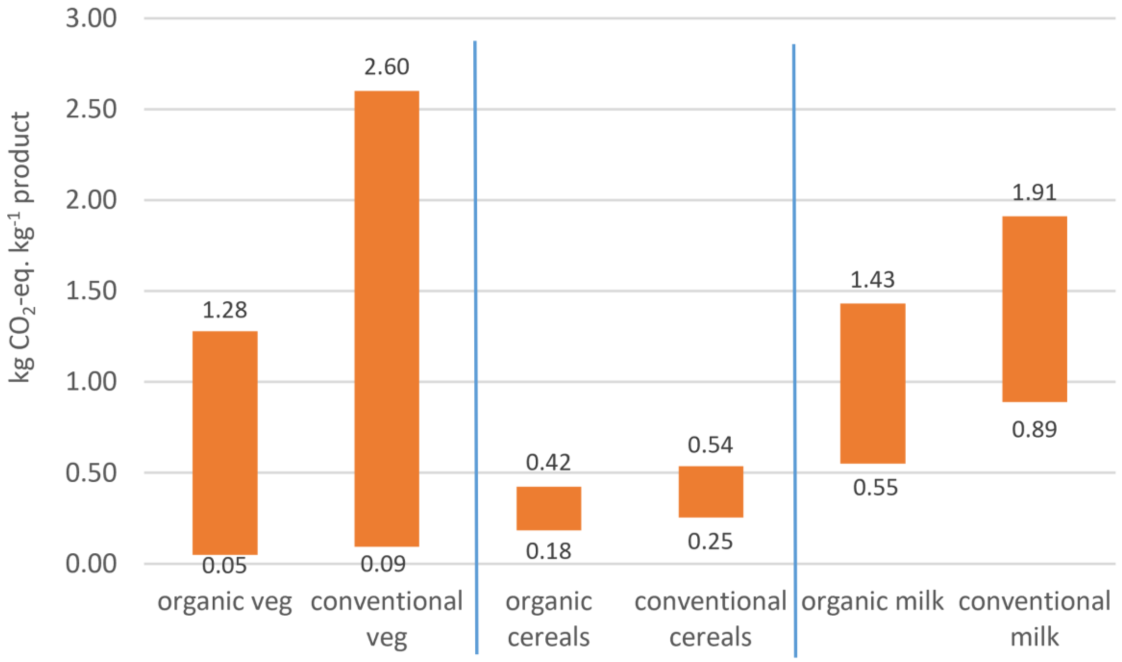


Figure 41, Emission intensity of organic vs conventional production for three food categories

For the maximum range emission reduction estimates in Figure 41 (the max. conventional estimate – the min. organic estimate), organic production could save up to 2.55 kg CO_2-eq. kg^{-1} for fruit and veg, up to 0.35 kg CO_2-eq. kg^{-1} for cereals and 1.36 kg CO_2-eq. kg^{-1} for milk[41], relative to conventional production. Based on the average quantities of these foods the hub users buy from their local hub (see section 6.3), the maximum potential emission reduction would equate to 493.7 kg CO_2-eq. $household^{-1}$ $year^{-1}$. However, due to the overlap in the ranges, organic production could actually increase emissions by up to 223.4 kg CO_2-eq. $household^{-1}$ $year^{-1}$ (the min. conventional estimate – the max. organic estimate).

Scaling up to the population level, the maximum emission reduction would be 1,719.4 t CO_2-eq. $year^{-1}$. If all households in the 'willingness to pay for ethical products' potential adopter segment decided to adopt, the resulting emission reduction would be 1,509.6 kt CO_2-eq. $year^{-1}$ (potential future population level, see Appendix 8.13 for calculations).

[41] Milk is used as a proxy for all dairy products in the calculations. Cereals is used as a proxy for bread and pastries (this will be an underestimate because one kg of bread requires less than one kg of flour)

8.4.3 Reducing food waste in the supply chain

Online food hubs reduce supply chain waste in two ways: 1) they harvest to order and so match supply with demand[42]; and 2) they do not impose strict aesthetic criteria for fresh produce[43], as is standard practice in conventional supply chains. These two aspects of the food hub business model represent a significant emission reduction potential. Drawing on the work of Poças Ribeiroa et al. (2019), Figure 42 shows the three food categories where most retail waste occurs. The alternative food network (indicated in red, <2% waste) compares favourably with mainstream retailers (indicated in orange, 0.6%-9% waste) for the percentage of food wasted at the retail stage of the supply chain.

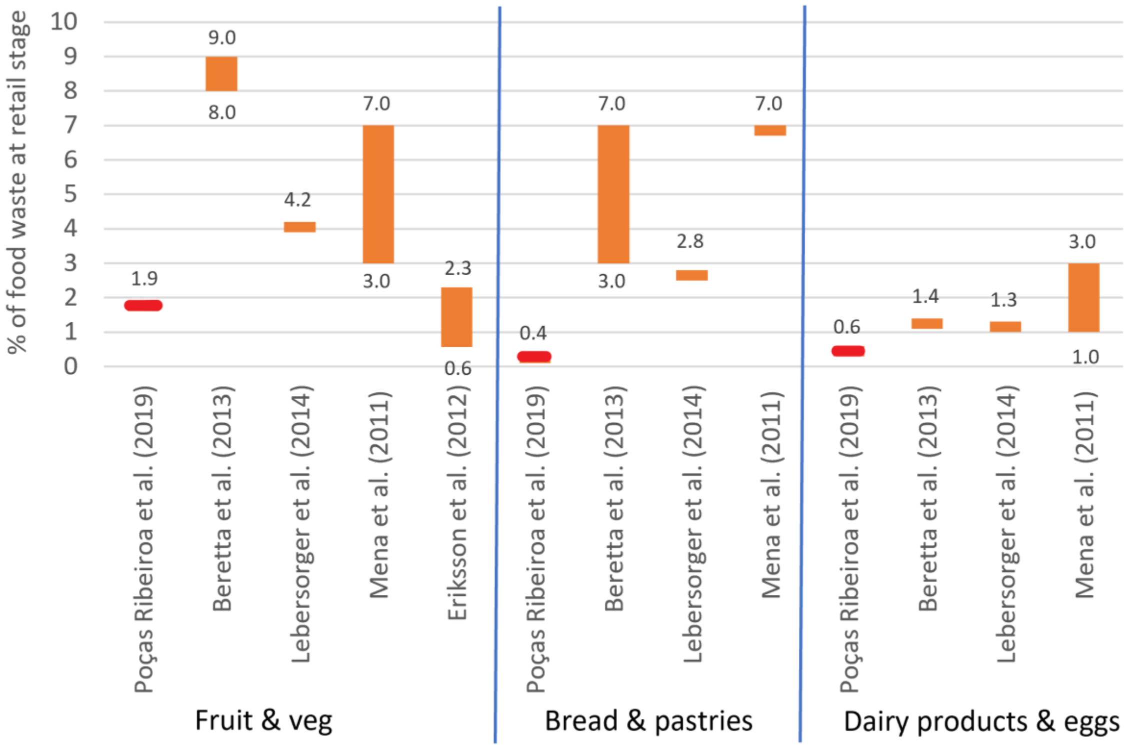


Figure 42, Percentage of food waste at retail stage for three food categories

From Figure 42, we can extrapolate that online food hubs may save up to 7.1% of fruit and veg waste, up to 6.6% of bread and pastries and up to 2.4% of dairy products and eggs, relative to mainstream retailers. In the high estimate scenario, this avoided food waste would equate to 6.7 - 34.2 kg CO_2-eq. household^{-1} year^{-1} (see Appendix 8.14 for LCA articles and calculations). If this avoided waste is applied to all current users of online food hubs in the UK, the associated emission

[42] Stated on the *Great British Food Hub* platform, March 2022: "All produce is supplied by LOCAL farmers and food & drink producers…Because they know their orders in advance there is NO WASTAGE!" [Local Farm Shops | Fresh Produce Near Me::The Great British Food Hub]

[43] Personal communication with hub managers in March 2019

reduction would be 23.3 - 119.0 t CO_2-eq. year^{-1} (population level). If all of the households in the 'willingness to pay for ethical products' potential adopter segment chose to adopt an online food hub, the resulting emission reduction would be 20.5 - 104.5 kt CO_2-eq. year^{-1} (potential future population level).

There are further potential emission savings for the fruit and veg. Retail waste comprises 0.3 M tonnes in the UK, compared to 1.6 M tonnes in primary production (WRAP, 2019). A major contributor to primary production waste is the aesthetic standards which are imposed by supermarkets[44] but implemented by farmers. Only two papers were found which quantify pre-farm gate waste attributed to aesthetic standards. Porter et al. (2018) estimate over a third of total farm production is lost for aesthetic reasons, which equates to 970 kt CO_2-eq. year^{-1} in the UK[45]. Hooge, van Dulm and van Trijp (2018) estimate losses of 2% - 40% relating to aesthetic criteria in the Netherlands and Germany. WRAP (2019) estimate 7.3% food waste in primary production, without attributing this to a specific causal factor.

8.4.4 'Last mile' transportation

Post-retail transportation is from the distribution centre or the supermarket to the consumer's home. These 'last mile' emissions are estimated to be as much as 5.8% of the food system's total CO_2-eq. (Stelwagen et al., 2021). A typical trip to the supermarket by car emits 4,274 g CO_2, whereas a typical home delivery by van emits between 181 - 4,274 g CO_2 (Edwards, McKinnon and Cullinane, 2009; Rizet et al., 2010). Using these LCA findings, the average emissions associated with car travel to supermarkets was calculated as 283 kg CO_2 household^{-1} year^{-1}. A weekly supermarket home delivery combined with a weekly food hub delivery would result in 19 - 283 kg CO_2 household^{-1} year^{-1}. If the avoided last mile emissions are applied to all current UK food hub users, the maximum potential emission reduction would be 918.5 t CO_2 year^{-1} (population level). Scaled up to the 'buy groceries online' potential adopter segment, the maximum potential emission reduction would be 293.3 kt CO_2 year^{-1} (potential future population level, see LCA articles and calculations in Appendix 8.15).

Some online food hubs such as *Goodery* in Norwich[46] use electric vehicles for their deliveries and this further reduces emissions, although mainstream retailers are also beginning to convert to electric vehicles[47]. Moreover, consumers are increasingly buying electric cars and so the emissions associated with driving to the supermarket will gradually decrease as combustion engine vehicles become obsolete and electricity supply decarbonises. It is therefore difficult to make robust claims of emission reduction relating to the use of electric vehicles for food hub delivery.

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[44] Some UK supermarkets are now looking to address this e.g. Morrisons' 'Wonky veg' and Tesco's 'Perfectly Imperfect'
[45] This would equate to 34.9 kg CO_2-eq. household^{-1} year^{-1} for each UK household
[46] *Goodery*. Climate Positive Groceries—Delivered—in Norwich, Norfolk – Goodery
[47] The Guardian, 2021. Tesco to begin UK's first commercial use of fully electric HGVs | Tesco | The Guardian

8.5 Discussion

The discussion considers three key themes: the potential emission reduction at the three analytical levels, some reduction mechanisms that were excluded from the analysis, and the limitations of the LCA synthesis approach.

8.5.1 Potential emission reduction at the household level

Local food systems are often described as low carbon but without substantiation on how they reduce emissions or to what extent ('food miles' excepted). This chapter identified six emission reduction mechanisms relating to consumer behaviour changes or supply chain characteristics and quantified, within uncertainty ranges, their relative emission savings. Figure 43 shows the *maximum* potential emission reduction in kg CO_2-eq. household^{-1} year^{-1} for the six mechanisms. The error bars indicate the uncertainty space, according to differing estimates in the LCA literature. To place these potential savings in context, the highest estimate for the food emissions of a typical UK household is 7685 kg CO_2-eq. household^{-1} year^{-1} (Hoolohan et al., 2013).

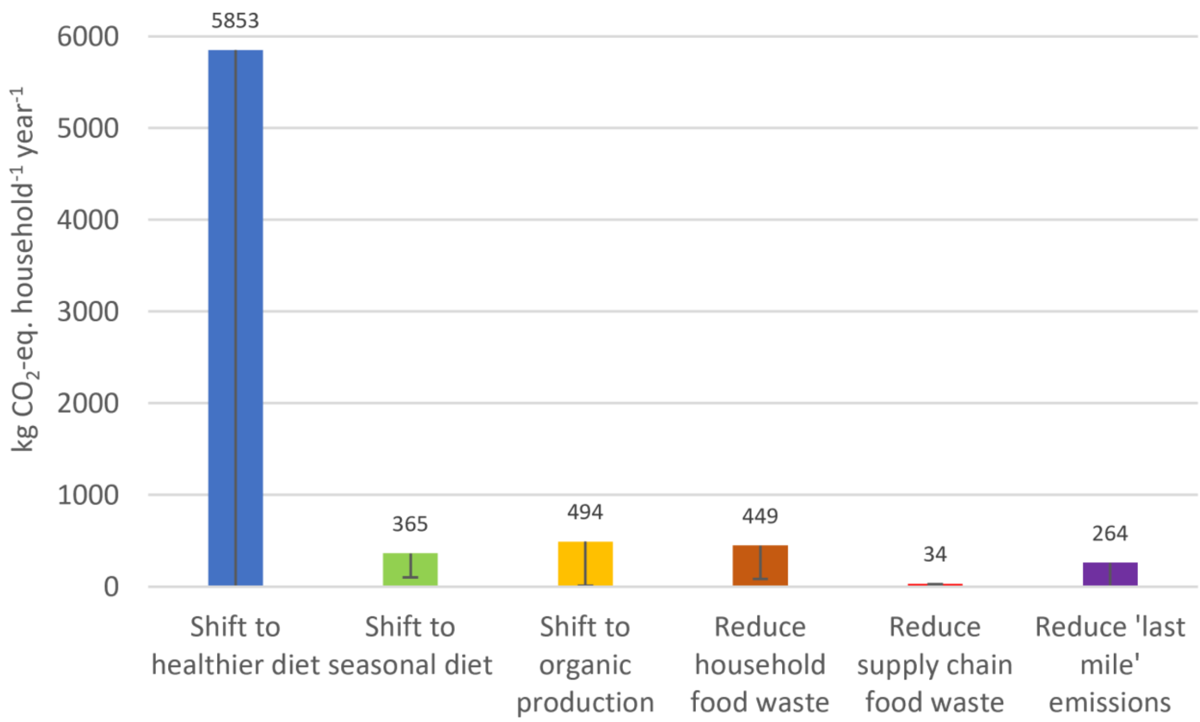

Figure 43, The relative emission reduction potential of six mechanisms, as a result of using an online food hub

The large emission saving of shifting to a healthier diet is apparent in Figure 43. This is primarily due to a 'healthy diet', as defined in national nutritional guidelines or healthy diet archetypes, implying a reduced consumption of meat and an increased consumption of fresh vegetables and pulses (Springmann et al., 2016; Quam et al., 2017). Shifting to a healthy diet does not necessarily require a change in dietary preference (e.g. from omnivore to vegetarian), although clear parallels can be drawn with choosing a flexitarian diet. One important observation is the role of online food hubs in supporting a transition to a low carbon diet, either as a means of sourcing foods which are compatible with a conscious decision to eat more healthily, or as an indirect consequence of changing food shopping habits and suppliers (see section 5.5.3). Whether the shift to a healthier diet is intentional or otherwise, the scope for reducing emissions is considerable.

Despite the prevalence of a healthy diet in Figure 43, the other mechanisms are not inconsequential and can be considered viable ways in which consumers can reduce their food carbon footprint. Thus, the second key finding is that a single consumer action, adopting an online food hub, provides multiple routes to achieving a climate mitigation outcome. Two of the emission reduction mechanisms can be summated: *reduce* supply chain waste and *reduce* last mile emissions. These mechanisms describe distinct processes of how food is managed or transported, with a combined maximum reduction of 298 kg CO_2-eq. household^{-1} year^{-1}. *Reduce* household waste decreases overall demand, therefore lessening the emission impact of the above two mechanisms and so it cannot be summated. The remaining three mechanisms relate to the food itself or how it is produced: *shift* to a healthier diet, a seasonal diet, or organic production. These mechanisms cannot be summated because of a risk of double counting the emission reduction, although one of the three mechanisms can be added to the two summative mechanisms to indicate an overall potential reduction at the household level[48]. Moreover, if an individual already eats a healthy diet prior to adopting an online food hub, they may still lower their carbon footprint through eating a seasonal diet or more organic produce, albeit to a lesser extent.

Returning to Schanes, Giljum and Hertwich's (2016) framing of 'mitigation options for consumers to reduce their food-related GHG emissions' (see Table 1), two of the mechanisms can be interpreted as 'direct reduction' measures: *shift* to a healthier diet and *reduce* household waste both infer consuming less of something (e.g. meat, and over-provisioning in general). The remaining four mechanisms can be interpreted as 'direct improvement' measures: *shift* to a seasonal diet or to organic production supports farming methods or supply chains that are less emission intensive; *reduce* supply chain waste through harvesting to order is more materially efficient; and *reduce* last mile emissions occurs through decreased use of private vehicles. This framing is useful because it highlights the interrelationship between food consumption and food production, although they are often treated as two distinct research fields (Huyard, 2020). The 'direct improvement' measures demonstrate how a consumption choice (buying from an online food hub) endorses particular food production systems and modes of delivery, irrespective of the consumer's motivations for adopting. The 'direct reduction' measures reveal how continued use of an alternative food supply chain can, over time, affect consumption behaviour by encouraging healthier eating or less wasteful habits.

[48] For example, reduce supply chain waste + reduce last mile emissions + shift to a seasonal diet = 663 kg CO_2-eq. household^{-1} year^{-1} (using the maximum potential emission reduction for each mechanism)

8.5.2 Potential emission reduction at the population and potential future population levels

UK food system emissions currently stand at 158 Mt CO_2-eq. year^{-1} (WRAP, 2021b). The purpose of calculating emission reductions at the 'population' and 'potential future population' levels was to explore the feasibility and scope for online food hubs to mitigate emissions at the system level. For the current population of hub users, the emission savings for each mechanism are not especially high (< 1750 t CO_2-eq. year^{-1}, with the exception of the 'healthier diet' mechanism). However, as described in Appendix 8.1, the total number of UK food hub users is unknown and so a conservative estimate was used. Emission reductions at the potential future population level are significantly larger, in the order of hundreds of kt CO_2-eq. year^{-1} for five of the six mechanisms (or even several Mt CO_2-eq. year^{-1} for the 'healthier diet' mechanism). At this level, online food hubs would make a meaningful contribution to mitigating UK food system emissions. This positive outcome is contingent on a scenario of widespread adoption, as well as increased supply. Possible approaches for boosting adoption are discussed in chapter 9.

8.5.3 Emission reduction mechanisms excluded from the analysis

There are three additional reduction mechanisms that were not considered because of a lack of available data on which to base calculations or assumptions. The first is pre-retail transportation (excluding air freight), from farm gate to the distribution centre or supermarket. Food hub produce travels an average of 25 miles from farm to consumer[49] and this is likely much less than the distance travelled in supermarket supply chains. However, the vehicle types and relative loads for both supply chains are unknown and likely very variable. The second mechanism is refrigeration. Energy use in cold chains is substantial, although determining emissions is difficult because they must be offset by the emissions saved through preventing food waste (Garnett, 2007; Accorsi, Gallo and Manzini, 2017). No data was collected in this study with respect to refrigeration or retail energy use in food hub supply chains. The third mechanism is packaging. Peano, Tecco and Girgenti (2018) found that alternative food networks use less plastic packaging and this can reduce emissions, depending on the product's susceptibility to spoilage. Aside from the photos in Appendix 7.5, no quantitative data was collected regarding the food hubs' use of plastic packaging.

Pre-retail transportation has the largest climate impact of these three excluded mechanisms, accounting for 11.5 - 15.6% of food system emissions (or 18.2 - 24.6 Mt CO_2-eq. year^{-1}), whereas refrigeration is estimated at 5.0 - 10.1 % of food system emissions (or 7.9 - 15.9 Mt CO_2-eq. year^{-1}) (Stelwagen et al., 2021; Garnett, 2007; Crippa et al., 2021). Relative to the other six reduction mechanisms, if online food hubs demonstrably and significantly lowered emissions by reducing refrigeration and pre-retail transportation, the likely emission reductions would be surpassed only by the 'shift to healthier diet' mechanism.

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[49] Distances stated on the websites of the *Great British Food Hub* Local Farm Shops | Fresh Produce Near Me::The Great British Food Hub and *Cultivate Oxford* Our Producers - Cultivate (cultivateoxford.org)

8.5.4 Limitations of the LCA synthesis approach

The limitations of this approach relate to the various sources of uncertainty that were described in the chapter introduction. This uncertainty cannot be removed and the consequences are a reliance on assumptions and a lack of precision in calculating emission estimates, challenges encountered by other scholars who have conducted LCA syntheses in the food domain (Hoolohan et al., 2013; Wang, Zhang and Schneider, 2021). Moreover, the uncertainty is amplified as the quantifications move from the respondent sample of this study (grounded in empirical data) to larger market segments (based on expectations of comparability and future adoption trajectories). However, the uncertainty and the assumptions are documented, either in the chapter text or the appendices, and so the emission calculations are open to scrutiny.

The main advantage of this approach is that it enables quantification of multiple emission reduction mechanisms, rather than focusing on a single consumer behaviour or supply chain activity. Climate mitigation leverage points in food supply chains can be identified and this has not yet been attempted for the use of online food hubs.

9 Discussion

The final chapter discusses the main contributions of this thesis and situates the findings within current developments in food system research, practice and policy. Thirteen recommendations are proposed to indicate how the health and climate benefits of online food hubs could be realised on a larger scale. Finally, the limitations of this study are presented.

Returning to the research questions, people use online food hubs for a range of perceived benefits that match their needs and preferences (RQ 1). The weekly delivery pattern becomes embedded within household food routines and affects other behaviours such as increased cooking from scratch and the consumption of healthy food (RQs 2 & 3). The hub users' positive communication and social influence are crucial in encouraging adoption, although exogenous factors such as the pandemic or trends towards environmental consumerism may also affect the rate of uptake (RQ 4). The ongoing use of online food hubs lowers GHG emissions through reduce and shift mechanisms associated with changes in food behaviour and a substitution of supply chains (RQ 5).

9.1 Contributions to the literature on online food hubs

This thesis applied Roger's (2003) DoI framework to analyse the diffusion of online food hubs. Two tenets of this framework are revisited here: the attributes of online food hubs which characterise the innovation appeal, and how to maximise the hub users' social influence to encourage adoption. Insights into altering food habits are highlighted. Finally, some recommendations for practice and research are presented.

9.1.1 Conceptualising the attributes of online food hubs

An important contribution of this study was to explore a wide range of attributes of online food hubs and establish their relative importance to consumers. This research fills the gap between Berti and Mulligan's (2016) two conceptualisations of the value proposition of food hubs, which are orientated more towards producers or the wider community than individual consumers (see section 2.5.1). Food quality, social and environmental benefits, shopping convenience and ensuring consistency with personal values were identified as the most salient attributes (see section 4.2). This section considers whether these findings align with the value proposition presented to consumers on the food hub platforms and interprets the results using key themes in the diffusion literature.

Consumer perceptions of the attributes of an innovation are crucial in determining its rate of adoption (Rogers, 2003; Pettifor et al., 2020). Rogers' (2003) framing of attributes was especially useful in this study, in particular *relative advantage* and *compatibility*. Supermarkets have a relative advantage over online food hubs with respect to several conventional attributes such as accessibility and cost, whereas food hubs are perceived to have a relative advantage for food quality and environmental benefits. Most of the attributes of online food hubs can be viewed through the lens of relative advantage with reference to mainstream retailers and practices. There are, however, other ways of conceptualising attributes and what they mean to consumers. One example is Levitt's ring model (1980). Figure 44 shows the most important attributes of online food hubs mapped onto this model. The attributes have been segmented into 'core' or primary attributes and 'non-core' or secondary/ tertiary attributes.

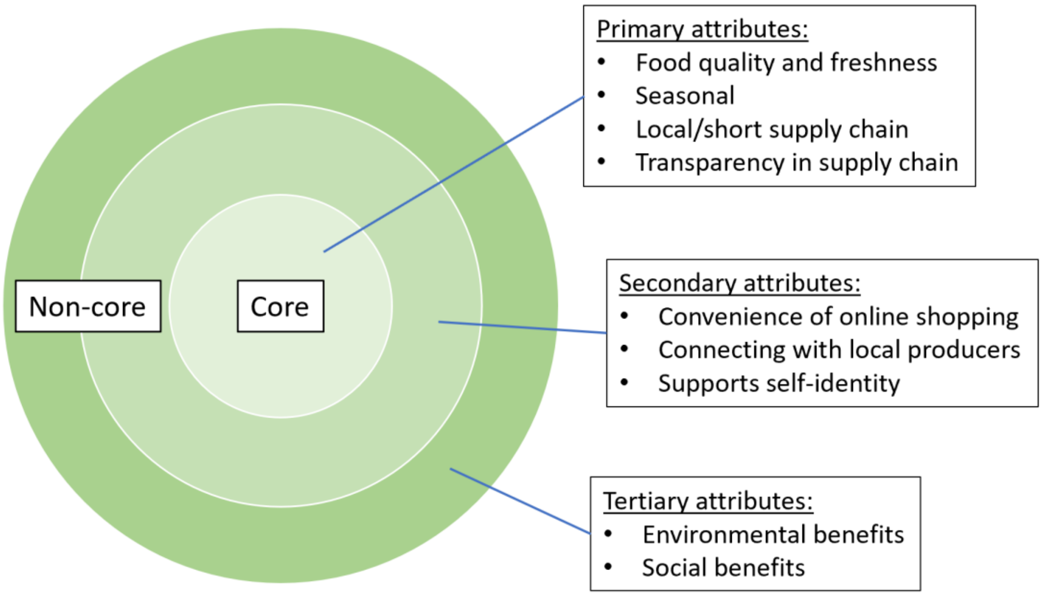

Figure 44, Core and non-core attributes of online food hubs. Adapted from Levitt (1980) and Pettifor and Wilson (2020)

The primary or core attributes are fundamental to the value proposition of online food hubs. They describe aspects of the food itself, for instance quality and freshness, or aspects of its production such as 'local-ness' and supply chain transparency. These elements of the value proposition are prominent on the food hub platforms, for instance:

> "The ultimate in traceability! Amazing produce from LOCAL farms and producers!" [50]

In their emphasis of the core attributes, the hubs strive to differentiate the food they offer from what is available in supermarkets. In particular, they reinstate the context or story of how the food was produced.

The non-core attributes are also important to the value proposition and there are two groups. The secondary attributes convey the customer experience of this way of buying food. This can relate to the convenience of ordering online, a consistency with personal identity or values, or the opportunity to talk to the producers and make social connections. For example:

[50] All 'value proposition' quotes duplicated from *Open Food Network*, see: [Open Food Network | Growing Local Food, Online.]
or *The Great British Food Hub*, see: [Local Farm Shops | Fresh Produce Near Me::The Great British Food Hub]

"Food Hubs are weekly online LOCAL markets which allow you to order from the comfort of your home, day or night."

"Producers and customers meet at the weekly Hub - a great opportunity to learn the processes that go into making your food!"

Tertiary attributes are also non-core but diverge from what online food hubs offer to customers to encompass the benefits they provide for the environment, society, or the local community:

"A fairer way to shop! Keeping 90% of what you spend in your LOCAL economy!"

"We think it's possible to create a food system with social and ecological health at its core."

Aside from ordering food online, the non-core attributes more clearly distinguish food hubs from supermarkets than the core attributes. Supermarkets and online food hubs both fulfil the core function of providing food, but online food hubs offer novelty through the non-core attributes in terms of the customer experience and the provision of public goods. This originality or added value of the non-core attributes matches previous conceptualisations of the consumer appeal of core vs non-core product features (Lee, Khan and Mirchandani, 2013; Armstrong et al., 2014; Pettifor and Wilson, 2020).

The most salient attributes of online food hubs identified by the survey respondents include both core and non-core attributes. This raises the question of whether the core or the non-core attributes are more important in the value proposition to consumers. Prior studies discovered that although non-core attributes can be especially appealing because of their novelty, the performance of the core attributes must remain above an acceptable level. Otherwise, core attributes can have a moderating effect on overall customer satisfaction (Brechan 2006; Slevitch et al., 2013; Lee, Khan and Mirchandani, 2013). The implication is that people may use an innovation for a variety of reasons but if principal functional needs are not fulfilled, then the added value of the non-core attributes becomes less important. Indeed, two of the main themes in the qualitative survey feedback centred on mistakes with orders and the short shelf life of some foods, both of which are core attributes. Moreover, hub customers often pay a premium for the produce and this raises their expectations regarding the core product attributes. If these expectations are repeatedly not met, discontinuance is the likely outcome.

Symbolic dimensions of food hub attributes

A further theoretical development of our understanding of attributes distinguishes the core and non-core into functional and symbolic dimensions using a 2 x 2 matrix (Axsen and Kurani, 2012; Sovacool and Axsen, 2018). Table 25 shows the attributes of online food hubs situated in these four domains. Private functional attributes directly benefit the customers of online food hubs and they correspond with the core attributes in Levitt's model. Public functional attributes describe how food hubs benefit society and they parallel the non-core attributes. Axsen and Kurani's (2012) framing is presented here because it introduces the idea of the symbolism, or what the attributes might represent for consumers. This builds on Rogers' (2003) understanding of compatibility with values.

Table 25, Four domains of attributes of online food hubs

	Functional	**Symbolic**
Private	Food quality and freshness Choice - seasonal, local Transparency in supply chain Convenience of online shopping	Supports self-identity
Public	Environmental benefits Social benefits	Reduce dependence on supermarkets

Adapted from Axsen and Kurani (2012) and Sovacool and Axsen (2018)

Private symbolic attributes relate to what online food hubs represent for their users. Four attributes were explored in the survey for this domain and the most salient was 'using food hubs fits well with my values and beliefs'. The results indicate that, for some individuals, buying from a food hub can be an expression of their self-identity or lifestyle choice such as caring about the environment or living in a sustainable manner. Using a food hub can also symbolise group membership and affinity with others in their local community who hold similar values. Thus, this aspect of appeal is not an intrinsic characteristic of food hubs or the service they provide but is discerned by the individual in terms of how using the food hub makes them feel. These findings resonate with research on how a pro-environmental identity can be an important determinant in purchasing and behavioural decisions, particularly in relation to food (van der Werff, Steg and Keizer, 2013; Steg, 2016; Gaterslebena, Murtagha and Abrahamseb, 2019; Vita et al., 2020). The symbolic meaning derived from actions which affirm personal values and support environmental or societal goals can strengthen self-identity and is distinct from functional benefits.

Public symbolic attributes signal a collective social message to other actors within a system. The attribute survey respondents did not identify a public symbolic attribute and this is likely a limitation of the survey instrument rather than an actual absence of this perception. Two questions were intended to explore whether using online food hubs would send a social message which challenges the dominant model of food provision: 'using them increases transparency in the food supply chain' and 'using them enables me to make informed choices because I know how the food is produced'. Between-group analysis revealed no statistically significant difference between early adopters and non-adopters for these two attributes. On reflection, both of these questions could be interpreted as referring to a private functional attribute and indeed the transparency one coalesced with three private functional attributes in the PCA (see section 4.3.1). Some of the interview respondents did identify a public symbolic dimension; using a food hub was seen as a form of political expression (using your pound as vote) or a deliberate act of reducing dependence on supermarkets because of their perceived unethical practices (see sections 5.3.4 & 5.3.5). Moreover, the hub platforms unequivocally articulate their aspiration of changing the food system:

> "Food, unincorporated. Sometimes the best way to fix the system is to start a new one."[51]

Online food hubs present their vision of a values-based food system which can be realised through empowerment, transparency and a shared responsibility for global commons resources. This social messaging highlights systemic problems, rather than a particular benefit to individual consumers.

The three theoretical lenses presented above are all valuable in understanding the value proposition of online food hubs and the consumer appeal of the attributes. Whichever lens is considered most useful, it is clear that the appeal of online food hubs is multidimensional. Supporting local producers and community goals is important to consumers, but online food hubs must also provide private benefits, whether functional or symbolic, in order to access new market segments. Online food hubs recognise this because the messaging on their platforms comprises a blend of private and public attributes. The following recommendation is proposed:

> Recommendation 1 (practice): *Online food hubs should continue to present a range of different attributes on their platforms in order to appeal to the broadest possible spectrum of consumers. The hubs could consider strengthening the value proposition with respect to compatibility and shopping convenience to reduce the likelihood of innovation rejection.*

9.1.2 Maximising online food hub users' social influence

This study identified word of mouth communication as especially effective in encouraging adoption of online food hubs (see section 7.2). The early adopters are proactive in spreading information about food hubs, they display a relatively high degree of social influence, and people ask them for advice prior to adoption. Food hub user social networks are characterised by a mix of homogenous and heterogenous contacts and so avoid the structural constraints which can inhibit diffusion (Valente, 2010; Barnes et al., 2016). These findings align with Rogers' (2003) characterisation of early adopter interpersonal communication and its pivotal role in the diffusion process. The results are also consistent with previous studies which found most food hub or veg box customers were introduced to the enterprise either through word of mouth or eWord of mouth (Thom and Conradie, 2013; Kurnia et al., 2015b). From this evidence, it can be concluded that the food hub users' communication behaviour would support a potential scaling up.

However, online food hubs remain a niche component of the food system and the number of adopters is well below what can be considered a 'critical mass' whereby adoption is self-sustaining (Moore, 2014). The current low number of food hub users inhibits diffusion, despite their positive

[51] Quote duplicated from *Open Food Network*, see: Open Food Network | Growing Local Food, Online.

messaging and favourable social network structure. Moreover, awareness of the innovation is limited because of the lack of mass media coverage, thus amplifying the importance of hub users' interpersonal communication. Two approaches for overcoming these obstacles are to create new information channels and to maximise the social influence of the early adopters.

Figure 45 shows the current information diffusion channels for online food hubs. On the left side is 'Word of mouth', with the food hub user located in group B - a group of homogenous individuals with shared social norms and high trust. People in group B are considered more likely to adopt based on the hub user's recommendations, but there is a risk of an echo chamber whereby everyone has already heard of the innovation, reducing the potential for further adoption. The hub user has a heterogenous contact in group A and so acts as a bridge in spreading information to this group. The right side of Figure 45 depicts 'eWord of mouth', which includes user-generated messages and targeted advertisements on social media. This channel can reach many potential customers much more rapidly than word of mouth communication, but the adverts lack the social influence dimension which is so effective in encouraging adoption. The challenge is therefore how to integrate social influence into this information channel, as indicated by the arrow.

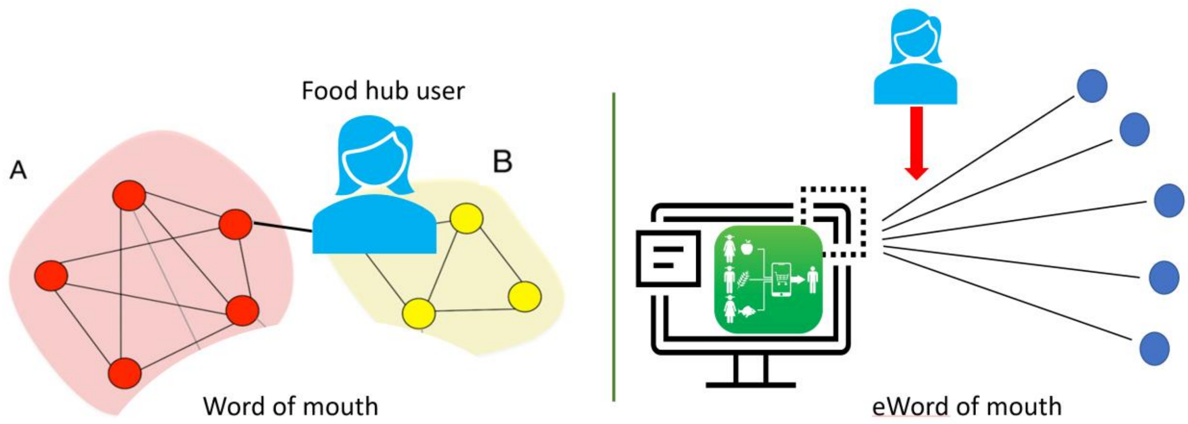

Figure 45, Information diffusion channels for online food hubs

Advertising on social media is a proven approach to reaching new customers and highlighting product attributes (Choi, Lee and Kim, 2010; Ashman, Solomon and Wolny, 2015; Kummar and Milestad, 2020). This would increase innovation awareness but entails a financial outlay for the food hubs. Consumer reviews are considered more trustworthy than service provider communication and so integrating a review mechanism such as *Trustpilot* into social media adverts and the hub platform could boost the impact of this investment (Zhang et al., 2014; Buskens, 2016; Voromontri and Kleib, 2018). Reviews essentially replicate peer recommendations and so introduce the social influence dimension into online marketing (Paul and Hogan, 2015; Littlechild, 2021). A further strategy could be a 'refer a friend' scheme to encourage user-generated reviews and direct messaging among their social networks, which has proved effective in other marketing settings (Berman, 2016).

A second aspect of the marketing strategy is the content of the message and the intended recipient. Food hub users adapt their word of mouth communication to match the perceived needs of potential adopters. Food hubs could mimic this approach in their online marketing by telling brief stories of existing hub users which potential customers may relate to, for instance how using a food hub helped them achieve a healthy diet or freed up time at the weekends. Another approach could be emphasising consistency with social identities around shared values, such as supporting local businesses or protecting the environment. Referring to sales of organic products, Persaud and Schillo (2016, p.141) suggest "initial market acceptance strategies should emphasize social identities since consumer innovators [read: early adopters] are more apt to make identity-driven purchases." The following recommendation is proposed:

> Recommendation 2 (practice): *Online food hubs could consider integrating a customer review mechanism into their platform to replicate social influence. Other possible marketing approaches include a 'refer a friend' scheme and emphasising social identities.*

9.1.3 Food behaviours and mitigation outcomes

The previous chapter described how online food hubs may reduce emissions through multiple mechanisms, with potentially large mitigation impacts at the household level. Using an online food hub once or twice will have a negligible effect; it is through the regular and repeated action of buying from a hub that reconfigured food behaviours such as a healthier diet or reduced food waste emerge, or the permeations of switching to a low carbon supply chain manifest. The mitigation impact of some low carbon innovations hinges on the initial adoption decision (e.g. installing solar panels or a heat pump), but for others, particularly service-based innovations, it is the recurring enactment of the adoption decision that results in an emission reduction. The implication for diffusion research in the context of environmental innovations is that a stronger emphasis on the use phase is necessary to identify and quantify environmental outcomes.

Considering the large body of literature which contends changing embedded habits is difficult (Verplanken et al., 1998; Macdiarmid, 2014; Dyen et al., 2018), online food hubs appear to achieve a modest degree of success, at least for the respondents in this study. Is there something which can be learnt from this example which could explain how some new food behaviours more readily displace existing food routines? The answer may relate to a 'layering' of perceived benefits, some of which only become apparent in the use phase. For instance, online food hubs and other regular food delivery services are experienced as 'making life easier':

> "The meaning of 'convenience' is reframed within the new practices through a redefinition of local seasonal availability as 'convenient', in that the consumer no longer has to expend so much time and effort deciding what to purchase or cook in a given week or month." (Kurz et al., 2015, p.119)

Thus, a single consumer decision (adopting an online food hub) satisfies the core function of providing food, but also requires less effort *and* encourages a healthier diet *and* supports consistency with environmental self-identity *and* provides opportunities for social interaction. Only a limited number of studies consider the impacts of an 'intervention' on broader food behaviours or how they relate to lifestyle options (Huyard, 2020; O'Neill et al., 2022). The accumulation of innovation attributes and the associated benefits, rather than a single compelling attribute, may explain why some individuals are prepared to invest effort into altering their habits.

9.1.4 Recommendations for further research

During the process of conducting this study, several interesting themes emerged which warrant further research. One observation is that a large body of scholarly work applies a cognitive approach to changing consumer behaviour, based on the premise that raising awareness of environmental issues will cause people to reflect on their own consumption patterns and consequently alter some of their behaviours. However, other research suggests pro-environmental intentions frequently do not translate into pro-environmental behaviours (Groening, Sarkis and Zhu, 2018; University of Essex, 2018). Approaches which focus on changing the context, trigger or habit of the resource-intensive consumption activity, rather than people's attitudes or understanding of environmental problems, have not received the same level of academic attention (Verplanken and Wood, 2006; Kurz et al., 2015). There is space for both lines of enquiry, but more research is needed which does not rely on a cognitive logic to change behaviour.

On a practical level, a second recommendation would be to carry out more intervention studies to explore different approaches to changing consumer behaviours. Intervention studies seek to identify exactly which behaviours are altered (it is not always the target behaviour) and measure the outcomes (Huyard, 2020; Devaney and Davies, 2017). These can be active intervention studies such as a 'living lab' where respondents participate in structured activity or programme with regular support from the researcher. Alternatively, they can be 'passive' intervention studies which consider the effects of an individual's independent decision to adopt an innovation or change their behaviour in some way (this thesis is an example of a passive intervention study). Both approaches provide robust evidence regarding which interventions are most effective in changing behaviour and can be used to inform the design of policy, products or services.

This thesis considered only one of the nine types of digital consumer innovations presented in Figure 2. These food apps and platforms vary in their function and value proposition, but all of them enable consumers to reduce their carbon footprint through waste reduction, sourcing food with less embodied emissions, or encouraging a dietary shift (see Appendix 1.1). The literature on digitally mediated changes to food consumption behaviour is sparse, particularly for latter two actions (Hedin et al., 2019). A small number of articles explore behaviour change outcomes from using food apps and present emission reduction estimates (see Appendix 1.2). On the evidence of these articles and this PhD thesis, this novel approach to demand side mitigation shows promise and should be investigated further. Future research could place emphasis not only on quantifying the emission outcomes, but also on how the adoption of food apps could be scaled up in order to maximise their purported benefits.

Finally, very few articles were discovered which use DoI to explore the adoption of consumer food innovations (in general, not just the digital ones). Given the prominence of the DoI framework in diffusion research and its broad application across multiple domains, this is surprising. The theory is characterised by its relative simplicity and its malleability to adapt to a range of research problems. There is increasing focus on demand side mitigation of food emissions and DoI is well suited to investigating how consumers perceive the appeal of various innovations which are presented as possible solutions to the climate problem.

The following recommendations are proposed:

> Recommendation 3 (research): *The increasing prevalence of service-based innovations should stimulate a stronger emphasis on the use phase in diffusion research. This is especially relevant when considering the outcomes of environmental innovations.*
>
> Recommendation 4 (research): *Further research is needed into how the use of innovations relates to the habitual behaviours they alter, instil or replace. This could include a focus on how consumers perceive a 'layering' of benefits vs the effort of changing their existing habits.*
>
> Recommendation 5 (research): *The role of digitally mediated changes to consumption behaviour should be investigated for the entire range of food apps and platforms. This research should include quantifications of their mitigation potential.*
>
> Recommendation 6 (research): *The functional and symbolic framing of attributes is a promising but under-explored avenue of research for understanding the adoption of environmental innovations, including online food hubs. In particular, the relative importance of functional vs symbolic attributes to consumers should be explored.*

9.2 Online food hubs' alignment with public policy objectives

This study has shown that using an online food hub can reduce food-related emissions and encourage healthier diets, both of which are prominent public policy goals. This section describes how policy initiatives could support the uptake of online food hubs, or reward farmers for the adoption of environmentally responsible practices.

9.2.1 The National Food Strategy

The 'National Food Strategy' (2021) is a major independent review of the UK food system, conducted for the Government and grounded on contributions from notable figures in the public health, agriculture and food business sectors, as well as members of the academic community. The strategy comprises 14 recommendations, three of which are particularly relevant to online food hubs.

Support healthier diets in low income households

Recommendation 6 of the National Food Strategy is:

> "The Government should expand the Healthy Start voucher scheme to all households earning under £20,000 with pregnant women or children under five." (2021, p.218)

'Healthy Start' provides vouchers that can be used to buy £4.25 worth of fruit, vegetables and milk per week. The scheme is open to all pregnant women under 18, as well as pregnant women and families with children aged three or under from low income households. Studies on the outcomes of Healthy Start have shown it is effective in helping families increase the quantity and variety of fruit and vegetables consumed. Moreover, participation in the scheme encourages healthier eating habits in general. The advised eligibility expansion should be accompanied by an awareness-raising campaign among potential recipients and local GPs/social services to increase uptake (ibid).

Recommendation 7 of the National Food Strategy is:

> "Trial a 'Community Eatwell' programme, supporting those on low incomes to improve their diets...Patients would receive an Eatwell Prescription for free fruit and vegetables, perhaps alongside access to local programmes that encourage healthy eating (e.g. cooking classes in community kitchens)." (2021, p.222)

As with Healthy Start, the proposed Community Eatwell programme would be targeted at individuals from low income households who would benefit from access to fresh produce and food skills training. Patients should be supported by a Link Worker - a non-clinical staff member with specialised training to support healthy eating - who would design a programme to suit their needs and help them engage with local services (ibid).

The strategy recommendations 6 and 7 are based on the mechanism that was also identified in this study - the regular provision of fruit and vegetables improves diets, not only by supplying the produce itself but also by encouraging positive eating habits and greater awareness of personal food consumption. These habits are reinforced by a weekly routine and by increasing food literacy (either through a structured training intervention, as above, or as an ad-hoc learning process in the case of food hub users). Online food hubs and other community food initiatives are well placed to collaborate with local authorities to implement these two recommendations. Food hubs already perform some of the functions described in the National Food Strategy, such as supplying fresh produce to low income households and providing training (see section 5.3.2). They are embedded within their local communities and they have experience in working with other community organisations and municipal authorities. Some local food initiatives already participate in the Healthy Start scheme (see Figure 46). The following recommendations are therefore suggested:

Recommendation 7 (policy): *Online food hubs should be included in the Healthy Start awareness-raising campaign as one of the retailers where participants can use their vouchers.*

Recommendation 8 (policy): *The Community Eatwell pilots could partner with online food hubs which already have the expertise, capacity and local knowledge to support the programme's objectives.*

Figure 46, Advertisement on Facebook from Banc Organics in South Wales, April 2022.

Strengthen government procurement of healthy, sustainable food
Recommendation 13 of the National Food Strategy is:

> "Strengthen Government procurement rules to ensure that taxpayer money is spent on healthy and sustainable food…All public sector organisations should be required to apply these standards. The Government should aim to increase the role of small and local suppliers in public food procurement." (2021, p.253)

This is essentially a recommendation to leverage the purchasing power of the 'public plate', whereby procurement and management strategies would enable local authorities, schools, hospitals and prisons to provide healthier, more sustainable food. The public plate comprises 1.9 billion meals a year and costs £2.4 billion, which is over 5% of the total UK food service turnover (ibid). The existing procurement arrangements have not resulted in healthy or sustainable food, as evidenced by a series of high profile campaigns to improve the quality of the food served in public canteens[52]. The authors of the National Food Strategy propose the Government revises its 'Buying Standards for Food' to incorporate health, environment and quality criteria in order to meet a 'Reference Diet'[53]. The existing 'Food for Life' accreditation scheme[54] would ensure the Reference Diet standards are met by individual caterers.

Local food networks have historically been excluded from supplying the public plate because of two challenges: 1) meeting the large scale of the food required, and 2) the complexity of the tendering process, both of which favour procurement contracts with larger businesses. Bath and North East Somerset Council recently conducted a pilot to source food for schools from local small businesses and found costs were reduced by 6% and there was greater transparency on the environmental benefits (Environment, Food and Rural Affairs Committee, 2021). There are plans to expand this to a larger pilot across the South West[55] using a Dynamic Purchasing System, through which supply can be aggregated to meet demand (the platform enables the selection of suppliers using various criteria, much like an online food hub but for commercial or public sector buyers). If the South West pilot is successful, the authors of the National Food Policy recommend scaling up the system nationally.

Online food hubs could supply public sector institutions with healthy and sustainably produced food and this would provide local economic benefits for farmers and smaller food enterprises. Food hub staff and producers have experience using platforms such as a Dynamic Purchasing System. The South West is relatively well serviced by online food hubs (see Figure 21) and they could participate in this pilot (if they are not already enlisted). The following recommendation is proposed:

> Recommendation 9 (policy): *Municipal authorities should contact online food hubs (see list in Appendix 7.1) to discuss possible procurement arrangements. This dialogue could explore the potential to scale up operations to meet demand, utilise food hub staff's knowledge of local producers, and articulate how the health and environmental criteria could be fulfilled and monitored.*

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[52] Jamie Oliver has fronted several campaigns to improve the standard of school meals. See: Campaign news | Jamie Oliver campaigns | Jamie Oliver
'Bite Back 2030' is an organisation which aims to improve access to healthy and nutritious food for young people. See: Our Campaigns | Bite Back 2030
Campaign for Better Hospital Food was a long running initiative which resulted in NHS England rolling out national food quality targets in 2016. See: Campaign for Better Hospital Food | Sustain (sustainweb.org)
[53] The 'Reference Diet' is a key component of the proposed Good Food Bill (National Food Strategy, 2021). Current dietary recommendations under the 'Eatwell guide' consider health but do not take the sustainability of the food into account.
[54] 'Food for Life' is a voluntary sustainable catering certification scheme run by the Soil Association, with the aim of transforming the food culture in public and private sector institutions. See: Home - Food for Life
[55] The pilot is scheduled to start in 2022 will be coordinated by the South West Food Hub CIC. See: South West Food Hub - Food and Drink | South West (thesouthwestfoodhub.co.uk)

Although this section focuses on policy, there is also a relevant recommendation for practice:

> Recommendation 10 (practice): *Online food hubs in the South West should endeavour to participate in the upcoming pilot. This would provide these hubs with a revenue source and, more importantly, hopefully demonstrate the viability of the local provisioning model for the public plate on a larger scale.*

9.2.2 Environmental Land Management schemes

Reducing emissions from agriculture is an important policy goal to meet the UK's climate commitments as set out in the Government's 'Carbon Budget' and '25 Year Environment Plan'[56]. The primary mechanism for achieving climate mitigation and other environmental objectives relating to land use in the UK is ELMs, which will commence in 2024 and replace the 'Basic Payments scheme' and 'Agri-environment schemes'. Farmers and other land managers will be financially incentivised to deliver a range of ecosystem services. Low carbon farming practices are mentioned in ELMs briefings[57] such as reduced application of synthetic fertilisers, maintaining good soil structure, increasing soil organic matter and afforestation. These are positive developments, particularly the focus on soil which has long been overlooked in environmental policy as a potential carbon sink (Soil Association, 2021). However, ELMs is still under consultation and was recently criticised for a lack of progress in developing the metrics, baseline measures and clear guidance regarding how the schemes would work. There are also concerns that ELMs could encourage food imports and therefore 'export' the environmental impacts of food production to countries with lower environmental standards [58] (Committee of Public Accounts, 2022). Given this operational uncertainty, it is difficult to say exactly how this major policy overhaul will affect the farmers who supply alternative food networks. Online food hub producers already employ low carbon land management practices and so would presumably qualify for ELMs subsidies.

What ELMs does not appear to consider is on-farm energy consumption related to the use of machinery, refrigeration or the heating of greenhouses[59]. Land management measures alone may be insufficient to reach net-zero targets and so ultimately energy use may also have to be considered through some form of policy mechanism. Moreover, if ELMs does result in more imported food, there is evidently a risk of increased air freight which could undermine the policy's climate mitigation objectives. Two very broad recommendations are:

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[56] BEIS, 2021b. *Sixth Carbon Budget*. See: UK enshrines new target in law to slash emissions by 78% by 2035 - GOV.UK (www.gov.uk)
DEFRA, 2018c. *The 25 year Environment Plan*. See: 25 Year Environment Plan - GOV.UK (www.gov.uk)
[57] DEFRA, 2022. *Environmental Land Management schemes: overview*. See: Environmental Land Management schemes: overview - GOV.UK (www.gov.uk)
[58] The concern is that turning land over to non-agricultural purposes such as the creation of wildlife habitats or flood buffer zones will reduce the land area for farming and result in price inflation for UK production.
[59] If this energy is produced on-site from renewable energy sources or energy recovery through biogas production, on-farm energy consumption may not be a concern.

Recommendation 11 (policy): *Develop a policy mechanism which would incentivise farmers to minimise on-farm energy-use (in addition to the land use practices for carbon sequestration proposed in ELMs).*

Recommendation 12 (policy): *Implement environmental auditing of air freighted food to establish the carbon implications of UK food imports, as well as to ascertain any indirect consequences of ELMs.*

9.2.3 Reducing food waste

Reducing food waste is another important policy objective for meeting climate mitigation targets. In accordance with UN SDG 12.3, the UK Government pledged to eliminate food waste from landfill and halve per capita food waste at retail and consumer levels by 2030 (UN, 2018; DEFRA, 2021b). Measures to reduce waste or redistribute surplus in the manufacturing, retail, hospitality and public sectors is considered in 'Our waste, our resources: a strategy for England' and progress was recently assessed in the 'Food Waste Reduction Roadmap' (DEFRA, 2018c; WRAP, 2020). However, waste reduction currently relies on voluntary participation rather than statutory regulation and there has been limited focus on avoiding waste in primary production. Thus, farmers and retailers who use a harvest to order model or do not impose stringent aesthetic criteria are currently not rewarded for reducing food waste and the associated emissions. This is counterintuitive because 'prevention' is the highest impact action in the 'Food and drink material hierarchy' (WRAP, 2021; see Figure 5).

Recommendation 13 (policy): *Consider legislation to incentivise or require food waste avoidance practices in retail and primary production, rather than relying on voluntary agreements.*

9.2.4 The role of government in the food system

The recommendations presented above imply two distinct roles for national and municipal government in the food system: 1) as a procurer of food, and 2) to create a purposeful and functional policy framework. The first role is relatively straight forward because local authorities can autonomously choose where they source food for the public plate and can align their purchasing decisions with broader social or environmental objectives. The second role is more contentious because any legislative intervention will have varying consequences for different actors in the food system. Small-scale farmers, particularly those involved in horticulture, have been operating in a difficult policy environment for some time:

> "Government subsidy accounted for 10% of the income of horticulture holdings, versus 79% for cereal producers. Fruit and vegetable production therefore, particularly production on under five hectares, has been underinvested compared to other farming sectors for at least 17 years. This, despite the fact that fruit and vegetables, with the possible exception of oily fish, are the only food group of which the government recommends we eat more." (Wheeler et al., 2020, p.3)

By removing the land area-based entitlement, ELMs will level the playing field considerably in terms of subsidy support and hopefully provide the intended environmental benefits. The National Food Strategy (2021) essentially asks if the Government could do more in terms of supporting access to healthy food, alleviating social justice concerns, and advocating more sustainable food supply chains. Online food hubs and other community food initiatives already fulfil these functions, albeit with limited resources, and so policy or fiscal support can be understood as an investment in healthcare, education and community well-being (Blay-Palmer et al., 2013; Psarikidou et al., 2018 & 2019; Wheeler et al., 2020). Moreover, there is a useful precedent because Healthy Start and the proposed Community Eatwell programmes are comparable with the Supplemental Nutrition Assistance Program[60] in the US, which for several years has successfully partnered with local food hubs to increase the intake of healthy food in low income households (Levkoe et al., 2018). Encouraging healthier eating habits at the population level will take time, but other behaviour-orientated policy interventions have proved successful and gained broad public support, such as the plastic bag levy (Kurz et al., 2015).

9.3 Limitations of the research design

The limitations of specific methods and potential sampling biases are discussed throughout this thesis and so are not repeated here (see sections: 4.5.4, 5.6.5, 6.4.2, 7.6.3, 8.5.4). Instead, the focus is on the limitations of the research design and the consequent weaknesses in the results. In their review of the literature on food behaviour during moments of change, Nash, Whittle and Whitmarsh observed:

> "There was significant variation in the way that food-related behaviours were operationalised and measured, with many studies relying on self-reported food consumption and/or measuring behaviour over short time periods or for a limited range of foods. These issues limit the generalisability of finding." (2020, p.5).

Recognising the potential for inaccuracy in self-reporting, as well as a lack of external validity in basing emission reduction estimates on food consumption over short time periods, a limited range of products, or a small respondent sample, this study applied a mixed method approach. The survey and interviews would provide insights into the hub users' food behaviours and motivations and the longitudinal purchasing data would reveal the shopping preferences of a relatively large number of respondents and so increase generalisability. The intention was to combine methods in order to take advantage of their relative analytical strengths and to moderate the weaknesses of each method (Creswell and Clark, 2017). The reality was a steep learning curve with regard to the challenges of conducting mixed method research. In particular, the purchasing data set required extensive

[60] The Supplemental Nutrition Assistance Program is a US government programme that offers nutrition assistance to eligible, low-income individuals and families. See: http://www.fns.usda.gov/snap/supplemental-nutritionassistance-program-snap . They have partnered with community food hubs such as The Food Project. See: The Food Project | Food. Youth. Community.

cleaning to standardise weights or volumes from multiple producers and bias was introduced by relying on assumptions where information was unavailable. Thus, the purchasing data did increase external validity but it also reduced internal validity due to these assumptions. Moreover, the anonymity prevented any heterogeneity analysis which significantly inhibited how the data could be used in combination with the data from other methods. Using secondary data may be more efficient and can capture information from a larger sample, but requires careful prior consideration as to the limitations of its application (ibid).

A second limitation is the large uncertainty ranges identified in the LCA synthesis (see Figure 43). This was not unexpected, considering the synthesis was based on numerous LCA studies which vary in their context, methodology and system boundaries. Nevertheless, claims of emission reduction would be easier to defend if the existing LCA research clustered within a more narrowly defined range for a given mechanism. If a wide uncertainty range is identified in an LCA synthesis, it must be preserved to present an accurate picture of the emission reduction potential[61]. Including a greater number of LCA articles and conducting a sensitivity analysis would identify 'outlier' studies, but removing outliers to narrow the range remains problematic because they may represent a legitimate deviation. A further consideration is that for some mechanisms, such as reducing 'last mile' emissions, the LCA corpus is quite small and so the evidence base is limited. What is discernible from the synthesis is that the majority of articles do indicate an emission reduction; very few infer an emission increase. Thus, we can be reasonably confident in the direction of the effect of using an online food hubs on emissions, even if the uncertainty ranges are large.

Finally, three additional emission reduction mechanisms were identified in chapter 8 but were not explored further due to a lack of empirical data on how individual food hub producers operate (this data would form the basis for assumptions of comparability with examples in the LCA literature). A brief review of the LCA literature revealed that two of the mechanisms, refrigeration and pre-retail transportation (excluding air freight), represent large potential emission savings relative to mainstream food supply chains (see section 8.5.3). Collecting the requisite data would entail contacting producers and establishing how various pre-retail activities are conducted. This would shift the research emphasis more towards producers than consumers, which was not the original aim of this study. Nevertheless, omitting two potentially important reduction mechanisms from the emission analysis is a clear oversight.

[61] 'Cherry picking' articles towards one end of the range would undermine the study, both in terms of research ethics and by distorting the findings and so lacking internal validity.

9.4 Reflection on the Diffusion of Innovations theoretical framework

DoI is a well-established theory for explaining how, why, and at what rate innovations spread among a social system. As discussed in the literature review, it has been broadly applied to explain adoption across multiple innovations and consumption domains (see section 2.1.1). There are, however, some limitations to the theory beyond those outlined by Rogers himself (see section 2.1.5) and these are briefly discussed here.

One observation relates to the aspatial nature of DoI. The theory proposes that diffusion is contingent on the characteristics of different adopter groups and the perceived attributes of the innovation, and these are undoubtedly important elements in understanding the adoption decision. However, aside from limited references to social norms, the context in which adoption occurs is notably absent from the theory (Shove, 1998; Lyytinen and Damsgaard, 2001). This context may be defined by formal societal or institutional structures, but it can also relate to a community or locale. Some innovations such as online food hubs are characterised by short supply chains whereby goods are produced, exchanged and used or consumed within a small geographic area. Indeed, foods are often labelled indicating their terroir or place-specific characteristics to enhance their appeal (Feldmann and Hamm, 2015). Furthermore, this study has shown that relational dimensions form a key part of the food hubs' value proposition - the personal connection between producers and consumers, but also the various activities which comprise a hub's wider engagement in their local community (see sections 5.3.2 & 5.4.3). Place-based context is therefore especially important in the adoption and ongoing use of online food hubs and this is not reflected in the DoI theory. This pertains not only to food innovations; spatial and social context is becoming increasingly important for innovation diffusion in other consumption domains where goods or services are produced, shared or repaired locally. Community energy projects[62] and sharing economy initiatives such as *Library of Things*[63] are pertinent examples.

A second observation is the insufficient consideration of the use phase in diffusion research (see sections 5.6.1 & 5.6.2). Digital technology has enabled an array of service-based innovations which are now prevalent in daily life and this necessitates a better understanding how consumers use and perceive an innovation post-adoption. These developments have occurred since the most recent edition of DoI was published in 2003 and so this is not a critique of the theory per se, but rather a recognition that the innovation landscape is changing rapidly and so our theoretical approaches for exploring adoption must also adapt. Novel business models and the growth of digitally mediated services have broad implications for how individuals make purchasing decisions, how the economy functions and, crucially, for anthropogenic impacts on the environment. Moreover, understanding the use phase is essential for avoiding discontinuance and potential negative communication about the innovation which can hinder diffusion (Talke and Heidenreich, 2013; see section 5.6.4). There are other theoretical frameworks or concepts which have made important contributions to our understanding of how individuals use technologies, integrate them into their daily routines alongside other habitual behaviours, and evaluate their performance or relevance to their lives. *Social Practice*

[62] See: Community Energy - GOV.UK (www.gov.uk)
[63] See: Library of Things | Borrow useful Things for your home, projects and adventures

Theory and *Moments of Change* are two prominent examples. The explanatory power of these sociological approaches does not detract from the relative strengths of DoI, namely understanding the adopters, their perception of attributes, and projecting the rate of uptake (see section 3.2.3). Instead, sociological approaches offer an alternative theoretical viewpoint from which to consider innovation adoption and the associated behaviour changes at the household, community or societal levels. DoI is a malleable theory and so integrating elements of *Social Practice Theory* is one option, but many scholars would argue their underlying ontological assumptions are too disparate to meaningfully combine them. Nevertheless, a greater emphasis on how innovations are used post-adoption would ensure DoI remains applicable to service-based innovations in the digital era, while remaining ontologically consistent. More research into the causes of discontinuance, as the negative potential outcome of the use phase, is also recommended.

Finally, this study has referred to food hub early adopters and non-adopters collectively as 'consumers'. The term 'consumer' is widely used in multiple literatures, including those on climate mitigation, innovation diffusion and marketing, to describe the influence of individuals with respect to their purchasing decisions and to explore the consequences of those decisions for the economy and the environment. The importance of social or environmental values in the shopping choices of some individuals is acknowledged through the differentiation of 'ethical consumers' (Lockie, 2009; Chaudhury and Albinsson, 2015). However, there is a cogent critique of how the term 'consumer' is used in these literatures - that it passively assumes an individual's role in society is limited to the consumption of goods and services based on their rational self-interest or hedonic motivations (Johnston, 2008; de Bakker and Dagevos, 2012). This assumption overlooks other fundamental roles individuals can play in determining how a society should function, for example as citizens, activists, prosumers, or participants in community interest initiatives. In some of these roles, individuals may articulate constitutional rights or demand political and corporate accountability with respect to the environment (de Moor et al., 2021). Even when enacting the role as a buyer of goods and services, 'ethical consumer' may be too narrow to describe how some individuals identify themselves and their values-based shopping decisions (Seyfang, 2006; Chaudhury and Albinsson, 2015).

One important response to this theoretical gap is the 'citizen-consumer' framing, which represents individuals as agents of change who actively use their consumption choices as expressions of citizenship. Proponents of this framing argue citizen-consumers identify collective rights and responsibilities with respect to a social and ecological commons and so do not necessarily act with an individualistic or self-interest mindset (Lockie, 2009; de Bakker and Dagevos, 2012). The framing is particularly relevant in the context of food, where citizen-consumers navigate the perceived constraints posed by dominant food system structures and incumbents through alternative models of consumption, such as slow food movements, prosumerism, community supported agriculture or indeed using an online food hub (Chaudhury and Albinsson, 2015; Kosnik, 2018). Respondents in this study viewed buying from the hub as an act of solidarity with producers to address asymmetric power relations, a symbolic protest against the economic system which underpins supermarket hegemony, or a means of signalling their values and identity to others in their community (see section 5.3). The citizen-consumer framing is not without its detractors, who argue the two roles are ideologically incompatible, at least within a growth-oriented neoliberal context (Johnston, 2008).

Nevertheless, the framing is a useful lens which allows for a more nuanced interpretation of how individuals think and act in terms of their own consumption behaviour. It enables investigation of how values interact with different forms of agency and this includes, but is not limited to, buying ethical products. Crucially, it portrays people as potential allies who can affect positive change through intentional consumption decisions, rather than as an impediment to achieving sustainability (de Bakker and Dagevos, 2012; Chaudhury and Albinsson, 2015).

9.5 Concluding remarks

This thesis presented new findings concerning the appeal of online food hubs, how they alter household food behaviours, and how their adoption and ongoing use can reduce GHG emissions. This research contributes to the literatures on innovation diffusion, the role of alternative food networks in the food system, and demand-side mitigation. The results also provide useful insights for food hub producers and staff regarding how the innovation could become more widely adopted. De-carbonising the agriculture and food sectors is an acute challenge and time is short, but online food hubs represent a viable model of food provision which delivers community and health benefits alongside climate mitigation.

Appendices

The appendix number refers to the thesis chapter it relates to.

Appendix 1.1 - Overview of consumer-facing low carbon innovations in the food domain

An important initial step in this project was to discover what demand-side low carbon innovations are currently being adopted in the food realm, particularly in a UK context. A comprehensive internet search was conducted and 102 innovations were identified. Key features were recorded such as the business model, the value proposition, the attributes, how consumers can use the innovation and the current scale of adoption. A basic comparative analysis of this information was carried out and two main dimensions emerged: 1) whether the innovation is digital or non-digital, and 2) the degree to which the innovation can be considered 'consumer-facing', rather than upstream (see Figure 2). Table 26 summarises the results of the internet search. The category refers to the two dimensions and the 'potential CO_2 impact' column states how the innovation *could* reduce emissions. The examples are primarily from the UK, although some innovations from other countries are included.

Table 26, Overview of consumer-facing low carbon innovations

Category	Innovation name	Definition	Potential CO_2 impact	Examples of the innovation
Consumer-facing, digital	P2P food sharing apps	Allow individuals to share surplus food with others in their locality. The food is typically free or exchanged for a donation to charity	Reduce food waste	*Olio, Hubbub, foodsharing.de, Share your meal, yonodesperdicio*
	Fridge inventory recipe apps	Enable individuals to monitor fridge or cupboard stock and construct recipes using ingredients which are close to expiry	Reduce food waste	*Plantjammer, NoWaste, Fridge Pal, Grocery Pal*
	11th hour apps	Enable cafes, restaurants and supermarkets to advertise short-dated or freshly prepared food to consumers in real time, at significantly reduced prices, with the aim of avoiding waste	Reduce food waste	*Too good to go, Lunchie, Karma, ResQ club, Leloca, No food wasted, 11th hour*

Category	Innovation name	Definition	Potential CO_2 impact	Examples of the innovation
	Meal kits	Home delivery of fresh produce which is pre-portioned for cooking specific recipes	Reduce food waste, source low carbon food	*Hello Fresh, Mindful Chef, Allplants, Gousto*
	Veg boxes	Home delivery (or collection at a pick-up point) of fresh produce bought direct from a local farmer or co-operative. Typically sold as an ongoing weekly subscription	Source low carbon food	*Riverford, Abel and Cole, FarmDrop, Fresh Range, Heartier, Svaigi*
	Online food hubs	Home delivery (or collection at a pick-up point) of fresh produce bought direct from multiple local producers. Consumers can pick and choose the items they want	Source low carbon food	*Open Food Network, Neighbourfood, The Great British Food Hub, The Food Assembly, Furrow*
	Sustainability info apps	Enable consumers to make environmentally sustainable choices when they are grocery shopping by providing information about products' environmental impact	Source low carbon food	*Open Food Facts, Setai, Green guide*
	Diet gamification apps	Use elements of gameplay to support efforts to reduce meat consumption	Dietary change	*Climatarian Challenge, Part-time Carnivore, Quit Meat*
	Carbon calculators	Allow consumers to assess and compare the embedded carbon emissions of food items, meals or their overall diet	Dietary change	*EcoGrocer, The Vegan Society Carbon Food Calculator, CoolClimate*
Upstream, digital	B2B surplus food redistribution platforms	Enable retailers or wholesalers to share surplus food with local charities	Reduce food waste	*Food Cloud, Fareshare, Food Waste Scotland, Neighbourly*
	Smart meters for restaurant waste	Allow restaurants and food service businesses to monitor food waste and use analytics to avoid wasteful practices	Reduce food waste	*Winnow, Mintscraps, Wise up on waste*

Category	Innovation name	Definition	Potential CO_2 impact	Examples of the innovation
	3D food printers	Enable restaurants or consumers to create foods using 3D printing technology	Source low carbon food	*ByFlow Focus, Foodbot, Zmorph*
Consumer-facing, non-digital	Surplus food cafes & supermarkets	Redirect surplus food from retailers or wholesalers to sell to consumers. Often use a 'pay as you feel' system, whereby people can choose to pay what they can afford	Reduce food waste	*The Real Junk Food Project, Wefood, The Warehouse, Approved Food, The Community Shop, Tiny Leaf, Rub and Stub*
	In-situ social messaging	Messages placed in supermarkets or self-service canteens to encourage consumers to avoid waste or consider the environmental impact of their dietary choices	Food waste, dietary change	*Wonky veg, Good to go, Supermarket dietary change campaigns (Coop and Ica in Sweden)*
	Community gardens/orchards & Community supported agriculture	Collective gardening to produce food which is shared among members or the wider community. CSA allows consumers to support growers by subscribing to the harvest in advance	Source low carbon food	*The Kindling Trust, The Community Farm, Sims Hill Shared Harvest*
	Domestic LED grow-boxes	Containers for growing salads and herbs in the home, using LED lighting	Source low carbon food	*Eddy the Growbot, SproutsIO, Grove*
	Identity campaigns	Use a shared identity message or competitive dynamic to reduce meat consumption, often for a specific period or day of the week	Dietary change	*Reducitarian, The Flexitarian, Meat free Mondays, Veganuary*
	Alt-meats	Meat substitutes which resemble conventional meat products in taste, texture and appearance. Made from insect, vegetable or cultured meat protein	Dietary change, source low carbon food	*Beyond Meat, Eat Grub, Impossible Foods, Eat Just*
Upstream, non-digital	Circular economy projects	A collaborative model of production and consumption which partners food businesses to share resources and redirect surplus, with the overall aim of avoiding waste	Reduce food waste	*The Pig Idea, Plant Chicago*

Category	Innovation name	Definition	Potential CO_2 impact	Examples of the innovation
	Gleaning networks	Coordinate volunteers, farmers and charities in order to salvage fresh fruit and vegetables that would otherwise be wasted. The food is distributed to those in need	Reduce food waste	*Gleaning Network UK, Sussex Gleaning Network, East Kent Gleaning Group*
	Public Plate initiatives	Procurement and management strategies to help public sector organisations, such as local authorities, schools or hospitals, to provide healthier or more sustainable food. Also used by staff canteens in private businesses	Reduce food waste, source low carbon food, dietary change	*One Two We, Food for Life, SusDish, Eaternity*
	Food Policy Councils	Convene citizens, government officials and stakeholders from diverse food-related sectors to examine how the food system is operating and develop recommendations on how to improve it	Reduce food waste, source low carbon food, dietary change	*Various cities and regions: Bristol, Cardiff, Brighton and Hove, Toronto, California*
	Aquaponics	A system that couples aquaculture with hydroponics to produce fish and plant products. Often situated in urban areas, close to local restaurants and consumers	Source low carbon food	*Bio-Aquafarm, ECF Farmsystems, Bristol Fish Project*
	Rooftop/underground farming	Food production using under-utilised urban space. The produce is sold to local restaurants or consumers	Source low carbon food	*Lufa Farms, Gotham Greens, Ecco-jager, Growing Underground, Brooklyn Grange, Food from the sky, Eagle Street Farm, Sky Greens, Grow Up*

Appendix 1.2 - Literature on food apps and platforms

Following on from Appendix 1.1, this appendix and reviews the literature on food apps and digital platforms which facilitate or influence consumers' dietary choices, food waste behaviours, or grocery shopping decisions. Most articles describe the function and associated benefits to consumers or food sector stakeholders, but very few provide quantitative estimates of the energy consumption, emission reduction, or waste avoided through using the innovation. This sparsity of research could be attributed to the relative novelty of food apps or the tendency to focus on supply-side solutions to address climate change. Only the publications with quantitative estimates based on the use of the app or platform in real-world settings are presented here.

Apps or platforms which encourage dietary change

A small number of apps aim to facilitate a dietary shift away from meat consumption. The value proposition for consumers centres on reducing personal carbon footprint, eating more healthily, and membership of identity-based groups to eat less meat.

Some apps monitor and record the GHG emissions of individual meals or daily food consumption to enable users to track their carbon footprint. Examples include *CoolClimate* and *Quit Meat*. Several articles evaluate the functionality of carbon calculator apps/platforms and their potential to influence consumer behaviour (Sullivan et al., 2016; Okumus et al., 2018). However, only Büchs et al. (2018) present data showing changes in consumption and their findings relate to travel habits and domestic energy use, but not food.

Other apps such as *Climatarian Challenge* and *Part-time Carnivore* gamify efforts to reduce meat consumption through personal goal-setting and rewards, or by creating a competitive dynamic between individuals or teams (Lee et al., 2013; Berger and Schrader, 2016). No articles with quantifications were found for diet gamification apps.

Apps or platforms which reduce food waste

A second group of apps are directed at reducing food waste, either within the household or through innovative forms of food purchase from retailers and hospitality venues. There are several food waste apps and they perform different functions, but the value proposition focuses on reducing waste or personal carbon footprint, saving money, exploring new types of cuisine, and building community networks for sharing food or addressing food poverty. Food waste apps have been more comprehensively researched than other types of food app.

Peer to peer (P2P) food sharing apps (*Olio, Hubbub*) allow individuals to share surplus food with others in their locality. The food is typically free or exchanged for a donation to charity. Schanes and Stagl (2019) describe the motivations and networks of users of the *foodsharing* platform in Austria. Collectively, these food sharers have salvaged 788,109 kg of food. Davies et al. (2018) describe various food waste initiatives and report 12,282,688 kg of food waste saved using *foodsharing* in Germany. Harvey et al. (2019) report 697,108 items of food that have been shared in 41 countries using the *Olio* app. Lim et al. (2017) trialled a 'social recipes' sharing app which triggered discussions among households about food waste but did not achieve an actual reduction. Farr-Wharton, Foth and Choi (2014) review three food sharing apps but do not provide quantifications. Zurek (2018) and Morrow (2019) discuss the safety risks and regulatory challenges of food sharing.

Fridge inventory recipe apps such as *Plantjammer* and *NoWaste* enable individuals to monitor fridge or cupboard stock and construct recipes using ingredients which are close to expiry. Phiri and Trevorrow (2019) and Woolley et al. (2016) investigated these apps and found a reduction in waste of 10% and 34% respectively. Murata et al. (2012) and Rouillard (2012) describe smart fridges which can inform consumers when items are approaching their expiry date. This was shown to be effective in reducing waste, although the studies do not present quantifications. Hong et al. (2014) discuss a smart garbage system in South Korea whereby consumers are incentivised to reduce waste by paying for disposal. They estimate food waste could be reduced by 33%.

11th hour apps (*Too good to go, Lunchie*) enable cafes, restaurants and supermarkets to advertise short-dated or freshly prepared food to consumers in real time and at significantly reduced prices. Davies et al. (2018) report 690 tonnes of CO_2 saved using the *Meal Saver/ResQ Club* platform in Germany. Three news articles provide quantitative estimates: Koh (2016) found 11th hour apps reduce food waste by 20%; Wong (2016) report an 18-25% reduction in waste using the *NoFoodWasted* app; and Ferguson (2019) estimated 15 million meals saved in the UK using *Too good to go*. Fuentes, Cegrell and Vesterinen (2021) explored why efforts to digitally reconfigure consumers' food practices fail. They find the success of the *Karma* app to be impeded by technical glitches and an incompatibility with existing food provisioning practices or daily work routines.

Apps which influence in-store shopping decisions

Another group of apps present sustainability information about products to consumers when they are grocery shopping. The value proposition comprises raising awareness of emission intensive foods, thus enabling consumers to make more environmentally sustainable choices in situ and without the burden of researching the carbon footprints of food items. Examples include *Open Food Facts* and *Setai*.

Clear et al. (2015) argue that assuming these apps will facilitate rational choice overlooks how food decisions are sensitive to contextual factors such as family preferences or hedonic impulse. Furthermore, these technologies entail a degree of inaccuracy because they use a proxy for each product group, due to the complexity of integrating carbon footprints for numerous ingredients. Atkinson (2013) suggests consumer trust may vary depending on the source of the information: governments, experts or the product manufacturers. Isley, Ketcham and Arent (2017) investigated consumer behaviour when using these apps and found carbon footprint was a significant differentiator in the choice of bottled water brand, with an emission saving of 23% relative to the control group. Moreover, the app encouraged consumers to choose cereals with less sugar, fat and salt, suggesting clear health benefits. Finally, Fuentes & Sörum (2019) explored the functionality of ethical consumption apps (*Green guide*, *Fairtrade* app) which motivate consumers by describing a problematic situation (how it is) and then communicating, in practical terms, the future ideal situation (how it should be), and how to get there through consumption choices.

Apps or platforms which enable the sale and home delivery of food

The final group are apps or platforms which facilitate the sale and home delivery of food from online specialists (as oppose to supermarket platforms and home delivery service). The value proposition centres on high quality produce, eating more healthily, new culinary experiences, supporting local producers, environmentally-friendly farming practices, shopping convenience and reducing waste.

Meal kit suppliers such as *Hello Fresh* and *Mindful Chef* offer home delivery of fresh produce which is pre-portioned for cooking specific recipes. Gee et al. (2019) found meal kits increase emissions relative to the equivalent meal from conventional grocery shopping, primarily because of the additional packaging. Conversely, Heard et al. (2019) and Wang, Zhang and Schneider (2021) discovered meal kits reduce emissions by 33% and 11% respectively, due to less waste and transportation. Hertz and Haulkier (2017) also find meal kits reduce waste, although they do not provide quantifications.

Veg box providers such as *Riverford* and *Abel and Cole* offer home delivery of fresh produce bought direct from a local farmer or co-operative and is typically sold as an ongoing weekly subscription. Coley, Howard and Winter (2009) found no emission reduction from buying veg boxes, although their analysis only considered transportation emissions. One veg box provider surveyed their customers and discovered 21% of respondents eat less meat and 28% waste less food since they joined the scheme, suggesting potential spillover effects on other food behaviours (Growing Communities, 2018). Pérez-Neira and Grollmus-Venegas (2018) compared an organic farm using direct marketing with two conventional farms which sell their produce to local mainstream retailers. They found organic farming consumed 43% less non-renewable energy per kg of fresh vegetables than conventional farming and direct distribution reduces GHG emissions between 64% and 91%.

Use of information and communications technology

A related theme is how information and communications technology is used to exchange information among consumers and food system actors. These generic digital innovations are sometimes used to influence consumer behaviour and so the relevant literature is briefly reviewed.

Young et al. (2017) describe social media and e-newsletter interventions by a UK supermarket to encourage their customers to reduce household food waste. Although the participating customers reported waste reductions, they were no different from the control group. The authors conclude that social media interventions may be less effective than face to face engagement for prompting behaviour change. Hearn et al. (2014) describe three functions of social media in creating sustainable food systems: it provides greater supply chain transparency; it (re)connects people to traditional and scientific sources of knowledge about food; and it enables discussions about environmental concerns and how best to resolve them. Vallauri (2014) investigated a community supported agriculture scheme which uses a blog to facilitate a dialogue between the farmer and his customers. Vallauri finds that farmers are increasingly producers of digital information, not only to convey what foods to expect in a given week, but also to participate in conversations about farming practices and environmental implications. Finally, Davies (2014) engaged food system stakeholders and citizens to consider three different sustainable eating futures. In general, the participants were ambivalent towards the role of digital technology in domestic food practices, although it was deemed useful as a tool for creating community food networks.

Appendix 3.1 - Questionnaire template

Figure 47 is a screenshot of the online survey that was presented to respondents, using Qualtrics software. A complete list of the questions and the response options is below.

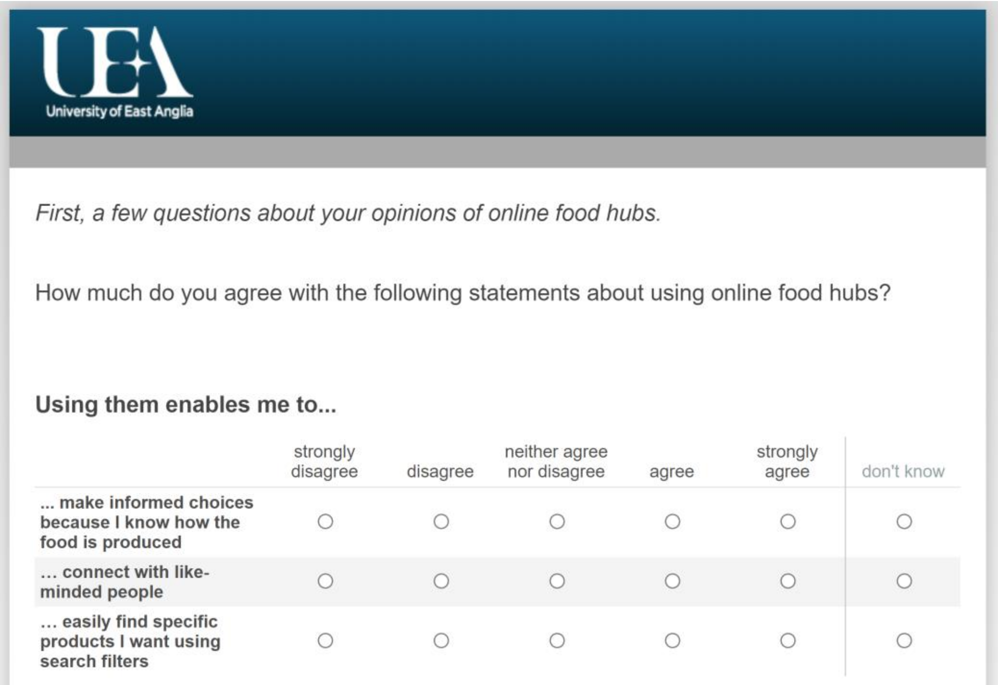


Figure 47, Screenshot of the questionnaire survey

Introduction (all respondents)

Welcome! This survey is about digital tools or apps which people use to buy food directly from producers.

The survey is part of a research project at the University of East Anglia, Norwich (Contact: mark.wilson@uea.ac.uk). The survey will take approx. 10 minutes - your participation is voluntary and will involve answering questions about food apps and your food preferences. Your data will be stored securely and will only be used for the purposes of this research.

Once you have completed the survey, you can enter a draw to win:
a top prize of £300 * or **one of three prizes of £80** * (* vouchers of your choice)

Q1.2 By clicking below, I agree to participate in this study:
Response options: I agree (1)

OK, let's get started! If at any point you don't know how to answer a question, or you prefer not to answer, just answer 'don't know'. If you are using a smartphone, some questions may be displayed more clearly by rotating your screen to horizontal.

Block 1: Adoption experience (all respondents)

Online food hubs provide apps or online platforms which allow people to buy food for delivery directly from different local farmers and producers offering a wide a range of products.

Examples include: 'Open Food Network', 'Farmdrop' and 'Neighbourfood'
Please note: This does not include veg boxes from a single producer, nor online sales from supermarkets or other food retailers.

Q1.5 Do you use an online food hub?
Response options: yes, currently (1) in the past, but not now (2) no, but I have heard of this (3) no, I have never heard of this (4)

Q1.6 What is the name of the online food hub?
Response options: __________ (1) don't know (2) *[early adopters and former adopters only]*

Block 2: Attributes of online food hubs (all respondents. Blocks 3 & 4 were identical but tailored to former adopters and non-adopters)

First, a few questions about your opinions of online food hubs.

How much do you agree with the following statements about using online food hubs?
Response options: strongly disagree (1) disagree (2) neither agree not disagree (3) agree (4) strongly agree (5) don't know (6)
[randomised order]

Q2.2 Using them saves...
- … money on food shopping
- … time on food shopping

Q2.3 Using them provides...
- … access to better quality food
- … fresher fruit and veg because it is harvested to order
- … access to seasonal food

Q2.5 Using them is convenient because the food can be...
- … ordered online
- … collected from a local pick-up point
- … delivered to my home

Q2.6 Using them helps to...

… support local businesses

… build connections between consumers and producers

… protect the environment

… tackle climate change

Q2.8 Using them...

… makes me feel positive about myself

… is compatible with my daily life

… increases transparency in the food supply chain

Q2.9 Using them...

… makes a good impression on others

… fits well with my values and beliefs

… has helped me address a problem I faced

… takes more effort than buying my food elsewhere

Q2.11 Using them enables me to...

... make informed choices because I know how the food is produced

… easily find specific products I want using search filters

… connect with like-minded people

Q2.12 Using the food hub app/online platform is easy *[early adopters only]*

Q111 Before when we asked you: 'Do you use an online food hub?' You answered: ________. Is that right?

Response options: yes (1) no, change my answer (2)

Q112 Do you use an online food hub? *[If answered 'no, change my answer' to Q111]*

Response options: yes, currently (1) in the past, but not now (2) no, but I have heard of this (3) no, I have never heard of this (4)

Block 5: Information/communication about online food hubs & social influence (early adopters, former adopters, 'have heard of' non-adopters)

The first section is complete, thank you! Now we're interested in how people receive information and who they talk to about online food hubs.

Q5.2 How did you first find out about online food hubs?

Response options: Internet search engine e.g., Google, Microsoft edge (1) General media e.g., TV, radio, newspapers, websites (2) Organisations, companies, local authorities, schools (3) Talking with friends, family or colleagues (4) Social media (5) Seeing what neighbours or people who live locally are doing (6) Other (please specify): ______ (7)

Q5.3 How important have these sources of information been in shaping your opinion of online food hubs?
Response options: never had information this way (1) not important (2) somewhat important (3) important (4) very important (5) don't know (6)
[randomised order]

Being aware of what people in general are doing
General media e.g., TV, radio, newspapers, websites
Organisations, companies, local authorities, schools
Talking with friends, family or colleagues
Social media
Seeing what neighbours or people who live locally are doing

Q5.4 Roughly, how many people would you say you have spoken with (in person or via phone/internet) about online food hubs in the last 6 months? (Don't worry if you have not spoken with anyone, just put 0)
Response options: ______ (1)

Q5.6/5.7 Of the _____ people you have spoken with about online food hubs, how many would you say are close friends?
We define 'close friends' as people you trust, discuss important things with, or regularly keep in touch with.
Response options: ______________ (1) don't know / prefer not to say (2)

Q5.8 How much do you agree with the following statements about online food hubs?
Response options: strongly disagree (1) disagree (2) neither agree not disagree (3) agree (4) strongly agree (5) don’t know (6)
[randomised order]

I often influence people’s opinions about them
Other people do not turn to me for advice on them
I often persuade other people to use them
People I know pick them based on what I have told them
Other people rarely come to me for advice about choosing them
My opinion on them seems not to count with other people

Block 6: Use of online food hubs in daily life (early adopters only)

You're doing great! Please tell us a bit about how you use the online food hub in your everyday life...

Q6.1 How long have you been using the food hub?
Response options: 0 - 5 months (1) 6 - 11 months (2) 1 - 2 years (4) more than 2 years (5) don't know (6)

Q6.2 Roughly how often do you place a food order with the hub?
Response options: once a week (1) once a fortnight (2) once a month (3) once every 2 months (4) once every 3 months or less often (5) I have never placed an order (6) don't know (7)

Q6.3 Roughly how much of your weekly food shopping do you buy from the food hub?
Response options: less than 10% (1) 10 - 20% (2) 21-30% (3) 31-40% (4) 41-50% (5) Over 50% (6) don't know (7)

Q6.4 Which items do you buy from the hub? (Please select all that apply) *[randomised order]*
Response options: fruit and veg (1) dairy and eggs (2) bread (3) meat (4) fish (5) deli or specialty items (6) basic store items for the cupboard (7) non-food items (8) other (9)

Q6.5 Please rank the items in terms of how frequently you buy them from the food hub:
1 = most frequent, 2 = 2nd most frequent etc. (click and drag the items into the correct position)
Response options: *[Selected choices from Q6.4 carried forward]*

Q6.6 Since you started using the hub, the amount of food you buy from <u>supermarkets</u> has...
Response options: increased a lot (1) increased slightly (2) not changed (3) decreased slightly (4) decreased a lot (5) I have stopped buying from supermarkets (6) don't know (7)

Block 8 – Use of innovation (identical to Block 6, but adapted for former adopters – plus these two additional questions)

Q8.5 Roughly when did you stop using the hub?
Response options: _________ (1)

Q8.6 Why did you stop using the hub?
Response options: _________ (1)

Block 7: Customer satisfaction and feedback (early adopters only)

You're doing great! Next, we'd very much like to hear your thoughts about how (food hub name)'s service to you could be improved.

Q7.1 Are there any items you would like to buy that (food hub name) does not currently offer?
Response options: ___________ (1)

Q7.2 Do you get enough information about the produce and our producers?
Response options: yes (1) no (2) Do you have any comments / suggestions? __________ (3)

Q7.3 What do you think of the pricing of our produce?
Response options: too expensive (1) it's about right (2) too cheap (3) Do you have any comments / suggestions? __________ (4)

Q7.4 What do you think of the delivery / collection process?
Response options: it works well (1) it could be improved (2) Do you have any comments / suggestions? __________ (3)

Q7.5 What are we doing well?
Response options: ________ (1)

Q7.6 How could we improve our service to you?
Response options: ________ (1)

Block 9: Adoption propensity (former and non-adopters only)

Q9.1 How likely are you to use an online food hub within the next year?
Response options:

	very unlikely										very likely
	0	10	20	30	40	50	60	70	80	90	100

(1)
don't know (2)

Blocks 10/11/12: Food and shopping behaviour (all respondents)

That's all our questions about online food hubs, thank you! In this section, we'll ask you some general questions about your daily food habits.

Q10.2 Which of these describe your dietary preferences? (please select all that apply)
Response options: omnivore (eat anything) (1) reduced meat (flexitarian) (2) fish but not meat (3) vegetarian (4) vegan (5) specific food intolerances (e.g., gluten, lactose) (6) other (7) don't know / prefer not to say (8)

Q10.3 Do you grow any of your own food?
Response options: yes (1) no (2) don't know (3)

Q10.4 Roughly how much of your weekly food shopping do you buy from…
(click and drag the sliders to indicate. Please ensure the overall total equals 100%)
[randomised order]

… Supermarkets (online or instore)
… Convenience stores or local corner shops
… Independent shops (bakery, butcher, green grocer, fish monger, deli)
… Online food hubs (this does not include veg boxes or supermarket online sales) *[early adopters only]*
… Local markets (stalls or farmers' markets)
… Veg box delivery
… Other

Q11.2 - 12.5 When choosing what food to buy, how much does it matter to you that the food...
Response options: not at all (1) not very much (2) somewhat (3) quite a lot (4) a great deal (5) don't know (6)
[randomised order]

… is quick to prepare
... was grown locally
… can be ordered online
… was grown using organic farming methods
... is healthy
... can be home-delivered
… the farmer has been paid a fair price
… well-known brands are available
… minimal plastic packaging is used
... you can try out new recipes
... the food is not highly processed
… you can collect loyalty card points
… it is clear where all the ingredients have come from
… the highest welfare standards for farm animals were used
... the cost is low

12.6 Do you use smartphone apps or digital platforms for any of the following? (Please select all that apply)
[randomised order]
Response options: Checking reviews of restaurants, cafes or pubs (1) Reducing food waste (2) Finding recipes (3) Monitoring or changing your diet (4) Ordering takeaway food (5) don't know / not applicable (6)

Q12.7 How often do you...
Response options: at least once a day (1) 4-6 times a week (2) 1-3 times a week (3) once a fortnight (4) once a month (5) never (6)
[randomised order]

… eat a meal which contains red meat *[Not vegetarian or vegan respondents]*
… eat a ready meal in the evening
… prepare a meal from scratch
… eat a vegetarian meal *[Not vegetarian or vegan respondents]*
… eat a 'meal deal' or a takeaway meal (including Deliveroo)
… eat a meal out (e.g. in a restaurant, café or other venue)

Block 13: Sociodemographic and household characteristics (all respondents)

Finally, we'd like to ask a few questions about you...

Q13.1 How old are you?
Response options: under 18 (1) 18-24 (2) 25-34 (3) 35-44 (4) 45-54 (5) 55-64 (6) 65+ (7) don't know / prefer not to say (8)

Q13.2 What is your gender?
Response options: female (1) male (2) other (3) don't know / prefer not to say (4)

Q13.3 What is the highest level of education you have completed?
Response options: no qualifications (1) GCSE or O-Level (2) A-Level (3) other school qualifications (4) undergraduate degree or higher (5) vocational qualifications (6) don't know / prefer not to say (7)

Q13.4 What is your employment status?
Response options: self-employed (1) part-time employed (2) full-time employed (3) unemployed (4) retired (5) looking after family or home (6) student (7) other (8) don't know / prefer not to say (9)

In the following questions, by 'household', we mean a person or a group of people who live together in their only or main home, and share important financial decisions to do with this home.

Q13.6 How many people are in your household (including yourself)?
Response options: _______ (1) don't know / prefer not to say (2)

Q13.7 Of the people in your household (including yourself), how many ...
... are children (under the age of 16)? _________
... are over the age of 65?__________

Q13.8 In a typical week, what level of responsibility do you have for the <u>food shopping</u> in your household?
Response options: responsible for all or most (1) responsible for about half (2) responsible for less than half (3) not responsible for any (4) each person is responsible for their own food shopping (5) don't know / prefer not to say (6)

Q13.9 Roughly what is your household's total combined income (before tax)?
Response options: less than £15,000 (1) £15,000 to £19,999 (2) £20,000 to £24,999 (3) £25,000 to £29,999 (4) £30,000 to £34,999 (5) £35,000 to £39,999 (6) £40,000 to £44,999 (7) £45,000 to £54,999 (8) £55,000 or more (9) don't know / prefer not to say (10)

Q13.10 We are interested in how the distance to supermarkets might influence people's food shopping preferences. Please could you provide your postcode? _________ (1)

Block 14: Completion

Thank you! That's all our questions. We really appreciate your help with our research.

Q14.1 Would you like to be entered into a prize draw to win a top prize of £300 or one of three £80 prizes (vouchers or your choice)?
Response options: yes (1) no (2)

Q14.2 Would you like us to send you a summary of our findings once we have analysed the data?
Response options: yes (1) no (2)

Q14.3 May we contact you again solely for the purposes of this research project?
Response options: yes (1) no (2)

Q14.4 Please provide your contact details - either email, phone or address (we will not share your details with anyone): (If answered 'yes' to any Q14.1, Q14.2 or Q14.3)
Response options: Name: ________ (1) You can contact me by email (enter email): _______ (2) You can contact me by text message (enter mobile phone number): ________ (3) You can contact me by post (enter address): ________ (4)

Appendix 3.2 - Questionnaire: food and shopping behaviour characteristics

Table 27, Questionnaire respondents (n=595): food and shopping behaviour characteristics

		Early adopter (n=221)		Non-adopter (n=374)	
Characteristic	**Category**	**Frequency**	**%**	**Frequency**	**%**
Dietary preference	*omnivore (eat anything)*	*68*	*30.8*	*194*	*51.9*
	reduced meat (flexitarian)	*76*	*34.4*	*81*	*21.7*
	fish but not meat	*16*	*7.2*	*20*	*5.3*
	vegetarian	*46*	*20.8*	*50*	*13.4*
	vegan	*27*	*12.2*	*26*	*7.0*
	food intolerances (e.g., gluten, lactose)	*31*	*14.0*	*40*	*10.7*
	other	*6*	*2.7*	*12*	*3.2*
	prefer not to say	*0*	*0.0*	*2*	*0.5*
Use of food apps	*Checking reviews of restaurants, cafes or pubs*	*127*	*57.5*	*224*	*65.2*
	Reducing food waste	*52*	*23.5*	*89*	*23.8*
	Finding recipes	*151*	*68.3*	*284*	*70.6*
	Monitoring or changing your diet	*59*	*26.7*	*127*	*34*
	Ordering takeaway food	*86*	*38.9*	*188*	*50.3*
		Frequency	**Valid %**	**Frequency**	**Valid %**
Responsibility for food shopping	*responsible for all or most*	*118*	*69.4*	*184*	*62.0*
	responsible for about half	*41*	*24.1*	*71*	*23.9*
	responsible for less than half	*4*	*2.4*	*23*	*7.7*
	not responsible for any	*3*	*1.8*	*5*	*1.7*
	each person is responsible for their own shopping	*4*	*2.4*	*14*	*4.7*
	Missing	*20*		*23*	
	N/A - single occupancy	*31*		*54*	
Grow some of your own food	*yes*	*108*	*52.4*	*154*	*42.0*
	no	*98*	*47.6*	*213*	*58.0*
	missing	*15*		*7*	

Eating habits		Early adopter (n=221) Frequency	Valid %	Non-adopter (n=374) Frequency	Valid %
Eat a meal which contains red meat	*at least once a day*	*1*	*0.8*	*8*	*2.8*
	4-6 times a week	*14*	*10.5*	*27*	*9.5*
	1-3 times a week	*60*	*45.1*	*135*	*47.7*
	once a fortnight	*28*	*21.1*	*53*	*18.7*
	once a month	*18*	*13.5*	*36*	*12.7*
	never	*12*	*9.0*	*24*	*8.5*
	missing	*19*		*22*	
	N/A – respondent is vegetarian or vegan	*69*		*69*	
Eat a ready meal in the evening	*at least once a day*	*3*	*1.5*	*4*	*1.1*
	4-6 times a week	*0*	*0.0*	*3*	*0.8*
	1-3 times a week	*8*	*4.0*	*51*	*14.4*
	once a fortnight	*23*	*11.5*	*68*	*19.3*
	once a month	*45*	*22.5*	*102*	*28.9*
	never	*121*	*60.5*	*125*	*35.4*
	missing	*21*		*21*	
Prepare a meal from scratch	*at least once a day*	*128*	*63.4*	*141*	*39.9*
	4-6 times a week	*56*	*27.7*	*123*	*34.8*
	1-3 times a week	*17*	*8.4*	*60*	*17.0*
	once a fortnight	*1*	*0.5*	*14*	*4.0*
	once a month	*0*	*0.0*	*10*	*2.8*
	never	*0*	*0.0*	*5*	*1.4*
	missing	*19*		*21*	
Eat a vegetarian meal	*at least once a day*	*26*	*19.5*	*25*	*8.8*
	4-6 times a week	*38*	*28.6*	*46*	*16.1*
	1-3 times a week	*52*	*39.1*	*80*	*28.1*
	once a fortnight	*10*	*7.5*	*39*	*13.7*
	once a month	*4*	*3.0*	*33*	*11.6*
	never	*3*	*2.3*	*62*	*21.8*
	missing	*19*		*20*	
	N/A – respondent is vegetarian or vegan	*69*		*69*	
	at least once a day	*0*	*0.0*	*1*	*0.3*

Eat a 'meal deal' or a takeaway meal (including Deliveroo)	*4-6 times a week*	*2*	*1.0*	*4*	*1.1*
	1-3 times a week	*18*	*8.9*	*47*	*13.3*
	once a fortnight	*36*	*17.8*	*88*	*24.9*
	once a month	*81*	*40.1*	*141*	*39.9*
	never	*65*	*32.2*	*72*	*20.4*
	missing	*19*		*21*	
Eat a meal out (e.g. in a restaurant, café or other venue)	*at least once a day*	*2*	*1.0*	*1*	*0.3*
	4-6 times a week	*3*	*1.5*	*3*	*0.8*
	1-3 times a week	*52*	*25.9*	*63*	*17.8*
	once a fortnight	*53*	*26.4*	*92*	*26.1*
	once a month	*85*	*42.3*	*172*	*48.7*
	never	*6*	*3.0*	*22*	*6.2*
	missing	*20*		*21*	
Shopping habits		**Mean**	**SD**	**Mean**	**SD**
% weekly food shopping bought from:	*Supermarkets (online or instore)*	*39.7*	*25.7*	*62.0*	*29.1*
	Convenience stores or local corner shops	*5.3*	*10.1*	*10.6*	*15.0*
	Independent shops (bakery, butcher, green grocer, fish monger, deli)	*11.3*	*13.4*	*11.7*	*16.0*
	Online food hubs (this does not include veg boxes or supermarket online sales)	*13.4*	*16.1*	*13.3*	*23.1*
	Local markets (stalls or farmers' markets)	*4.0*	*8.4*	*7.5*	*15.8*
	Veg box delivery	*26.0*	*25.3*	*6.6*	*16.1*
	Other	*1.8*	*7.9*	*1.6*	*5.4*

Appendix 3.3 - Questionnaire: coding of early adopter qualitative responses

The early adopters were asked six open-ended questions in the attributes survey about their experience of using the hub and their level of satisfaction (Q7.1-7.6). Four of the research themes are deductive codes based on these questions (cost, delivery, communication, product range). Subsequent inductive coding resulted in the separation of these broad codes into sub-categories or codes, as well as the identification of new themes.

Table 28, Coding of qualitative responses from questionnaire survey

Research theme	Code	Coding frequency
Communication	Information to consumer	69
	Information to hub or producers	7
	Product Information	32
	Publicity	9
	Social Influence	3
Cost	Expensive	37
	Value for money - negative	14
	Value for money - positive	23
Customer Service	Customer service - negative	3
	Customer service - positive	45
	General feedback - negative	29
	General feedback - positive	31
	Mistakes with orders	21
Delivery	Deliveries frequency	8
	Delivery charges	6
	Delivery system	3
	Delivery timing	13
	Home delivery	29
	Pick-up point	11
Environmental aspects	Animal welfare	2
	Carbon footprint	9
	Food waste	8
	Sustainable or Environment	14
Food attributes	Food intolerance	8
	Organic	29
	Production methods (not specifically organic)	9

Research theme	Code	Coding frequency
	Quality or Freshness - negative	18
	Quality or Freshness - positive	45
	Seasonal food	11
	Vegan or Vegetarian	10
Compatibility and values	Compatibility with daily life	27
	Identity	13
	Values or ethics	21
Packaging	Packaging (not plastic or refills)	24
	Plastic reduction	28
	Refills	14
Products	Bread	3
	Cupboard stock	38
	Dairy and eggs	14
	Deli or speciality	11
	Fish	4
	Fresh produce	17
	Meat	6
	Non-food items	26
	Specific items	5
Product range	Locavore shop vs online	14
	Range - insufficient	31
	Range - sufficient	34
Shopping experience	Customisation of orders	31
	Ease of use/convenience	18
	Not easy to use/inconvenience	10
	OFN Platform	18
	Quantity or price points	21
	Recipes or meal planning	8
	Trialability	2
Social aspects	Community	10
	Connection with producers	18
	Supporting local or small businesses	13
Supply chains	Imported food	11

Research theme	Code	Coding frequency
	Supermarket supply chain	18
	Local supply chains	46
	Scale of operation	10
	Transparency	13

Appendix 3.4 - Interview protocol

This appendix is the questions and structured elicitation activity instructions for the semi-structured interviews with the early adopters. The card sort and ranking activities were presented to the respondents by sharing the researcher's screen during the video call.

<u>**Purpose of interview**</u>

I'll just briefly explain the purpose of this interview.
My research is looking at whether online food hubs have the potential to reduce carbon emissions compared to longer supply chains.
Choosing to buy food from a local hub rather than from a supermarket is related to **other household decisions around food** – this is what I am exploring in these interviews.
What food people buy from what shops, and why. There are no right or wrong answers.

Explain 'what ifs':

- If the connection is weak, we may have to switch off the video but keep the audio on
- If the connection drops, just click on the meeting link again
- If that doesn't work, we might have to resort to old fashioned telephone
- During the interview, if you have any questions for me, or you would like me to clarify my questions to you, feel free to stop me anytime

Am I ok to start recording the interview?

Start recording on MS teams

Card sort - Profile shopping baskets (5 mins)

We'll start by talking a bit about where you buy your food.

Share screen

Can you see this table? In the first column there are 8 categories or types of foods which you can buy from (hub name), such as fruit and veg, bread, and so on. In the next 3 columns we have 3 types of shops: online food hubs, supermarkets (this includes Express stores) and 'other' …other can be green grocers, convenience stores, basically anything which isn't a food hub or supermarket.

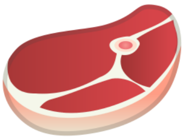
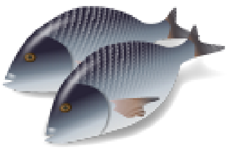
<u>Primary shop</u>

E1.1 Please tell me where you buy the largest quantity of that particular type of food, in a typical week. This is 'largest' in terms of the amount of food, <u>not</u> how much it costs.

<u>Secondary shop</u>

E1.2 For 'fruit and veg', do you buy some items from anywhere else other than from (the online food hub)?

Activity - card sorting exercise

Food Category		Online food hub	Supermarket	Other
Fruit and veg				
Dairy and eggs				
Bread				
Meat				
Fish				
Deli or speciality items				
Basic items for the cupboard				
Non-food items				

Summarise their current shopping basket

Pre-adoption shop

E1.3 Now think back to before you started using the hub. Where did you used to buy….?

Summarise the pre-adoption shopping basket

Activity 1 - Shopping behaviour (10 mins)

E1.4 Who tends to do the food shopping in your household?

Substitution

E1.5 You buy most of your … from (hub name) – why do you buy these items from the hub instead of the supermarket?

E1.6 Do you still buy some of your fruit and veg from supermarkets or other shops?

Follow-up if yes:

Why do you buy some items from (hub name) and some from (Tesco)?

E1.7 Do you grow any of your own food?

Hub use

E1.8 How long have you been using (hub name)?

E1.9 Roughly how often do you place an order with the hub?

E1.10 Approximately how much do you spend each week at the hub?

Locavore customers only – does that include your veg box?

Niche items

E1.11 Are there any items you can only buy from (hub name) that you can't buy anywhere else?

What are they?

E1.12 How important is the availability of these items in your decision to use online food hubs?

E1.13 Do you use (hub name) to buy speciality foods or treats for a social event, such as hosting a dinner?

Follow up if yes: Before the pandemic, did this happen very often?

Shifting to online shopping

E1.14 Do you do more of your food shopping online, not only from food hubs, but in general since you started using (hub name)?

Follow up if yes: Why is this?

E1.15 Has the pandemic affected how you shop?

Follow up if yes: In what ways?

E1.16 Do you think these changes in your shopping habits will remain after the pandemic is over, or will you revert to how you previously shopped?

I'm going to stop sharing my screen now.

Stop sharing screen

Activity 2 - Household dynamics and food behaviours (20 mins):

Household dynamics and decision making (also see diet)

E2.1 In your household, how do you decide what food to buy and where to buy it?

E2.2 How about cooking meals? Do you share this role, or does one person tend to do more of the food preparation?

E2.3 Have your (or the main chef's) cooking habits changed since you started using (hub name)?

Clarification if necessary: For instance, the number of meals you cook from scratch every week, or your general enjoyment of cooking?

Follow up if yes: Why is this?

Waste

E2.4 How often do you throw away unused ingredients or leftovers?

Follow up: Do you think this has changed since you started using (hub name)?

Values or household expectations

E2.5 Are there any values or ethical considerations which are important in your household's eating or shopping decisions?

Clarification: this could be do with how the food is produced, farmer livelihoods, animal welfare etc.

E2.6 Has using the food hub had any impact on your sense of personal identity?

Do you feel more aligned with any particular social or ethical position, or do you use it simply as a customer because they sell the items you want?

Constraints

E2.7 Do you ever feel time constrained when shopping for food?

Follow up if yes: Does this affect where you choose to buy your food?

E2.8 Is it easy to get to the local supermarkets or shops?

Follow-up if no:

Does this affect where you choose to buy your food?

Which is more convenient – going to the supermarket or ordering from the food hub?

E2.9 Is the food from the hub expensive?

Follow-up if yes:

Does this affect how much of your weekly shop you buy from the hub, or what items you decide to buy?

E2.10 Do you find the Open Food Network website easy to use?

E2.11 Did you find the shift from 'shop anytime' to 'receiving your food on a weekly cycle' easy to adapt to?

E2.12 Food hubs tend to stock a narrower range of some products compared to a supermarket. Does this make it easier or harder to do your food shopping?

Satisfaction

E2.13 Think back to when you first started using the hub…Have your reasons for using it changed over time? Are your reasons for using it now the same as when you first started?

E2.14 Is there anything you don't like about buying from the hub?

Activity 3 - Dietary change (meat or health) (10 mins)

Dietary preference

E3.1 How would you describe your diet…are you omnivore, flexitarian, vegetarian, vegan, pescatarian, another type of diet?

E3.2 Were you already vegetarian/pescatarian when you started using the hub?

E3.3 Does everyone in your household eat a (vegetarian/omnivore) diet?

Follow up if no: What is their diet?

Dietary shift

E3.4 Think about the kinds of food you typically eat every week in your household…Have you noticed a change in the types of food you eat since you started using the hub?

Follow-up if yes:

In what ways has your diet or eating habits changed?

Do you eat more or less of any particular foods?

Why do you think it has changed?

E3.5 Does using the hub make it easier or harder to find foods which match your (vegetarian/flexitarian/healthy) diet?

E3.6 Would you say you eat more or less takeaways or ready meals now than before?

E3.7 Would you say you a healthier or less healthy diet now than before?

E3.8 You mentioned you eat a more seasonal diet now – Did you find this an easy transition, to eat more seasonally?

Activity 4 - Social Influence (15 mins)

Now we are going to talk a bit about who you talk to about (hub name)

E4.1 How did you first find out about (hub name)?

Follow up:

Can you remember if anyone recommended the hub to you?

Was this recommendation important in your decision to start using the hub?

Ranking exercise to explore strong/weak ties

I'm going to share my screen again for the next exercise.

Share screen

Instructions: In the table you can see 4 groups of people: a) friends or family who use food hubs, b) friends or family who do not use food hubs, c) acquaintances or other people you know who use food hubs, d) acquaintances who do not use food hubs.

Activity – Ranking of communication with strong/weak ties

	Friends/family	Acquaintances/other people you know
They use (hub name)	a)	c)
They do not use (hub name)	b)	d)

E4.2 Think about the people you talk to about online food hubs. Which category would you say the majority of them fall under? (*Write '1' in this category*). How about the next largest group? (*Write '2' in this category*). Do you speak to anyone in the other 2 groups about online food hubs (*Write 'N/A' for this category*(*s*), *if no)*

<u>Follow-up questions</u>
The largest group you speak to is 'friends who use online food hubs'
E4.3 What do you talk about? (content)

E4.4 When you discuss (hub name), would you say you are generally positive or negative about your experience of using the hub? (evaluative)

E4.5 How often do you talk to someone from group a) about food hubs? (frequency)

E4.6 Do you tend to communicate face to face or through social media? (form)

E4.7 What is the context or situation in which you speak to acquaintances who do not use food hubs?

E4.8 Do you know of anyone who you recommended (hub name) to has then started using the hub?
 Follow up: How many people have become hub users?

E4.9 For those people who do not use food hubs, are there any barriers you know of which might prevent them from using them?

E4.10 You haven't spoken to many/any people from this groups….was that a conscious decision or the topic simply hasn't come up?

Repeat follow-up questions for one or two other groups (*Ensure both friends and acquaintances who do <u>not</u> use food hubs are discussed – if relevant*)

<u>Other information sources</u>

E4.11 Think about the information you receive about the hub - how much comes from the hub itself, via promotional materials, social media posts, and how much from other sources such as the news, magazines etc.

E4.12 Is there any social interaction among hub users, such as cooking clubs, regular meet-ups in a café (before the pandemic), or communication on social media platforms?

E4.13 Do you use any other food related digital platforms, such as food waste apps, diet change apps, last minute deals for fresh produce?

Exit survey

E5.1 How many people are in your household (including yourself)?

____ or prefer not to say

E5.2 ... are children (under the age of 16)?

____ or prefer not to say

E5.3 How old are you?

1) 24 or under
2) 25-34
3) 35-44
4) 45-54
5) 55-64
6) 65+

prefer not to say

E5.4 What is the highest level of education you have completed?

1) no qualifications
2) GCSE or O-Level
3) A-Level
4) other school qualifications
5) undergraduate degree or higher
6) vocational qualifications

prefer not to say

E5.5 What is your employment status?

1) self-employed
2) part-time employed
3) full-time employed
4) unemployed
5) retired
6) looking after family or home
7) student
8) other

   prefer not to say

E5.6 Roughly what is your household's total combined income?
(before tax)

1) less than £35,000
2) more than £35,000

   prefer not to say

Wrap up

E5.7 Do you have any questions for me, or can you think of anything that I should have asked you?

Would it be ok to email you to clarify if, during my write up of this interview, something pops up that is unclear?

The voucher might take a couple of weeks to be credited to your account, but it will get there eventually. That's it, thank you again for your time, have a lovely rest of your day. *Stop recording*

Appendix 3.5 - Interviews: coding of qualitative responses

Most of the codes in Table 29 were based on the research objectives of the interviews and so are deductive. A few inductive codes (indicated by *) were added as interesting findings emerged from the respondents' answers.

Table 29, Coding of qualitative responses from semi-structured interviews

Research theme	Code	No. of respondents	Coding frequency
Shopping behaviour	Shopping habits now	20	107
	Shopping habits pre-adoption	18	31
	Shift to online shopping	17	37
	Impact of pandemic	20	93
Experience of using the food hub	Hub use	20	42
	Convenience	17	41
	Availability of niche items	16	39
	Open Food Network platform	18	30
	Appeal of food hub	20	98
	Dissatisfaction with food hub	19	35
	Motivation shift since adoption	17	18
	Using the hub as a producer *	7	31
Values	Values important in food decisions	20	213
	Impact on sense of identity *	7	24
	Trust & relational aspects *	15	58
Constraints which may affect where to shop	Constraints - Access	19	57
	Constraints - Money	19	58
	Constraints - Product range	20	72
	Constraints - Time	17	43
	Barriers to adoption of food hubs	19	43
Household food behaviour	Household decision making	20	60

Research theme	**Code**	**No. of respondents**	**Coding frequency**
	Cooking habits	19	86
	Food waste habits	20	39
	Growing own food	15	38
Diet	Healthy diet	19	50
	Dietary preference	20	67
	Seasonal diet	17	35
Communication & social influence	Innovation discovery	18	24
	Communication about hubs	20	54
	Information sources	17	22
	Social activities *	16	25
Use of other food apps	Food apps	16	16

Appendix 3.6 - Interviews: retailers where respondents buy their food

The interview respondents (n=20) were presented with eight food categories and asked which shops they tend to use to buy items under each category (E1.1-1.2). The results are shown in Table 30 and we can see that online food hubs were cited most frequently across all food categories, followed by supermarkets and then local independent shops. Regarding individual food categories, 19 respondents use their local hub to buy fruit & vegetables and the hubs are also key suppliers of dairy & eggs and non-food items. Supermarkets and wholesalers are important suppliers of cupboard stock and non-food items.

Table 30, Retailers where food hub users buy their food

	Number of respondents for each food category								
Location/supplier	Fruit & veg	Bread	Dairy & eggs	Meat	Fish	Basic items for cupboard	Deli or speciality items	Non-food items	**Most frequently mentioned suppliers across all categories**
Online food hub	19	10	18	5	6	12	10	13	93
Supermarket	8	6	6	6	6	16	9	11	68
Local independent (butcher, baker, grocer, deli)	4	5	3	7	5	1	7	3	35
Wholesaler	0	0	0	0	0	6	1	5	12
Health food shop	0	0	0	N/A	N/A	2	2	0	4
Grow/produce own food	4	N/A	3	0	0	N/A	N/A	N/A	7
Bake own bread	N/A	8	N/A	N/A	N/A	N/A	N/A	N/A	8
Other veg box provider	2	0	0	0	0	0	0	0	2
Milk delivery	0	0	3	N/A	N/A	N/A	N/A	N/A	3
Refill store	0	0	0	N/A	N/A	1	0	2	3
Other	1	0	3	3	2	0	0	2	11

Appendix 3.7 - Interviews: food hub use characteristics

Table 31, Interview respondents (n=20): food hub use characteristics

Characteristic	**Category**	**Frequency**	**%**
Food hub	*Glasgow Locavore*	*8*	*40*
	Tamar Valley Food Hubs	*12*	*60*
Duration using the hub	*Less than 2 years*	*3*	*15*
	2 - 3 years	*8*	*40*
	4 - 5 years	*3*	*15*
	6 - 7 years	*4*	*20*
	8 years or more	*2*	*10*
Order frequency	*Weekly*	*19*	*95*
	Fortnightly	*1*	*5*
Expenditure Group*	*Upper*	*6*	*30*
	Middle	*8*	*40*
	Lower	*5*	*25*
	All 3, it depends on the season	*1*	*5*

* The groups were determined using the mean monthly expenditure percentiles for each hub (lower: 1-33%, middle: 34-67%, upper: 68-100%) using the Open Food Network purchasing data (see further explanation in Appendix 6.1).

Appendix 4.1 - PCA of food shopping preferences

Table 32, Rotated component matrix for PCA with orthogonal rotation of 14 food shopping preferences

Shopping preference	1. ethics and health	2. conventional shopping attributes	3. Shopping convenience	Communalities
		Component		
The food was grown locally	0.790	-0.135	0.170	0.672
The farmer has been paid a fair price	0.756	-0.073	0.115	0.590
Minimal plastic packaging is used	0.735	-0.084	0.034	0.549
It is clear where all the ingredients have come from	0.720	-0.025	0.130	0.536
The highest welfare standards for farm animals were used	0.717	-0.110	0.099	0.536
The food is healthy	0.680	-0.028	-0.053	0.466
The food was grown using organic farming methods	0.671	-0.213	0.269	0.568
The food is not highly processed	0.660	-0.001	-0.129	0.452
You can collect loyalty card points	-0.033	0.754	0.133	0.587
Well-known brands are available	-0.139	0.728	0.161	0.576
The cost is low	-0.080	0.706	-0.160	0.531
The food is quick to prepare	-0.090	0.667	0.186	0.487
The food can be home-delivered	0.150	0.109	0.894	0.833
The food can be ordered online	0.100	0.206	0.891	0.847
Percentage of variance explained	*32.2%*	*17.5%*	*9.1%*	
Eigenvalue	*4.5*	*2.4*	*1.3*	

Note 1: major loadings for each item are shown in bold

Note 2: Table 32 is identical to Table 7, but shows the complete factor loadings for the PCA of shopping preferences

Appendix 4.2 - Between-group analysis of 15 shopping preferences

The attribute survey respondents were asked the following question for 15 shopping preferences (Q11.2-12.5):

(Q12.1) When choosing what food to buy, how much does it matter to you that...

	not at all	not very much	somewhat	quite a lot	a great deal	don't know
... it is clear where all the ingredients have come from?	○	○	○	○	○	○

Differences between the two groups' responses for the relative importance of the 15 shopping preferences were explored using independent-samples t-tests and Mann-Whitney U tests. The non-parametric tests were carried out because the data failed some of the assumptions of parametric tests, namely that the data was non-normally distributed and that the unidirectional scale data is ordinal. The parametric and non-parametric approaches produced consistent results with respect to statistical significance, direction and effect size. This finding supported the use of parametric approaches as the basis for the between-group analysis. The results of the independent samples t-tests and the Mann-Whitney U tests are shown in Table 33.

Figure 48, on the following page, shows the means of the food shopping preferences for the early adopters (blue bars) and non-adopters (orange bars). The figure reveals that the highest ranked preferences for both groups are those which align with attributes of online food hubs, such as minimal plastic packaging and high animal welfare standards. Although the two groups are broadly similar in terms of their most important preferences, independent-samples t-tests found statistically significant differences in their mean responses. The non-adopters placed greater importance than the early adopters on the more established shopping attributes such as low cost or food which is quick to prepare. The early adopters placed greater emphasis on environment, health and convenience in their food shopping preferences.

Table 33, Comparing early adopters' and non-adopters' shopping preferences using independent samples t-tests and Mann-Whitney U tests

	Independent samples t-test					Mann-Whitney U test				
Shopping preference	Mean early adopter	Mean non-adopter	p-value	Cohen's d	Effect size - Cohen	Median early adopter	Median non-adopter	p-value	U-Score	Z-score
the food is quick to prepare	2.53	3.11	.001	-0.561	medium	2	3	.001	45902.5	6.287
the food was grown locally	4.22	3.51	.001	0.720	medium	4	3	.001	22047	-7.685
the food can be ordered online	3.11	2.66	.001	0.354	small	3	2	.001	22667	-4.096
the food was grown using organic farming methods	3.98	3.17	.001	0.720	medium	4	3	.001	21678	-7.695
the food is healthy	4.52	4.13	.001	0.509	medium	5	4	.001	25995	-5.731
the food can be home-delivered	3.29	2.67	.001	0.481	small	3	3	.001	26272	-5.322
the farmer has been paid a fair price	4.44	4.0	.001	0.511	medium	5	4	.001	25811.5	-5.434
well-known brands are available	1.91	2.47	.001	-0.541	medium	2	2	.001	45058	5.875
minimal plastic packaging is used	4.61	4.22	.001	0.460	small	5	4	.001	26675.5	-5.191
you can try out new recipes	3.24	3.34	.302	-0.091	N/A	3	3	.240	37072	1.176
the food is not highly processed	4.41	4.12	.001	0.337	medium	5	4	.001	28062.5	-4.304
you can collect loyalty card points	2.04	2.69	.001	-0.567	medium	2	3	.001	45649	6.106
it is clear where all the ingredients have come from	4.2	3.87	.001	0.385	small	4	4	.001	28712	-4.125
the highest welfare standards for farm animals were used	4.61	4.15	.001	0.525	medium	5	4	.001	24059	-5.962
the cost is low	3.14	3.66	.001	-0.586	medium	3	4	.001	46617	6.486

Note 1: Statistically significant differences are shown in bold

Note 2: For the independent samples t-tests, Shapiro-Wilk's test showed that none of the shopping preferences are normally distributed

Note 3: For the independent samples t-tests, Levene's test for equality of variances was used to determine homogeneity of variance between the two groups

Note 4: For the Mann-Whitney U tests, the distributions of the two groups were all similar, so medians were compared rather than mean ranks

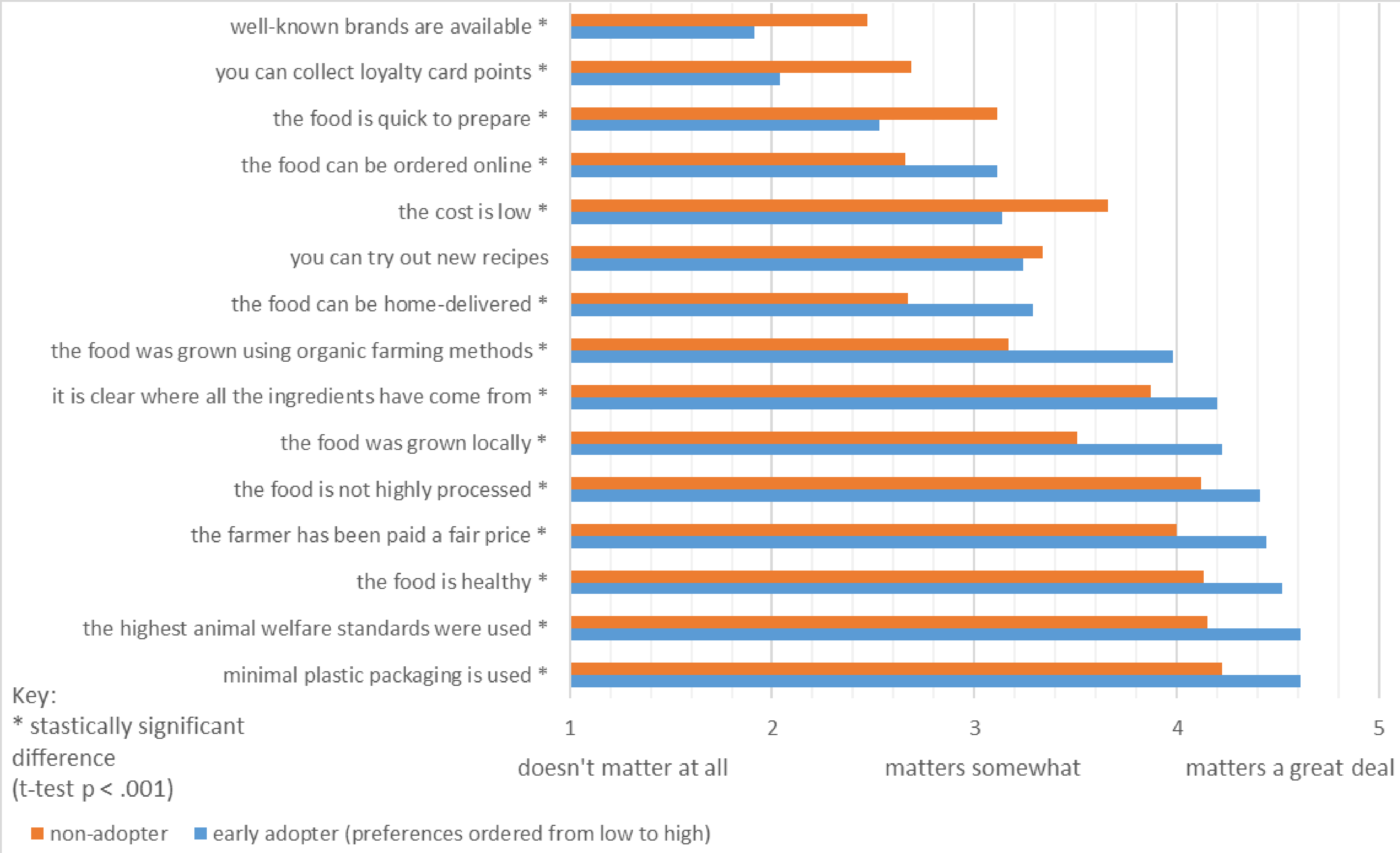


Figure 48, Comparing early adopters' and non-adopters' shopping preferences

Appendix 4.3 - PCA of online food hub attributes

Table 34, Rotated pattern matrix for PCA with oblique rotation of 22 online food hub attributes

	Component							
Attribute	1. Env. & Soc. benefits	2. Compatibility	3. N/A	4. Identity	5. Food Quality	6. Convenience	7. Money & time	Commu-nalities
Helps protect the environment	0.851	0.116	-0.011	0.057	0.006	-0.013	0.000	0.741
Helps tackle climate change	0.845	0.062	-0.068	0.081	0.031	-0.035	-0.025	0.732
Builds connections between consumers and producers	0.786	-0.209	0.145	-0.116	0.039	0.091	0.120	0.719
Helps support local businesses	0.685	0.019	-0.045	-0.043	-0.149	0.112	-0.080	0.515
Takes less effort than buying food elsewhere	0.039	0.740	-0.009	-0.205	0.039	0.081	0.157	0.624
Compatible with my daily life	0.035	0.590	0.193	0.370	-0.030	0.124	0.048	0.542
Easily find specific products using search filters	-0.093	0.119	0.773	-0.086	0.078	0.227	-0.008	0.686
Connects me with like-minded people	0.065	-0.157	0.689	0.184	-0.070	-0.100	0.152	0.575
Helps me make informed choices about my food	0.254	0.096	0.604	-0.001	-0.249	-0.143	-0.064	0.525
Helps me address a problem I face	-0.089	-0.025	0.043	0.807	0.069	0.067	-0.009	0.671
Makes a good impression on others	0.123	-0.267	-0.058	0.607	-0.014	0.080	0.156	0.490
Makes me feel positive about myself	0.172	0.225	0.045	0.525	-0.238	-0.055	-0.020	0.417
Fits wells with my values and beliefs	0.319	0.232	0.038	0.442	-0.161	-0.023	-0.123	0.394
Provides better quality food	-0.031	0.079	-0.046	0.029	-0.837	0.060	0.084	0.721
Provides fresher produce	-0.029	-0.205	0.109	-0.110	-0.832	0.056	0.116	0.776
Provides seasonal produce	0.077	0.018	-0.084	-0.003	-0.783	0.113	-0.124	0.654
Increases transparency in the food supply chain	0.163	0.077	0.240	0.227	-0.470	-0.113	-0.128	0.392
Home delivery convenience	0.083	0.138	-0.085	0.103	-0.076	0.751	-0.047	0.615
Online ordering convenience	0.032	0.158	-0.011	0.009	-0.164	0.744	0.003	0.606
Collecting from local pick-up convenience	0.042	-0.234	0.218	0.030	-0.005	0.606	0.055	0.475
Saves money on food shopping	0.014	-0.030	0.055	0.060	-0.028	-0.090	0.879	0.788
Saves time on food shopping	0.001	0.355	-0.053	-0.004	-0.047	0.126	0.676	0.604
Percentage of variance explained	*30.2%*	*9.3%*	*7.0%*	*6.4%*	*5.0%*	*4.4%*	*4.2%*	
Eigenvalue	*6.6*	*2.0*	*1.5*	*1.4*	*1.1*	*1.0*	*0.9*	

Note: major loadings for each item are shown in bold

Note: Table 34 is identical to Table 13 but shows the complete factor loadings for the PCA of the 22 attributes

Appendix 4.4 - Between-group analysis of 22 online food hub attributes

Differences between the two groups' Likert scale rankings for the 22 attributes were explored using independent-samples t-tests and Mann-Whitney U tests. The non-parametric tests were carried out because the data failed some of the assumptions of parametric tests, namely that the data was non-normally distributed and that Likert scale data is ordinal. The parametric and non-parametric approaches produced consistent results with respect to statistical significance[64], direction and effect size. This finding supported the use of parametric approaches as the basis for the between-group analysis. Table 35 shows the results of the independent samples t-tests and Mann-Whitney U tests.

Figure 49 below shows the means of the 22 attributes for the early adopters (blue bars) and non-adopters (orange bars). The figure reveals three important findings. First, the relatively high means indicate that most respondents either *agree* or *strongly agree* with the statements, suggesting that their perception of the appeal of online food hubs is generally positive. Second, the early adopters tend to rank higher than the non-adopters; this was the case for 13 attributes where there is a statistically significant difference between the two groups, whereas there were only three attributes where non-adopters rank higher. Third, although early adopters generally ranked higher, the effect size is small (using Cohen's d) for ten of the attributes and medium for the remaining three. Statistically significant differences but small effect sizes indicate that early adopter and non-adopter perceptions are not substantially dissimilar.

[64] With the exception of 'increases transparency in the food supply chain': The Mann-Whitney U test identified a statistically significant difference between the two groups, but the independent samples t-test did not.

Table 35, Comparing early adopters' and non-adopters' perceptions of 22 online food hub attributes using independent samples t-tests and Mann-Whitney U tests

	Independent samples t-test					Mann-Whitney U test				
Attribute	Mean early adopter	Mean non-adopter	p-value	Cohen's d	Effect size - Cohen	Median early adopter	Median non-adopter	p-value	U-Score	Z-score
Saves money on food shopping	2.77	2.90	.138	-0.132	N/A	3	3	.105	35524	1.620
Saves time on food shopping	3.84	3.52	.001	0.330	small	4	4	.001	30262.5	-3.920
Provides access to better quality food	4.43	4.19	.001	0.334	small	5	4	.001	31832.5	-4.095
Provides access to fresher produce	4.15	4.34	.008	-0.241	small	4	4	.017	42510.5	2.397
Provides access to seasonal food	4.62	4.46	.005	0.243	small	5	5	.001	32791	-3.561
Ordering online convenience	4.52	4.25	.001	0.380	small	5	4	.001	29514	-4.89
Collecting from local pick-up convenience	3.83	3.81	.792	0.025	N/A	4	4	.948	29851	0.065
Home delivery convenience	4.56	4.30	.001	0.340	small	5	4	.001	28768	-5.182
Helps support local businesses	4.69	4.41	.001	0.391	small	5	5	.001	31388	-5.02
Builds connections between consumers and producers	4.10	4.18	.322	-0.085	N/A	4	4	.497	40167.5	0.68
Helps protect the environment	4.39	4.03	.001	0.438	small	4	4	.001	28978.5	-4.901
Helps tackle climate change	4.30	3.90	.001	0.480	small	4	4	.001	27212	-5.212
Makes me feel positive about myself	4.11	3.90	.005	0.243	small	4	4	.007	33714.5	-2.721
Compatible with my daily life	4.19	3.73	.001	0.550	medium	4	4	.001	26545	-6.721
Increases transparency in the food supply chain	4.31	4.20	.122	0.140	small	4	4	.015	33413	-2.421
Makes a good impression on others	3.32	3.39	.403	-0.074	N/A	3	3	.174	36879	1.36
Fits well with my values and beliefs	4.54	4.05	.001	0.619	medium	5	4	.001	26157	-7.35
Helps me address a problem I face	3.33	3.25	.298	0.091	N/A	3	3	.285	34196.5	-1.069
Does not take more effort than buying my food elsewhere	3.60	2.98	.001	-0.625	medium	4	3	.001	25102	-7.150
Enables me to make informed choices because I know how the food is produced	4.15	4.16	.883	-0.013	N/A	4	4	.831	39185	-0.214
Search filters enable me to easily find the specific products	3.58	3.85	.001	-0.313	small	4	4	.001	40017.5	3.370
Helps me connect with like-minded people	3.30	3.56	.002	-0.277	small	3	4	.002	42079	3.1

Note 1: Statistically significant differences are shown in bold

Note 2: For the independent samples t-tests, Shapiro-Wilk's test showed that none of the attributes are normally distributed

Note 3: For the independent samples t-tests, Levene's test for equality of variances was used to determine homogeneity of variance between the two groups

Note 4: For the Mann-Whitney U tests, the distributions of the two groups were all similar, so medians were compared rather than mean ranks

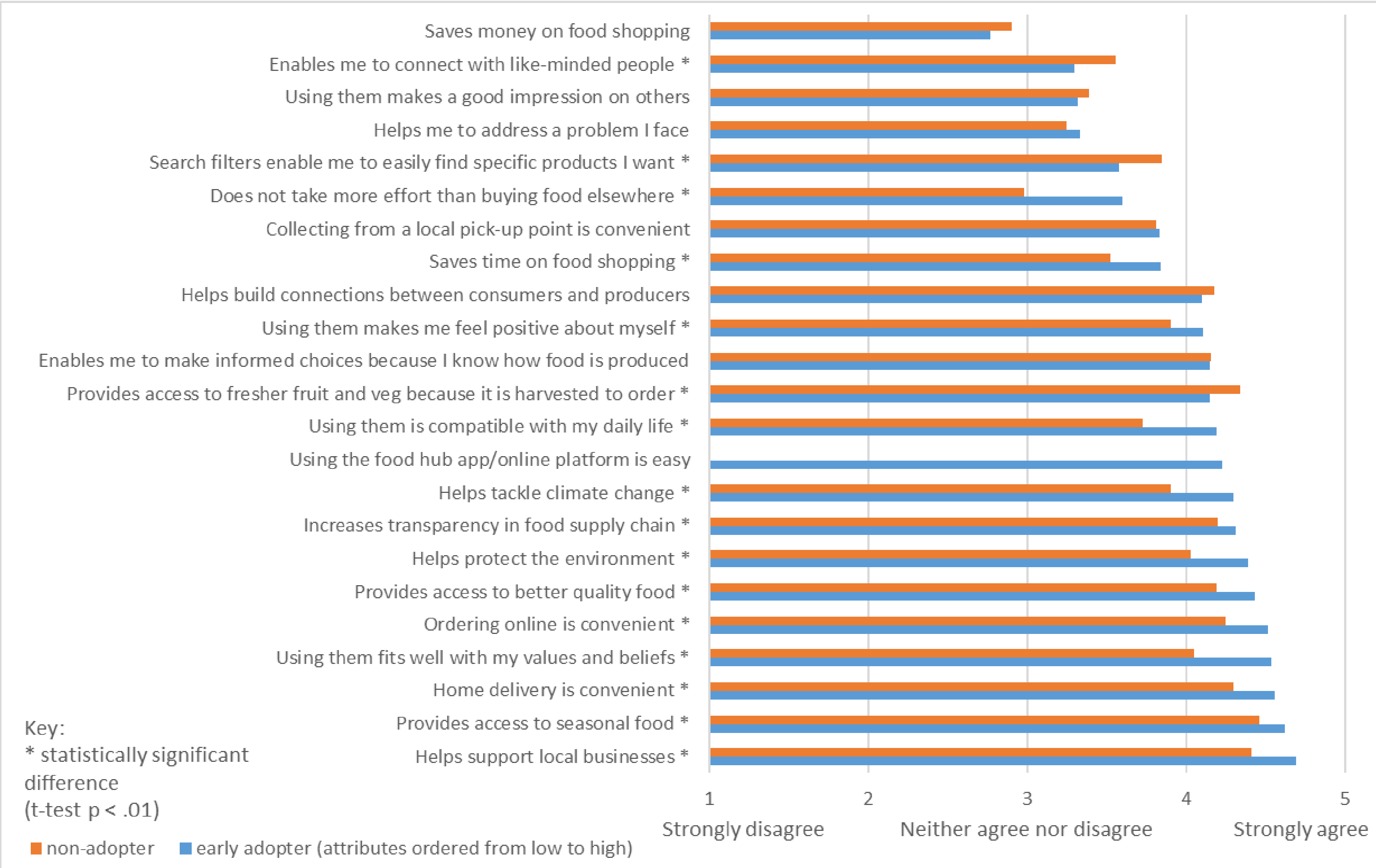


Figure 49, Comparing early adopters' and non-adopters' perceptions of 22 attributes of online food hubs

Appendix 4.5 - Developing the logistic regression model to predict food hub adoption

This appendix describes the process of developing the binomial logistic regression model of the most important predictors of adoption. Independent variables were included in the model on the basis of a statistically significant difference between the early adopters and the non-adopters in the between-group analyses. Independent variables were excluded because there was no statistically significant difference between the two groups or, in the case of some of the nominal variables, the sample size for a particular response category was too small to function in a logit model. The variables, both included and excluded, are listed in Table 36 below. Shopping behaviour, household size, and the appeal and shopping preference PCA components are scale variables. Four nominal variables relating to food and cooking behaviour, as well as three sociodemographic and household characteristics, were converted to dummy variables to enable integration into the model.

Table 36, Variables included/excluded from the binomial logistic regression models

Variable category	Code	Variables included in analysis	Variables excluded from analysis
Appeal components	A1	Environmental and societal benefits	Money and time
	A2	Compatibility with daily life	
	A3	Choice	
	A4	Identity	
	A5	Food quality and trust	
	A6	Convenience	
Shopping preference components	B1	Food ethics	
	B2	Conventional shopping attributes	
	B3	Shopping convenience	
Shopping behaviour	C1	% of weekly food shop from supermarket	% weekly food shop from: independent shops, veg box, convenience stores, farmers' markets, other
Food and cooking behaviour	1	Dietary preferences: omnivore/reduced or no meat diet	Dietary preferences: pescatarian, other diet, food intolerances
	2	Grow food: no/yes	Use of food apps
	3a	Frequency of vegetarian meals: eat a vegetarian meal 3 times a week or less/4 times a week or more	Frequency of: eat out, eat a meal deal/takeaway, eat a ready meal in the evening
	3b	Frequency of cooking from scratch: not every day/every day	
Social influence			Opinions shaped by talking with friends, family or colleagues
Sociodemographic and household characteristics	4	Education: do not have a degree/have a degree	Education: GCSE, A levels, vocational qualifications, other qualifications
	5	Employment: not full time or self-employed/full time or self-employed	Employment: part-time, retired, student, other
	D	Household size	Household lifecycle: children under 16, adults over 65
	6	Household combined income: less than £30,000/£30,000 or above	Gender
			Age
			Responsibility for household food shopping

Table 37 shows various combinations of the 18 variables described above which were tested in the process of developing the logit model. The variables are denoted by their associated code from Table 36. Number 14 was chosen as the best model, based on three criteria: a high percentage accuracy classification (78.2% of respondents correctly predicted), a relatively high R square (.432), but with a low number of variables (six) included. However, we can see from Table 37 that some other models were also parsimonious and effective in predicting adoption, such as model 12.

Table 37, Different combinations of independent variables tested in developing the logit model

Model number	Variables included in model	% predicted correct (baseline)	Nagelkerke R Square	% accuracy in classification
1	All 18 variables	63.8	.561	83.0
2	B1, B2, B3, C1	63.6	.371	75.6
3	C1, B1, B2, B3, 3b, 4, 6	62.7	.394	75.9
4	A1, A2, A3, A4, A5, A6	65.0	.350	76.2
5	A1, A2, A3, A4, A5, A6, C1, B1, B2, B3, 3b, 4, 6	64.0	.531	79.7
6	A1, A2, A6, C1, B1, B2, B3, 3b, 4, 6	64.0	.450	76.7
7	A2, A6, C1, B1, B2, 3b, 4, 6	64.0	.419	75.4
8	A2, A6, C1, B2, 3b, 6	63.9	.412	75.2
9	A2, C1, 6	64.1	.363	74.8
10	A2, A5, C1, B1, B2, B3, 3b, 4	65.0	.460	78.0
11	A2, C1, B1, B2, B3, 3b, 4	65.4	.443	76.3
12	C1, B1, B2, B3, 3b, 4	65.4	.432	78.2
13	C1, B1, B2, B3, 3b, 4, D	65.0	.460	78.0
14	**A2, C1, B2, B3, 3b, 4**	**65.4**	**.432**	**78.2**
15	A2, B2, B3, 3b, 4	65.4	.406	75.6
16	C1, 1, 2, 3a, 3b, 4, 5, D, 6	62.4	.324	73.9
17	A2, B2, 3b, 4	65.4	.356	73.6
18	A2, B2, 4	65.4	.334	73.7

Appendix 6.1 - Variation in food hub users' expenditure

The three expenditure groups were determined using the mean monthly expenditure percentiles for each hub (lower: 1-33%, middle: 34-67%, upper: 68-100%). The expenditure ranges for the three groups within each hub are shown in Table 38.

Table 38, Lower, middle and upper expenditure ranges for Tamar and Locavore customers

	Tamar Valley Food Hub			Locavore		
Group	Mean monthly exp. (£)	Standard deviation	Exp. range (£)	Mean monthly exp. (£)	Standard deviation	Exp. range (£)
Lower exp. group	49.65	20.48	23.77 - 86.15	14.00	3.23	8.57 - 18.11
Middle exp. group	115.90	19.69	87.79 - 152.61	27.29	6.11	18.34 - 42.60
Upper exp. group	236.83	76.96	158.26 - 462.19	65.77	21.95	42.75 - 129.08

Variation in expenditure

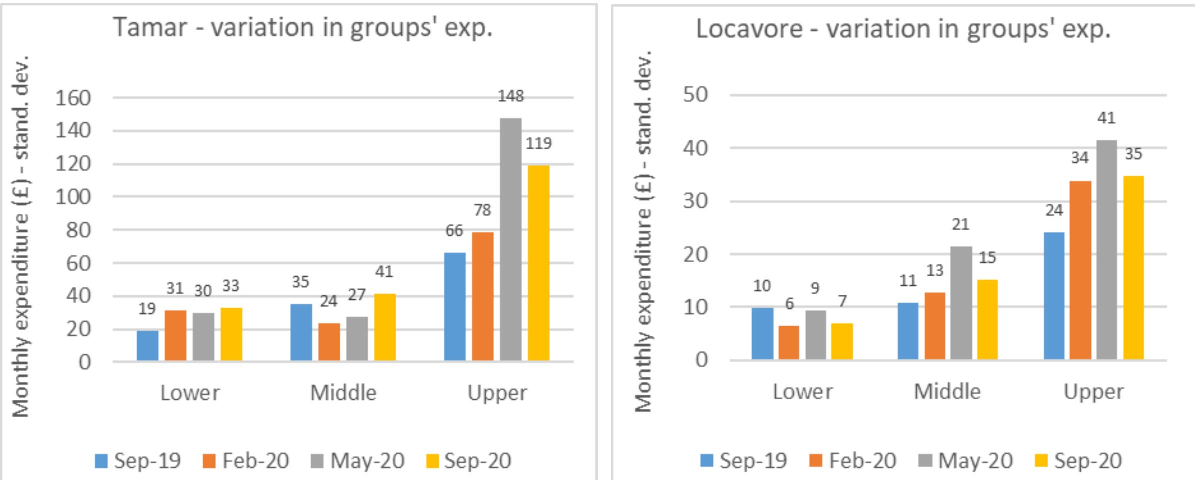


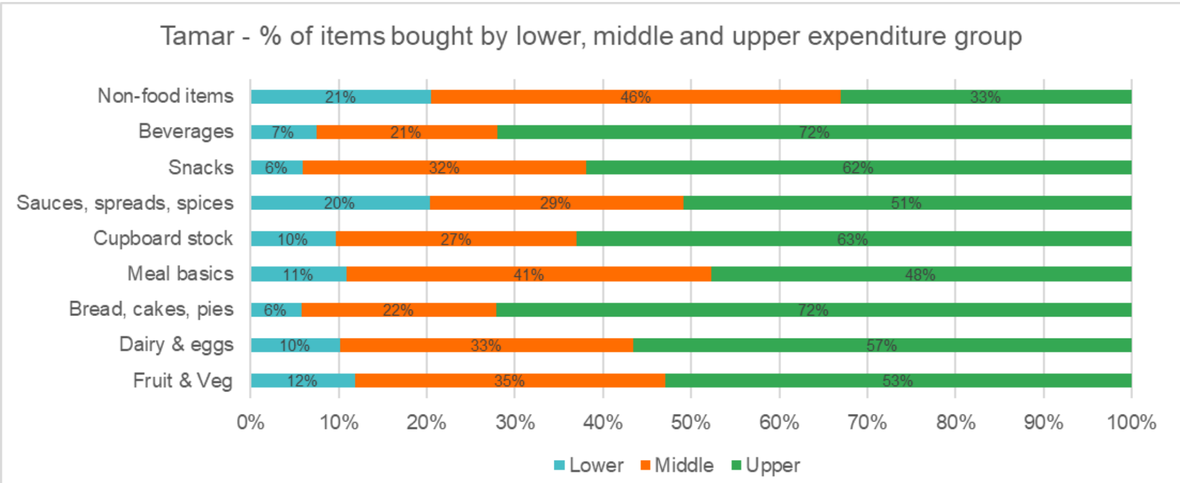
Figure 50, Monthly expenditure (£) standard deviation for lower, middle and upper expenditure customers

Three groups were relatively homogenous in the variation in their monthly expenditure over the 4 months: Tamar lower and middle, as well as the Locavore lower group. The two upper groups and the Locavore middle group displayed more variation in their shopping basket expenditure, with standard deviations increasing noticeably in May-20.

From Table 38 and Figure 50 we can infer that as the hub customers' mean expenditure increases, the variation in their shopping basket sizes also increases.

Appendix 6.2 - Proportion of purchases by expenditure groups for nine food categories

Figure 51 shows the proportion of purchases of the three groups within each food category, using 'number of items bought' as the metric for calculating the percentages. The upper expenditure group (green bars) buys as much as the other two groups combined for most food categories. A further observation is that the middle group buys proportionally more non-food items and the upper group buys proportionally more snacks, beverages and meal basics.



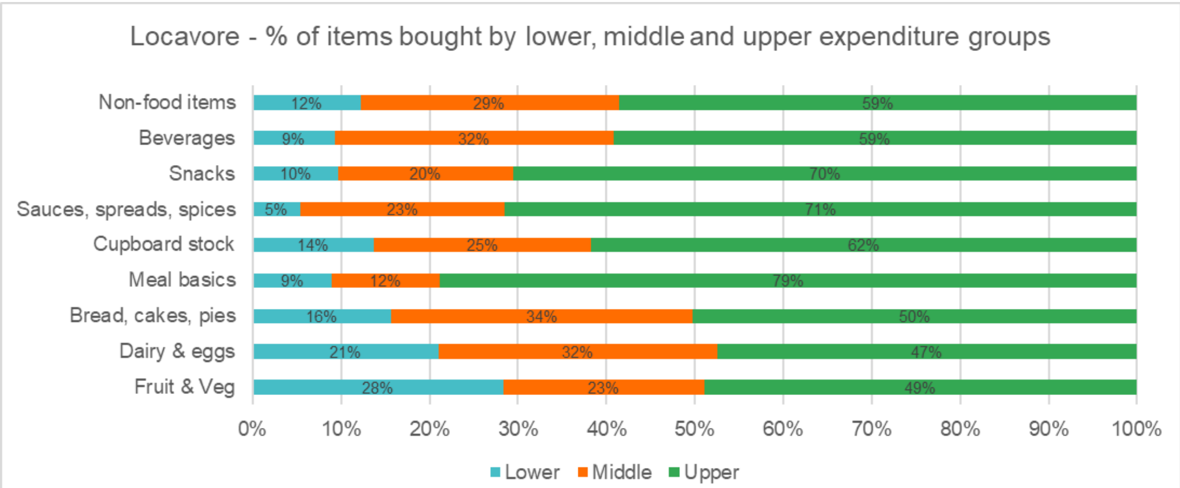
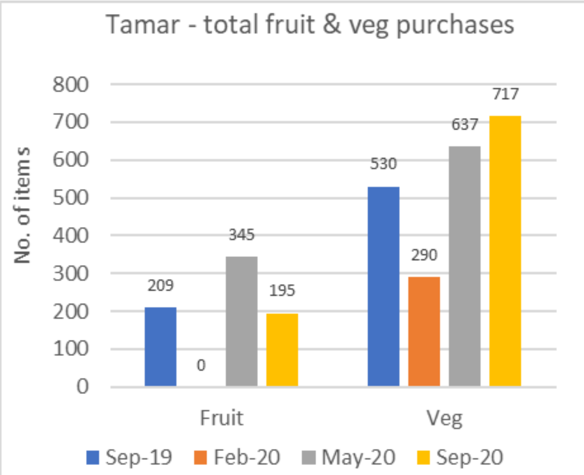


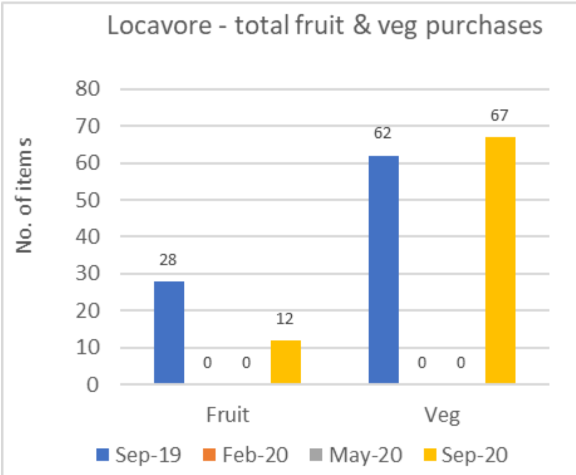
Figure 51, Percentage of items bought by lower, middle and upper expenditure customers

Appendix 6.3 - Food hub users' purchasing trends

The purchasing data was used to investigate trends in shopping behaviour over the four months for *Tamar* and *Locavore* customers. The nine broad food categories were disaggregated into 25 more specific categories in order to investigate possible trends in greater detail, with 'number of items bought' as the metric. Sales of the following foods increased notably over the four months: tins & meal ingredients, dry cupboard stock (rice, pasta etc.), breakfast items, nuts, seeds, dried fruit, juices & soft drinks, preserves, sauces and spreads. This reiterates the finding that cupboard stock is increasingly an important element of the food hub basket, at least for some customers. The most relevant findings with respect to diet and food basket composition are presented below

Fresh fruit & veg





Note – different scales on y axis

Figure 52, Fruit & veg - number of items bought each month

Figure 52 shows that sales of fruit were relatively consistent, whereas veg sales increased. *Locavore* operates a veg box scheme separately and so Figure 52 comprises of optional fruit and veg 'add-ons'. There was apparently no additional fruit or veg for sale in Feb-20 or May-20 at *Locavore*. *Tamar* sells small fruit bags (10 items) and small veg bags (4 or 5 items); these are coded as single items.

Fresh fruit

Tamar sales of fruit peaked in May-20, but Sep-19 and Sep-20 levels were similar. *Locavore* sales in Sep-20 were less than half the Sep-19 levels, which can be explained by a very limited range in Sep-20. Most of the fruit sold by *Tamar* is locally produced (apples, strawberries, raspberries, grapes) whereas the 'add-on' fruits sold by Locavore (bananas, kiwis, lemons) are imported.

Fresh vegetables

Tamar sales dipped sharply in Feb-20, likely reflecting the limited range available in Spring, before rising in May-20. Sep-20 sales were 35% higher than Sep-19. *Locavore* sales in Sep-19 and Sep-20 were similar.

Meal basics

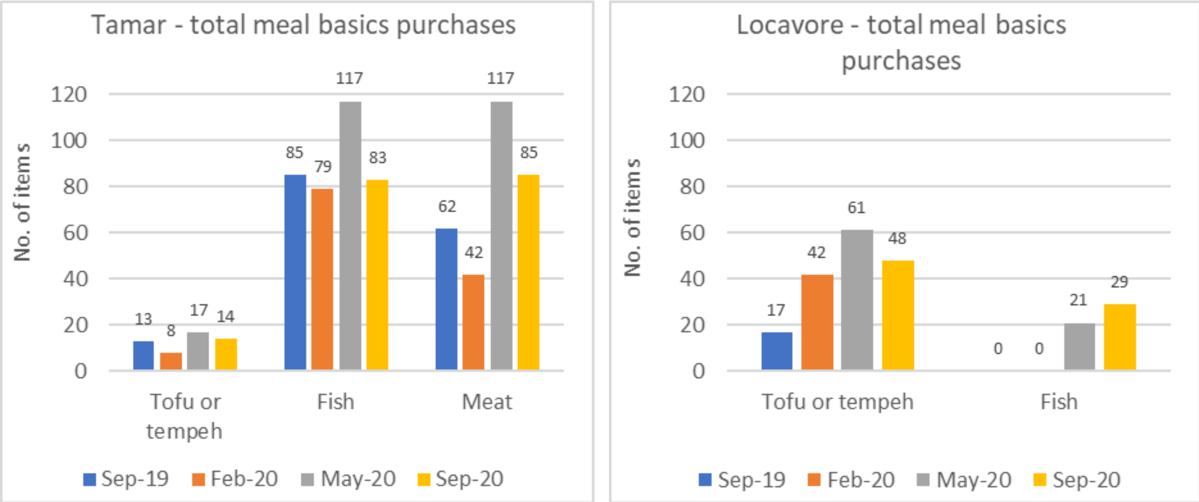


Figure 53, Meal basics - number of items bought each month

Figure 53 shows that sales of meat and soya products increased. Demand for fresh fish was consistent but increased for tinned fish.

Tofu and tempeh

Tamar sales were fairly consistent, but Locavore sales almost tripled from Sep-19 to Sep-20. *Locavore* sales were more than 3 times *Tamar*'s sales.

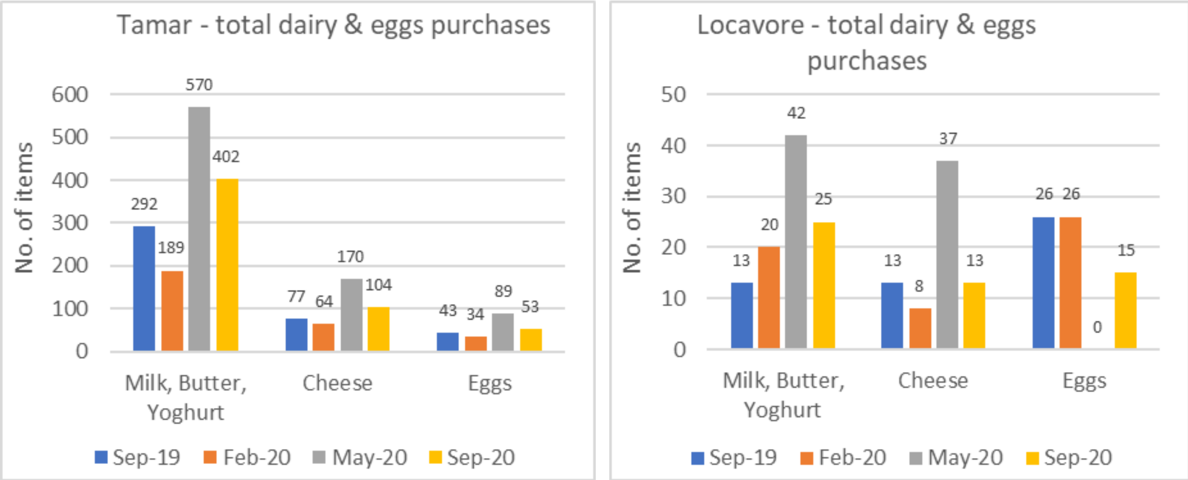
Fish

Tamar sales were consistent, aside from the peak in May-20. *Locavore* appears to have started selling canned fish in May-20 and demand increased in Sep-20 by 38%. *Tamar* sells fresh fish: catch of the day (various), salmon, smoked salmon, pilchards, scallops. *Locavore* sells canned fish: tuna, sardines, mackerel (all in olive oil).

Meat

Tamar sales dipped in Feb-20 but then almost tripled in May-20. Sep-20 sales were 37% higher than Sep-19. *Tamar* sells: Pork (chops, bacon, sausages, ribs, roasting joint), Beef (steak, mince, chunks, roasting joint, burgers, oxtail, ox tongue), Chicken, Lamb, Goat. *Locavore* sells meat but, like the veg boxes, these items are not sold through the *Open Food Network* platform and so this data was unavailable.

Dairy & eggs



Note – different scales on y axis

Figure 54, Dairy & eggs - number of items bought each month

Figure 54 shows that sales of dairy products increased, irrespective of the clear spike in May-20. Sales of eggs were fairly consistent over the 4 months.

Milk, butter, yoghurt

Both *Tamar* and *Locavore* experienced a marked increase in May-20, before decreasing in Sep-20 but remained 38% higher (*Tamar*) and 92% higher (*Locavore*) than Sep-19 levels. *Tamar* dairy sales were approximately 14 times that of *Locavore*'s. Both hubs sell butter and yoghurt, and *Tamar* also sells milk and cream. *Locavore* sells soya yoghurt (not shown in Figure 54), for which sales were steady for the first 3 months but then doubled in Sep-20.

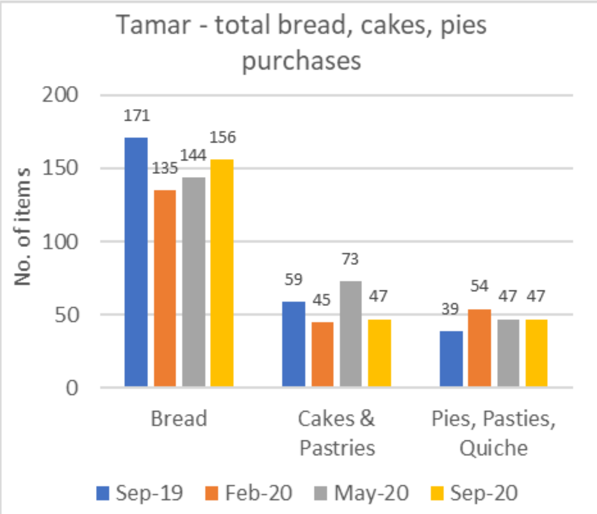
Cheese

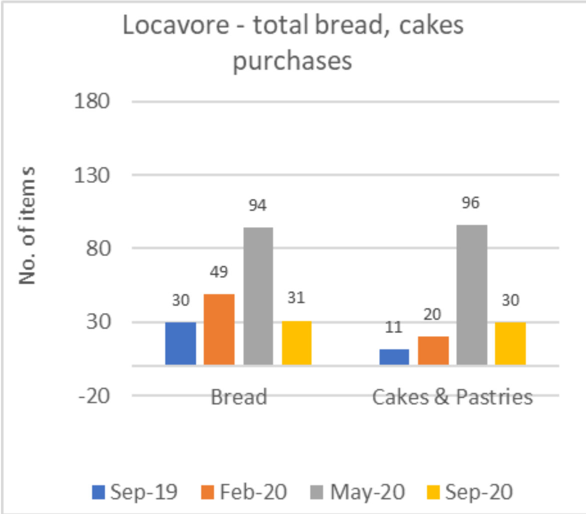
Tamar sales dipped in Feb-20 but then doubled in May-20. Sales in Sep-20 were 35% higher than Sep-19. *Locavore* sales were fairly consistent, although demand tripled in May-20. *Tamar* sells a much wider range of cheeses than *Locavore*.

Eggs

Sales of eggs were consistent in Sep-19 and Feb-20 for both hubs. *Tamar* sales doubled in May-20 and were 23% higher in Sep-20 compared to Sep-19. *Locavore* sales dropped to zero in May-20 (eggs may not have been sold on their OFN shop in May) and were 42% lower in Sep-20 relative to Sep-19.

Bread, cakes, pies





Note – different scales on y axis

Figure 55, Bread, cakes & pies - number of items bought each month

Figure 55 shows that sales of bread and pies & pasties were fairly consistent, whereas sales of cakes & pastries fluctuated.

Bread

No significant change in demand, with the exception of a large increase for Locavore in May-20. *Tamar* sales were approximately 3 times those of *Locavore*'s. Both hubs offer a wide range of breads.

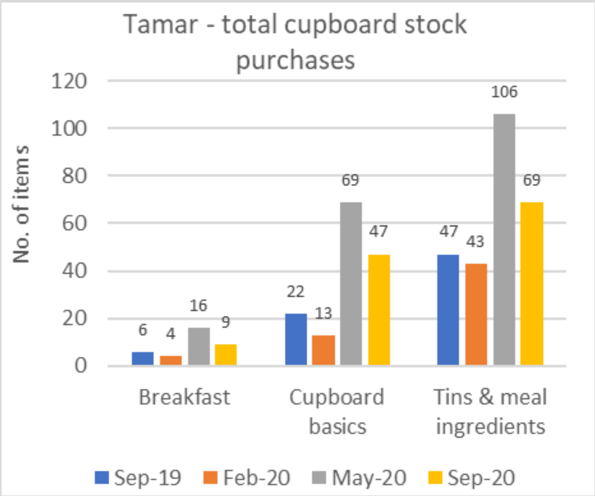
Cakes & pastries

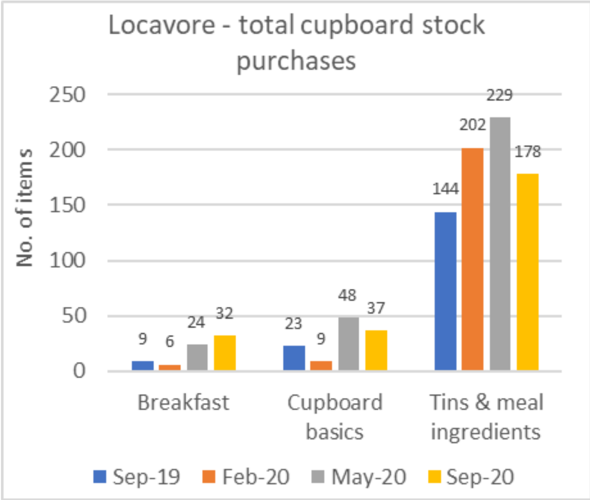
Tamar sales were fairly constant over the 4 months. *Locavore* sales, however, were 173% higher in Sep-20 compared to Sep-19. *Locavore* in particular experienced a spike in May-20. Both hubs offer a wide range of cakes and pastries.

Pies, pasties, quiche

Tamar sales were reasonably consistent. *Locavore* do not sell these products.

Cupboard stock





Note – different scales on y axis

Figure 56, Cupboard stock - number of items bought each month

Figure 56 shows that sales increased in all three cupboard stock categories over the four months.

Breakfast items

Breakfast purchases increased for both hubs; *Tamar* sales were 50% higher in Sep-20 relative to Sep-19, and Locavore's were 256% higher. This includes: cereals, granola, muesli, oats.

Cupboard basics

Both hubs experienced a peak in demand in May-20. Compared to the Sep-19 baseline, *Tamar* sales in Sep-20 more than doubled and *Locavore*'s increased by 61%. This includes: pasta, noodles, rice, flour, sugar. *Tamar* also sells spelt, buckwheat, cous and quinoa.

Tins & meal ingredients

Both hubs experienced a peak in May-20. Compared to the Sep-19 baseline, *Tamar* sales in Sep-20 increased by 47% and Locavore's by 24%. This includes: pulses, yeast, sausage mix, falafel mix, passata, pesto, dried mushrooms. Tins of chopped tomatoes, coconut milk, beans. *Locavore* also sells peas and dahl.

Appendix 6.4 - References for estimating food weights where information was unavailable

This appendix is a description of how item weights were estimated if the information was not available in the *Open Food Network* purchasing data or on the suppliers' websites. Weights were estimated using similar items sold by other UK-based suppliers as points of reference. A number of relevant aspects were considered in this process: the price paid for the item relative to comparable items in the *Open Food Network* data, or otherwise from alternative suppliers; a photo of the item on the supplier's website (if available) which could provide some indication of its weight; and the type of item if different varieties exist. This process ultimately entailed subjective decisions and so Table 39 below and the 'Assumption level' column in Table 19 are presented to make these decisions as transparent as possible.

Table 39, References for estimating item weights in food hub purchasing data

Food category	Reference sources
Bread ^^	*Column Bakehouse* provided weights in the *Open Food Network* data, but *Pepper Street Bakers* did not and no information was available on their website. A large loaf was therefore assumed to be 800g and a small loaf 400g, as per UK legislation on bread weights. *Riverford* also use these bread weights. Bread rolls and scones assumed 55g each; pack of 4 Knaekbroed assumed 150g; 4 x pizza dough balls assumed 1000g; Boule loaf assumed 400g. Sources: Pepper Street Bakers: http://pepperstreetbreads.yolasite.com/breads.php ; UK bread legislation: https://www.fob.uk.com/about-the-bread-industry/how-bread-is-made/legislation ; Bakery / Riverford ; Bun weights: https://www.nutracheck.co.uk/CaloriesIn/Product/Search?desc=bread%20roll&page=0
Cakes, buns, pastries ^^	*Vals' cakes* provided weights in the *Open Food Network* data, but *Pepper Street Bakers* did not. Loaf cakes assumed 400g; filled pastries, swirls & muffins assumed 100g; scones & buns assumed 55g each; unfilled pastries assumed 70g; large torte assumed 1000g; flapjack assumed 150g; sourdough almond croissants assumed 100g. Sources: Pastry & scone weights: https://www.delifrance.com/uk/products/viennoiserie/croissant.html ; https://goldstandardbaking.com/croissant-varieties/
Fish ^^^	All tinned fish and some of the fresh fish weights were provided in the *Open Food Network* data. However, no information was provided on *Pengelly*'s website for 'catch of the day' items. One white fish portion assumed 140g, taking into account the type of fish and the amount paid relative to supermarkets. Salmon fillets assumed 120g; Scallops assumed 100g; sardines assumed 200g. Sources: https://pengellys.co.uk/ ; https://kuuleats.com/r/92/pengellys-famous-fishmongers-east-looe/o ; Tesco Finest Skinless & Boneless Cod Loin - Tesco Groceries ; Chilled Fish & Seafood - Tesco Groceries

Fresh fruit ^^^	Most fruit weights were stated in the *Tamar* data, whereas the Locavore data included weights for Sep-20 but not for Sep-19. The *Locavore* Sep-20 range was very limited and so *Riverford* was used as a reference because they sell imported fruits (Tamar do not). The 'what things weigh' website was used as a reference for the average weight of particular fruits. Grapes assumed 150g (based on the low price paid); 1 x apple or pear assumed 180g. *Locavore* customers were assumed to buy a small fruit bag weighing 975g with each *Open Food Network* order they place, as per their business model (see explanation in 'Fresh veg', below). The weight of a small fruit bag was assumed using the average weight of a Locavore large fruit bag (2955g) over 4 consecutive weeks in January and February 2021 as a guide (the contents of the fruit bag were weighed by a *Locavore* customer and the findings were emailed to the researcher). The large fruit bag weight was then scaled to a small bag according to the relative price. A *Tamar* small fruit bag was assumed 975g to match a *Locavore* small fruit bag as they are comparable on price. Sources: Fruit weights: https://weightofstuff.com/average-weight-of-all-fruits-and-vegetables/#:~:text=Average%20Weights%20of%20Vegetables%20%28A%20to%20Z%29%20,%205%20g%20%2024%20more%20rows%20 ; http://www.fromkarenskitchen.com/tips/produce_weight_yield_chart.php: ; lemons weight: https://whatthingsweigh.com/how-much-does-a-lemon-weigh/ ; apples weight https://whatthingsweigh.com/how-much-does-an-apple-weigh/
Fresh veg ^^^	Fresh veg was by far the most diverse of the food categories and many of the weights were provided in the data. For those items where weights were not stated, two websites in particular were used as references: 'what things weigh' for the average weight of individual vegetables, and *Riverford* which sells comparable items and usually states the weight. Cabbage assumed 907g, beetroot 113g, cucumber 250g, elephant garlic 450g, chervil 25g a bunch (based on low price paid), golden beetroot 600g (comparable with other beetroots sold by *Open Food Network*), 1 leek 300g, 2 x little gem lettuce 250g, lettuce 163g, small pumpkin 1500g, winter squash 1200g, small marrow 800g, cauliflower 500g, swede 500g, bunch of radishes 150g, spring greens 400g per head, small artichokes 70g, aubergine 600g, fennel bulb 500g, 2 x bulls horn pepper 340g, chilli pepper 50g, pointed cabbage 600g, roll of collard greens 300g, butternut squash 1100g, kohlrabi assumed 150g, punnet of cherry tomatoes 100g (based on low price paid), courgettes 100g (based on low price paid), pea shoots or micro basil in punnet 50g. The weights of veg boxes/bags were assumed using the average weight of a *Locavore* extra-large veg box (9421g) over 4 consecutive weeks in January and February 2021 as a guide (the contents of the veg box were weighed by a *Locavore* customer and the findings were emailed to the researcher). The weights were then scaled according to the relative price of a particular box or bag. A *Locavore* standard veg box assumed 4711g; a Tamar veg bag without potatoes assumed 1401g or 1682g (two prices listed); a *Tamar* veg bag with potatoes assumed 2172g or 2534g (two prices listed); a *Tamar* organic veg box assumed 6387g. Every *Locavore* order is assumed to incorporate one standard veg box, as per their business model where *Open Food Network* orders constitute 'add-

	ons' to their existing veg box order (it is not possible to order from the online food hub unless they have already ordered a veg box) Sources: Fruit & veg weights: https://weightofstuff.com/average-weight-of-all-fruits-and-vegetables/#:~:text=Average%20Weights%20of%20Vegetables%20%28A%20to%20Z%29%20,%205%20g%20%2024%20more%20rows%20 ; http://www.fromkarenskitchen.com/tips/produce_weight_yield_chart.php: ; Elephant garlic: https://www.specialtyproduce.com/produce/Elephant_Garlic_850.php ; Lettuce: https://hannaone.com/Recipe/weightlettuce.html ; Aubergine: https://www.brandeastfortune.co.uk/product/aubergine ; Fennel: https://www.howmuchisin.com/produce_converters/fennel ; Kohlrabi : https://www.nutrition-and-you.com/kohlrabi.html ; Vegetables / Riverford
Meat ^	Most meat weights were provided in the *Open Food Network* data. A few of the sausage orders were assumed 500g to match other *Tamar* sausages orders. Some lamb orders were matched by relative price to lamb orders where the weight was provided. Burgers were estimated using the supermarket equivalent. A whole chicken was assumed to be very large - 2200g, based on the high price paid relative to supermarkets. Sources: Tesco's https://www.tesco.com/groceries/en-GB/products/256278098 ; https://www.tesco.com/groceries/en-GB/search?query=burgers
Pies & pasties ^^	*Helluva Pasties*, Callington, is one of *Tamar*'s suppliers and its item weights were available in the *Open Food Network* data. Items from other *Tamar* pie & pasty suppliers were matched to *Helluva*. The weights of cottage pie and beef lasagne were assumed the same as comparable items from supermarkets. Sources: Helluva Pasties: https://www.helluvapasties.co.uk/shop/ ; http://www.langmansrestaurant.co.uk/the-pasty-shop/ ; Tesco's: https://www.tesco.com/groceries/en-GB/search?query=cottage%20pie ; https://www.tesco.com/groceries/en-GB/search?query=beef%20lasagne
Quiche ^^	Quiche was assumed 400g, as per comparable items from supermarkets. Sources: Tesco's https://www.tesco.com/groceries/en-GB/search?query=quiche
Sweet biscuits ^	Most weights were provided in the *Open Food Network* data. Cookies were assumed 200g, as per comparable items from supermarkets. Sources: https://www.tesco.com/groceries/en-GB/products/276132127
Tea ^	No brand information was provided in the *Open Food Network* data except for Tick Tock. Weight was assumed the same as comparable items from supermarkets, taking into account the number of T-bags in the box. Sources: Tesco's :https://www.tesco.com/groceries/en-GB/search?query=tea%20bags
Veg ready meals ^^	Veg pasties were assumed 310g, as per *Helluva Pasties*. Veg tarte was assumed 450g and vegetable pies were assumed 568g, as per comparable items from supermarkets. Sources: Helluva Pasties: https://www.helluvapasties.co.uk/shop/ ; Tesco's: https://www.tesco.com/groceries/en-GB/search?query=vegetable%20pie

Appendix 7.1 - Potential adopter populations for each food hub platform

Table 40, Populations of the cities and towns served by an online food hub

Neighbourfood	Population of city/town[1]	Year of population data[2]
Ashbourne	9,163	2019
Balfron	2,100	2016
Birmingham - Kings Heath	2,897,303	2019
Blairgowrie	9,020	2016
Comrie	1920	2016
Derby	248,700	2011
Dumbarton	20,560	2016
Edinburgh - Leith	518,500	2016
Edinburgh - Stockbridge	-[3]	-
Falkland	1,160	2011
Folkestone		
Frome	26,203	2014
Killin	760	2019
Megginch (Perth and Dundee)	195,710	2016
Newark	27,700	2011
Newry	26,967	2011
Nottingham	321,500	2015
Nottingham - West Bridgford	-	-
Peebles	8940	2016
Pitlochry	2,776	2011
Stirling	37,610	2016
Potential adopter population	**3,838,092**	

Great British Food Hub	Population of city/town	Year of population data
Aberdeen and shires	214,610	2016
Allan (and Stirling)	5,380	2016
Glasgow East	985,290	2016
Glasgow West	-	-
London - Penge	9,787,426	2018
Milngavie	12,940	2016
Oban	8490	2016
Stirling Farmers' market	-	-
Potential adopter population	**11,014,136**	

Food hubs with own platform	Location	Population of city/town	Year of population data
Dean Forest Food Hub	Forest of Dean	86,791	2019
Goodery	Norwich	213,166	2019
Potential adopter population		**299,957**	

Open Food Network	Location	Population of town	Year of population data
Aberystwyth food hub	Aberystwyth	18,093	2011
Algy's Farm Shop	Bintree	300	2011
Ash and Elm Horticulture	Llanidloes	2,929	2011
Banc Organics	Llanelli	26,225	2019
Bentley Urban Farm	Doncaster	109,805	2011
Bowhouse link	St Monans	1,340	2006
Cambridge Food hub	Cambridge	124,798	2011
Cockermouth online market	Cockermouth	8,761	2011
Coupar Angus Market Garden	Perth	-	-
Cultivate Oxfordshire	Oxford	-	-
Cusgarne organic farm shop	Truro	18,766	2011
Down Farm	Winkleigh	1,305	2011
Eriol Farmer	Bristol	670,000	2019
Food Lochober	Fort William	5,760	2016
Good Food Exeter	Exeter	131,405	2019
Greycraig Cottage	Dunfermline	50,380	2012
Growing links community garden	Penzance	21,200	2011
Harvest Fresh	London	-	-
Haverfordwest Food Hub	Haverfordwest	12,042	2011
Hearty Growers	Belfast	341,877	2019
Helston local food hub	Helston	11,700	2011
Hidden Veg	Castle Douglas	4,080	2016
In my back yard	Seaton	12,815	2012
JQ Slow Food Birmingham	Birmingham	-	-
Kehelland Trust Food hub	Camborne	20,845	2011
Kent food hubs - Ashford	Ashford	74,204	2011
Kent Food hubs - Folkestone	Folkestone	46,698	2011
Liskeard Hive	Liskeard	9417	2011
Locavore	Glasgow	-	-
Mercia food hub	Tamworth	76,696	2011
Nancealverne Market Garden	Penzance	-	-
Peninsula producers food hub	St Davids	1,600	2011
Sail Cargo London	London	-	-
Sesi Food and Household refills	Oxford	152,450	2017

Shipborne Farmers market	Tonbridge	41,293	2018
Stroudco	Stroud	32,670	2011
Suie Fields	Castle Douglas	-	-
Tamar Valley Food Hubs	Plymouth	262,100	2019
Taunton Country Market	Taunton	69,570	2011
The Charmouth Dragon Real Food shop	Bridport	13,569	2011
The Good Fill	Oxford	-	-
The Green Bowl	Elphin	-	-
The Tree - St Andrews	St Andrews	17,580	2016
Tribe zero waste	Abingdon	39,809	2018
Tuston Market Garden	Hereford	60,800	2011
Wild Bread bakehouse	Faversham	19,316	2011
Woodlea Stables	Cupar	9,020	2016
Wye Farmers' Market	Wye	2,282	2011
Y Pantri Glas	Llandeilo	1,795	2011
Potential adopter population		**2,518,195**	

[1] For cities which list 'city' and 'urban area' populations, the 'urban area' figure was used. The potential populations of the smaller towns are likely to be underestimates because rural food hubs typically serve a large geographic area.
[2] Population data is predominantly from the Census, National Records of Scotland, or district council data.
[3] The dash symbol (-) indicates that the population of this town has already been counted as it is served by more than one online food hub.

Appendix 7.2 - Social influence: summary of statistical analysis

This appendix presents the results of the most relevant statistical analysis conducted for the social influence questions included in the survey.

Innovation discovery

Early adopters (n=221) and non-adopters who have heard of online food hubs before (n=112) were asked how they first found out about online food hubs (Q5.2). A chi-square test of homogeneity was run, with an adequate sample size established according to Cochran (1954). The two multinomial probability distributions were not equal in the population, $\chi2(6) = 54.937$, $p = .001$. Observed frequencies and percentages are presented in Table 41. Post hoc analysis involved pairwise comparisons using multiple z-tests of two proportions with a Bonferroni correction. Statistical significance was accepted at $p < .0083$. There were statistically significant differences in the proportion of early adopters who discovered online food hubs by talking with friends, family or colleagues than non-adopters (n=60, 27.9% versus n=11, 10.3%, small effect size using Cramer's V). There were also statistically significant differences in the proportion of non-adopters who discovered online food hubs through social media than early adopters (n=50, 46.7% versus n=28, 13.3%, medium effect size using Cramer's V). There were no statistically significant differences between the two groups for the remaining five ways to discover online food hubs.

Table 41, Crosstabulation of early adopters' and non-adopters' innovation discovery

Mode of discovery	Early adopters	Non-adopters
Internet search engine e.g., Google, Microsoft edge	30 (14.0%)	6 (5.6%)
General media e.g., TV, radio, newspapers, websites	9 (4.2%)	10 (9.3%)
Organisations, companies, local authorities, schools	29 (13.5%)	12 (11.2%)
Talking with friends, family or colleagues	60 (27.9%)	11 (10.3%)
Social media	28 (13.3%)	50 (46.7%)
Seeing what neighbours or people who live locally are doing	11 (5.1%)	3 (2.8%)
Other (please specify)	48 (22.3%)	15 (14.0%)

Importance of information sources

Early adopters and non-adopters were asked how important different sources of information have been in shaping their opinion of online food hubs (Q5.3) (Response options: never had information this way (1) not important (2) somewhat important (3) important (4) very important (5) don't know (6)). A series of Mann-Whitney U tests were run to determine if there were differences in the importance of information sources between the two groups. Distributions of their responses were similar, as assessed by visual inspection. The median response was statistically significantly higher for non-adopters than early adopters for four of the six information sources (small effect size using *r*) The results are shown in Table 42.

Table 42, Comparing early adopters' (n=221) and non-adopters' (n=112) perceptions of the importance of information sources, using Mann-Whitney U tests

Information source	Median early adopter	Median non-adopter	p-value	U-Score	Z-score	r value	Effect size
Being aware of what people in general are doing	3	3	**.005**	12254.5	2.806	0.160	small
General media e.g., TV, radio, newspapers, websites	2	3	**.003**	12523.5	2.922	0.166	small
Organisations, companies, local authorities, schools	2	3	**.028**	12365	2.203	0.124	small
Talking with friends, family or colleagues	4	4	.500	10373	-0.675	N/A	N/A
Social media	3	4	**.001**	13633	3.878	0.218	small
Seeing what neighbours or people who live locally are doing	2	3	.377	11454	0.883	N/A	N/A

Note: statistically significant differences are shown in bold

Communication behaviour and social network structure

The survey included two questions on communication behaviour and social network structure. The respondents were asked how many people they had spoken with (in person or via phone/internet) about online food hubs in the last 6 months (Q5.4) and the results are shown in Table 43. Early adopters had spoken to an average of 9.5 (± 15.2) people whereas non-adopters had spoken to an average of 2.4 (± 3.9) people, a statistically significant difference of 7.1 (95% CI, 4.9 to 9.3), $t(261.7) = 6.433$, $p < .001$ (medium effect size using Cohen's *d*). The respondents were then asked how many of the people they had spoken to are close friends (Q5.6/5.7). For the early adopters, 64% were close friends or homophilous connections, and so 36% were heterophilous connections.

Table 43, Comparing early adopters' (n=221) and non-adopters' (n=112) communication density (talking to others about online food hubs), using independent samples t-tests

Communication density	Mean EA	Mean non-adopter	p-value	Cohen's d	Effect size - Cohen
No. of people spoken to in past 6 months	9.5 (± 15.2)	2.4 (± 3.9)	**.001**	0.564	medium
% of people spoken to who are close friends	64%	52%			

Appendix 7.3 - PCA of opinion leadership scale

One common approach of measuring opinion leadership is the 'self-designating method', whereby respondents are asked questions to determine how they perceive their influence on others (Rogers, 2003). A well-established opinion leadership scale (Flynn et al., 1996; Goldsmith & De Witt, 2003) was included in the survey to measure these perceptions for early adopters and for non-adopters who have heard of online food hubs (Q5.8). The 6-item scale was reduced to two underlying constructs, 'having influence' and 'giving advice', using PCA. Due to the large number of missing responses (skipped questions) across the scale, it was considered necessary to replace these missing values using *item mean substitution* (see section 4.3.1 for a full explanation of this choice of imputation). The suitability of PCA was assessed prior to analysis. The 6-item scale had a good level of internal consistency, as determined by a Cronbach's alpha of 0.79. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.75, classified as 'middling' according to Kaiser (1974), and all individual KMO measures were greater than 0.6. Bartlett's test of sphericity was statistically significant ($p < .001$), indicating that the data was likely factorizable. The interpretability criterion indicated that a two-component solution provided the simplest structure (using oblique rotation) and this is consistent with how the scale has been used previously (ibid). Collectively the two components explain 72.0% of the total variance.

Table 44, Rotated pattern matrix for PCA with oblique rotation of 6 opinion leadership items

	Component		
Opinion leadership item	1. Influence	2. Advice	**Communalities**
I often influence people's opinions about them	**0.873**	0.017	0.763
People I know pick them based on what I have told them	**0.869**	-0.022	0.756
I often persuade other people to use them	**0.868**	0.033	0.755
Other people do not turn to me for advice on them	0.153	**0.804**	0.670
My opinion on them seems not to count with other people	-0.216	**0.793**	0.675
Other people rarely come to me for advice about choosing them	0.314	**0.713**	0.607
Percentage of variance explained	*49.5%*	*22.6%*	
Eigenvalue	*3.0*	*1.4*	

Note: major loadings for each item are shown in bold

Appendix 7.4 - Shopping preferences of different adopter groups vs a UK population sample

Rogers (2003) divides people into five categories depending on their propensity to adopt an innovation, shown in Figure 57. Adoption propensity was explored in attribute survey by asking the non-adopters (n=374) to indicate on a sliding scale how likely they are to use an online food hub within the next year (0 = very unlikely, 100 = very likely; this question, Q9.1, was asked towards the end of the survey and so the non-adopters had previously been presented with ample information about what an online food hub is). The mean response was 54 (± 28), which suggests a moderate degree of interest in using food hubs. These respondents were then differentiated into a high or low adoption propensity group using the median (60). Between-group analysis found no statistically significant differences for sociodemographic/household characteristics, dietary preferences or cooking habits. However, the high propensity or 'early majority' group consistently ranked higher than the low propensity group for the attributes of online food hubs (Q2.2-2.12) and this reinforces the adoption propensity question.

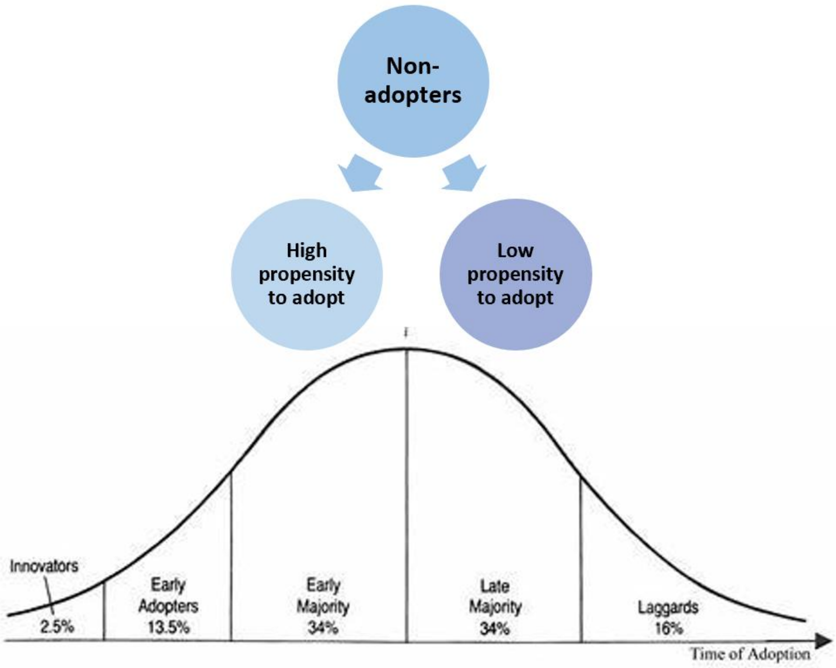


Figure 57, Segmenting attribute survey non-adopters into Rogers' adopter categories

A further application of differentiating the non-adopters was to enable comparison with a UK population sample for six food shopping preferences (replicated from NatCen, 2015) which are associated with attributes of online food hubs. Figure 58 shows that over half of the UK population sample consider fair payment for farmers and minimal food processing to matter 'a great deal' or 'quite a lot' (the green bars). This finding supports a potential scaling up. However, the early and late majority groups place greater importance than the UK population sample for all four shopping preferences (the remaining two preferences are discussed in section 7.4.1). This would suggest the non-adopter respondents are not comparable with the UK population with respect to these four aspects of using online food hubs and this finding is less promising for scaling up.

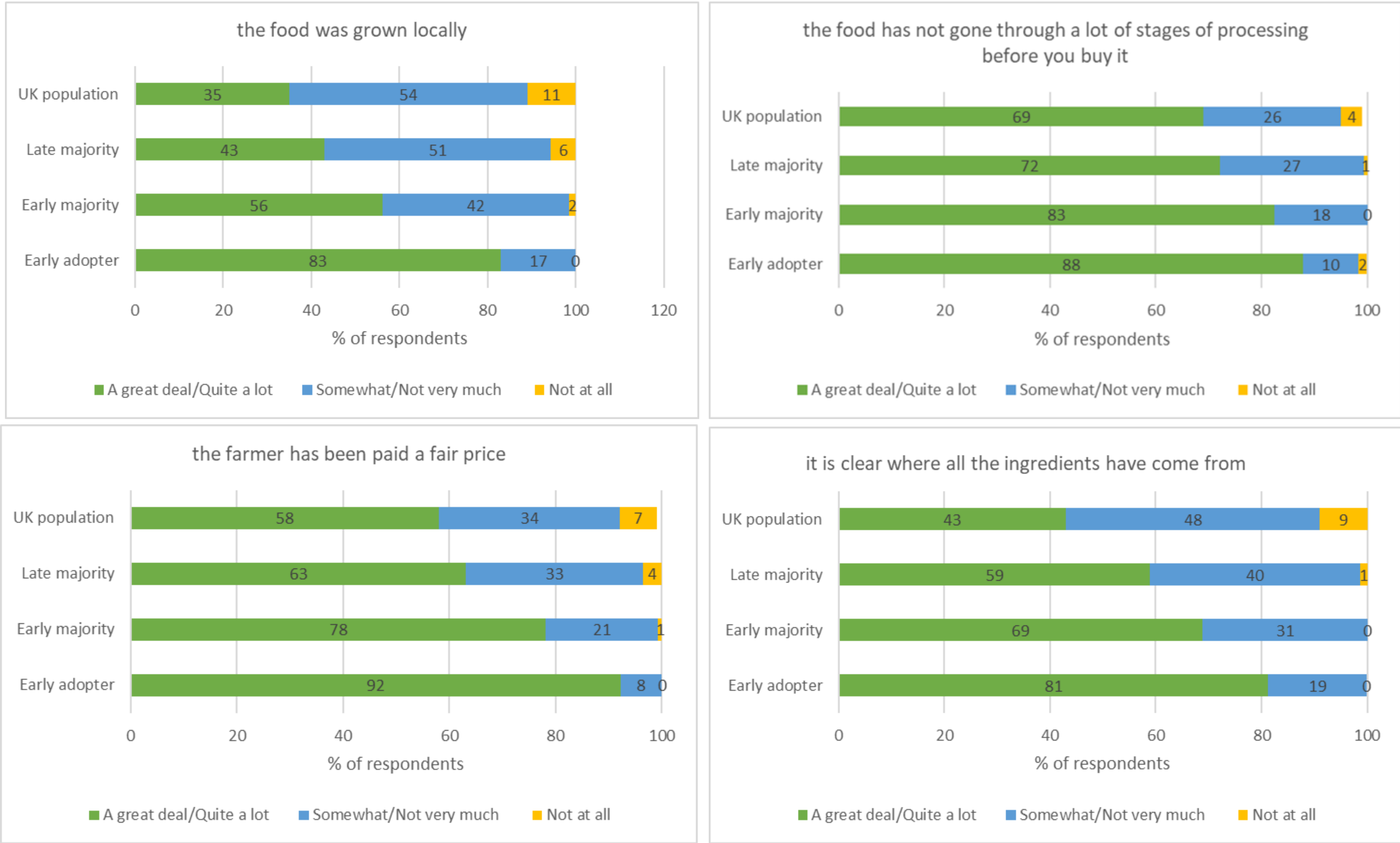


Figure 58, Comparing the shopping preferences of three adopter groups with a UK population sample (NatCen, 2015)

Appendix 7.5 - Photos of Locavore fruit and vegetable set boxes

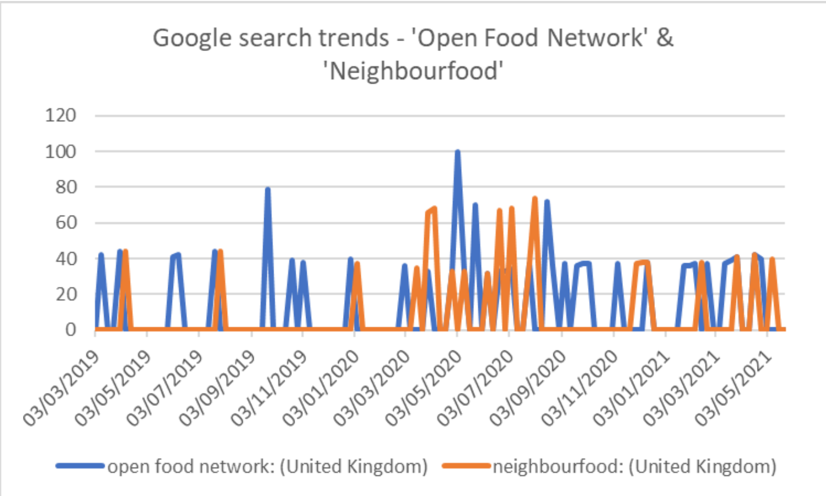
A *Locavore* customer took photos and recorded the weights/quantities of their food hub delivery over a four week period in January 2021. A selection of the photos are presented below to show the packaging typically used: for the veg box - re-usable box, one paper bag, one compostable bag and one single use plastic bag; for the fruit box - only the re-usable box. This quantity of plastic packaging is considerably less than the plastic packaging used for the same quantity of food bought from a supermarket.

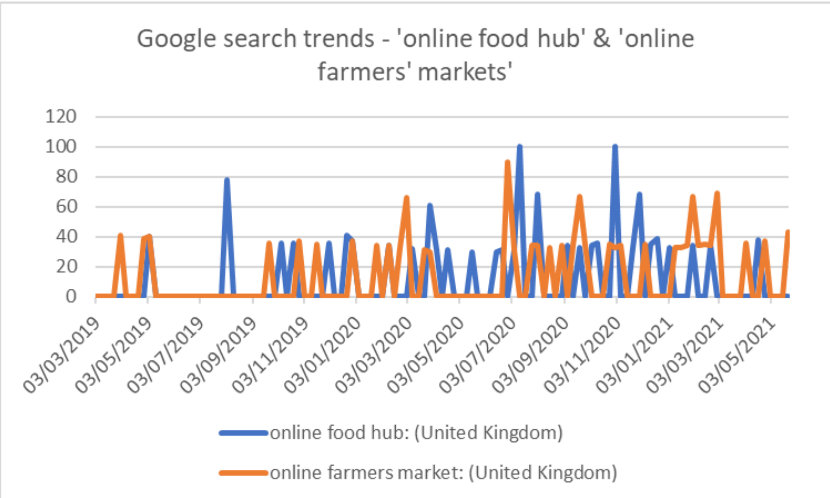
Figure 59, Photos of Locavore fruit and veg set boxes

Photos taken in January 2021 by a *Locavore* customer (I5)

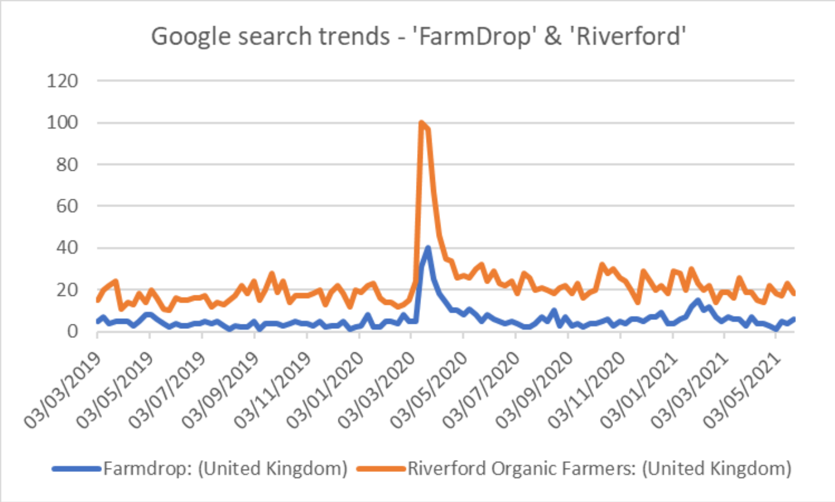
Appendix 7.6 - Google searches for food home delivery companies during the pandemic

Figure 60 below shows Google search engine inquiries[65] in the UK from March 2019 to May 2021 for the following terms: 'online food hub', 'Open Food Network', 'Neighbourfood', 'online farmers' market', 'veg box', 'food delivery', 'FarmDrop', 'Riverford'. The x axis is time and the y axis is a scale of 0-100 which has been normalised to allow comparability across different times and locations (see Google Trends for a technical description of their process of normalisation). All of the graphs show a marked increase in the number of searches during the pandemic.





[65] See: Google Trends



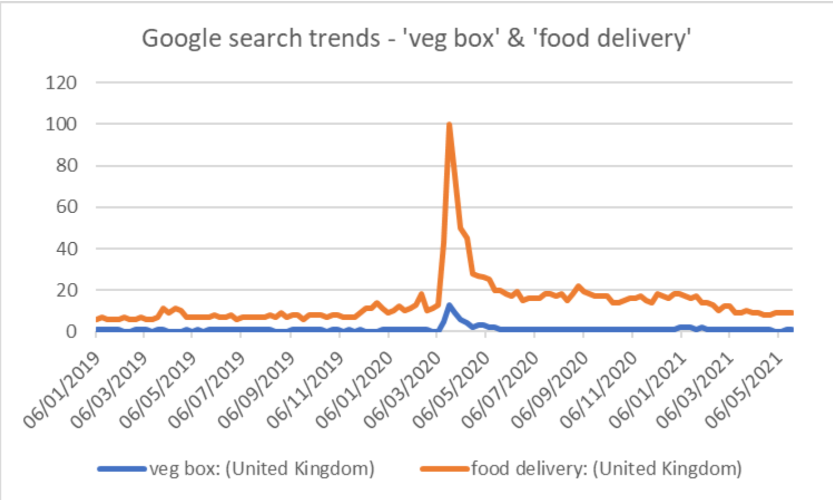


Figure 60, Google searches for food home delivery companies during the pandemic

Appendix 8.1 - Estimated population of online food hub users in the UK

The exact number of online food hub users in the UK was not available and so estimating the population required some assumptions. Of the 595 attribute survey respondents, 259 can be identified as a customer of one of six food hubs which use the *Open Food Network* platform. Taking an average for these six hubs equals 43 users per hub. Multiplying this average by the 81 existing online food hubs that we know about (see section 7.1) equates to a population of 3483 hub users in the UK (see Equation 1)

This is likely an underestimate because:

1) The 259 attribute survey respondents are only a sample of the total number of hub users from the six food hubs. Some online food hubs undoubtedly have more than 43 users. *Glasgow Locavore*, one of the larger food hubs, gained 400 new customers during the pandemic (see section 7.5.1), in addition to their existing customer base.
2) There will be more than 81 online food hubs in the UK because some food hubs have created their own platform, rather than using an open source platform such as *Open Food Network*. Although every effort was made to identify all of the existing food hubs, the list in Appendix 7.1 is by no means exhaustive.

In the absence of more accurate information, 3483 is accepted as a (very) conservative estimate of the population of UK food hub users.

Equation 1, Calculating the population of online food hub users in the UK

$$\text{Estimated population of food hub users in the UK}$$

$$= (\text{no. of known hub users from the attribute survey} \; / \; \text{no. of food hubs that partipated in the attribute survey})$$

$$* \text{ total number of known food hubs in the UK}$$

$$= (259 \,/\, 6) * 81$$

$$= 3483$$

Appendix 8.2 - Calculation of potential adopter segments for online food hubs

Table 45 presents the potential adopter segments and based on shared characteristics with current hub users and calculated using Equation 2. Two quantifiable limiting factors were identified which reduce the scope for adoption: 1) the unavailability of online food hubs in many locales, and 2) a lack of digital competences. The column on the right shows the final potential adopter segments, as represented in Figure 36.

Equation 2, Calculating potential adopter segments based on shared characteristics with online food hub users

$$\text{Potential adopter segment (as a percentage of UK population)} =$$

$$\text{Comparable UK population segment}$$

$$(\text{e.g. \% of UK population that are 'concerned about climate change'} - \text{see section 7.4})$$

$$* \ \text{\% of UK households that can access an online food hub } (26\% - \text{ see section 7.1})$$

$$* \ \text{\% of UK population with digital skills } (90\% - \text{see section 7.3})$$

$$= 76\% * 0.26 * 0.9 = 18\%$$

Table 45, Potential adopter segments based on shared characteristics with online food hub users

		% of UK population	
Adopter segment category	Characteristic	Potential adopter segment	Potential adopter segment after limitations 1 & 2 are applied
Shopping preference	Buy groceries online	17%	4%
	Low cost is not important	53%	12%
Environmental and social values	Sales of ethical products	11%	3%
	Willingness to pay for ethical products	46%	11%
	Willingness to pay for reduced plastic	51%	12%
	Concerned about climate change	76%	18%
Dietary preference	Healthy food is important	83%	19%
	Eat a flexitarian, vegetarian or vegan diet	14%	3%
Cooking behaviour	Cook every day	60%	14%
	Enjoy cooking	67%	16%
Socio-demographic	Have a degree or higher	42%	10%

Appendix 8.3 - Emissions of the UK-average diet

Table 46 presents LCA studies which quantify the emissions of the UK-average diet - assumed as 'omnivore' which represents 86% of the UK population (Food Standards Agency, 2019; Finder, 2022). The associated emissions range from 2914 - 7685 kg CO_2-eq. household^{-1} year^{-1} (max. & min. estimates are shown in bold).

Table 46, Articles with CO_2-eq. quantifications of the UK-average diet

Source	Source text	Country	kg CO_2-eq. person^{-1} day^{-1}	kg CO_2-eq. person^{-1} year^{-1}	kg CO_2-eq. household^{-1} year^{-1} [66]
Hoolohan et al. (2013, p.1065)	"The current UK-average diet is found to embody 8.8 kg CO_2e person^{-1} day^{-1}."	UK	8.81	3216	**7685**
Scarborough et al. (2014, p.179)	"GHG emissions in kilograms of carbon dioxide equivalents per day (kg CO_2e/day) were 7.19 (7.16, 7.22) for high meat-eaters (>=100 g/d), 5.63 (5.61, 5.65) for medium meat-eaters (50- 99 g/d), 4.67 (4.65, 4.70) for low meat-eaters (<50 g/d)"	UK	4.67-7.19	1705-2624	4074-6272
Macdiarmid et al. (2012, p.633)	"The GHGe of food supplied and consumed in the United Kingdom in 1990 has been estimated to be 152 metric ton CO_2e/y, which, by simply dividing by the size of the population, is equivalent to 7.28 kg CO_2e/d…with adjustment for the different energy requirements of the population age and sex structure, the total GHGE for the diet of an average woman (aged 19–50 y) was estimated to be 6.74 kg"	UK	6.74-7.28	2460-2657	5880-6351

[66] kg CO_2-eq. household^{-1} year^{-1} was calculated by multiplying the kg CO_2-eq. person^{-1} year^{-1} by 2.39, which is the UK average household size (Office for National Statistics, 2021b).

Source	Source text	Country	kg CO_2-eq. person^{-1} day^{-1}	kg CO_2-eq. person^{-1} year^{-1}	kg CO_2-eq. household^{-1} year^{-1} [66]
Aston, Smith and Powles (2012, p.6)	"Total daily GHG emissions attributable to measured dietary intakes were estimated at 4.58 kg CO_2-e in men and 3.34 kg CO_2-e in women."	UK	3.34-4.58	1219-1672	**2914**-3995
Meier and Christen (2013)	See Figure 2, p.883	Germany	-	2100	5019
van Dooren and Aiking (2016)	See Table 4, p.694	Nether-lands	3.52	1285	3071
van de Kamp et al. (2018)	See Table 3, p.19	Nether-lands	4.3-5.8	1570-2117	3751-5060
Scheelbeek et al. (2020, p.5)	"Individuals with intermediate-to- high adherence to EWG recommendations showed a reduction in average dietary GHG footprints...an average of 3.8 kg CO2eq/day (95% CI: 3.7 to 3.9 kg CO2eq/day), 4.3 kg CO2eq/day (95% CI: 4.1 to 4.4 kg CO2eq/day) and 5.4 kg CO2eq/day (95% CI: 5.2 to 5.6 kg CO2eq/day)."	UK	5.4	1971	4711

Appendix 8.4 - Emissions of a healthy diet

Table 47 presents LCA studies which quantify the emissions of a healthy diet. The associated emissions range from 1832 - 4302 kg CO_2-eq. household^{-1} year^{-1} (max. & min. estimates are shown in bold).

Table 47, Articles with CO_2-eq. quantifications of a healthy diet

Source	Source text	Healthy diet definition	kg CO_2-eq. person^{-1} day^{-1}	kg CO_2-eq. person^{-1} year^{-1}	kg CO_2-eq. household^{-1} year^{-1} [67]
Esteve-Llorens et al. (2019, p.711)	"The estimation of GHG emissions corresponding to the menus designed following the recommendations of the Atlantic diet represents...an average of 3.01 kg CO_2eq person^{-1} day^{-1}."	Atlantic diet	3.01	1099	2626
Martin and Brandão (2017)	See Figure 10, p.11 - 'Nutrition diet'	Swedish nutritional guidelines		1490	3561
van de Kamp et al. (2018)	See Table 3, p.19	Dutch nutritional guidelines	2.1-4.2	766-1533	**1832**-3664
Röös et al. (2015, p.163)	"The climate impact of the SNÖ, Riksmaten and LCHF diets was 1.4, 1.9 and 2.3 tonne CO_2e per capita and year."	Swedish nutritional guidelines		1400	3346
Meier and Christen (2013)	See Figure 2, p.883	German nutritional guidelines	4.93	1800	**4302**
van Dooren and Aiking (2016)	See Table 4, p.694	Dutch nutritional guidelines, Mediterra-nean diet	3.07-3.24	1121-1183	2678-2826

[67] kg CO_2-eq. household^{-1} year^{-1} was calculated by multiplying the kg CO_2-eq. person^{-1} year^{-1} by 2.39, which is the UK average household size (Office for National Statistics, 2021b).

Source	Source text	Healthy diet definition	kg CO_2-eq. person^{-1} day^{-1}	kg CO_2-eq. person^{-1} year^{-1}	kg CO_2-eq. household^{-1} year^{-1} [67]
Scheelbeek et al. (2020, p.5)	"Individuals with intermediate-to- high adherence to EWG recommendations showed a reduction in average dietary GHG footprints...an average of 3.8 kg CO_2eq/day (95% CI: 3.7 to 3.9 kg CO_2eq/day), 4.3 kg CO_2eq/day (95% CI: 4.1 to 4.4 kg CO_2eq/day) and 5.4 kg CO_2eq/day (95% CI: 5.2 to 5.6 kg CO_2eq/day)."	UK nutritional guidelines	3.8-4.3	1387-1570	3315-3751
Wilson et al. (2013)	See Table 3, p.5	Asian diet, Mediterra-nean diet	4.03-4.68	1471-1708	3516-4083

Appendix 8.5 - Calculation of healthy diet emission reduction

This appendix presents the calculation of the annual emission reduction of eating a healthy diet at the potential future population level. This is the maximum range emission saving (based on LCA studies presented in Appendices 8.3 & 8.4) and scaled up to the 'healthy food is important' potential adopter segment.

Equation 3, Calculating the annual emission reduction of eating a healthy diet - potential future population level

$$\text{Healthy diet emission reduction at the potential future population level } (\text{Mt CO2} - \text{eq. year}^{-1})$$

$$= \text{emission reduction } (\text{kg CO2} - \text{eq. household}^{-1}\text{ year}^{-1})$$

$$* \text{ no. of UK households (Office for National Statistics, 2021b)}$$

$$* \text{ potential adopter segment (see section 8.1)}$$

$$= 5853 \text{ kg CO2} - \text{eq. household}^{-1}\text{ year}^{-1} * 27{,}800{,}000 * 0.19$$

$$= 30{,}915{,}546 \text{ t CO2} - \text{eq. year}^{-1}, \text{or } 30.9 \text{ Mt CO2} - \text{eq. year}^{-1}$$

Appendix 8.6 - Calculation of household food waste emission reduction

This appendix presents the calculations for the emissions associated with avoidable household food waste in the UK.

Equation 4, Calculating the annual avoidable household food waste (by weight) - household level

$$\text{Avoidable food waste household}^{-1}\text{ year}^{-1}$$
$$= \frac{\text{Total avoidable household food waste in the UK year}^{-1}\text{(WRAP, 2018)}}{\text{no. of UK households (Office for National Statistics, 2021b)}}$$
$$= \frac{\text{4,995,000 tonnes year}^{-1}}{\text{27,800,000 households}}$$
$$= \text{180 kg household}^{-1}\text{ year}^{-1}$$

Using estimates by WRAP (2018), the 180 kg avoidable (e.g. excluding inedible parts) food waste household^{-1} year^{-1} in the UK is comparable with the 143-210 kg household^{-1} year^{-1} in Denmark (Martinez-Sanchez et al., 2016). UK avoidable household food waste equates to 74 kg capita^{-1} year^{-1} (using Equation 4, but dividing by 'total UK population' rather than 'no. of UK households'), which again is comparable but somewhat higher than 47 kg capita^{-1} year^{-1} in the Netherlands (Netherlands Nutrition Centre, 2014).

Equation 5, Calculating the annual emissions of avoidable household food waste - household level

$$\text{Avoidable food waste emissions household}^{-1}\text{ year}^{-1}$$
$$= \text{kg CO2} - \text{eq. tonne}^{-1}\text{ waste}$$
$$* \text{ tonnes food waste UK household}^{-1}\text{ year}^{-1}$$
$$= \text{2500 kg CO2 eq. tonne}^{-1}\text{ waste (high estimate, using Tonini, Albizzati and Astrup, 2018)}$$
$$* \text{ 0.18 tonnes food waste household}^{-1}\text{ year}^{-1}$$
$$= \text{449 kg CO2} - \text{eq. household}^{-1}\text{ year}^{-1}$$

Key assumptions

Food waste avoidance was considered the optimal scenario because this is a 5 - 12 times larger GHG saving than if all food waste were used for bioenergy production (Salemdeeb et al., 2017). Thus, potential emission savings of energy recovery through anaerobic digestion of food waste were not included in these calculations. Table 48 presents LCA studies which quantify the emissions of avoidable household food waste. The column on the right indicates the associated emissions of avoidable household food waste, which ranges from 88 - 449 kg CO_2-eq. household^{-1} year^{-1} (using Equation 5, above; max. & min. estimates are shown in bold).

Table 48, Articles with CO_2-eq. quantifications of avoidable household food waste

Source	Source text	Country	kg CO_2-eq. tonne^{-1} food waste	kg CO_2-eq. household^{-1} year^{-1}
Tonini, Albizzati and Astrup (2018, p.756)	"For Food Service and Households, the impact equalled 3100 and 2500 kg CO_2-eq. t^{-1}, respectively"	UK	2500	**449**
Salemdeeb et al. (2017, p.443)	"Shopping is accountable for 70 kg CO_2-eq. per tonne food and the GHG burden associated with home storage and preparation is 420 kg CO_2-eq. per tonne"	UK	490	**88**
Chapagain and James (2011, p.19)	"The average carbon footprint of avoidable household food waste is 330 kg CO_2 eq. per person per year." [68]	UK	789	142
Bernstad Saraiva Schott and Andersson (2015, p.219)	"The results from the waste composition analyses indicate that an average of 35% of household food waste is avoidable. Minimization of this waste could result in reduction of greenhouse gas emissions of 800-1400 kg/tonne of avoidable food waste."	Sweden	800-1400	144-252

Equation 6, Calculating the annual emission reduction of avoidable household food waste - potential future population level

$$\text{Emissions from avoidable food waste reduction at potential future population level (kt CO2} - \text{eq. year}^{-1})$$

$$= \text{emission saving (kg CO2} - \text{eq. household}^{-1}\ \text{year}^{-1}) * \text{no. of UK households (Office for National Statistics, 2021b)} * \text{potential adopter segment (see section 8.1)} * 20\% \text{ of adopters assumed to reduce food waste}$$

$$= 88 \text{ kg CO2} - \text{eq. household}^{-1}\ \text{year}^{-1} (\text{low estimate}) * 27{,}800{,}000 * 0.14 * 0.2$$

$$= 68{,}531 \text{ t CO2} - \text{eq. year}^{-1}, \text{or } 68.5 \text{ kt CO2} - \text{eq. year}^{-1}$$

[68] This figure was converted from 'per capita' (330 kg) to 'per household' (789 kg) by multiplying to the UK average household size of 2.39 (Office for National Statistics, 2021b). This matches the functional unit of the other three LCA articles.

Appendix 8.7 - Emissions of field/passive greenhouse vs heated greenhouse production

Table 49 presents LCA studies which quantify the emissions of two production methods (max. & min. estimates are shown in bold).

Table 49, Articles with CO_2-eq. quantifications of field or passive greenhouse production vs heated greenhouse production

				kg CO_2-eq. kg^{-1} crop	
Source	Text	Crop	Country	Field/ passive	Heated green-house
Shen et al. (2021, p.743)	"Greenhouse cherry cultivation presented a GWP value (7.2 kg CO_2-eq kg^{-1}) seven-fold higher than that of open-field cultivation (0.9 kg CO_2- eq kg^{-1})."	Cherries	China	0.90	7.20
Ntinas et al. (2017, p.3620)	"The main results showed that annual carbon footprint values varied between 0.1 and 10.1 CO_2-eq/kg tomato."	Tomatoes	Greece, Germany	0.07	**10.10**
Neira et al. (2018)	See Table 3, p.1632	Tomatoes	Spain	0.39	1.33
Theurl et al. (2017, p.134)	"Greenhouse gas emissions of unheated vegetables are lower with 0.06-0.12 kg CO_2 equivalent versus 0.61-0.64 kg CO_2 equivalent per kg fresh product crops from heated systems."	Winter vegetables (not specified)	Austria	**0.06**-0.12	**0.61**-0.64
Marttila et al. (2021, p.8)	"The functional unit (FU) is set as 1 ton for both...The GWP of the Finnish greenhouse tomato production varied between 857 and 6523 kg CO_2-eq. FU^{-1} in this study" *Functional unit converted*	Tomatoes	Finland	0.86	6.52
Marttila et al. (2021, p.9)	"The GWP of the Finnish greenhouse cucumber production varied between 1379 and 2951 kg CO_2-eq. FU^{-1}."	Cucumber	Finland	**1.38**	2.95
Jungbluth , Keller and König (2015)	See Figure 6, p.651	Green asparagus	Switzer-land	0.6-1.0	3.90

Table 50 shows a range of 0.04 - 2.54 kg CO_2-eq. kg^{-1} produce for 34 crops produced in field or passive greenhouses (unless otherwise stated), identified by Clune, Crossin and Verghese (2017) in their systematic review. This range is comparable with the range presented in Table 49.

Table 50, Fruit, vegetable and staples GWP values. Duplicated from: Clune, Crossin and Verghese (2017, p.12)

Group	Classification	Foods included	Median	Mean	Stdev	Deviation from mean	Min	Max	Q1	Q3	No. of LCA studies	No. of GWP values[a]
Vegetables field grown	Brassica	Cabbages, other brassicas	0.23	0.32	0.30	94%	0.12	0.64	0.22	0.38	4	5
	Bulbs, roots and tubers	Onions, garlic, beetroot, swedes and carrots	0.18	0.21	0.12	55%	0.04	0.57	0.14	0.29	21	53
	Leaves	Varieties of lettuce	0.37	0.38	0.14	38%	0.13	0.62	0.27	0.46		26
	Vegetables	Vegetables (all field grown vegetable)	0.37	0.47	0.39	83%	0.04	2.54	0.19	0.60	33	140
	Stem shoots	Asparagus	0.83	0.92	0.49	53%	0.18	2.54	0.60	1.05	5	28
	Brassica	Broccoli and cabbage	0.50	0.57	0.33	58%	0.12	1.73	0.38	0.69	1	26
Fruits field grown	Pome	Apples, pears and quinces	0.29	0.34	0.18	52%	0.18	0.89	0.22	0.38	22	40
	Pepo	Fruit of the gourd family including cucumber, gherkins, zucchini, papaya and melons etc	0.30	0.34	0.29	85%	0.08	1.30	0.18	0.32	13	32
	Hesperidium	Fruits of the citrus family including oranges, mandarins, lemons and limes	0.33	0.35	0.12	34%	0.22	0.59	0.25	0.46	10	28
	Fruit	Fruits (all field grown fruit)	0.42	0.50	0.32	64%	0.08	1.78	0.28	0.63	77	250
	Drupe	Stones fruits including cherries, dates, plumbs, apricots, peach, olives, and coconuts.	0.45	0.57	0.36	63%	0.22	1.78	0.32	0.67	1	19
	Multiple fruit	Pineapples and figs	0.45	0.68	0.50	73%	0.40	1.78	0.44	0.61	5	7
	True berry	Tomatoes, grapes, avocado, peppers, kiwi fruits, guava etc.	0.45	0.52	0.26	50%	0.08	1.40	0.35	0.66	24	83
	Aggregate fruit	Strawberries and raspberries	0.60	0.66	0.35	53%	0.20	1.50	0.38	0.84	15	22
	Musa	Bananas	0.72	0.79	0.30	38%	0.42	1.37	0.48	1.04	10	17
Staples	Cereal	Barley, maize, oats, rye, corn and wheat	0.50	0.53	0.22	42%	0.11	1.38	0.38	0.63	31	90
	Legume	Peas, beans, peanuts, ground nuts, and lentils	0.51	0.66	0.45	67%	0.15	2.46	0.36	0.83	16	51
	Tree nuts	Chestnuts, almonds, hazelnuts, palm nuts-kernels, pistachios, cashew nuts and walnuts	1.20	1.42	0.93	66%	0.43	3.77	0.61	2.13	7	21
	Seeds	Rapeseed (canola), mustard seed, sesame seed and sunflower seed	1.41	1.46	3.70	61%	0.88	2.09	1.15	1.75	1	3
	Cereal	Rice	2.55	2.66	1.29	48%	0.66	5.69	1.64	3.08	12	27
Greenhouse Fruit and vegetables[c]	No auxiliary heating (passive)	Melons, peppers, tomatoes and zucchini	1.10	1.02	0.49	48%	0.32	1.94	0.54	1.35	5	15
	Natural gas heated greenhouse	Lettuce, strawberries and tomatoes	2.07	2.58	1.35	52%	1.16	5.90	1.72	2.88	8	25
	Fuel/oil heated greenhouse	Cucumbers, lettuce, peppers and tomatoes	2.82	2.77	1.17	42%	0.90	4.51	2.01	3.65	3	8
	LPG heated greenhouse	Tomatoes	3.40	2.59	0.42	16%	3.10	3.70	3.25	3.55	2	2
	Average from all heated greenhouse[b]	Cucumber, melons, lettuce, peppers, strawberries, raspberries, tomatoes and zucchini	2.13	2.81	1.61	57%	0.84	7.4	1.74	3.7	18	53

Appendix 8.8 - Emissions of air freight vs road transportation

Table 51 presents LCA studies which quantify the emissions of road transportation vs air freight. Air freighted food typically comprises perishable fresh produce such as fruit and vegetables (max. & min. estimates are shown in bold).

Table 51, Articles with CO_2-eq. quantifications of the mode of transportation

				kg CO_2-eq. kg^{-1} crop		
Source	Text	Crop	Domestic country	Domestic production (road transport)	Imported by road (within Europe)	Imported by air (from outside Europe)
Jungbluth, Keller and König (2015)	See Figure 6, p.651	Green asparagus	Switzerland	1.90	**2.10**	18.70-**24.90**
Michalsky´ and Hooda (2015)	See Table 4, p.38	Apples	UK	0.42	0.55	13.09
Michalsky´ and Hooda (2015)	See Table 4, p.38	Cherries	UK	0.42	0.68	12.16
Michalsky´ and Hooda (2015)	See Table 4, p.38	Straw-berries	UK	0.94	1.23	**7.35**
Michalsky´ and Hooda (2015)	See Table 4, p.38	Garlic	UK	0.67	0.87	11.42
Michalsky´ and Hooda (2015)	See Table 4, p.38	Peas	UK	0.39	**0.60**	10.64

The 'kg CO_2-eq. kg^{-1} crop' metric presented in Table 51 above enables direct comparison with the emissions associated with field or passsive greenhouse vs heated greenhouse production (see Appendix 8.7). However, transportation emissions are often presented using a distance metric: g CO_2 eq. t-km^{-1}. Table 52 is duplicated from Lopez et al. (2015) and shows the emissions for road transportation range from 31 - 400 g CO_2 eq. t-km^{-1} (metric ton), compared to 435 - 2000 g CO_2 eq. t-km^{-1} for air freight. The large differences between road and air freight emissions presented in Table 52 supports the similarly large differences observed in Table 51. Table 52 also shows the emissions associated with sea and rail transportation are considerably less than road or air.

Table 52, Emissions per ton-km by mode of transport according to different sources. Duplicated from Lopez et al. (2015, p.426)

	Sea	Rail	Road	Air	Other
Cadarso et al. (2010).	18	17	50	540	25
Weber and Matthews (2008).	7–14	18	180	680	16–180
Klimke (Europ. Commission, 2011).	10–40	30–100	60–150		
Cristea et al. (2013).	4.5–12.1	22.7	119.7	476–1020 (912, US)	
McKinnon and Piecyk (2012) (1)	14	22	62	602 (2)	
Ecotransit (2011) (3)	8–47	6–18	40–85	490–2000	
Van Essen (2008).	25–45	38–40	110–140		
EPA (2008).	29.83	15.66	182.68	948.83	
Howitt et al. (2011).				690–820	
DEFRA (2011).	2.5–20	28.5	88.5–259	610–1360	
Buhaug et al. (IMO, 2009).	5.7–32.1	10–119	80–156	435/474–1100/1800	
Facanha and Horvath (2006).				660	
Hileman et al. (2008).				1000	
DSV (4)			80		
LIPASTO(5)	10–42	9.2–26	31–366.8	595–1404	
Regmi and Hanaoka (2010) (6)	13–20	28.3	118.6–400.1		
Westra and Eppink (2008).	24			514–553	
This paper	**14**	**18**	**75**	**690**	**25**

Appendix 8.9 - Calculation of seasonal diet emission reduction

Hub users buy on average 1053 g of vegetables and 192 g of fruit per week from the food hub (93% and 24% of the UK-average, respectively - see section 6.3). No information was collected in this study regarding the food they buy from other retailers (e.g. in addition to their food hub order). Thus, a potential emission reduction from eating a seasonal diet which avoids air freight and heated greenhouse production can be proposed only for quantities of fresh produce they buy from the online food hub. Equation 7 was used to calculate this emission reduction.

Equation 7, Calculating the annual emissions of fresh produce bought from online food hubs

$$\text{Emissions to produce vegetables in average food hub basket (kg CO2} - \text{eq. household}^{-1}\text{ year}^{-1})$$

$$= \text{Average consumption of food hub vegetables household}^{-1}\text{ year}^{-1}\text{ (kg)}$$

$$* \text{ kg CO2} - \text{eq. kg produce}^{-1}$$

$$= 130.9 * 0.06 \text{ (low estimate, see } \mathit{Table}\text{ 49)}$$

$$= 7.9 \text{ kg CO2} - \text{eq. household}^{-1}\text{ year}^{-1}$$

Table 53 below shows the emissions of a local seasonal diet, as an outcome of using an online food hub, are between 7.9 - 274.8 kg CO_2-eq. household^{-1} year^{-1} for vegetables and between 1.4 - 50 kg CO_2-eq. household^{-1} year^{-1} for fruit (top two rows). The subsequent rows in Table 53 show the emission reduction at the household level for 'avoided heated greenhouse' and 'avoided air freight' scenarios.

Key assumptions

No data on the quantity of fresh fruit and vegetables produced in heated greenhouses and consumed in the UK was found. 11% of UK food imports are from the Netherlands and they grow 35% of their fresh produce in greenhouses (Glotech, 2018; Statistics Netherlands, 2022). It is therefore assumed that 3.85% of the fresh produce consumed in the UK is grown in heated greenhouses. This is likely to be a conservative estimate because the UK will import heated greenhouse produce from countries other than the Netherlands, as well as producing food using heated greenhouses in the UK.

It was difficult to find recent data on the quantity of food air freighted to the UK, but a DEFRA report from 2007 states that approximately 9% of fresh fruit and vegetables imported from Africa were transported by air. It is therefore assumed that 9% of the fresh produce bought from mainstream retailers is air freighted to the UK

Table 53, Emissions of avoided heated greenhouse production and avoided air freight - household level

	Average consumption person^{-1} week^{-1} (g)	Average consumption household^{-1} week^{-1} (g) [69]	Average consumption household^{-1} year^{-1} (kg)	Low estimate (kg CO_2-eq. household^{-1} year^{-1})	High estimate (kg CO_2-eq. household^{-1} year^{-1})
Emissions of fresh produce bought from online food hub				0.06 kg CO_2-eq. kg^{-1} crop	2.1 kg CO_2-eq. kg^{-1} crop
Vegetables	1053.0	2516.7	130.9	7.9	274.8
Fruit	191.5	457.7	23.8	1.4	50.0
Total				9.28	324.8
'Avoided heated greenhouse' scenario: 3.85% of fresh produce				0.6 kg CO_2-eq. kg^{-1} crop	10.1 kg CO_2-eq. kg^{-1} crop
Vegetables			5.0	3.0	50.9
Fruit			0.9	0.5	9.3
Total				3.6	60.1
Adjusted total*				3.2	47.6
'Avoided air freight' scenario: 9% of fresh produce				7.4 kg CO_2-eq. kg^{-1} crop	24.9 kg CO_2-eq. kg^{-1} crop
Vegetables			11.8	87.2	293.3
Fruit			2.1	15.9	53.3
Total				103.0	346.6
Adjusted total*				102.2	317.4

* Adjusted total: The 'avoided air freight' scenario assumes emissions are avoided for 9% of fresh produce, but the fresh produce from online food hubs (e.g. that replaces the air freighted produce) also entails emissions. Thus, the associated emissions for 9% of food hub produce is subtracted from the 'avoided air freight' emissions to provide a more accurate estimate of overall avoided emissions. The same process was carried out for 'avoided heated greenhouse' but using a 3.85% subtraction.

[69] Average consumption household^{-1} week^{-1} was calculated by multiplying the average consumption person^{-1} week^{-1} by 2.39, which is the UK average household size (Office for National Statistics, 2021b).

Equation 8 shows the calculation for the annual emission reduction resulting from a seasonal diet, scaled up to the potential future population level.

Equation 8, Calculating the annual emission reduction of eating a seasonal diet - potential future population level

$$\text{Emission reduction of a seasonal diet at the potential future population level } (\text{kt CO2 year}^{-1})$$

$$= [\text{Emission reduction from 'avoided heated greenhouse' } - \text{ Table 53 – low estimate}$$

$$(\text{fruits and vegetables combined, kg CO2 household}^{-1}\text{ year}^{-1})$$

$$+ \text{ Emission reduction from 'avoided air freight' } - \text{ Table 53 – low estimate}$$

$$(\text{fruits and vegetables combined, kg CO2 household}^{-1}\text{ year}^{-1})]$$

$$* \text{ no. of UK households (Office for National Statistics, 2021b)}$$

$$* \text{ potential adopter segment ('Concerned about climate change' } - \text{ see section 8.1)}$$

$$= [3.2 + 102.2] * 27{,}800{,}000 * 0.18$$

$$= 527.4 \text{ kt CO2 year}^{-1}$$

Appendix 8.10 - Emissions of organic vs conventional vegetable production

Table 54 presents LCA studies which quantify the emissions of two production methods for vegetables, fruits and salad (max. & min. estimates are shown in bold).

Table 54, Articles with CO_2-eq. quantifications of organic vs conventional production of vegetables, fruits & salads

Source	Source text	Crop	Country	Organic or alternative production (kg CO_2-eq. kg^{-1} crop)	Conventional production (kg CO_2-eq. kg^{-1} crop)
Pérez-Neira and Grollmus-Venegas (2018)	See Table 2, p.64	squash, chard, leek, green pepper, tomato, cabbage, cauliflower, zucchini, broccoli, eggplant, spinach, onion, other produce	Spain	0.106	0.129-0.143
Kulak, Graves and Chatterton (2013)	See Table 6, p.74	apple, beans, carrot, courgette, lettuce, onion, pepper, potato, pumpkin, spinach, strawberry, tomato	UK	**0.05**-1.24	0.42-**2.60**
de Backer et al. (2009, p.14)	"GWP100, is 0.094 kg CO_2-equivalents/kg leek for the conventional system and 0.044 kg CO_2-equivalents/kg	leek	Belgium	0.044	**0.094**

Source	Source text	Crop	Country	Organic or alternative production (kg CO_2-eq. kg^{-1} crop)	Conventional production (kg CO_2-eq. kg^{-1} crop)
	leek for the organic system”				
de Jesus Pereira, Filho and La Scala Jr. (2021, p.1)	“The carbon footprint to produce 1 kg of intercropped vegetables (0.105 kg CO_2eq kg^{-1}) was about five times lower than that in the monoculture (0.516 kg CO_2eq kg^{-1})”	cucumber, lettuce, tomato	Brazil	0.105	0.516
Aguilera, Guzmán and Alonso (2015)	See Table 2, p.719	legumes, herbaceous crops	Spain	0.161-0.195	0.215-0.238
Foteinis and Chatzisymeon (2016, p.2469)	“When results are expressed per product unit then organic lettuce cultivation emits 1282 kg CO_2e/tn... the CO_2 emissions of conventional lettuce cultivation per product unit are 631 kg CO_2e/tn...due to the high yield of conventional cultivation.”	lettuce	Greece	**1.282**	0.631
Venkat (2012)	See Table 5	blueberries, apple, grapes, strawberries, lettuce, broccoli	US	0.17-0.73	0.11-0.83

Appendix 8.11 - Emissions of organic vs conventional cereal production

Table 55 presents LCA studies which quantify the emissions of two production methods for cereals (max. & min. estimates are shown in bold).

Table 55, Articles with CO_2-eq. quantifications of organic vs conventional cereal production

Source	Source text	Crop	Country	Organic or alternative production (kg CO_2-eq. kg^{-1} crop)	Conventional production (kg CO_2-eq. kg^{-1} crop)
Nemecek et al. (2011)	See Table 4, p.225	potatoes, winter, wheat, beetroot, winter barley	Switzerland	0.302-0.363	0.336-0.431
Moudrý et al. (2018, p.911)	"These values amount to 0.460 kg CO_2e / kg of grain for wheat, 0.537 kg CO_2e / kg of grain for rye and 0.358 kg CO_2e / kg of grain for oat. In organic farming, these values amount to 0.423 kg CO_2e / kg of grain for wheat, 0.298 kg CO_2e / kg of grain for rye, 0.303 kg CO_2e / kg of grain for oat."	wheat, rye, oat	Czech Republic	0.298-**0.423**	0.358-**0.537**
Meisterling, Samaras and Schweizer (2009, p.226)	"the GWP impact of producing 0.67 kg of conventional wheat flour (for a 1 kg bread loaf), not including product transport, is 190 g CO_2-eq, while the GWP of producing the wheat	wheat	US	0.213	**0.253**

Source	Source text	Crop	Country	Organic or alternative production (kg CO_2-eq. kg^{-1} crop)	Conventional production (kg CO_2-eq. kg^{-1} crop)
	organically is 160 g CO_2-eq" *Quantity converted to 1 kg of grain - to match the functional unit of the other articles*				
van Stappen et al. (2015)	See Table 3, p.227	wheat	Belgium	0.307	0.349
Tricase et al. (2017)	See Table 3, p.3757	barley	Italy	0.259	0.349
Aguilera, Guzmán and Alonso (2015)	See Table 2, p.719	cereals	Spain	**0.183**	0.315

Appendix 8.12 - Emissions of organic vs conventional milk production

Table 56 presents LCA studies which quantify the emissions of two production methods for milk (as a proxy for dairy products) (max. & min. estimates are shown in bold).

Table 56, Articles with CO_2-eq. quantifications of organic vs conventional milk production

Source	Source text	Country	Organic or alternative production (kg CO_2-eq. kg^{-1} milk)	Conventional production (kg CO_2-eq. kg^{-1} milk)
Haas, Wetterich and Köpke (2001)	See Table 5, p.48	Germany	1.0-1.3	1.3
de Boer (2003)	See Table 3, p.75	Sweden, Netherlands, Germany	0.69-1.30	**0.89**-1.30
Cederberg and Mattsson (2000)	See Figure 4, p.56	Sweden	0.95	1.10
Guerci et al. (2013)	See Table 4, p.137	Denmark, Germany, Italy	**0.55-1.43**	1.11-**1.91**
Schader et al. (2014)	See Table 5, p.233	Switzerland	0.89-1.10	-

Appendix 8.13 - Calculation of organic production emission reduction

Food hub users buy on average 1244g of fruit and vegetables, 126g of bread and pastries and 554.5g of dairy products from their local hub each week (see section 6.3). Table 57 shows this quantity scaled up to per household per year and the associated maximum potential emission reduction from organic production, relative to conventional production.

Table 57, Maximum potential emission reduction of organic production - household level

	Food hub produce individual^{-1} week^{-1} (g)	Food hub produce household^{-1} year^{-1} (kg)	Organic production - maximum potential reduction (kg CO_2-eq. kg^{-1})	Maximum potential reduction (kg CO_2-eq. household^{-1} year^{-1})
Fruit & veg	1244.5	154.67	2.55	394.4
Bread & pastries	126	15.66	0.35	5.54
Dairy products	554.5	68.91	1.36	93.72
Total	-	-	-	493.66

Equation 9 shows the calculation for the emission reduction resulting from organic production for three fresh produce food categories, scaled up to the potential future population level.

Equation 9, Calculating the annual emission reduction of organic production - potential future population level

$$\text{Organic production emission reduction} - \text{potential future population level (kt CO2 year}^{-1})$$

$$= \text{Maximum potential emission reduction from organic production (kg CO2 household}^{-1}\text{ year}^{-1})$$

$$* \text{ no. of UK households (Office for National Statistics, 2021b)}$$

$$* \text{ potential adopter segment ('Willingness to pay for ethical products' } - \text{ see section 8.1)}$$

$$= 493.7 * 27{,}800{,}000 * 0.11$$

$$= 1{,}509.6 \text{ kt CO2 year}^{-1}$$

Appendix 8.14 - Calculation of supply chain food waste emission reduction

Table 58 presents articles which report percentages of retail stage food waste that were used to determine the relative waste reduction from switching supply chain. The maximum waste reduction is 7.1% of fruit & veg waste, 6.6% of bread & pastries and 2.4% of dairy products (see Figure 42) (max. & min. estimates are shown in bold).

Table 58, Articles with percentages of retail stage food waste, by food category

			% of food wasted		
Source	Source text	Country	Fruit & veg	Bread & pastries	Dairy products & eggs
Ribeiroa et al. (2019)	See Table 2, p.215	Poland	1.9	**0.4**	**0.6**
Beretta et al. (2013, p.770)	"Compared to the losses in the stores (8–9%), they are of minor relevance…For bread and pastries, the average losses are estimated at 3–7%"	Switzerland	8-**9**	3-**7**	1.4
Lebersorger and Schneider (2014, p.1911)	"Food loss amounts to 1.3% of the sales of dairy products, 2.8% for bread & pastry and 4.2% for fruit & vegetables."	Austria	4.2	2.8	1.3
Mena, Adenso-Diaz and Yurt (2011)	See Figure 3, p.653	UK and Spain	3-7	**7**	1-**3**
Eriksson, Strid and Hansson (2012)	See Table 3, P.18	Sweden	**0.6**-2.3	-	-

Food hub users buy on average 1244g of fruit and vegetables, 126g of bread and pastries and 554.5g of dairy products from their local hub each week (see section 6.3). Table 59 shows this quantity scaled up to per household per year (3rd column) and the corresponding quantity of avoided food waste at the retail stage (using the maximum waste reduction percentages; 4th column). The low and high estimates for the associated emission reduction (5th and 6th columns) are based on Salemdeeb et al. (2017) and Tonini, Albizzati and Astrup (2018) (see Table 48) and calculated using Equation 10 below.

Table 59, Emissions of avoided food waste at the retail stage

	Food hub produce individual^{-1} week^{-1} (g)	Food hub produce household^{-1} year^{-1} (kg)	Avoided waste at retail stage household^{-1} year^{-1} (kg)	kg CO_2-eq. household^{-1} year^{-1} (low estimate)	kg CO_2-eq. household^{-1} year^{-1} (high estimate)
Fruit & veg	1244.5	154.67	10.98 (7.1% waste)	5.38	27.45
Bread & pastries	126	15.66	1.03 (6.6% waste)	0.51	2.58
Dairy products	554.5	68.91	1.65 (2.4 % waste)	0.81	4.13
Total	-	-	-	6.70	34.17

Equation 10, Calculating the annual emission reduction of avoidable retail food waste

$$\text{Emission reduction of avoidable food waste at retail stage } (\text{kg CO2} - \text{eq. household}^{-1}\ \text{year}^{-1})$$
$$= \text{produce bought from hub } (\text{t household}^{-1}\ \text{year}^{-1})$$
$$* \ \%\ \text{waste reduction sourcing from an alternative food network}$$
$$* \ \text{emission saving } (\text{kg CO2} - \text{eq. tonne food waste}^{-1})$$
$$= \ 0.155 \text{ t fruit \& veg household}^{-1}\ \text{year}^{-1} * 0.071 \text{ (for fruit \& veg)}$$
$$* \ 490 \text{ kg CO2} - \text{eq. tonne food waste}^{-1} \text{ (low estimate: Salemdeeb et al., 2017)}$$
$$= 5.38 \text{ kg CO2} - \text{eq. household}^{-1}\ \text{year}^{-1}$$

Appendix 8.15 - Calculation of ‘last mile’ emission reduction

This appendix presents the calculations for the emissions associated with post-retail transportation: grocery home delivery vs using a personal vehicle to travel to the supermarket. Table 60 shows the LCA studies on which the calculations are based - these articles used different metrics and so some conversions were necessary to enable comparison between them. The emissions of an average trip to the shops by car (4274 g CO_2, from Edwards, McKinnon and Cullinane, 2009) was used as the baseline (max. & min. estimates are shown in bold).

Table 60, Articles with CO_2-eq. quantifications of home delivery vs use of personal vehicle

Source	Source text	Country	Baseline - g CO_2 per average trip to the shops by car	g CO_2 per average home delivery by van
Edwards, McKinnon and Cullinane (2009, p.2)	“A typical van-based drop produced 181 g CO_2, compared with 4,274 g CO_2 for an average trip to the shops by car and 1,265 g CO_2 for an average bus passenger.” *Metric: g CO_2 per average shopping trip/home delivery*	UK	4,274	**181**
Siikavirta et al. (2003, p.83)	“Depending on the home delivery model used, it is possible to reduce the GHG emissions generated by grocery shopping by 18% to 87% compared with the situation in which household members go to the store themselves.” *Metric: percentage change relative to use of personal vehicle*	Finland	4,274	556-3,505
Rizet et al. (2010, p.6162)	See Figure 5, p.6162 *Metric: g CO_2 eq. kg^{-1} produce*	France	4,274	940-**4,274**

UK consumers make on average 105 shopping trips per year and a personal vehicle is used for 63% of these trips (Song et al., 2009, p.10). People typically buy food for their entire household and so the associated emissions are assumed to represent the household level rather than individual level. Equation 11 shows the calculation for the emissions resulting from driving to the supermarket, equating to 283 kg CO_2 $household^{-1}$ $year^{-1}$.

Equation 11, Calculating the annual emissions of driving to the supermarket

$$\text{Grocery shopping car journey emissions household}^{-1}\text{ year}^{-1}\text{ (kg CO2)}$$
$$= \text{no. shopping trips year}^{-1} * 63\% \text{ (Song et al., 2009)}$$
$$* \text{ g CO2 per average trip (Edwards, McKinnon and Cullinane, 2009)}$$
$$= 105 * 0.63 * 4274$$
$$= 282725.1 \text{ g CO2, or 283 kg CO2 household}^{-1}\text{ year}^{-1}$$

Table 60 shows the emissions associated with the average grocery home delivery range from 181 g CO_2 as a low estimate to 4274 g CO_2 as a high estimate (e.g. identical to a car journey). Food hub users typically buy a proportion of their weekly food from their local hub and the remainder from a supermarket or independent high street shops (see section 6.1.1 and Appendix 3.6). If we assume: 1) they are regular hub customers who order from the hub each week; and 2) they use a supermarket home delivery service once a week, the associated emissions are calculated as 19 kg CO_2 household^{-1} year^{-1} (See Equation 12) as a low estimate. The high estimate would be 283 kg CO_2 household^{-1} year^{-1} and so zero emission saving.

Equation 12, Calculating the annual emissions of weekly food hub and weekly supermarket home delivery

$$\text{Food hub delivery} + \text{supermarket home delivery emissions household}^{-1}\text{ year}^{-1}\text{ (kg CO2)}$$
$$= \text{no. home deliveries year}^{-1}\text{ (Song et al., 2009)}$$
$$* \text{ g CO2 per average delivery (low estimate} - \text{Edwards, McKinnon and Cullinane, 2009)}$$
$$= 105 * 181$$
$$= 19005 \text{ g CO2, or 19 kg CO2 household}^{-1}\text{ year}^{-1}$$

An alternative scenario is the hub users receive a weekly food hub order and drive to the supermarket once a week. In this situation, the associated emissions are calculated as 232 kg CO_2 household^{-1} year^{-1} (See Equation 13) as a low estimate. The high estimate would be 283 kg CO_2 household^{-1} year^{-1}.

Equation 13, Calculating the annual emissions of weekly food hub delivery and weekly car journey to the supermarket

$$\text{Food hub delivery emissions} + \text{grocery shopping car journey emissions household}^{-1}\text{ year}^{-1}$$
$$= \text{g CO2 weekly hub delivery emissions (Edwards, McKinnon and Cullinane, 2009)}$$
$$+ \text{ g CO2 weekly car journey emission (Edwards, McKinnon and Cullinane, 2009)}$$
$$= (52 * 181) + (52 * 4274)$$
$$= 9412 + 222248$$
$$= 231660 \text{ g CO2, or 232 kg CO2 household}^{-1}\text{ year}^{-1}\text{ (low estimate)}$$

Assuming the maximum 'last mile' emission reduction and scaling up to the potential population level would result in a saving of 293.3 kt of CO_2 year^{-1}, shown in Equation 14.

Equation 14, Calculating the annual 'last mile' emission reduction - potential future population level

$$\text{'Last mile' emission reduction at potential future population level (kt CO2 year}^{-1}\text{)}$$
$$= \text{(Car journey emissions [kg CO2 household}^{-1}\text{ year}^{-1}\text{e. g. Equation 11]} -$$
$$\text{home delivery emissions [kg CO2 household}^{-1}\text{ year}^{-1}\text{ e. g. Equation 12])}$$
$$* \text{ no. of UK households (Office for National Statistics, 2021b)}$$
$$* \text{ potential adopter segment ('Buy groceries online' } - \text{ see section 8.1)}$$
$$= (283 - 19) * 27{,}800{,}000 * 0.04$$
$$= 293.3 \text{ kt CO2 year}^{-1}$$

In summary, regular supermarket *or* food hub home delivery represents a significant potential emission saving compared to driving to the supermarket. Sources of uncertainty in these calculations include the differing LCA estimates of home delivery emissions and the assumption of the hub users' supermarket shopping frequency corresponding with Song et al. (2009).

Appendix 9.1 - List of recommendations for practice, research or policy

This appendix is a compiled list of the recommendations proposed in chapter 9.

Recommendations for practice

Recommendation 1: *Online food hubs should continue to present a range of different attributes on their platforms in order to appeal to the broadest possible spectrum of consumers. The hubs could consider strengthening the value proposition with respect to compatibility and shopping convenience to reduce the likelihood of innovation rejection.*

Recommendation 2: *Online food hubs could consider integrating a customer review mechanism into their platform to replicate social influence. Other possible marketing approaches include a 'refer a friend' scheme and emphasising social identities.*

Recommendation 10: *Online food hubs in the South West should endeavour to participate in the upcoming pilot. This would provide these hubs with a revenue source and, more importantly, hopefully demonstrate the viability of the local provisioning model for the public plate on a larger scale.*

Recommendations for research

Recommendation 3: *The increasing prevalence of service-based innovations should stimulate a stronger emphasis on the use phase in diffusion research. This is especially relevant when considering the outcomes of environmental innovations.*

Recommendation 4: *Further research is needed into how the use of innovations relates to the habitual behaviours they alter, instil or replace. This could include a focus on how consumers perceive a 'layering' of benefits vs the effort of changing their existing habits.*

Recommendation 5: *The role of digitally mediated changes to consumption behaviour should be investigated for the entire range of food apps and platforms. This research should include quantifications of their mitigation potential.*

Recommendation 6: *The functional and symbolic framing of attributes is a promising but under-explored avenue of research for understanding the adoption of environmental innovations, including online food hubs. In particular, the relative importance of functional vs symbolic attributes to consumers should be explored.*

Recommendations for policy

Recommendation 7: *Online food hubs should be included in the Healthy Start awareness-raising campaign as one of the retailers where participants can use their vouchers.*

Recommendation 8: *The Community Eatwell pilots could partner with online food hubs which already have the expertise, capacity and local knowledge to support the programme's objectives.*

Recommendation 9: *Municipal authorities should contact online food hubs (see list in Appendix 7.1) to discuss possible procurement arrangements. This dialogue could explore the potential to scale up operations to meet demand, utilise food hub staff's knowledge of local producers, and articulate how the health and environmental criteria could be fulfilled and monitored.*

Recommendation 11: *Develop a policy mechanism which would incentivise farmers to minimise on-farm energy-use (in addition to the land use practices for carbon sequestration proposed in ELMs).*

Recommendation 12: *Implement environmental auditing of air freighted food to establish the carbon implications of UK food imports, as well as to ascertain any indirect consequences of ELMs.*

Recommendation 13: *Consider legislation to incentivise or require food waste avoidance practices in retail and primary production, rather than relying on voluntary agreements.*

List of acronyms and abbreviations

BECCS	bioenergy with carbon capture and storage
BEIS	Department for Business, Energy and Industrial Strategy (UK government)
B2B	business to business
CI	confidence interval
CO_2	carbon dioxide
CSA	community supported agriculture
DEFRA	Department for Environment, Food and Rural Affairs (UK government)
DoI	Everett Rogers' (2003) *Diffusion of Innovations* theoretical framework
E (2.3)	semi-structured interview question (number 2.3)
ELMs	Environmental land management scheme, administered by DEFRA
Ex.	research expectation (based on the literature review or DoI framework)
Exp.	expenditure
FAO	Food and Agriculture Organization of the United Nations
FCRN	Food Climate Research Network, University of Oxford
GHG	greenhouse gas
GWP	global warming potential
I (7)	semi-structured interview respondent (number 7)
IPCC	Intergovernmental Panel on Climate Change
kg CO_2-eq.	kilograms of carbon dioxide equivalent
kt CO_2-eq.	kilotonnes of carbon dioxide equivalent
LCA	Life Cycle Analysis
Mt	Million tonnes
NatCen	National Centre For Social Research
N/A	not applicable
OFN	Open Food Network
p	p-value or probability
PCA	Principal Component Analysis
PhD	Doctor of Philosophy
P2P	peer to peer
Q (10.4)	attribute survey question (number 10.4)
RQ(s)	research question(s)
S (569)	attribute survey respondent (number 569)
SD	standard deviation
SDGs	United Nations Sustainable Development Goals
SILCI	Social Influence and *disruptive* Low Carbon Innovations research project
t CO_2-eq.	tonnes of carbon dioxide equivalent
UEA	University of East Anglia
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
WHO	World Health Organization

Definitions of key terms

Term	Definition used in this project
app	A digital application. This includes apps which can be downloaded by a user onto a mobile device, as well as digital platforms which function within internet browsers. Online food hubs tend to operate via a platform, but some also use an app.
attribute	A feature or characteristic of an innovation which describes a function or a benefit it can provide to a consumer. Innovations tend to have several attributes. If a potential user perceives the attributes as appealing, this increases their adoption propensity.
business model	Describes the rationale and process of how value will be created and delivered through the exchange of a good or service. This entails a relationship, primarily between a supplier or service provider and a consumer. Alternative business models facilitate exchanges between two consumers (where they adopt roles of 'provider' and 'user', e.g. P2P), or between two businesses/organisations (e.g. B2B).
consumer-facing (or end-user) innovation	An innovation which offers end-use goods and services directly to consumers. Consumer-facing innovations can be contrasted with upstream innovations, see below.
conventional supply chain	The mainstream supply chain comprised of farmers, wholesalers and supermarkets, through which the majority of UK consumers obtain their food.
CO_2 equivalent (or CO_2-eq.)	A metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential. The amounts of other gases are converted to the equivalent amount of carbon dioxide with the same global-warming potential. The agriculture sector is responsible for significant emissions of two greenhouse gases (in addition to carbon dioxide): methane and nitrous oxide.
demand-side mitigation	Solutions for mitigating climate change that target the consumption behaviour, purchasing decisions, lifestyles and social norms of end-users or consumers. Demand-side mitigation can be contrasted with supply-side mitigation, see below.
early adopter	An individual within the first 16% of a social system or population to adopt an innovation according to Rogers' (2003) *Diffusion of Innovations* theoretical framework (following the 'innovators', who comprise the first 2.5%; see Figure 4). All of the respondents in this study can be considered early adopters of online food hubs. The term is used interchangeably with 'food hub user' and 'hub customer' in this thesis.

Term	Definition used in this project
food behaviour	Consumers' food consumption patterns. This encompasses multiple activities: dietary choice, purchase, preparation, eating, storage, sharing, recycling and waste of food.
food miles	The distance food is transported from farm to consumer.
household (level)	Individuals living in one home who make shared decisions on their consumption behaviour. People tend to buy food for the entire family or household rather than individually and so 'household' was considered a more useful unit of analysis than 'per capita' for this project.
Life Cycle Analysis	A common method for determining the environmental impacts associated with all stages of a product's manufacture, use and disposal (see section 2.2.3 for more information).
population (level)	The total number of individuals in an area or making up a whole. In this project, the population level refers to the estimated total number of online food hub users in the UK (see Appendix 8.1)
potential future population (level)	The total number of individuals in a social system who may decide to adopt an online food hub, assuming full adoption according to Rogers' diffusion curve (see Figure 4). This hypothetical population was formulated on the basis of the potential adopters sharing one or more characteristics with the early adopters (see Appendix 8.2). It is anticipated these similarities would indicate an increased propensity to adopt.
supply-side mitigation	Solutions for mitigating climate change that target efficiency measures, policies or technological innovation. Emissions are reduced in the supply chain for a good or service, rather than during the consumption or use phase. Supply-side mitigation can be contrasted with demand-side mitigation, see above.
upstream innovation	An innovation which aims to improve the performance or efficiency of the supply chain for a good or service. In the context of food, this could be a new farming practice or a more efficient mode of transportation, although some upstream innovations are visible and accessible to consumers (see Figure 2). Upstream innovations can be contrasted with consumer-facing innovations, see above.
value proposition	The message associated with an innovation, product or service which promises to create value for an individual consumer or for broader society. It conveys information about how the consumer will experience the innovation through its functionality, business model, or some other perceived benefit.

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