ONLINE SHOPPING AND LAST-MILE DELIVERIES

Briefing Report

Technical Report CUED/C-SRF/TR18

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1. Introduction

Policy commitments to reduce greenhouse gases (GHG) in the UK and many other countries require the road freight industry to achieve major change in relation to this aspect of vehicle activity. In the UK, the road freight industry has pledged support to the government's voluntary commitment to reduce GHG emissions from heavy goods vehicles by 15% by 2025 (from 2015 levels) and will also play its part in the government's commitment to bring all GHG emissions to net zero by 2050. As an ever-increasing proportion of retailing shifts online in the UK, the last-mile deliveries associated with this trend are a growing source of GHG emissions in the road freight industry.

This briefing report provides a review of the shift towards online retailing in the UK and the last-mile delivery it results in, and the transport intensity, GHG emissions and other impacts associated with this phenomenon. It considers the logistics operations, consumer purchasing, technological, land-related and policy measures that could be taken by various stakeholders to help mitigate these impacts.

The term 'last-mile delivery' in this report refers to the final commercial transport stage in the retail supply chain of goods purchased online by consumers. This last-leg of commercial transport takes place between the final point of despatch of the goods (be that a warehouse, depot, fulfilment centre or shop) and the delivery point nominated by the consumer, which could be their home, workplace, a collection point, locker bank or other location from which the consumer collects these goods.

Chapters 2-8 discuss online retailing and last-mile deliveries prior to the start of the Covid-19 epidemic. The impacts of the Covid-19 epidemic on retailing, both in-store and online and on last-mile deliveries are discussed in chapter 9.

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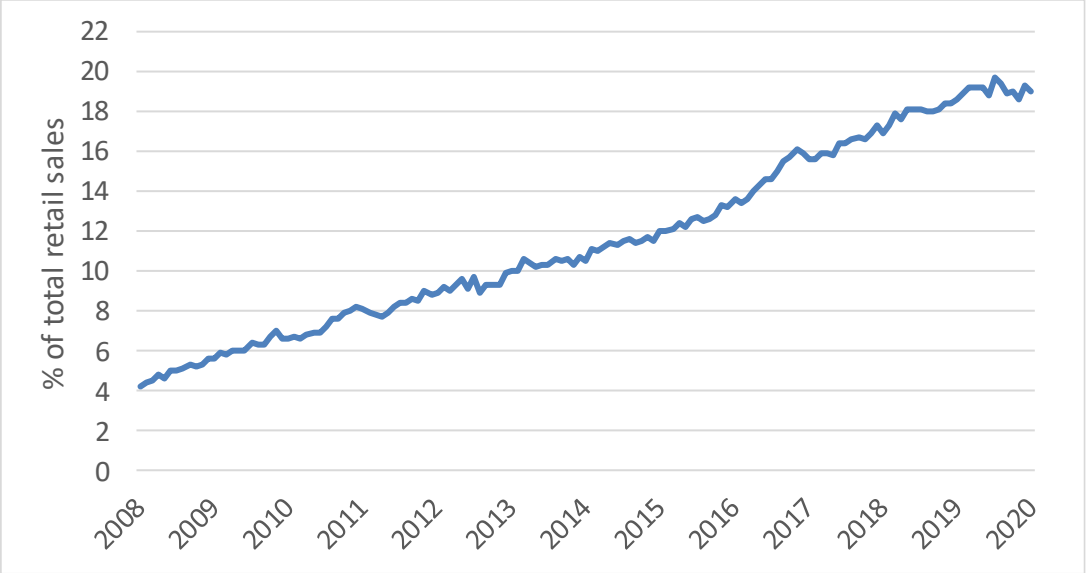
2. Growth and developments in online retailing

2.1 Importance of the UK online retailing market

Survey work by the Office for National Statistics shows that online retailing of physical goods accounted for twenty per cent of all retail spending in the UK in January 2020 (seasonally adjusted data – Office for National Statistics, 2021a). The growth in the proportion of total retail sales accounted for by online shopping has been rapid in recent years (see Figure 2.1). It has subsequently increased far more as a result of the Covid-19 pandemic (see chapter 9 for further discussion of the impact of the pandemic on online shopping in the UK).

Figure 2.1: Online sales as a percentage of total retail sales in the UK prior to Covid-19 (Jan 2008 - Jan 2020)



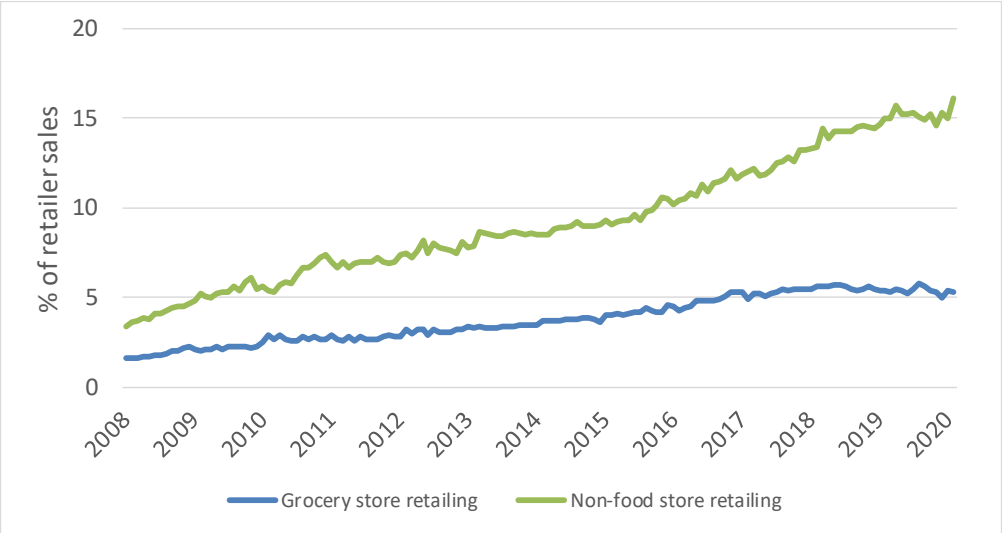
Note:
Data is seasonally adjusted.
Based on average weekly sales data for each month.
Most recent data point is for January 2020.
Source: Office for National Statistics, 2021a.

Online sales as a proportion of total retail sales increased at an annual average rate of 14% between 2014 and 2019 (calculated from data in Office for National Statistics, 2020). However, absolute and relative online shopping growth rates in 2018-2019 were lower than in previous years. In 2018 and 2019 online shopping as a proportion of total retail sales increased by only 10% and 8% respectively compared with the previous year, and between January and September 2018 and January and September 2019 there was an increase of 12% in total online spending, compared with 15-19% in the three preceding years (calculated from data in Office for National Statistics, 2020). A survey of online shopping in the UK by the Interactive Retail Media Group (IMRG) and Capgemini indicates that in July 2019 the year-on-year rolling average growth rate in online shopping sales was 6.5% (Office for National Statistics, 2020; IMRG and Capgemini, 2015 and 2019). However, growth in online spending is increasing much faster than is the case for UK retailing as a whole.

Figure 2.2 provides a breakdown of online retail penetration rates between food and non-food in the UK since 2008 until the onset of the Covid-19 epidemic. Overall online penetration rates were approximately three times higher in non-food than food retailing in January 2020 (15% of non-food retailer sales, compared to 5% on food retailer sales) (Office for National Statistics, 2021a). There was strong growth in online penetration rates in both sectors over the entire period since 2008, but online food penetration rates remained relatively flat between 2017 and the start of 2020,

whereas non-food penetration rates continued to grow, albeit at a slower rate than previously since mid-2018.

Figure 2.2: Online food and non-food sales as a percentage of retailer sales in the UK prior to Covid-19 (Jan 2008 - Jan 2020)



Note:
Data is seasonally adjusted.
Based on average weekly sales data for each month.
Most recent data point is for January 2020.
Source: Office for National Statistics, 2021a.

Despite this recent reduction in total online shopping expenditure growth rates, forecasts continuing to predict strong growth in online shopping in the UK. One forecast indicates 34% growth between 2018 and 2023, while another predicts 59% growth between 2018 and 2024 (Global Data, 2018a; Mintel, 2019a). In terms of the proportion of total retail sales in the UK, one forecast estimates that online shopping will account for 28% by 2024, while another expects that online shopping will overtake store-based sales by 2028, accounting for 53% of UK total retail sales (Mintel, 2019a; (Retail Economics & Womble, Bond and Dickinson, 2019). Factors cited to explain this predicted absolute and relative growth include: the penetration of smartphone and tablet technologies; improving online connectivity; the tendency among younger shoppers to shop online; continued reduction in physical stores; increasing use of artificial intelligence; and faster, cheaper last-mile deliveries and returns (Retail Economics & Womble, Bond and Dickinson, 2019).

Online retailing in the UK has a higher penetration rate than elsewhere in Europe. In 2019 online retailing accounted for 16% of retail sales in Germany, 11% in France, 10% in the Netherlands, 5% in Spain, and 4% in Italy. Online shopping is estimated to have accounted for approximately 16% of total retail sales in the USA in 2019 when calculated on a comparable basis (Centre for Retail Research, 2020a).

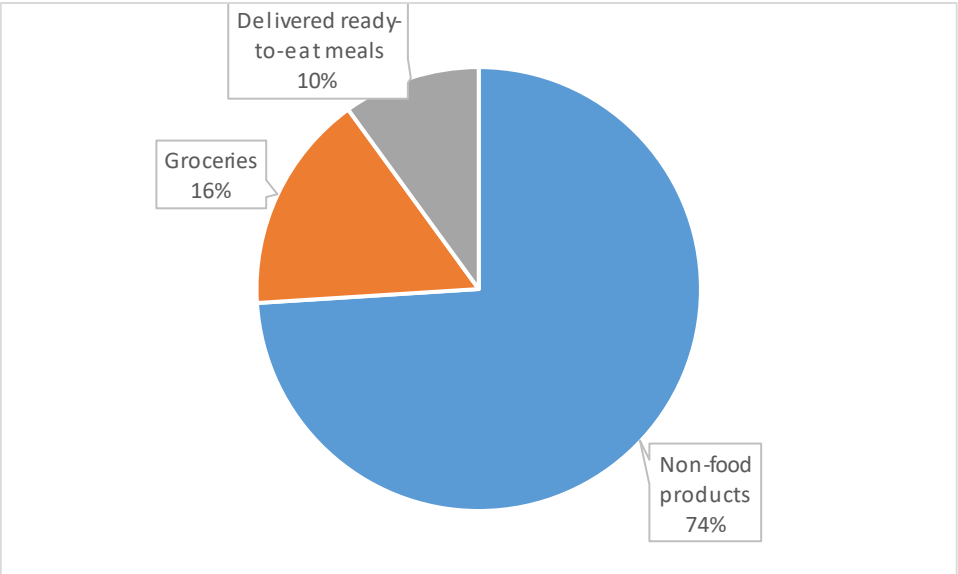
It has been estimated that the three largest online retailers, Alibaba, Amazon, and JD.com, account for approximately 40% of global online retail sales (Briest, 2019).

2.2 Market size of online retailing in the UK

Office for National Statistics data indicates that total non-food and grocery online shopping sales in the UK totalled £68 billion in 2018 (calculated from Office for National Statistics, 2020). In terms of the importance of different sectors within these online shopping sales, online grocery sales were estimated to be £12 billion in 2018, accounting for approximately 7% of total grocery sales (Mintel, 2019b), while online non-food sales were estimated to be £56 billion, accounting for approximately 25% of total non-food sales (Mintel, 2019a and Global Data, 2018a). These market size estimates

exclude online orders of delivered meals, which are estimated to have generated total sales of £8 billion in the UK in 2018 (MCA, 2018 quoted in AHDB, 2019). From this information it is possible to estimate that online shopping sales of physical goods (including grocery, non-food and meals) in the UK in 2018 amounted to approximately £76 billion, of which non-food product sales accounted for 74%, grocery sales for 16%, and delivered meals for 10% (see Figure 2.2).

Figure 2.2: Online shopping for physical goods by sector in the UK in 2018 (based on sales revenue)

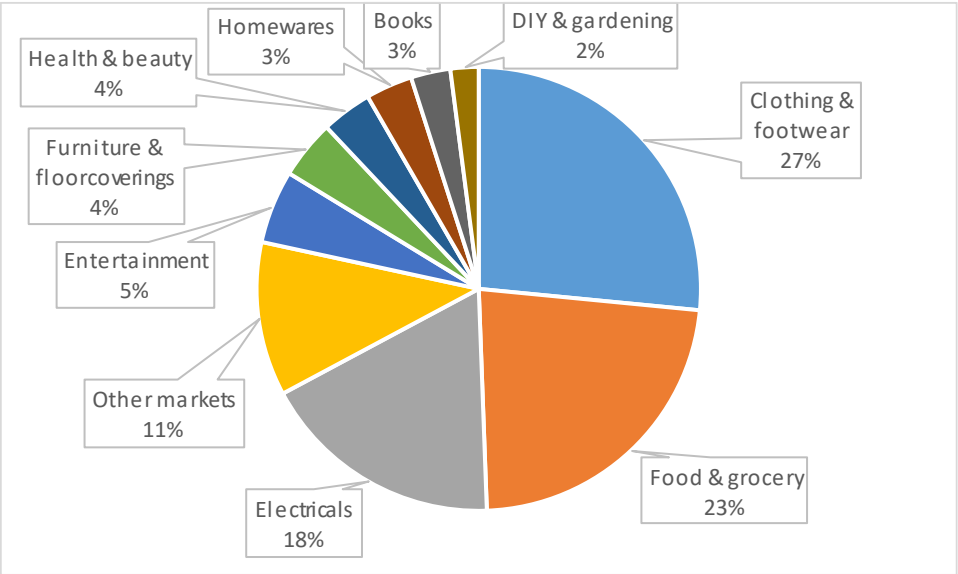


Source: Calculated from various sources including ONS, 2020, Global Data, 2018a, MCA, 2018, Mintel, 2019b).

The non-food sector comprises both smaller items that are delivered as parcels, and larger, heavier items, including furniture and white goods (fridges, freezers, washing machines, dishwashers etc.) that are delivered by two-person delivery crews due to their weight and size and which also require installation. Online sales of these larger, heavier goods requiring two-person delivery were estimated to represent approximately 20% of total online non-food sales in the UK in 2018 (Global Data, 2018a; Global Data, 2018b), with the remaining 80% of online non-food sales representing smaller items delivered as parcels and packages. The demand for these large two-person products is growing very slowly compared to the strong growth for online small non-food products and the last-mile parcel deliveries they result in (Global Data, 2018b).

A survey shows the breakdown of UK online retailing for physical products (including groceries but excluding meal delivery) by sales in 2018 as follows: clothing & footwear (27%), food & grocery (23%), electricals (18%), other including toys and games, sports equipment, jewellery, and stationery (11%), entertainment (5%), furniture and floorcoverings (4%), health & beauty (4%), homewares (3%), books (3%), and DIY & gardening (2%) (see Figure 2.3) (Global Data, 2018a). The proportion of total retail spending accounted for by online shopping varies by sector, ranging from approximately 9% in the grocery sector to 60% in books and 75% in entertainment (Global Data, 2018a). Another survey shows that the types of items purchased online which the greatest proportion of respondents reported buying in the previous 12 months were: clothing and footwear (57% of respondents), books, CDs, DVDs and computer games (39%), food and drink (35%) and cosmetics and toiletries (33%). Other product types that 20%-30% of respondents had bought online in the previous 12 months included: furniture and home furnishings, toys and games, consumer electronics and electrical and DIY and gardening products (Mintel, 2019a).

Figure 2.3: UK online retailing in 2018, sales revenue by sector



Note: 'Other markets' includes: toys and games, sports equipment, jewellery, stationery and opticians. Ready-to-eat meal deliveries are not included.
Source: Global Data, 2018a.

Year-on-year growth rates in the three sectors of online shopping in 2018 were: 12% in the revenues of parcels carriers, 9% in online grocery sales, and 13% in online spending on ready-to-eat delivered meals (Mintel, 2019a; Mintel, 2019b, MCA, 2019).

Online retailing of non-food small items predominantly involves orders placed with professional, full-time retailers (so-called Business-to-Consumer orders - B2C). However, a small but growing proportion of these orders are placed with private individuals who, as well as having another main form of work, sell products either made by themselves or that they have purchased second-hand and sell at a mark-up in their spare time, usually on online marketplaces such as Amazon Marketplace, eBay, and Etsy. This is referred to as Consumer-to-Consumer orders – C2C).

Other sectors in which online orders and last-mile deliveries are growing include prescription and over-the-counter medicines. No estimates of the size of this online market are currently available. However, there were approximately 350 registered online pharmacies in the UK in 2019, the largest of which, Pharmacy2U, was dispensing approximately 250,000 items per month in 2018, and has continued to grow since (Barrow, 2019; DHL, 2019). Although online pharmacies currently account for only a small portion of the total prescription medicine and over-the-counter health product markets, it should be noted that these are sizeable markets. The cost of NHS primary care prescribing (i.e. prescriptions issued by General Practitioners in England) was £9.0 billion in 2018, and the value of the over-the-counter medicine market (such as pain killers, cough and cold remedies, and vitamins and minerals that can be purchased without a prescription) was £2.6 billion in Britain in 2017 (Ewbank et al., 2018; Connelly, 2017). Many prescription and over-the-counter medicines ordered online are able to fit through the letterbox when delivered to home, so do not require the customer to be present to receive them.

2.3 Online retailers and last-mile delivery operators in the UK

There are eleven third-party parcel carriers that offer national next-day delivery services for business-to-consumer (B2C) and business-to-business parcel movements in the UK (namely APC, DHL, DPD, DX, FedEx Hermes Parcelnet, Royal Mail which includes Parcelforce, Tuffnells, UPS and Yodel). Concentration is taking place in this national next-day market with FedEx purchasing TNT in 2016, DHL acquiring UK Mail in 2016, and Citylink going into administration in

2014. In addition, Amazon Logistics carries out in-house last-mile logistics services via agents for non-food products purchased from Amazon. There are also many smaller next-day parcel carriers that either work in specific sectors or localities, as well as same-day parcel couriers such as CitySprint and Addison Lee.

The leading third-party parcel carriers, who are responsible for last-mile deliveries of these smaller non-food items together with business-to-business parcels are estimated to have had total sales revenues of £10.0 billion in the UK in 2017-2018, and to have handled 2.6 billion parcels (Ofcom, 2019). Another estimate that attempts to take account of the total UK parcels market including smaller carriers and same-day couriers estimates total sales revenues of £12.6 billion and 3.6 billion parcels in 2018 (Mintel, 2019c). These parcel volumes include both business-to-consumer (B2C) parcels and business-to-business (B2B) parcels, with B2C accounting for approximately three-quarters.

Online grocery retailing and last-mile delivery is offered on a widespread basis in the UK by eight retailers (namely Amazon, Asda, Iceland, Morrisons, Ocado, Sainsbury, Tesco, and Waitrose). Of these, Tesco generates by far the greatest online sales, approximately twice as much as its nearest rivals Sainsbury, Asda and Ocado (Mintel, 2019b). Marks and Spencer entered into a joint venture with Ocado called Ocado Retail in August 2019, acquiring a 50% stake, in order to gain a stronger presence in online grocery retailing. Ocado Retail has a 15% market share of the UK grocery delivery market based on sales and makes 316,000 grocery deliveries per week (Marks and Spencer, 2019). The Co-op offers online shopping from some of its urban stores, making last-mile delivery on a same-day basis by cargo cycle. With the exception of Ocado Retail and Amazon, all the other major online grocery retailers also operate physical stores. In addition, there are many smaller online retailers offering direct-to-consumer sales for their brands (especially wine and other drink sellers), as well as recipe box and vegetable box online retailers. It can be estimated that in 2018 approximately 100 million online grocery orders were placed over the course of the year in the UK, with Tesco alone responsible for approximately 30 million of them.

Just Eat, Deliveroo and Uber Eats are the main specialist meal ordering marketplaces and delivery companies in the UK. Amazon Restaurants closed its marketplace and delivery service in London in 2018 and in US cities in 2019 due to the fierce competition (Perez, 2019). However, Amazon was the largest investor in Deliveroo's latest investment funding round in 2019 in which it raised $575 million (Russell, 2019). Other major companies in the meal delivery market include takeaway chains especially in the pizza sector (including Dominos, Pizza Hut, and Papa Johns). McDonalds and Kentucky Fried Chicken have also commenced delivery services, working in conjunction with Uber Eats. In addition, many independent restaurants especially those offering Chinese and Indian meals, take their own orders and make deliveries themselves. The average order value of the largest platform provider, Just Eat, was £19.05 in 2018 (Just Eat, 2019a). Using this average spend, the total market size of £8 billion indicates that there were approximately 400 million last-mile ready-to-eat meal deliveries in 2018.

2.4 Revenues and profitability in the online retailing sector in the UK

Despite the growth in consumer spending on online shopping in the UK, achieving company profitability in this market is a far more challenging proposition. Concerns have been expressed about the long-term profitability of online retailing for non-food, grocery and delivered meals (Oliver Wyman, 2015). The 2014 profit and loss statements of online-only (also known as 'pure-play') retailers showed that only 5 of the 13 listed in Internet Retailer's '2015 Top 500 Guide' that were publicly traded (excluding e-retailers that are divisions of larger companies where e-retail net income is not broken out) generated a profit in that year. Meanwhile, their median year-on-year sales increase was approximately 15% (Enright, 2015). The same profitability problem affects store-based (i.e. multi-channel) retailers in their online retailing division, who are also experiencing reduced sales levels and profitability in their physical retail outlets at the same time. A survey of approximately 300 executives in European and North American online retailers, manufacturers and logistics providers found that 42% of respondents' companies' profit margin had decreased

over the previous 108 months, while profit margins had remained stable in 41% of respondents' companies and had increased in 17% of respondents' companies (eft, 2018a).

Major challenges facing online retailers in their efforts to achieve profitability include: i) that consumers can easily compare online prices between retailers (more so than in a store-based shopping environment), and that this transparency in prices has led many retailers to heavily discount their goods in order to attempt to gain sales volume; ii) given the number of online retailers and the level of price competition between them, it is difficult for new entrants and smaller online retailers to gain orders and sales volume – it also results in the need to spend substantial money on website design, marketing and advertising to achieve brand presence; iii) product return rates for non-food online shopping are typically far higher than for in-store purchases; iv) the delivery charges for online retailing (if there is any charge at all – many retailers provide 'free' delivery in an effort to generate online sales) typically do not cover the logistics costs (Goldberg, 2019).

Online retailers often have relatively low net profit margins (if they actually make a profit), from 0.5% to 3.5% (Ross, 2019). Amazon, the largest Western online retailer, reported a profit for the first time in its history in the first six months of 2016. It achieved a net profit margin of just below 2% from then until 2019 (despite having a market capitalization of over $900 billion - Ross, 2019). Amazon reported year-on-year sales growth of 24% in the third quarter of 2019, but a reduction in profitability of 25% which it attributed to higher shipping costs in its efforts to provide one-day shipping to its Amazon Prime members (BBC News, 2019a). The company had made a similar announcement about rising shipping costs linked to one-day deliveries in quarter 2 of 2019. This led to Amazon failing to meet profit targets for the first time in two years (Rana and Dastin, 2019). Despite these profitability issues, Amazon is capturing an ever-growing proportion of the online sales market share. Taking into account both goods it sells itself and goods sold on its marketplace, Amazon's revenue in 2015 was equivalent to 33% of all retail goods sold online in the United States compared with 29% in 2014. By 2018 this had increased to 49% (Lunden, 2018).

A survey of online experts suggested that in Europe more than 80% of luxury retail brands make a profit from online operations, compared to more than 60% of large, bulky consumer electrical and sportswear retailers, less than 50% of fashion goods and small consumer electrical retailers, and less than 10% of grocery retailers (Strategy&, 2017).

Next plc, the clothing and homeware retailer with both a physical store and online presence, provides an interesting case study. In its Annual Report for the year ending January 2019, the company reported that store sales and profit had fallen by 8% and 21% respectively over the previous 12 months, while online sales and profit had increased by 15% and 14% respectively. However Next plc also reported that, "every additional order online has increased variable costs, such as warehouse picking and delivery costs. Last year, every Pound of Next business that transferred from Retail (i.e. store) to Online cost an additional 6p" (Next plc, 2019a). In its most recent Half Year Results, Next plc further reported that growth in its online business and sales and the related requirements to handle an increasing number of unique items has put a strain on its warehousing infrastructure and required more warehouse workers. The company has had to increase its number of warehouses and total warehousing space, and operate same-day warehouse-to-warehouse stock movements to collate all customer items ordered in a single parcel. Even without wage inflation, "the average cost per unit picked has increased by +10% since 2016" (Next plc, 2019b).

It was recently reported that, "the economics of online and the potential to make it profitable vary widely from (apparel and fashion) sector to sector" (Anita Balchandani of McKinsey & Co. quoted in Sutherland, 2019). A UK department store apparently told suppliers that any online order under the value of £30 is unprofitable (Sutherland, 2019). Even in the same sector, online-only retailers' sales and profitability situations can vary substantially depending on pricing, website and other decision-making. For instance, ASOS, the online fashion clothing retailer, which experienced rapid sales and profit growth in recent years, reported a 14% increase in sales but an 87% fall in pre-

tax profits for the six months to February 2019 compared with the same period in the previous year. The company explained that this was due to website traffic problems and heavy discounting that was required to match competitors (BBC News, 2019b). By contrast, Boohoo, ASOS' online fashion retail rival, reported sales growth of 48% and a pre-tax profit increase of 38% in the year to February 2019 (Jahshan, 2019).

Whereas physical retail stores generate ever-increasing profit margins as sales volumes increase (as the overhead costs are largely fixed), online retailers do not experience the same rate of increasing profit margins as sales increase, due to picking and delivery costs per order remaining essentially the same with each new order (i.e. not falling per order as order levels increase). Therefore, online sales do not benefit from economies of scale to anything like the same extent as store–based sales. Research in the grocery sector has indicated that, while retailers' costs are split 56%:44% between fixed and variable costs for in-store sales, online retailers' costs are split 30%:70% between fixed and variable costs (Foley Retail Consulting, 2017).

In addition, the picking and delivering costs for an online order at any given company are essentially the same regardless of the order value. Therefore, average order value is of key importance to the profitability of online sales. However, many retailers do not discourage, and even actively encourage, small orders through their pricing policies in their efforts to attract customers and sales.

By contrast, retail chains with many physical shops require stock levels that are far greater in total than if they were an online-only retailer with one or a small number of warehouses. For instance, a multiple clothes retailer with physical stores needs far more stock than an online-only retailer if they want to have the full range of clothes available in all sizes and colours, which results in far greater levels of capital being tied up in this stock. In addition, the store-based retailer cannot quickly or easily change this range of clothes if demand changes, but an online retailer can hold far less stock and change their decisions about what to sell to meet demand and, for example, changes in weather than their store-based counterpart.

Research has shown that the average operating profit margins for the UK's top-10 store-based (i.e. multi-channel) non-food retailers more than halved between 2011 and 2015, from 6% in 2011 to 2.5% in 2015 (OC&C Strategy Consultants, 2016). This research also indicated that even in-house click-and-collect services for non-food retail (i.e. which customers collect from store themselves) cost UK retailers four times more than traditional in-store purchases by consumers. Meanwhile, the last-mile delivery of parcels was found to be 5-23 times more expensive than in-store purchases for retailers (depending on parcel size and delivery service). At the same time, consumers were found to be unwilling to meet these last-mile delivery costs (OC&C Strategy Consultants, 2016).

It is likely that grocery retailers have never made any profits on online sales ever since the origin of online food sales, but have until recently been prepared to withstand these losses in their efforts to increase sales volumes and market share and keep city analysts appeased. A report from 2001, in the early days of online grocery shopping, highlighted this exact same profitability problem, with losses being made on each order (Browne et al., 2001).

Research carried out in 2015 by Kurt Salmon for Retail Week estimated that the typical cost to a major UK supermarket chain of fulfilling an average £100 online order, in which the grocer picked the items ordered in-store, is between £28 and £30 (taking into account the costs of distribution, wages, marketing, fuel, and vehicle leasing or maintenance). The research indicated that supermarkets were making an average gross margin of approximately £25 for every £100 online order, resulting in each online order for home delivery that they take resulting in a loss to them of £3 to £5. Assuming approximately 90 million annual grocery home delivery orders in the UK, it was calculated that this equated to a total loss to UK supermarkets of approximately £300 million per annum in 2015. The research estimated that the actual operating cost of transporting an average £100 order to a customer's home (i.e. the last-mile component of the home delivery

operation) was £8 to £9, whereas typical delivery charges to consumers were £1 to £6 for home deliveries, depending on the order size (Tugby, 2015). The research suggested that supermarkets were incorporating the picking and delivery costs associated with online orders into store operating costs, while other costs including online advertising were being allocated under marketing budgets (Tugby, 2015). The head of Sainsbury's online services stated that supermarkets had "destroyed" the value of online grocery shopping by under-charging for deliveries. He said that grocers needed to "learn to charge for these amazing services we offer our customers". Meanwhile, Aldi's UK head admitted that he could not see a means of achieving profitability in online grocery "anywhere in the market" (Tugby, 2015).

A 2018 survey of 500 grocery retailers and consumer product firms together with 2,900 consumers in five countries found that, on average, each grocery last-mile delivery cost retailers approximately $10 but consumers are only charged approximately $8, resulting in a typical $2 loss per delivery. Only 1% of consumer respondents would be prepared to pay the total cost incurred. Ninety nine per cent of executives stated that online orders are less profitable than in-store orders - on average, 19% less profitable (Capgemini Research Institute, 2019).

In 2018, the meal ordering marketplace Just Eat's order numbers increased by 28% on the previous year to 221 million, with a revenue of £779 million, an increase of 43% on 2017. Just Eat achieved an EBIDTA (operating profit before interest, taxation, depreciation, amortisation and non-recurring items) of £174 million in 2018, which is a 6% increase on 2017. Profit before tax was £102 million in 2018, compared with a loss of £72 million in 2017 (Just Eat, 2019b). Just Eat did not originally provide its own delivery services, instead it took orders and payments and then passed orders to restaurants for preparation and delivery. However, it begun to implement its own delivery operation to provide last-mile services for some of its orders in 2018. In the UK in 2018 it invested £21 million in the roll-out of these last-mile delivery services and recruited 2,000 delivery couriers covering approximately 35% of Just Eat's addressable customer population. This was expanded to 5,200 delivery couriers in the first six months of 2019. It also continues to work with a third-party courier. Just Eat reported "an improving trend in the delivery economics reaching breakeven on a gross profit basis in our more mature zones (Just Eat, 2019a, 2019b).

Deliveroo, the meal ordering marketplace and delivery company, reported revenues of £277 million in 2017, an increase of 116% on the previous year. However, losses increased from £129 million in 2016 to £184 million in 2017. During 2017, Deliveroo raised another $493 million of investment, giving the company a valuation in excess of $2 billion, and then raised another $575 million in 2019 (Roofoods Ltd, 2018; Russell, 2019).

Retailers providing online shopping have, until now, felt unable to raise product prices, or even the explicit price charged for delivery services (where these services are explicitly priced – which they are often not). This is due to the level of competition they face from retail competitors, both in terms of price and delivery services offered. In fact, in recent years the level of last-mile delivery service offered to the consumer has tended to become ever-more enhanced (in terms of the speed of delivery, specific delivery time slots offered, delivery day guarantees, product returns policies, etc.), further increasing logistics and delivery costs to the retailer, whilst overall product prices and any explicit delivery charges have either failed to keep pace, or have not increased at all.

In addition to causing profitability problems for the retailers, the under-pricing of last-mile delivery services has also resulted in financial difficulties for logistics companies providing these home delivery services to retailers. For instance, parcel carriers in the UK have experienced ever-growing demands from retail customers for increases in the quality of their logistics services offered, without related increases in the unit prices paid. This has caused severe financial difficulties for some major parcel carriers (see Allen et. al., 2016). Data indicates that the price that carriers receive per parcel handled has been falling over the last five years (Ofcom, 2014-19, see Table 2.1).

Table 2.1: Changes in parcel volumes, revenues and rates per parcel in the UK, 2013/14-2018/19

Year	Change in total parcel volume	Change in total parcel revenue	Change in revenue per parcel
2013/4-2014/5	+7%	+3%	-4%
2014/5-2015/6	+14%	+13%	-1%
2015/6-2016/7	+7%	+5%	-2%
2016/7-2017/8	+9%	+4%	-5%
2017/8-2018/9	+9%	+4%	-5%

Note: Data is for domestic parcels.
Source: calculated from data in OFCOM, 2015-2019.

However, despite this mismatch between what consumers are willing to pay for online shopping deliveries and the cost of providing these services, this is not currently causing retailers to dramatically rethink their delivery options and operations. Instead, in their efforts to increase their online sales, retailers are continuing to offer faster delivery services to customers without covering or recouping these costs.

The differential between the cost of last-mile delivery operations and the revenues received for it indicates the importance retailers should place on controlling these delivery costs. Last-mile deliveries are the most expensive part of the entire logistics operations per item handled. Minimising these costs will involve retailers rethinking warehousing systems and locations, picking and packing arrangements, delivery services offered to consumers, and delivery systems operated from fulfilment centres to the consumer.

2.5 Online shopping behaviour of consumers

A survey of 2,000 online consumers in the UK, found that, in 2018, 95% of adult internet users (i.e. over 16 years old) had shopped online in the past year. Taking into account those who do not use the internet, this is equivalent to 88% of the UK population (Mintel, 2019a). Approximately one third of online shoppers in the UK said that in 2018 they shopped online at least once per week, approximately 50% shopped once or twice per month, while the remaining 15% only shopped online a few times per year. The frequency of online shopping varied by age, with far more of those aged 16-44 shopping online at least once per week than older consumers, and far more of those aged 55 and over shopping online only a few times per year than younger consumers (Mintel, 2019a).

Another UK survey showed that those aged 16-34 shopped online most frequently, with 29% placing an order at least once per week, another 24% ordering once a fortnight, and a further 21% ordering once per month. On average, those aged 16-34 placed 2.7 online orders per month. By contrast, approximately 15% of those aged 55 and over ordered at least once per week, 15% once per fortnight, and 35% once per month, with the remaining 35% placing orders every six months or even less frequently. On average, those aged 55 or over placed 1.5 online orders per month (Retail Economics & Womble, Bond and Dickinson, 2019).

An international survey of 18,000 respondents in 2017 found that the most important reasons given by consumers for shopping online rather than in a store were: ability to shop at any time (mentioned by 58% of respondents), ability to compare prices (54%), better prices available online (46%), to save time (40%), convenience of not going to shops (39%), greater variety/selection (29%), free delivery offers (29%), and the convenience of having all goods available in one location (27%) (KPMG, 2017). In a UK survey of 10,000 online consumers in 2018 respondents identified the following factors as being of greatest importance in determining their use of online shopping: convenience (42%), lower prices (35%), save time (27%), can shop anytime (26%), better

selection (23%), product not available elsewhere (18%), ability to compare prices (18%), more product information available online (11%), and prompted by an online promotion (10%) (Global Data, 2018a).

In a 2017 international survey, the most important factors cited by respondents when deciding which company to buy from online were: the lowest price available (with 57% of respondents mentioning this), enhanced delivery options (43%), easy product returns policy (40%), payment options (34%), and ability to see if the product is in stock (33%) (KPMG, 2017). In a UK survey, respondents rated product prices, cost of delivery and product availability as the three most important factors when placing orders, in this order of importance (Retail Economics & Womble, Bond and Dickinson, 2019). Survey results indicate that the most important checks carried out by online shoppers in the UK before placing a non-food order in 2018 are: price offered by different retailers (mentioned by 57% of respondents), checking delivery and returns services (42% of respondents), and searching for a discount voucher (31%). Twenty three per cent of respondents said they go to a physical store to see these products before ordering online (Mintel, 2019a).

Seventy four percent of survey respondents said that they had used a computer to place an online shopping order in 2018, compared with 44% by mobile phone and 30% by tablet. The use of computers is becoming relatively less common over time, while the use of mobile phones is increasing, with 16-34 year-olds reporting that they are more likely to use a mobile phone than a computer (Mintel, 2019a). Survey work has indicated that online sales via smartphones and tablet devices increased by 75% between 2014 and 2018 (IMRG and Capgemini, 2015 and 2019). Approximately two-thirds of consumers reported having used their mobile phone to look up products while in a physical store in 2017 (KPMG, 2017). A survey of 10,000 UK online consumers showed that, in 2018, 88% of orders were placed while at home, 7% while at work, 4% while in a physical retail store, and 1% while in a public place (Global Data, 2018a).

For meal deliveries, a survey of 1,600 users showed that 81% of respondents had ordered meals direct from a restaurant or takeaway (online, by phone, or in person), while 34% had ordered online via a third-party platform provider in 2018 (Mintel, 2019d). Some third-party platform providers for meal deliveries offer monthly subscription services that provide unlimited deliveries for a fixed monthly fee.

Survey work indicates product category differences in the average time UK consumers spend searching online for products and the number of products they view before placing an order: this ranges from 6.6 days and 8 products viewed from start of browsing to order placement for beauty products, to 10.0 days and 19 products for consumer electronics (Criteo, 2016). This survey also indicated differences between product categories for the proportion of orders placed on impulse. On average, impulse purchases by respondents accounted for 28% of all online orders placed, ranging from 25% in consumer electronics to 38% in baby care products (Criteo, 2016).

Delivery subscription services have become increasingly common in the UK in recent years, permitting consumers to receive free deliveries. A survey indicates that 39% of respondents had access to Amazon Prime in 2018, while 24% of grocery shoppers were part of such a scheme. Approximately 25-30% of consumers placing clothing orders with ASOS and Boohoo are members of such delivery schemes (Mintel, 2019a).

2.6 Difficulties for physical store-based retailing and in-restaurant dining in the UK

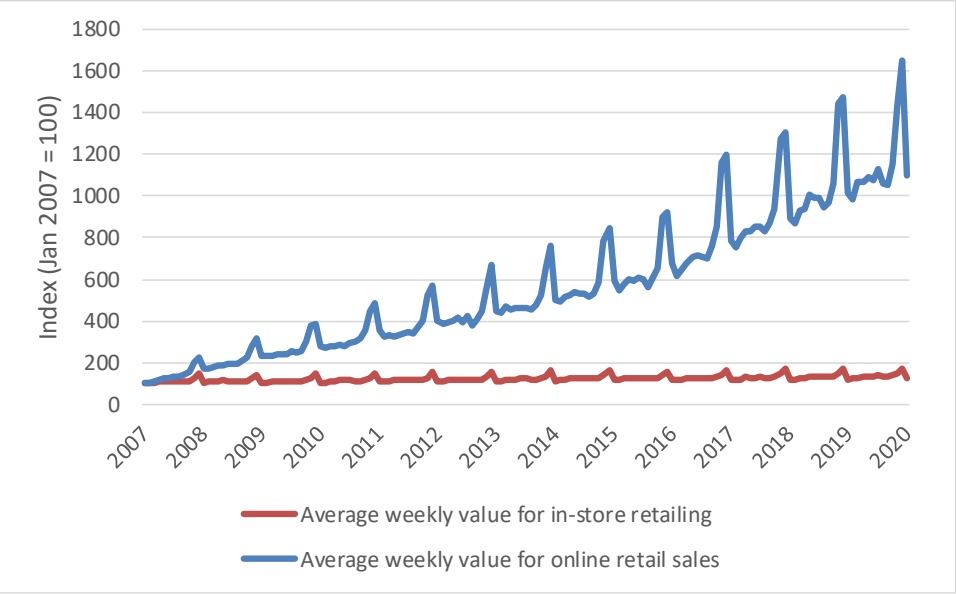
Store-based retailing has suffered a severe downturn in recent years, with many shops and eat-in restaurants experiencing falls in retail sales and profitability, and many chains and independent stores closing across the UK. Several household names have ceased trading and gone into administration in the last four years including Woolworths, BHS, Toys R Us, Blacks, Poundworld, 99p stores, Mulityork, HMV, MFI, Beales, Austin Reed, My Local, Netto Store 21, Linens Direct, Bathstore, Bonmarche and Mothercare. In addition, Staples took the decision to close all 106 of

its physical stores in 2016 (Butler, 2019; Centre for Retail Research, 2018; Centre for Retail Research, 2019a). Major restaurant chains including Jamie's Italian, Byron, Strada, and Prezzo have all announced site closures. There was a 20% increase in restaurant insolvencies in 2017 and a report indicated one third of the top restaurant chains in the UK were loss-making (Butler, 2018b; Davies, 2018).

Nearly a quarter of FTSE General Retailers issuing warnings in the first half of 2018 (double the number of a year earlier), and this rose again by the end of the third quarter in 2019, with 31% of FTSE retailers having issued profit warnings in the previous twelve months (EY, 2019). Several major retailers including Debenhams, Marks & Spencer, Topshop owner, and Arcadia, have announced plans to close further stores (Butler, 2019). The British Retail Consortium announced in October 2019 that employment in quarter three in the UK retail industry comprised 85,000 fewer jobs than 12 months earlier, a fall of 2.8% (British Retail Consortium, 2019).

Figure 2.4 shows the comparison between changes in total UK store-based retail sales (including online sales) and total UK online sales since 2007. This shows the extremely strong growth in online sales compared with the flat performance in store-based sales.

Figure 2.4: Change in UK store-based and online retail sales, Jan 2007 – Jan 2020 (Index Jan 2007 = 100)



Note: Based on average weekly sales data for each month.
Non-seasonally adjusted data.
These figures do not take account of price inflation.
Does not include restaurant and online meal delivery sales.
Source: Calculated from data in Office for National Statistics, 2021a.

Several factors are responsible for these trading difficulties being experienced by physical retailers and eat-in restaurants, of which the growth in online shopping is an important one. Other factors cited by physical retailers, retail analysts, trade associations and politicians include: there being too much retail space in total; the fragmented ownership of retail stores and town centre property resulting in a barrier to co-ordinated response; a lack of investment in stores and weak forward planning in response to retail change; the overhead costs of business rates and rents being high; the lack of a level playing field in terms of taxation between online and store-based retailers (with the latter paying business rates and the former not); increases in the national living wage; rising pensions costs; high property rental costs; and the devaluation of sterling (Deloitte, 2017; Butler, 2019; Centre for Retail Research, 2019b; Housing, Communities and Local Government Committee, 2019; House of Commons Treasury Committee, 2019). The Covid-19 epidemic has severely worsened this situation – see chapter 9 for further discussion.

Other research has indicated that although online retailing is growing faster than store-based retailing, not all store-based retailers are struggling. A US study found that between 2007 and 2016, “a vastly disproportionate share in income growth had gone to high household incomes” (Deloitte, 2018), while the share of non-discretionary expenditure by those in the low-income group had increased substantially (including housing and food), leaving them with little or no disposable income, and in many cases being in debt even before consideration of their purchasing of discretionary items. The middle-income group also saw no increase in their disposable income, with only the high-income group experiencing an increase in their disposable income over the period. Overall, 80% of consumers had less disposable income for discretionary purposes, which is likely to have resulted in their increased use of discount retailers. By studying the revenues of different types of US retailer it was found that, over the previous five years, retailers in ‘premier’ and ‘price-based’ groups had experienced strong growth in store sales, while retailers in the middle had experienced virtually no sales growth (Deloitte, 2018). The analysis also found that in the US, there were more store openings than closures between 2015-2017 among retailers studied, but that while discounters and premier retailers had been opening stores, it was the retailers in the middle that had been closing stores (Deloitte, 2018). A similar situation may be occurring in the UK, as retailers in the middle (i.e. neither discounters nor premier) appear to be suffering the greatest difficulties in store-based retailing.

As a result of these pressures on retailing, there have been substantial store closures in the UK – it is estimated that approximately 35,000 shops closed between January 2018 and October 2019 (Centre for Retail Research, 2019b). Sectors most affected by closures since 2007 are clothing stores, shoe shops and off-licences (Centre for Retail Research data reported in Rhodes, 2018). Shop vacancy rates in the UK were 13.0% in the first half of 2019 (Local Data Company quoted in Imms, 2019). Across the entire UK retailing vacancy rates are lowest in retail parks and highest in shopping centres. The oversupply of shops in the UK is forecast to rise to 20% (approximately 100,000 shops) (Local Data Company, 2018; The Grimsey Review, 2018). Many UK town centres are being adversely affected by this decline in store-based retailing and footfall is reducing. Data based on 24 hours per day, 7 days per week measurements in 150 UK town and city centre locations shows that footfall decreased by 17% over the period 2009-2017 (this is based on footfall for all purposes not just retail – Springboard quoted in Millington et al., 2018).

Despite the decline in physical store sales in recent years, stores remain important within retail sales in terms of store sales as well as in terms of stores being used as in-house click and collect locations for online purchases, and used for in-store, in-person browsing by consumers who order online. Taking into account these various roles played by stores (i.e. including click and collect and in-store browsing), it has been estimated that, in 2017, stores were involved in 84% of all retail sales in the UK (Global Data, 2018a).

3. Key attributes of last-mile delivery operations

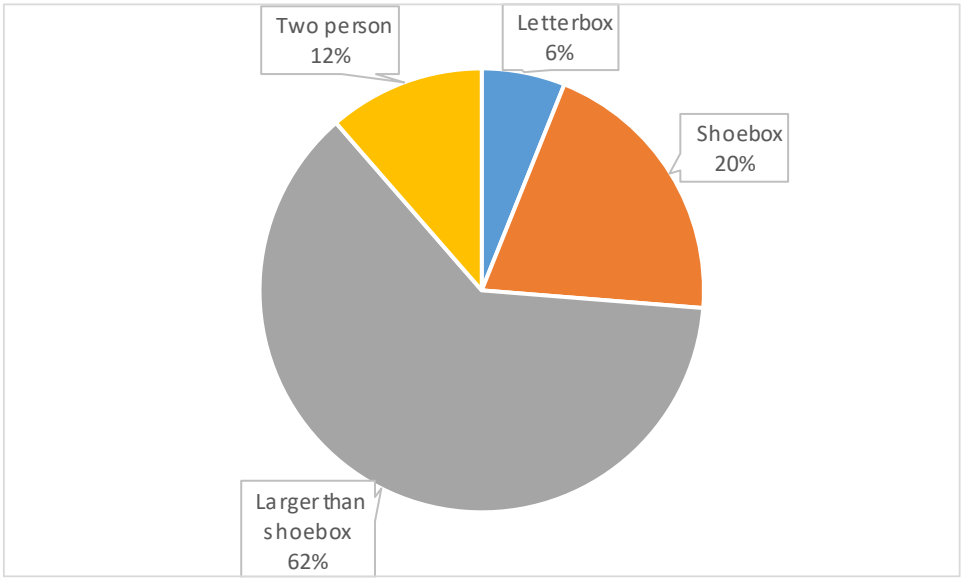
As explained in section 2.4, Amazon and Next have recently referred to the high and growing costs of their last mile deliveries (BBC News, 2019a; Rana and Dastin, 2019; Next plc, 2019a; Next plc, 2019b). A survey of 500 online retailing executives in 2018 found that delivery operations account for 41% of last-mile logistics costs (compared with 20% for sortation, 16% for handling, 13% for warehousing, and 11% for other supply chain costs (Capgemini Research Institute, 2019).

All grocery and ready-to-eat meals are delivered by one person using a vehicle. Refrigerated vans are used for most grocery deliveries (made on a multi-stop basis), while bicycles, cargo cycles and mopeds are used for small, same-day grocery deliveries in some urban areas. Ready-to-eat meals are delivered using bicycles, mopeds, motorbikes and cars. The vast majority of non-food items ordered online by consumers are relatively small and light, and are delivered as parcels and packages by one person using a van or car. Some larger, heavier non-food items such as electrical white goods (e.g. washing machines, refrigerators, dishwashers), large assembled furniture (e.g. sofas, dining tables, cupboards) and some gardening and DIY items are delivered by two-person crews using larger, heavier goods vehicles. Other online consumer orders of heavy products including building materials and gardening products such as turf and soil are typically delivered by one person using larger, heavier goods vehicles (HGVs) with mechanical handling equipment. In the case of all of these heavy/large products, even prior to online shopping they have always been delivered to consumers' homes rather than being collected by consumers, so, in these cases, online shopping has had little if any effect on who is responsible for this final transport leg to the consumer.

The most commonly used vehicle type for last-mile deliveries is therefore the van, with bicycles, electric bikes, mopeds, motorcycles and larger rigid HGVs also used depending on the type of delivery involved. These vehicles differ substantially in terms of their volume and weight carrying capacities, which has no limiting effect on last-mile deliveries involving a single meal in terms of ready-to-eat meal deliveries, but which can constrain the number of items and orders that can be carried on other types of multi-stop last-mile vehicle trip. These vehicle carrying constraints can have operational implications for the greatest possible load size of a same-day grocery delivery serviced using bicycles or mopeds, and for parcel deliveries which involve multi-drop delivery rounds. In terms of the fuel source of these last-mile delivery vehicles, at the end of 2018, 98.1% of cars, of motorcycles, and more than 99% of light and heavy goods vehicles licensed in the UK were either petrol or diesel fuelled (Department for Transport, 2019). By the end of 2018 there were 200,000 Ultra Low Emission (ULE) vehicles licensed in the UK, which represents 0.5% of all licensed vehicles. Of these ULE vehicles, 93% were cars, 4% were light goods vehicles, 2% were other vehicles, 1% were motorcycles, and less than 0.5% were heavy goods vehicles, buses and coaches (Department for Transport, 2019).

Online retailing survey data indicates that only 6% (by sales revenue) of non-food and grocery orders were sufficiently small to fit through a letterbox. Deliveries that were too big to fit through a letterbox delivered by one person accounted for 82% of online orders (by sales revenue), while online orders requiring a two-person delivery due to size and/or weight accounted for 12% of online orders (by sales revenue) (see Figure 3.1 – Global Data, 2018a).

Figure 3.1: Physical size of non-food and grocery online orders in the UK in 2018, based on sales revenue



Source: Calculated from data in Global Data, 2018a.

Data compiled from UK non-food online retailers shows that, in December 2018, 27% of parcels were despatched internationally. Of those despatched domestically within the UK, the delivery lead time arrangements were as follows: 52% were sent 'economy', 43% were sent 'next-day' anytime, 2% were sent 'next-day' with a guaranteed time slot, 2% were sent for a guaranteed Saturday or Sunday delivery, and less than 1% were sent by same-day delivery. This data was largely unchanged from other months in 2018 (IMRG and Metapack, 2019).

According to retailers and logistics service providers, customers are requesting ever-improved last-mile delivery services. In survey work among 300 executives in European and North American last-mile retailers, manufacturers and logistics providers, respondents said that their customers were requesting improvements in delivery flexibility (65% of respondents), speed of delivery (61%), real time visibility (51%), delivery options (45%), and specific delivery time slot selection (41%) (eft, 2018b). A survey of 146 online retail executives in the UK found that their greatest perceived challenges were: customer expectations about delivery times (mentioned by 49% of respondents), rising shipping costs (47% of respondents), and customer expectations of free or low-cost shipping (44% of respondents) (Retail TouchPoints, 2018).

Table 3.1 provides a summary of the service characteristics and logistics components of each of the last-mile delivery sectors.

Table 3.1: Key service features of online shopping last-mile delivery systems by sector

Service feature	Grocery retail		Non-food small items	Non-food large items	Ready-to-eat delivered meals
Typical lead time from order to delivery (i.e. responsiveness of delivery)	Same-day to several days depending on consumer choice	Instant (usually 1-2 hours of placing delivery)	1 or more days (plus small % of same-day deliveries)	1 day to several weeks	Usually within 15-60 minutes
Incidence of delivery failure	Low	Low	High	Low	Very low
Return rates	Low	Low	High	Low	Very low
Type of delivery operation	Multi-drop trips	Single drops	Multi-drop trips	Multi-drop trips	Single drop trips
Type of vehicle/s used for last-mile delivery	Refrigerated vans	Mopeds and bikes	Vans (with some cars)	Lorries	Mopeds, bicycles and cars
Typical number of orders delivered per trip	10-25	1	50-200	5-10	1
Average size of delivery	Several bags full	Up to about small 20 items	One to several parcels	Single item but large and heavy	Single bag/box
Typical time taken at delivery point (i.e. unloading time)	Less than 10 minutes	Less than 5 minutes	Less than 5 minutes	10-60 minutes (due to installation)	Less than 5 minutes
Number of delivery personnel on/in vehicle	One	One	One	Two	One
Location from which delivery vehicles are despatched	Supermarkets and fulfilment centres	Grocery stores	Logistics depots / fulfilment centres	Logistics depots	Shops (restaurants and takeaways)
Delivery location	Home or customer collection ('click and collect' facility)	Home or workplace	Home, workplace or customer collection (collection point or locker bank)	Home	Home or workplace
Bookable delivery times available?	Yes, 1- or 2-hour delivery slots	Delivery within 2 hours of placing order	Not usually, but some carriers provide delivery day and time information	Most offer delivery time slots for extra charge	Delivery within 15-60 mins of order
Who carries out the delivery operations	Supermarket	Supermarket or platform provider	Parcel carrier	Logistics operator or retailer	Restaurant or platform provider

Source: Produced by the authors based on the review of research.

4. Issues associated with last-mile parcel deliveries

4.1 Delivery service levels and speed of delivery

The time elapsed between orders being placed and goods being delivered to customers is an important factor in the transport and environmental intensity of the last-mile delivery operation. The lead-time between order placement and despatch of the goods has the potential to affect the ability of the carrier to: (i) carry out consolidated deliveries (in which more than one customer's order can be transported and delivered at once); (ii) achieve high levels of drop density (i.e. achieve a situation whereby many customer orders in a relatively concentrated geographical area are available for delivery by the same vehicle thereby reducing inter-drop distances travelled between delivery addresses; (iii) ensure that all the items in a single order are provided to the customer in a single delivery. Obviously, because of the time-sensitive nature of hot ready-to-eat meals, these are typically despatched individually. However, in the case of non-food and grocery deliveries there is the opportunity for last-mile deliveries to be combined together on a single vehicle.

However, evidence suggests that the lead-time between orders being placed and delivered to customers is reducing over time. This would appear to be due to retailers (and carriers) offering consumers ever-quicker response times, and so-called 'free' deliveries and membership schemes, which can allow the placement of unlimited small order sizes without any delivery charges in order to win their custom (see section 4.3 for further discussion of 'free' delivery and membership schemes offering 'delivery passes'). These services are being offered to increase retailer brand loyalty, increase turnover and market share, and respond to a perceived desire for fast delivery among consumers. Several surveys, summarised below, indicate the consumer demand for such service levels and retailers' responses to these demands.

An international survey of online food and non-food consumers in five countries including the UK in 2018 found that, on average, across all five countries, they rated last-mile delivery services as having a Net Promoter Score (NPS) of minus nine. Respondents in the UK alone, on average, gave last-mile delivery services a Net Promoter Score (NPS) of zero (Capgemini Research Institute, 2019). These survey findings indicate dissatisfaction or at best neutrality with respect to last-mile delivery services in the countries studied. The top reasons for consumers' views were high delivery prices (59% of all respondents felt delivery prices were too high), unavailability of same-day delivery (47% of respondents said they couldn't get same-day deliveries), and late deliveries (43% of respondents said that deliveries have arrived late on many occasions (Capgemini Research Institute, 2019).

This same international survey of online consumers indicates that shorter lead-time offers by retailers from point of ordering to delivery for food and non-food online products increase consumers' loyalty to the company. Fifty three per cent of consumer respondents said they would increase their loyalty to an online retailer if it offered next day delivery. In addition, 61% and 55% would increase their loyalty if the retailer offered same-day delivery and delivery within two hours of ordering respectively (Capgemini Research Institute, 2019). In this same study the authors found that 95% of online food and non-food retailers surveyed already offered next-day delivery, 80% already offered same-day delivery, and only 19% offered delivery within two hours (Capgemini Research Institute, 2019).

A 2018 survey of 10,000 UK online consumers found that 71% had made use of next-day delivery options, 59% had made use of named-day delivery options, 59% had made use of specific time slot delivery, and 44% had made use of same-day delivery options (Global Data, 2018a). In terms of what consumers would be willing to pay for same-day delivery, 62% of respondents said they would pay £1-5, 13% would pay £6-10, and 26% would pay more than £10 (Global Data, 2018a).

Data compiled from UK non-food online retailers shows that, in December 2018, 27% of parcels were despatched internationally. Of those despatched domestically within the UK the delivery lead time arrangements were as follows: 52% were sent 'economy', 43% were sent 'next-day' anytime, 2% were sent 'next-day' with a guaranteed time slot, 2% were sent for a guaranteed Saturday or Sunday delivery, and less than 1% were sent by same-day delivery. This data was largely unchanged from other months in 2018 (IMRG and Metapack, 2019).

Between 2013 and 2015, the proportion of next-day delivery for non-food online shopping in the UK increased by 50%. Research indicates that over the same time period in the UK, the proportion of consumers willing to wait 3-5 days for their parcel to arrive reduced by 10% (OC&C Strategy Consultants, 2016 - the research involved an online survey of more than 1,000 consumers).

Many commentators expect increasing demand for improved delivery service levels among regular online consumers, and retailers competing aggressively with each other to improve the delivery service level provision to gain market share. A consultancy report has argued that the three key factors customers want in relation to last-mile delivery are 'Fast', 'Free' and 'Further control' (Accenture, 2019). Another report emphasises that consumers want rapid deliveries "at low to no cost" (Bouvet and Kaltenbach, 2017). The authors quote 2017 survey results showing that 46% of respondents expect next day delivery to be free, 44% would pay $5 or less, and only 19% are prepared to pay more than $5 for same day delivery (Accenture, 2017 quoted in Bouvet and Kaltenbach, 2017).

Results of a UK survey of online consumers show that the main three last-mile delivery service factors that could would result in them making more online purchases are: the price charged for deliveries (47% of respondents mentioned this), ease of returns (26% of respondents mentioned this) and faster delivery (26% of respondents mentioned this) (Retail Economics & Womble, Bond and Dickinson, 2019).

A survey of 528 UK online non-food shoppers found that 59% of respondents stated that a positive delivery experience incentivises them to shop again with a retailer, 58% of respondents stated that the provision of a greater range of delivery options led to them choosing to purchase goods from one online provider rather than another, and 44% of respondents said they wanted retailers to offer one-hour delivery responses (MetaPack, 2018). In the same survey, respondents identified the top three factors that result in an unsatisfactory delivery experience as: delivery arriving later than promised (51% of respondents), deliveries not made in line with a requested time slot (41% of respondents), and the packaging being damaged on arrival (16% of respondents) (MetaPack, 2018).

An analysis of non-food online retailers in America shows that in December 2018 a parcel from Amazon took, on average, 3.2 days from when the order was placed to its delivery to a customer. For all other retailers it took an average of 6.0 days. For both Amazon and other retailers, the lead time from order to delivery had fallen over the preceding 36 months (from 4.2 days in the case of Amazon and 9.0 days for other retailers) (Rakuten Intelligence, 2019).

When orders involve multiple items, the speed with which items are despatched, and the various locations that items are held at can result in a single order being split into multiple deliveries. One study found that in a large online retailer the number of parcel shipments increased by 3.75%–6% due to 10%–15% of order splitting (Xu et al, 2009).

China is the economy with the greatest proportion of instant and same-day deliveries, which already account for more than 10% of all parcel deliveries (with approximately 3 million same-day items and 400,000-500,000 instant deliveries made each day) (World Economic Forum, 2020).

4.2 Product returns

A major problem that faces online retailers is the cost and logistics requirements caused by product returns. Product returns were estimated to represent 8% of total UK online sales by value in 2018 (Global Data, 2018d). A 2018 survey of UK online retailers found that 5% of respondents reported a significant increase in returns over the previous 18 months, 26% reported a slight increase, and 13% reported a decrease (Retail TouchPoints, 2018). This suggests that product return rates in the UK may have been increasing over this period. Product returns increase retailer's last-mile transport costs as they are often paying for the returns or subsidising them. Returns also have several other detrimental impacts on retailers. Some returns are not resalable through the same channel at an affordable cost due to missing components, instructions and damage to the packaging; even when products are resalable, they often require labour to check, repackage and relabel them; return rates are very difficult to predict and plan for in terms of ordering and inventory management; for items that have a short shelf life, such as seasonal fashion clothing, returns can be unresalable due to the very short product retailing life; some returns need

to be relocated to another distribution centre for fulfilment centre involving further transportation; returns also results in administrative costs for the retailer in communicating with the customer, and the manner and efficiency with which retailers manage the returns process can have an important bearing on customer satisfaction and repeat orders given the effort involved in returning items and then waiting for refunds.

A survey of UK retailers responding to the greatest product return challenges they faced identified the cost of returns as their greatest challenge (48% of respondents), followed by customer issues with packing/shipping items for return (39%), impact on bottom-line revenue of reselling returned items (28%), communicating effectively with shoppers about returns rules/processes (23%), cost/logistics of crediting shoppers' accounts/providing refunds (23%), minimizing fraudulent returns (22%), and managing in-store staff requirements for returns processing (18%) (Retail TouchPoints, 2018). Sixty nine per cent of online shopping respondents in a 2019 UK survey stated that online retailers limiting their ability to return goods would make online shopping less appealing (Mintel, 2019a), while in another UK survey in 2018 73% of respondents said that they would not use an online retailer if they had to pay for returns, and 54% of respondents agreed with the statement that, "When purchasing online, I often buy more items than I expect to keep" (Global Data, 2018d).

Returns have been estimated to account for 8% of all non-food and grocery online sales by value in the UK in 2018 (Global Data, 2018d). Return rates tend to vary by product sector. The same survey of UK online consumers found the clothing and footwear sector has by far the highest return rates (of 20% by value), while several sectors including homewares, electricals, DIY and gardening, and furniture and floorcoverings have return rates of 7-8% by value. Food and grocery have the lowest return rate of less than 1% by value. Thirty four percent of survey respondents had returned one or more clothing and footwear items purchased online in the previous 12 months, whereas 10-16% of respondents had returned furniture and floorcoverings, DIY and gardening products (Global Data, 2018d).

A survey of UK online non-food retailers despatching parcels found they experienced on average a return rate of 22% of orders (either part or all of the order – IMRG, 2020a). Clothing was found to be the sector with the highest return rates, with online clothing retailers reporting return rates ranging from 22-37% of orders (IMRG, 2020a).

A recent BBC radio programme interviewed two online clothing experts who said that average return rates in UK online clothing are approximately 40% of orders, with return rates of up to 60-70% of orders in high end womenswear. This refers to at least part of an order being returned (BBC, 2019c). A European report refers to some online clothes retailers with return rates in excess of 50% (Strategy&, 2017).

Return rates are highest in the clothing and footwear sector due to specific features of the products involved, including their value, whether the shopper likes how they look on them, whether they fit the shopper, and purchasers buying several sizes and returning those that do not fit. For clothing and footwear, the specific reasons for returns in 2018 were: doesn't fit properly (60% of respondents), looks different to image on site (18%), ordered multiple items (intended to return one or more) (16%), incorrect item received (14%), item was of poor quality (13%), item faulty (11%), change of mind (10%), item/parcel damaged on arrival (7%), item arrived too late (2%), and other reason (1%) (Global Data, 2018a).

In a 2018 survey of 1,500 UK online clothes shoppers, 25% of those who had bought clothing and accessories in the last three months had returned an item. Fifty five per cent had returned clothing or accessories as they didn't fit, 32% as they didn't suit them, 21% as the items were not what they had expected, and 18% as they had ordered more than one to try on different sizes (Royal Mail, 2018a).

A survey of UK online consumers in 2018 showed that the most common reasons for consumers returning goods in general were: incorrect item received (26% of respondents), item faulty (19%), item or parcel damaged on arrival (19%), item was of poor quality (11%), item looked different to image on site (8%), change of mind (7%), ordered multiple items (intended to return one or more) (5%), item arrived too late (2%), and other reason (2%) (Global Data, 2018a).

The product return options offered to consumers vary by retailer (especially in terms of whether or not they have physical stores, and whether they make use of collection points and locker bank services). The

cost of return options can also vary between retailers (in terms of whether or not the consumer has to pay for the return transportation of the item. A survey of UK online consumers shows that for returning items to retailers, the postal system is most commonly used, followed by returning the items to a retailer's physical store. The survey results indicated that 39% of respondents returned items via the postal system, 33% returned goods to a retailer's physical store, 15% made use of a carrier's collection service, 10% returned goods via a store-based collection/drop off point, and 2% returned goods via a locker (Global Data, 2018a). These top two return options (return by post or to retailer's store) are two to three times more commonly used than returning items via a parcel carrier's collection service, and three to four times more commonly used than returning items via a collection point. The survey indicated that a very small proportion of parcels are returned via locker banks (Global Data, 2018d). The return option used is also related to the size of the item, with larger items less likely to be returned by post due to Royal Mail limits on package size handled. Survey work indicates that the majority of UK consumers expect online returns to be provided free by the retailers (Global Data, 2018d).

Several sales features are likely to increase the rate of product returns in the UK. These include: free deliveries, retailers offering services whereby consumers have 30 days before having to pay for items, and membership schemes (which allow consumers to receive unlimited free deliveries in a given period of time in return for a fixed fee), For instance, Amazon offers its Prime members a 'Prime Wardrobe' service in which a customer can order up to 6 items and is then given seven days to try and return at no cost to themselves the items they do not want. They then only pay for the items they choose to keep (Amazon, 2020a). In a 2018 survey of UK online shoppers, 59% said they would be more likely to use a retailer if it offered a 'try before you buy' service (Royal Mail, 2018b).

In a survey of online shoppers in the UK approximately 75% of respondents said they received a free returns service from clothing and footwear retailers they had used. The same proportion of respondents stated that they wouldn't buy these items from a retailer if a free return service was not offered (Global Data, 2018d).

Several major UK online clothing retailers, including ASOS and Next, have experienced recent increases in logistics costs (see section 2.4), with return rates being an important factor in these rising costs. ASOS, the major online clothing and footwear online retailer, has trialled various methods including recommending the correct size of item to order based on the consumer's weight, height, and preferred style of fit preference, and also online images of items that provide consumers with an all-round view of footwear. In early 2019, ASOS also announced changes to its return policy in April 2019; this extended the time allowed for returns from 28 days to 45 days, but warned that customers deemed to be misusing the returns system may have their account suspended (BBC, 2019a).

Next altered its returns service in 2018. Originally customers paid £3.99 for a parcel carrier to collect their product return but had this fee deducted from their next order; under the revised arrangement customers are charged £1 for each carrier collection or return to a Hermes parcel shop, with returns to stores remaining free (Clark, 2018).

However, retailers are cautious about altering their returns policy as survey work has shown that consumers like free returns policies. A UK survey in 2018 found that 69% of respondents said that limiting the ability to return items would make online shopping less appealing (Mintel, 2018a). Another 2018 survey of UK consumers found that 64% of respondents 'always' or 'regularly' check an online retailer's returns policy before deciding whether to buy or not, 44% of respondents said that the retailer's returns policy when shopping online had deterred them from placing an order, and 61% of respondents said they would be 'somewhat likely' or 'very likely' to shop more with retailers that make the returns process easier (Metapack, 2018). In another UK survey in 2018, 60% of respondents said they would be unlikely to use a retailer again following a difficult returns experience, and 52% said they would be unlikely to shop with them again if they charged for returns (Royal Mail, 2018b).

4.3 'Free' deliveries and delivery passes

In **s**ection 4.1, survey results were provided that indicate consumers' concerns about last-mile delivery charges, with an international survey in 2018 finding that 59% of respondents felt delivery prices were

too high (Capgemini Research Institute, 2019), while a UK survey showed that respondents rated the price charged for deliveries as the most important factor in their use of online shopping (Retail Economics & Womble, Bond and Dickinson, 2019).

Further survey work in the UK also emphasises the importance of delivery charges in consumers' perceived experience and use of online shopping services. In a survey of 528 UK consumers about non-food online shopping, 'free' delivery was the most important consideration for 68% of respondents when placing the majority of their orders, 80% of respondents said 'free' delivery would incentivise them to buy more during sales periods, 73% of respondents stated that they had increased the number of items purchased to take advantage of a minimum spend 'free' delivery option, 40% of respondents had abandoned shopping carts because of a lack of a 'free' delivery offer, while 38% would choose one retailer over another if they had a loyalty/membership scheme providing free delivery (MetaPack, 2018).

In another UK survey in 2019 1,500 respondents were asked what factors would increase their likelihood of shopping with a retailer: 55% said free delivery, 42% said lowest price for the goods, 32% said free returns, and 30% said having the products that they wanted (Royal Mail, 2019a). Another survey of 1,000 UK online consumers in 2019 showed that 57% of respondents said that free delivery greatly impacts their ordering decision, 37% said that it somewhat impacts their ordering decision, and 6% said it did not affect their ordering decision at all. A survey of a similar size in the US in 2019 showed that 72% of respondents said that free delivery greatly impacts their ordering decision (Alix Partners, 2019).

Retailers are facing rising consumer expectations for free and fast delivery. For example, according to a survey among 1,000 American online consumers, the maximum time that the average shopper is prepared to wait from ordering to receiving the delivery in the case of a free delivery was 4.5 days in 2019. This compares with 5.5 days in 2012 (Blaeser and Gopal, 2019). Survey work by the same organisation carried out a year earlier showed that in 2018 US Amazon Prime members (a paid-for subscription service that provides free deliveries) expected their deliveries to arrive within 3.8 days, compared to an average of 4.5 days for non-Amazon Prime members (Alix Partners, 2018).

Some non-food online retailers are using 'free' deliveries and returns as a means by which to compete and gain custom. As indicated above, 'free' deliveries have become of key importance for a sizeable proportion of consumers, and a fundamental issue in choosing which retailers to shop with.

In recent years, several major online retailers in the non-food, grocery and ready-to-eat meals delivery sectors have introduced what are referred to as 'delivery passes'. These are membership schemes that provide subscribers with 'free' deliveries. Members have to pay either a monthly or annual subscription for their delivery pass, and often, in the case of grocers, still have to spend a minimum amount to qualify for free home delivery. In addition, some schemes limit members to one 'free' delivery per day. All of the major online grocery retailers, except Waitrose, have introduced delivery passes; while Amazon provides the best-known delivery pass, which is known as 'Amazon Prime'. ASOS and Boohoo, the online-only clothes retailers, also offer a delivery pass. Some of these retailers offer peak and off-peak delivery passes, each with a different subscription rate, which vary in terms of the times or days on which home deliveries are made to members. Some retailers also provide members with extra perks in addition to their 'free' home deliveries. In the case of Amazon, it provides free same-day deliveries (where available) as part of its 'Prime' service. Annual subscription fees vary by sector: grocery delivery passes typically range from £50-£120 per retailer depending on the service level required by the customer (time of delivery and whether same-day or next-day), Amazon Prime costs £79 per year, while ASOS and Boohoo offer annual passes for £9.95 and £9.99 respectively.

Retailers have introduced these delivery passes in the hope of increasing brand loyalty, total spending per consumer, and frequency of order placement. Delivery passes are also intended to overcome the dislike that regular online shoppers have for delivery charges on a per order basis. Research has indicated that approximately three-quarters of Amazon Prime customers shop with Amazon at least two to three times a month, compared with approximately 20% of non-Prime customers (Retail Week in partnership with Metapack, 2016).

Survey work has shown that approximately 25% of all online grocery shoppers currently have delivery passes, while approximately 45% of consumers who do all their grocery shopping online currently have

one. One third of online grocery shoppers who currently do not have a delivery pass expressed an interest in subscribing in the future, according to a recent UK survey (Mintel, 2019b).

Some online takeaway and other restaurant home-delivered meal retailers also provide delivery passes. In the case of Deliveroo, for example, Deliveroo Plus is a subscription programme which allows customers to pay a monthly or annual fee instead of delivery fees on each Deliveroo order placed in the UK. The monthly price for this service is £11.49. Uber Eats started offering an 'Eats Pass' in 2019 which provides free unlimited deliveries in selected UK cities.

However, it is important to note that 'free' delivery membership schemes of this type are only likely to be relevant to online retailers in high-frequency sectors such as grocery, clothing and general retailing, and in which consumers are prepared to show brand loyalty. In addition, although helping to increase spending per head, these schemes can also result in higher product return rates among users, with the consequent implications for business costs as well as transport intensity.

4.4 Failed last-mile deliveries

The vast majority of parcel (and other types of) last-mile deliveries are to customers' homes; consumer survey data suggests that 85% of respondents state that their home is the delivery destination for their online parcel orders (IMRG, 2020b). Not all parcel deliveries to consumers' homes succeed on the first attempt due to factors including: the limited size of letterboxes, the frequency with which there is no-one available to receive goods that do not fit through letterboxes at residential addresses, and the fact that receivers' signatures are required for some deliveries. Online retail survey data indicates that only 6% (by sales revenue) of non-food and grocery orders were sufficiently small to fit through a letterbox (Global Data, 2018a). Data compiled from UK non-food online retailers shows that, during the period July-December 2018, approximately 3% of deliveries found no-one at home to receive the goods, and the driver had to leave a card explaining they had attempted the delivery and instructing the customer what would now happen (IMRG and Metapack, 2019). Over the same period approximately 90% of deliveries took place 'on-time' (the meaning of 'on-time' depends on the service by which the item was sent; those sent with either a day and/or time guarantee can be late, whereas those sent by an economy service cannot). Therefore, according to this dataset, overall during this six-month period, approximately 13% of orders failed to meet the consumer's delivery time expectations (IMRG and Metapack, 2019). However, this may represent an under-reporting of failed deliveries given that delivery personnel often choose not to write out cards when no-one is at home, and instead simply try to redeliver the item the following day.

Relatively few estimates of parcel failed delivery rates are available, and most that are available are outdated. A 2006 study found that approximately a quarter of deliveries of parcels failed (McLeod and Cherrett, 2006). In 2008 the IMRG estimated that 11% of first-time deliveries to homes fail (IMRG, 2008). Another source suggests that failed delivery rates among parcel carriers range from 2 to 30 per cent, depending on the carriers' policies for dealing with the situation of no one being home to receive the item (Beveridge, 2007). Other studies by academics have assumed delivery failure rates of 30% in their analysis, considering this representative (McLeod et al., 2006; Song et al., 2009; Belet et al., 2009).

While some carriers, on finding that no-one is at home, attempt to leave the item in alternative locations, such as with neighbours, in the garden shed or another place deemed suitable, others may require signatures as a proof-of-delivery and cannot do so (McKinnon and Tallam, 2003). When the delivery location for a personal online order is a workplace, delivery success rates will be higher than for a residential address. However, some workplaces either discourage or ban their employees from having personal deliveries made to their workplace due to concerns about the burden on the post room. Some policymakers and Business Improvement Districts have also urged employers to discourage or ban personal deliveries to workplaces in central London in the belief that it adds to congestion and pollution in busy areas (for instance, see Transport for London, 2018) but research evidence to support the objectives of such a policy does not currently exist.

Some retailers and carriers have implemented initiatives to improve the customer experience when waiting for deliveries. This can include customer feedback surveys, while others use technology to inform the customer about the delivery status – some provide text and email messages and phone calls to

update the customer about the driver's progress and expected time of arrival, while other provide real-time tracking systems for customers to monitor the driver's progress. Survey work among 300 executives in European and North American last-mile retailers, manufacturers and logistics providers found that 47% have implemented delivery feedback surveys, and 40% have increased last mile visibility for customers (eft, 2018b). Another survey of 146 retail executives found that the tools used to provide customers with delivery status information include: email notifications (86% of respondents), online tracking services (38%), text messages (33%) and phone calls (29%) (Retail TouchPoints, 2018). The implementation of such technological services has the potential to reduce delivery failure rates.

Respondents in a 2019 Royal Mail survey of 1,500 UK shoppers were asked to state the delivery points they were prepared to use for non-food orders. The responses in order of preference were: home (89% of respondents), click and collect in retailers' store (24%), collection point in a convenience store (11%), someone else's home (10%), collection point in a Post Office (9%), and workplace (9%) (Royal Mail, 2019b). This contrasts with the results of the same Royal Mail survey five years earlier which showed that if consumers were selecting a delivery address other than home, 43% said their neighbour's home, 15% said a friend's or family member's home, 12% said a post office, 11% said a Royal Mail sorting office, 11% said a work address, and 6% said a convenience store (Royal Mail, 2014). In-house click and collect may, therefore, have become more popular over this period where retailers with physical stores offer such a service.

Another method used by retailers and carriers to reduce failed deliveries is that of click and collect services through which customers collect their goods from shops, other collection points or locker banks (see section 4.5 for further details).

4.5 Collection point and locker facilities and services

Rather than having online orders delivered to home (or workplace), some non-food retailers offer consumers the opportunity to collect their goods themselves from a convenient local location. This is sometimes referred to as 'unattended' last-mile delivery (as the customer does not need to be present when the delivery takes place). This collection location can take the following three forms:

- In-house click and collect - a fulfilment channel for online shopping which allows customers to order goods online from a retailer and then collect them from a physical store or other standalone collection facility operated by that retailer. This option can therefore only be offered by retailers that operate both online and physical store retailing.

- Third-party click and collect from a collection point - a staffed counter in a building such as a shop, petrol station or other dedicated facility run by a third party. Collection points are typically located in existing retail outlets (for instance Collect+ in the UK has counters in branches of Asda, Costcutter, Nisa, Spar and McColls). Examples of other collection point service providers in the UK include Local Collect, myHermes ParcelShops, Parcelly, Doddle, Pass My Parcel, UPS Access Points, DHL Access Points, and DPD Pickup Shops, and Post Office (for deliveries handled by the Royal Mail).

- Click and collect from a locker bank - an unstaffed (or, far less typically, staffed) set of lockers located either outdoors or inside a building. The lockers available vary in terms of: (i) the extent to which they have fixed-configuration lockers or can be modified in terms of locker unit size in the immediate or longer term; (ii) the technology that they deploy; (iii) whether they are dedicated to a single retailer or can be used by a wide range of different retailers (referred to as 'agnostic'). The types of location that locker banks can be found in include railway stations, petrol stations, shopping centres, workplaces and residential estates. Examples of locker banks in the UK include those operated by DHL, Amazon, and InPost.

All of these three services provide consumers with the opportunity to avoid missing deliveries that are too large to fit through a home letterbox (and thereby receive goods more quickly than is the case with a failed delivery), and not have to stay indoors waiting for deliveries. They can thereby help reduce the failed deliveries to consumers' homes that occur for parcel deliveries, as well as reducing the last-mile delivery activity associated with having to visit each customer's home in turn (Paazl, 2019). In these ways,

these delivery services can also help to reduce last-mile operating costs for retailers and carriers. The concept of collection points and locker banks first emerged for field engineers requiring parts for their daily activities, but was later transferred to online shopping as a customer fulfilment channel.

Online orders making use of in-house click and collect services were estimated to represent 12% of total UK online sales by value in 2018 (Global Data, 2019). In-house click and collect services are more commonly used for certain sectors and products than others. For instance, in-house click and collect represented 26% of all online clothing and footwear sales in the UK, compared with 12% of total online electrical sales, 3% of total online grocery sales, 1% of total online book sales, and less than 1% of total online entertainment sales (DVDs, CDs and computer games) (Global Data, 2019). The latter two sectors/product categories typically fit through consumers' letterboxes so are not subject to failed deliveries, which is one of the factors encouraging consumers to opt for click and collect.

In a survey of 500 UK online consumers, 62% of respondents had used in-house click and collect services (Metapack, 2018). Consumers make use of in-house click and collect for various reasons: for some it provides a cheaper option than having a home delivery, for others they intended to visit the store anyway but wanted to ensure the goods they wanted were in stock and waiting for them. Survey work with UK consumers indicates that there are several reasons for using in-house click and collect services: to avoid paying home delivery charges (48% of respondents mentioned this as a reason), to ensure stock is available when visiting the store (43%), to minimise time spent in stores (32%), to avoid having to wait in for deliveries (27%), and to obtain goods as quickly as possible (19%) (Global Data, 2019). This same survey found that 25% of consumers using in-house click and collect either tried the item on in-store or examined it, with 75% of consumers not checking the goods or trying them on at the point of collection (Global Data, 2019). In terms of the trips consumers make to collect their online purchases from stores, in a 2018 survey 53% of respondents travelled with the specific purpose of collecting their order and did not visit other stores as part of this trip, 27% of respondents travelled with the specific purpose of collecting their order but did visit other stores while out, and 21% of respondents were planning to go shopping anyway (Global Data, 2019). A survey of UK online retailers with in-house click and collect in their stores found that approximately 90% of these retailers offered 'free' deliveries to consumers using the service (Oracle, 2016).

Retailers with a network of physical stores hope that click and collect services for online sales will encourage consumers to purchase more goods when collecting their orders. Survey work with UK consumers indicates that approximately 15% of consumers either always or often purchase other goods in-store when collect their online orders, with approximately 55% sometimes purchasing other items when collecting, and 30% never purchasing anything in-store (Global Data, 2019). These additional in-store purchases were most common in grocery stores, and least common in clothing and footwear stores. What evidence exists suggests that, on average, in-house click and collect does lead to additional in-store spending when collecting goods; however, it involved spends of less than £20 in the case of grocery retailers, and less than £10 in the case of non-food retailers (Global Data, 2019).

An American survey of online consumers suggested the reasons for using in-house click and collect services were, in order of importance: the scale of last-mile delivery charges (50% of respondents mentioned this), immediate need for a product (50%), product discounts offered by retailers if collecting in store (43%), the scale of last-mile delivery charges, the time taken to receive home deliveries (33%), and retailers offering a broader assortment of products for online sale if collecting from store (28%) (Alix, 2018).

Online orders making use of third-party click and collect services (both collection points and locker banks) were estimated to represent 1.3% of total UK online sales by value in 2018 (Global Data, 2019). These third-party click and collect options are therefore far less popular with UK online consumers than in-house click and collect services (which are estimated to account for approximately 12% of online sales). The main reasons for this difference are due to: (i) unlike in-house click and collect services, consumers are often charged for deliveries made to locker banks and collection points; and (ii) major store-based retailers with click and collect services often do not offer collection point and locker banks services. In a survey of 500 UK online consumers, 37% of respondents had used a collection point or locker bank (Metapack, 2018). Several companies have established substantial collection point and locker bank networks in other European countries including DHL, Kiala, and Point Relais (Morganti et al., 2014).

However, like in-house collection facilities, third party collection points and lockers have the potential to be used for order collection, a collection point for failed deliveries to the home, and a location at which goods can be returned.

A survey of UK consumers suggests that, as with in-house click and collect services, some consumers collecting goods from a collection point in a convenience store make additional purchases in-store. Approximately 20% of consumers either always or often purchase other goods in-store when collecting their online orders, with approximately 45% sometimes purchasing other items when collecting, and approximately 35% never purchasing anything in-store (Global Data, 2019). Dedicated collection points (i.e. that only provide this service rather than being sited in a shop selling other products) are unlikely to be financially viable due to their staffing requirements and land rental costs. Doddle, a network of dedicated collection points located at railway stations, launched in the UK in 2014 (BBC, 2014; Network Rail, 2014). However, the company closed these dedicated facilities in 2017 due to financial losses and instead began operating click and collect counters in retail partners' stores (Armstrong, 2017).

Locker banks have several benefits over collection points as a means of receiving home shopping, including their accessibility at any time of day or day of week, and their security. However, current limitations of locker banks include their limited size per locker and total storage capacity which prevents their use for larger products, as well as the inability of many to handle chilled or frozen food. Locker banks are likely to continue to be most suited to shoebox-sized parcels. Many staffed collection points located in existing retail outlets tend to have limited storage space which also affects the goods they can hold for collection, and their ability to handle larger returns which makes the consideration of using other third-party collection points and locker banks an increasingly necessary one (Verdict, 2014).

A study of using agnostics lockers to serve online deliveries to a block of residential flats in Seattle resulted in a 78% time saving for carriers compared to a driver having to make door-to-door deliveries on each floor and using lifts to travel between floors. In addition, it entirely removed the problem of failed deliveries (Urban Freight Lab, 2018a). Locker banks have been taken up far more rapidly in Germany than the UK. DHL installed Packstations (locker banks) in all German cities with populations of more than 100,000 inhabitants, with 2,400 of them located in railway stations (SUGAR, 2011). Locker banks tend to be more effective from a sustainable delivery perspective if they can be used by a wide range of retailers (i.e. agnostic) rather than dedicated to a single retailer or carrier, as this helps to ensure that the parcel throughput makes maximum use of their available capacity.

However, there are various logistical and planning issues that need to be addressed for locker banks to play a major role in last-mile delivery. These include planning regulations concerning their siting, the affordability and availability of such land, and the optimum design of lockers to maximise their potential to accommodate a wide range of products, and operational issues such as when customers do not collect their goods promptly, thereby rendering the locker unusable. Locker banks are ideally located close to public transport facilities for customers to collect goods as part of daily commuting and without the need to use cars (Urban Freight Lab, 2018b). They could also be located close to other places with substantial footfall that people regularly visit such as shops, pubs and gyms where they avoid the need for dedicated trips. They can also be located in large buildings such as multi-tenanted offices or hospitals and thus used for deliveries to both businesses and workers, thereby also reducing current delivery vehicle dwell times at such sites. Both locker banks and collection points have the potential to increase dedicated car trip generation so need to be carefully planned in locations that people already visit for other purposes and which are readily accessible on-foot, by bike and public transport to avoid this occurring.

The lack of willingness on the part of many consumers to pay more for a wider choice of alternative delivery locations can make investments in third-party collection points and locker banks difficult for companies to justify and generate a financial return on.

4.6. Other factors influencing the efficiency of last-mile deliveries

Last-mile delivery efficiency and driver inexperience

Last-mile delivery personnel have to carry out many tasks each day in the course of their work, each of which influences their operational efficiency. These tasks include (Bates et al., 2018):

- Vehicle routeing decisions
- Picking the best vehicle stopping location
- Optimising walking routes – from the parked vehicle to the delivery/collection point
- Locating point of entry to the building – which may not correspond with the delivery/collection address,
- The journey inside the building to the point of delivery/collection – and gaining whatever proof of delivery/collection is required
- Make decisions about what to do when no-one is available to receive the delivery/provide the collection.

In addition, multi-drop parcel delivery drivers have to decide how to pack the parcels into their vehicles at the depot and then find the appropriate parcels each time they stop to make a delivery and, in dense urban areas with high drop densities, have to decide how to group deliveries together in walking tours. All of these tasks are highly challenging, and the latter is an under-researched optimisation task. Finding the entry point to commercial buildings and residential apartments to make a delivery when this is not the front door or the address registered on the paperwork or computer system can result in lost time and additional driving distance.

Research has indicated that there are major differences in operational performance between couriers of different levels of experience working on the same parcel delivery rounds. In one such case, an experienced driver was found to drive 44% less distance per parcel, spend 35% less total time per parcel, and 39% less parking time per parcel than an inexperienced driver. The variation in effectiveness of the couriers related to better route planning and exploitation of accumulated knowledge (Bates et al., 2018). It takes several months for a novice driver to begin to acquire the knowledge and experience necessary to gain efficiency in their delivery operations, and several years to reach their potential. It is currently based on tacit knowledge gained through experience and use of memory, rather than codified and supported by computing technology. However, the last-mile delivery industry suffers from high rates of worker turnover and, in parcel delivery - the longest-established sector - the average age of drivers is relatively high, with many personnel who have carried out the work for twenty years or more soon to retire. This is likely to lead to a reduction in the average rate of delivery efficiency unless steps are taken to help and support new entrants in acquiring this knowledge.

In addition, currently available proprietary vehicle routeing software does not take account of the walking component of parcel delivery in dense urban areas, and instead bases the solutions it provides on algorithms that only consider the vehicle movement component. As a result, this routeing software produces results that are non-optimal in situations where substantial walking is involved.

Time spent inside buildings making deliveries

In making deliveries, couriers often have to spend considerable amounts of time inside buildings where the customer lives or work. This can involve ascending and descending staircases, waiting for and using lifts in blocks of flats and multi-tenanted offices, and penetrating deep inside major buildings such as hospitals and town halls. The time the driver has to spend inside the building making these deliveries increases vehicle kerbside dwell time and total delivery working time. Research using elevation tracking in the City of London, a key financial district of the city, has shown that couriers had to travel vertically inside buildings to reach approximately 15% of delivery locations on their daily rounds (these rounds include consignees not located in multi-tenanted buildings, so the proportion of multi-tenanted, multi-storey buildings in which this is necessary is considerably higher) (Clarke et al., 2018).

Road and kerbside space and time capacity

Worsening traffic conditions and difficulties finding suitable kerbside parking space in urban areas is making parcel deliveries ever more difficult to perform to exacting customer service levels. For example, average speeds fell by 13% (from 16.6 to 14.5 mph) on 'A' roads in London between 2015 and 2018 (Department for Transport, 2020a). Parking difficulties are forcing drivers to spend more time driving while searching for a stopping location, to park further from the point of delivery, and cover increasing distances on foot. Traffic congestion and difficulties experienced in finding parking spaces are likely to increase in London and other cities as ever greater proportions of road and kerbside space are dedicated to bus and cycle lanes, and other road users such as disabled drivers.

The lack of parking facilities in dense urban areas is likely to cause growing problems for last-mile deliveries in which drivers have to deliver orders to each customer's home or workplace, which is the main method for these deliveries at present. Research has identified the seriousness and scale of these delivery problems that arise in close proximity to the delivery point and the lack of a planning approach to these difficulties (Butrina et al., 2017).

The availability and affordability of logistics land

Affordable logistics land from which to operate local last-mile delivery depots and fulfilment centres are becoming increasingly difficult to find due to rising urban land values in the UK and Europe. Only Amazon appears to have the financial resources to acquire prime urban land for last-mile logistics in any quantity in the UK. These increases in land values have forced many freight transport companies including parcel operators to relocate their central urban depots to cheaper peripheral areas (Hesse, 2008) which has led to the suburbanisation of warehousing and distribution facilities (Cidell, 2010; Hesse, 2008; Dablanc and Rakotonarivo, 2010). Often referred to as 'logistics sprawl' (Dablanc et al., 2014), this has the effect of increasing stem mileages (the distance from the depot to the first delivery address, and from the last delivery address back to the depot) resulting in increased vehicle kilometres. In the case of Paris, research has suggested that between 1974 and 2010, the typical stem mileage from parcel companies' depots to their delivery areas increased by 12 kilometres (from 6 km to 18 km) (Dablanc et al., 2016). Industry forecasts indicate that the demand for logistics land servicing last-mile delivery in urban areas in the UK and the rest of Europe is likely to continue to grow in the coming years as the penetration of online shopping continues (Cushman and Wakefield, 2017; Turley, 2017; Turley, 2019).

4.7 Summary

Table 4.1 summarises the transport and GHG emission impacts of various characteristics of last-mile delivery operations and their link to operating costs by type of delivery. All of the characteristics are related to operating costs, so positive change has the potential to both reduce transport and environmental impacts while at the same time reducing delivery costs. Some of these characteristics are concerned with strategic decisions by retailers and carriers (e.g. delivery lead times, vehicle selection), some are consequences of consumer behaviour (e.g. product return rates), some are related to driver experience and knowledge and the extent to which inexperienced drivers are supported by suitable technological aids, and some are related to infrastructure provision.

Table 4.1: Impact of characteristics of last-mile deliveries on vehicle activity, kerbside use, GHG emissions and operating costs per item delivered

Last-mile operating characteristics	Last-mile delivery sectors involved	Impact on vehicle kms per item delivered	Impact on GHG emissions per item delivered	Impact on kerbside use per item delivered	Impact on operating costs per item delivered
Delivery lead time (time between placing order and delivery)	G,P,L	✓	✓		✓
Product returns	P	✓	✓	✓	✓
Failed delivery	P	✓	✓	✓	✓
Distance between delivery points on the vehicle journey*	G,P,L	✓	✓		✓
Vehicle routeing and scheduling	G,P,L,M	✓	✓		✓
Finding entry point to building	P,M	✓	✓		✓
Driver walking/driving strategy*	P	✓	✓	✓	✓
Driver ability to find items in vehicle at delivery point*	P			✓	✓
Having to deliver to desk in large, multi-tenanted buildings	P,M			✓	✓
Availability of logistics land for depot/transhipment*	P	✓	✓		✓
Availability of kerbside stopping locations	G,P,L,M	✓	✓	✓	✓
Vehicle carrying capacity	G,P,L,M	✓	✓	✓	✓
Vehicle fuel source	G,P,L,M		✓		✓

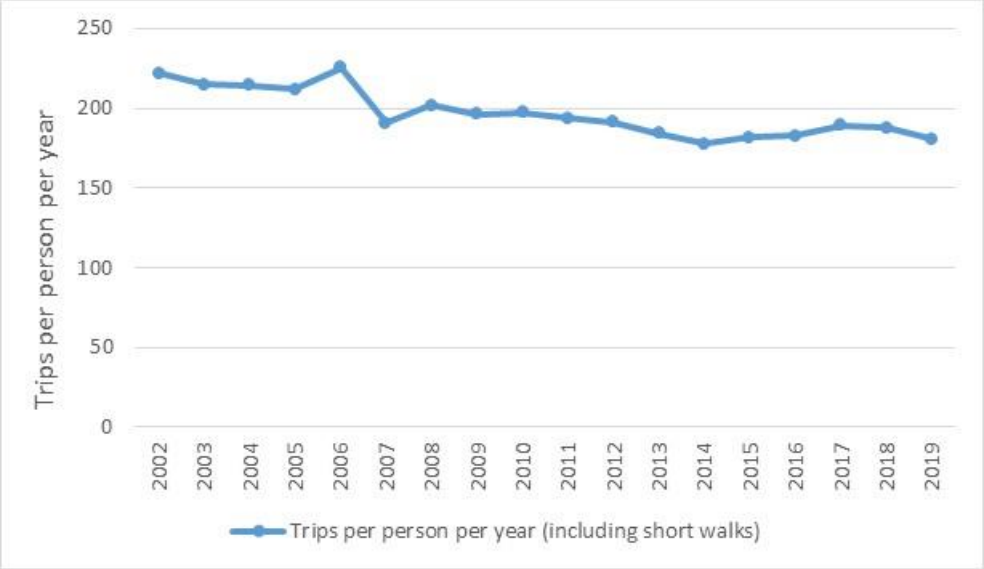
Key:
G = grocery delivery
P = parcel delivery
L = large, non-food two-person delivery (e.g. white goods or furniture)
M = ready-to-eat meal delivery
✓ - indicates a link between characteristic and impact
* - these refer specifically to multi-stop last-mile delivery operations (rather than point-to-point single stop trips)

Source: authors' own judgement based on review of research evidence.

5. Trends in shopping transport by consumers

Data from the Department for Transport's National Travel Survey (also referred to as 'NTS') has been used in this chapter to provide insights into shopping transport by consumers (Department for Transport, 2020b). Shopping accounted for 19% of total personal travel trips (a trip being a one-way course of travel with a single main purpose) and 11% of total personal travel mileage in England in 2019. The relative importance of shopping travel has been diminishing over the past twenty years – in 2002 it accounted for 21% of all personal trips and 13% of all personal mileage. In absolute terms, the number of shopping trips per person and total shopping mileage per person have also fallen. Shopping trip rates per person fell by 19% between 2002 and 2019 while shopping mileage per person fell by 23% over the same period (see Figures 5.1 and 5.2 and Table 5.1). In 2002 individuals made, on average, 4.3 shopping trips per week, but by 2019 this had reduced to 3.5 shopping trips per week. As discussed in section 2.1, this corresponds to the period over which online shopping has been increasing, but there are potentially several factors involved in these changes in shopping travel which are discussed in this chapter and chapter 6.

Figure 5.1: Number of shopping trips per person in England, 2002-2019



Source: Department for Transport, 2020b.

Figure 5.2: Distance travelled on shopping trips per person in England, 2002-2019

Source: Department for Transport, 2020b.

The average time taken for shopping trips has remained constant in England at approximately 17 minutes per trip in 2002 and 2019. Average shopping trip lengths have also remained stable over the period (4.1 miles in 2002 and 3.9 miles in 2019).

Table 5.1: Change in shopping trips per person in England 2002-2019

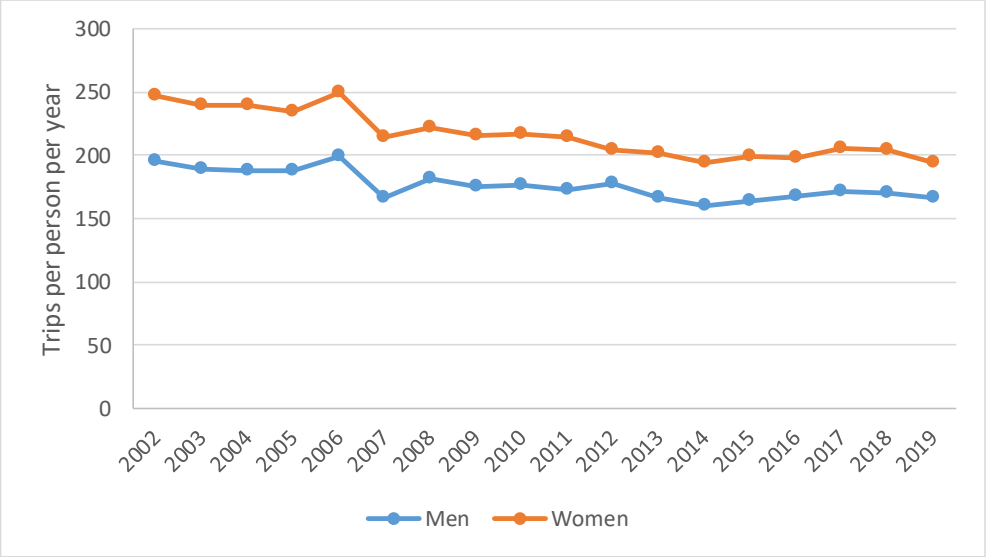
Shopping trips per person in England	2002	2019	% change 2002-2019
Number of all shopping trips	222	181	-19%
Shopping trips as % of all trips	21%	19%	-8%
Total distance of all shopping trips	906	700	-23%
Shopping distance as % of all distance travelled	13%	11%	-15%

Source: calculated from Department for Transport, 2020b.

Food shopping and non-food shopping accounted for almost exactly the same number of trips in England in 2017 (51% and 49% of all shopping trips respectively in 2017). However, due to their differing average trip lengths (2.7 miles for food shopping and 5.1 miles for non-food shopping), food shopping was responsible for 36% of total personal shopping trip mileage and non-food shopping for 64%.

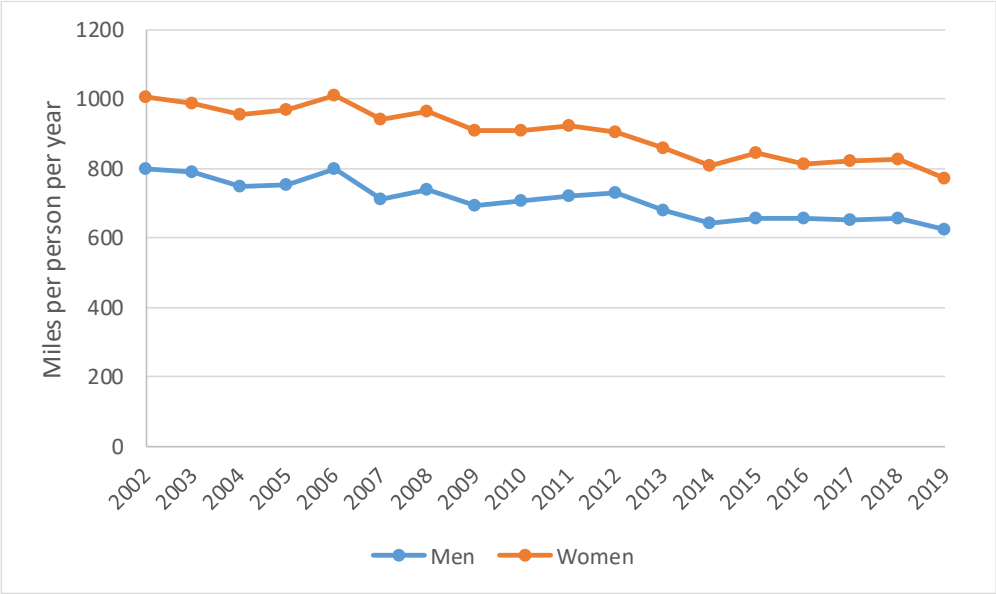
There are differences in the average shopping trips and mileages per person in England based on gender, with women engaging in 16% more trips and 23% more total distance travelled on these trips in 2019. Both genders reduced their shopping travel between 2002 and 2019, with men and women reducing their shopping trips by 14% and 22% respectively, and with both genders reducing their total shopping travel distance by 18% (see Figures 5.3 and 5.4).

Figure 5.3: Number of shopping trips per person in England by gender, 2002-2019



Source: Department for Transport, 2020b.

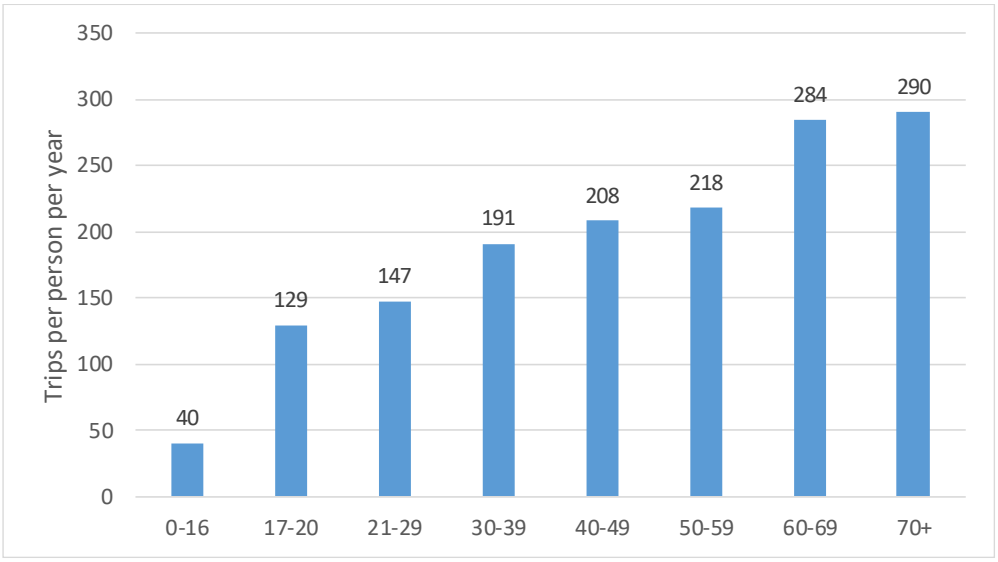
Figure 5.4: Distance travelled on shopping trips per person in England by gender, 2002-2019



Source: Department for Transport, 2020b.

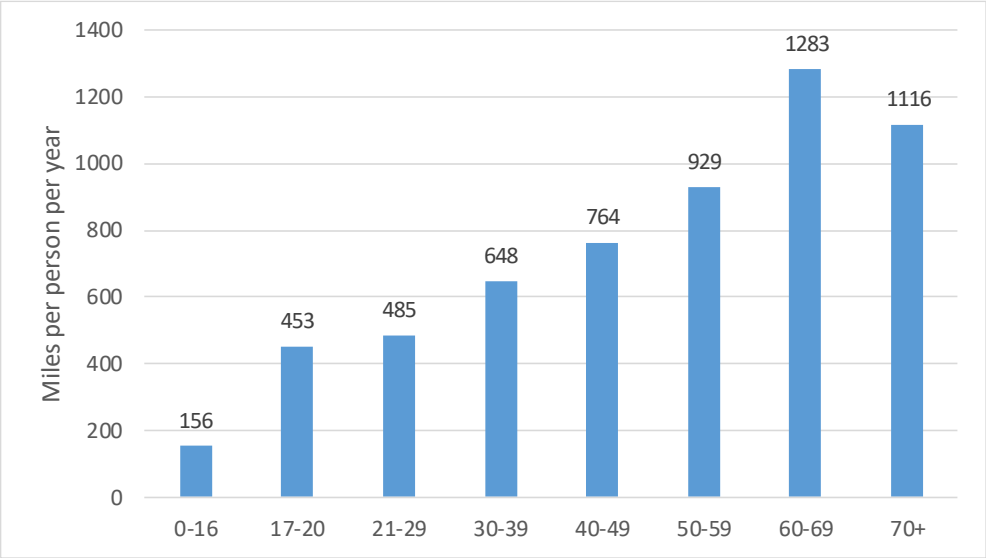
There are also differences in the average shopping travel activity per person in England based on age group, with activity rates increasing with age. Those aged 60 and over made twice as many shopping trips than those aged 17-29 in 2019, and travelled total distances that were on average 2.6 greater in making these trips (see Figures 5.5 and 5.6).

Figure 5.5: Number of shopping trips per person in England by age category, 2019



Source: Department for Transport, 2020b.

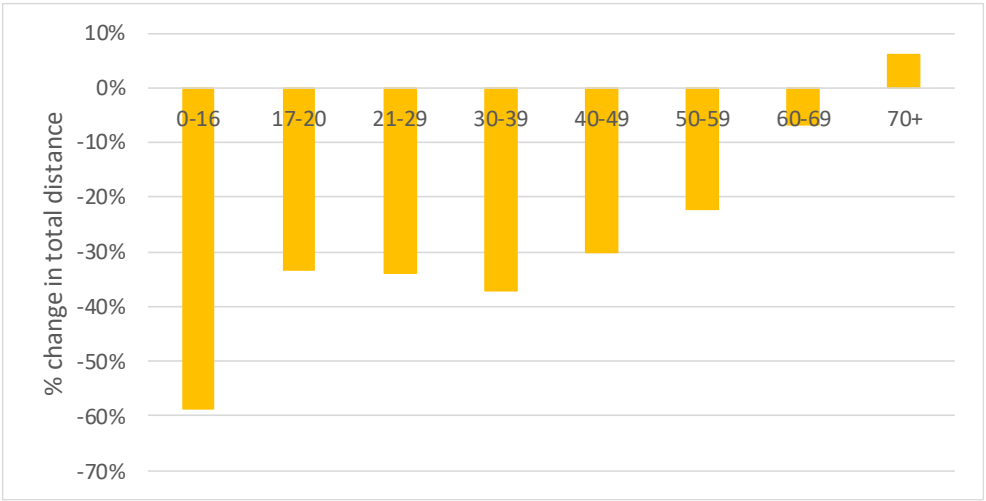
Figure 5.6: Distance travelled on shopping trips per person in England by age category, 2019



Source: Department for Transport, 2020b.

There are also differences in terms of how different age groups have altered the total shopping distance travelled annually between 2002 and 2019 (see Figure 5.7). Whereas younger age groups have considerably reduced their shopping travel over time, this is far less the case among those aged 60 and over (see Figure 5.7).

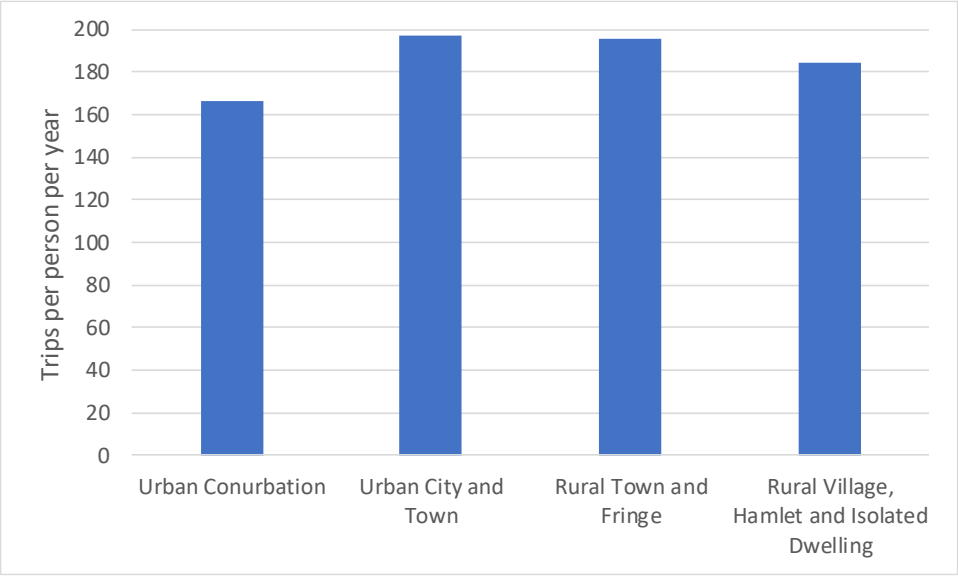
Figure 5.7: Change in total distance travelled on shopping trips per person in England 2002-2019 by age group



Source: calculated from Department for Transport, 2020b.

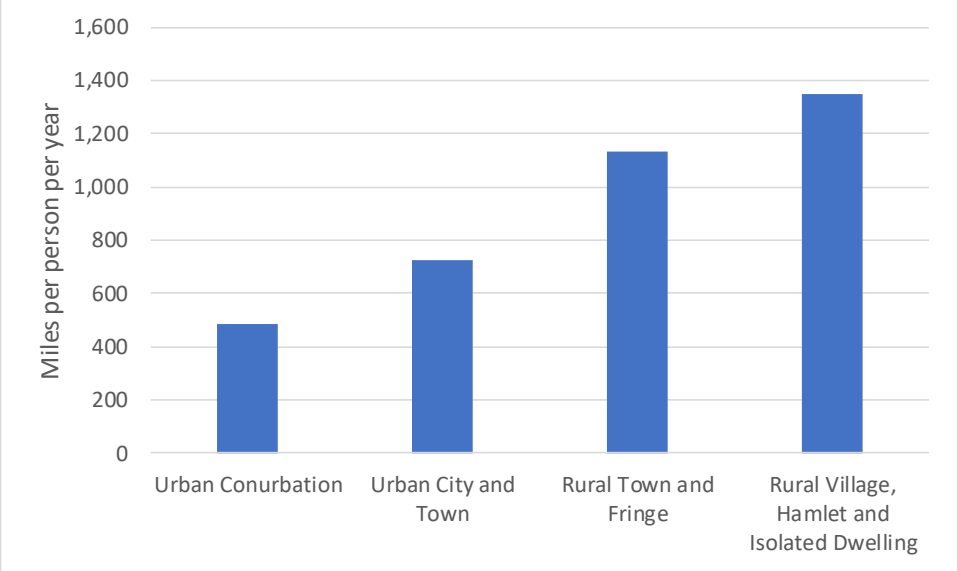
Shopping travel activity also varies with the residence location of the individual, with those living in large conurbations engaging in fewer trips than those living in smaller urban and rural locations (see Figure 5.8). Average shopping trip lengths also vary with residence location (varying from 2.7 miles in an urban conurbation to 7.3 miles in a rural village or hamlet in 2019). This results in considerably greater shopping mileages covered per person as the density of residence location diminishes (see Figure 5.9) and also in total shopping travel time per year (47 hours for those living in conurbations in 2019, compared to 59 hours for those in rural villages and hamlets).

Figure 5.8: Number of shopping trips per person in England by residence location, 2019



Source: Department for Transport, 2020b.

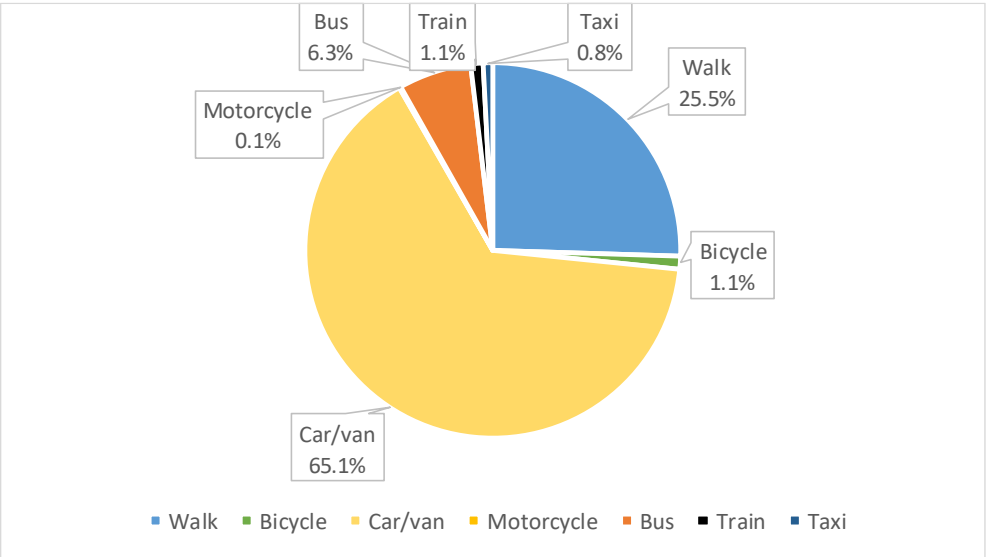
Figure 5.9: Distance travelled on shopping trips per person in England by residence location, 2019



Source: Department for Transport, 2020c.

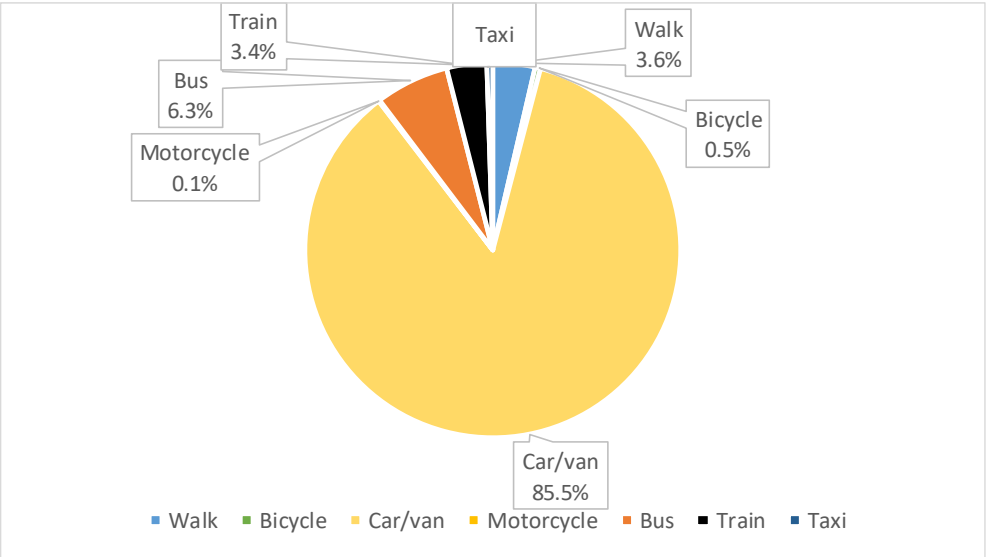
In terms of transport modes used for shopping, the car (and van) predominates, accounting for 65% of all trips and 86% of total distance travelled in 2019 in England (see Figures 5.10 and 5.11). Public transport accounted for 7% of all shopping trips and 10% of shopping mileage, while walking accounted for 26% of trips and 4% of mileage in 2019. Since 2002 there has been no discernible modal shift away from car use for shopping mileage travelled and car use increased over this period in terms of its share of shopping trips (from 61% to 65% of all shopping trips).

Figure 5.10: Shopping trips by main mode in England, 2019 (proportion of shopping trips)



Source: Department for Transport, 2020b.

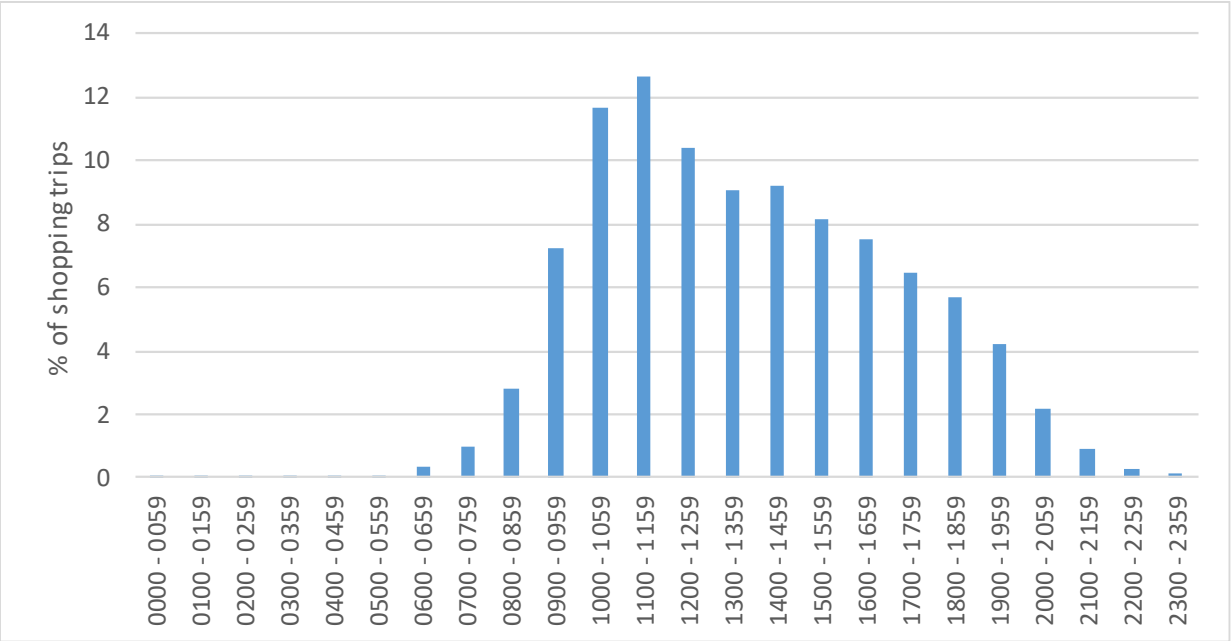
Figure 5.11: Shopping trips by main mode in England, 2019 (proportion of distance travelled)



Source: Department for Transport, 2020b.

Figure 5.12 shows the start time of shopping trips carried out by car on weekdays between 2013 and 2017.

Figure 5.12: Start time of shopping trips by car in England, 2013-17 (Mon-Fri)



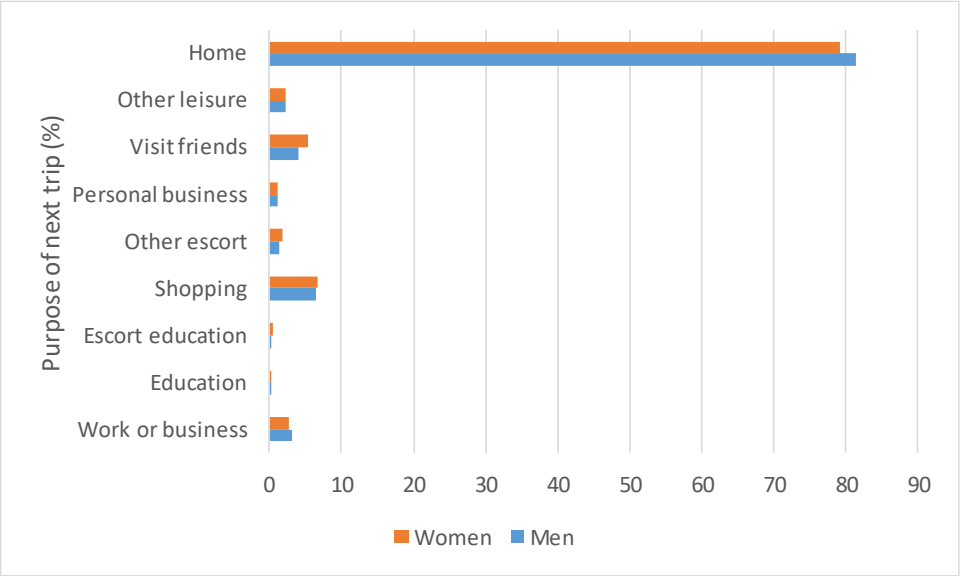
Source: Department for Transport, 2020c.

Some trips made by individuals (a trip being a one-way course of travel with a single main purpose) are linked trips, with the overall journey involving more than one trip for more than one purpose. These are referred to in the NTS survey as 'trip chains'. Figure 5.13 shows the purpose of the next trips after a shopping trip using NTS data for 2019. This indicates that approximately 80% of trips following a shopping trip involve travelling home. The other trips following a shopping trip (in order of importance) were: another shopping trip, a visit to friends, a work/business trip, and a trip for another leisure purpose. Figure 5.14 shows the trip purpose that precedes a shopping trip. In 2019, 30% of shopping trips by women and 25% of trips by men were preceded by another trip. Approximately 6-7% of these shopping trips for both men and women were preceded by another shopping trip, while work/business trips, escorting children to school and other purposes accounted for the rest.

NTS data also provides the difference in grocery and non-food shopping trips made by shoppers in England in 2017. On average, people made 97 grocery shopping trips per year, travelling a total of 265 miles, a mean trip distance of 2.7 miles per trip, with food shopping accounting for 4% of the average annual total distance travelled per person. By comparison, on average, people made 92 non-food shopping trips per year, travelling a total of 474 miles, a mean trip distance of 5.2 miles per trip, with non-food shopping accounting for 7% of the average annual total distance travelled per person.

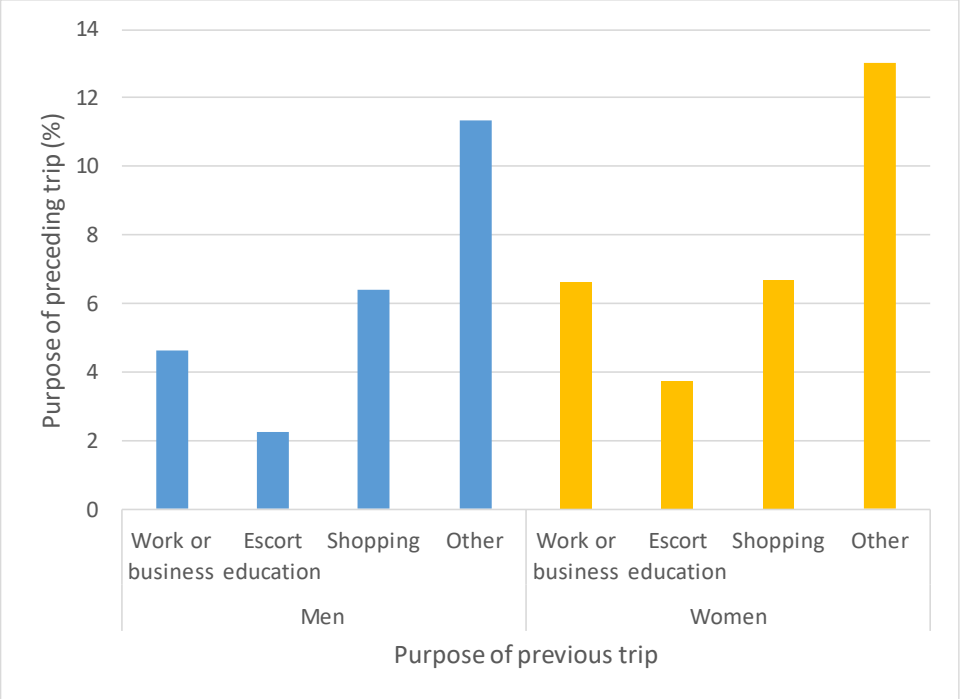
It is possible to estimate total car shopping travel and associated greenhouse gas (GHG) emissions in Britain, using the NTS data, together with DfT data providing total car travel for all purposes and BEIS data providing total GHG emissions from car use. This provides an estimate that car-based shopping travel resulted in 47 billion vehicle kilometres in 2018 which resulted in 7.1 million tonnes of GHG emissions. Of this car-based non-food shopping is estimated to have resulted 30 billion vehicle kilometres and 4.5 million tonnes of greenhouse gas (GHG) emissions in Britain in 2018, while car-based grocery shopping travel is estimated to have resulted in an estimated 17 billion vehicle kilometres and 2.5 million tonnes of greenhouse gas (GHG) emissions (calculated using car travel and GHG emissions data from Department for Transport, 2020c).

Figure 5.13: Purpose of next trip after a shopping trip, England 2019



Source: Department for Transport, 2020b.

Figure 5.14: Purpose of trip preceding a shopping trip, England 2019



Source: Department for Transport, 2020b.

6. Online shopping and consumers' travel behaviour

6.1 Introduction

As a result of technology and retailers' objectives to increase sales, products offered to the consumer have increased over time in range, choice and complexity. The retail trade has always offered luxuries and aspirational products in addition to basic necessities. However, for much of retailing history, such luxuries were only available to a small wealthy minority of consumers. Retailing in developed economies has grown substantially in importance economically over recent decades as the average disposable income has increased and credit financing has become increasingly available and accessible. This has allowed a growing proportion of individuals in developed economies to purchase increasing quantities of expensive products. For many people living in developed economies, and increasingly across the world, retail has become a leisure activity in addition to being a necessity. This has led some commentators to talk of a 'consumer society' and a 'consumption culture'.

In the last decade, other observers have questioned whether in developed economies the era of 'peak stuff' has been reached, with consumers turning away from the increasing acquisition of products in favour of the purchasing of experiences such as holidays, meals, and new activities (for instance, Goodall, 2011). It is too soon to say if these discussions of 'peak stuff' in developed economies are borne out by retail sales data, and meanwhile growth in the retailing of products is continuing in economically successful emerging economies such as China and India.

6.2 Retailing- and shopping-related definitions

Retailing

The term 'retail' originally referred to the sale of commodities in small quantities or parcels (early 15th century) from the Old French meaning 'piece cut off, shred, scrap, paring'. By comparison, wholesaling refers to selling 'in large quantities' to retailers, merchants and business users. Modern use of the term retailing has the following connotations:

- Sales in small quantities to a consumer
- Often occurs in retail stores and physical markets
- But can also take place through direct selling (vending machines, door-to-door sales, postal catalogues and electronic channels)

Consumer

The term 'consumer' has had several meanings since it first emerged. It refers to someone who:

- 'squanders or wastes' (C.15th)
- 'destroys the exchangeable value of a commodity by using it' (C.18th)
- 'trades money for goods or services as an individual' (modern)

Customer

The term 'customer' refers to 'a patron; one who purchases or receives a product or service from a business or merchant, or intends to do so' (c.1400 from the Medieval Latin 'custumarius' literally meaning 'pertaining to a custom or customs').

Shop/shopping

The term 'shop' has also had several meanings since it first emerged in the 13th century. It has meant:

- a 'booth or shed for trade or work' (C.13th) - derived from the Old French 'eschoppe' meaning a 'lean-to booth', of Germanic origin.
- A 'building or room set aside for sale of merchandise' (C.14th)

Since the late 18th century 'to shop' and 'shopping' meant, to visit shops for the purpose of examining or purchasing goods. Meanwhile usage of the term 'to shop around', meaning to seek alternatives before choosing, was first recorded in 1922.

6.3 The history of retailing and shopping travel in the UK

The shopping travel behaviour and patterns of consumers is closely linked to the geographical organisation of the retail supply chains associated with the provision of products and the availability and affordability of transport services. Traditionally, consumers purchased products from their local market due to travel distances and limitations in transportation. However, over time, consumers were able to begin to make decisions about who and where from, and how to acquire the products they wished to purchase.

Trade and selling has traditionally taken place in physical market locations, with freight transport and logistics facilitating this trade and playing an important role in the selection of market locations. Since the late 12th century estates and their tenants in England have been selling their agricultural surpluses (Farmer, 1991). The main methods of selling surpluses was by taking them to a regular market in a nearby centre of population. The Domesday Book records only 60 markets in the entire country, but during the 13th century there was a rapid expansion in the founding of markets, especially in small towns and villages (Masschaele, 1997). At this time, founding a new market was a form of Royal franchise and was subject to many rules and regulations. This included rules about the permissible distances between markets – a legal treatise in 1250 provides a rule of thumb that two markets should not be located closer than six and two-thirds miles, which was deemed to be a feasible distance for a producer to travel to market, sell goods and return home before nightfall (Masschaele, 1997). Although markets were not evenly distributed throughout the country, records show that the distance goods were typically transported to market was about 8 miles in the case of Colchester, and 7 miles for Winchester and Gloucester (Farmer, 1991). The growth in the number of markets meant that by the mid-14th century producers and traders were able to choose between several markets within approximately two hours journey time (Farmer, 1991).

A town market's success depended on whether it attained the status of a regional market acting as a distribution point for goods to and from smaller markets and the countryside. In some areas markets took place on successive days, allowing traders to pass from one market to the next selling their wares and acquiring the specialities of each market. This market system helped to link town and country; trade at a village market was usually local but was part of a network that stretched to larger centres (Farmer, 1991).

Over time many smaller town and village markets began to disappear (Dyer, 1989). The later a market was founded, the smaller the chance of its success, as the earliest markets tended to have the best sites in terms of accessibility and contained existing settlements of artisans and craftsmen (Farmer, 1991). This reduction in markets took place despite the population having returned to or even surpassed its former peaks prior to the Black Death (Everitt, 1967). Instead, it reflects those selling goods selecting the markets that were most beneficial to them, which was facilitated by the growing use of horse-drawn carts which allowed them to travel further to more lucrative markets (Farmer, 1991).

In Tudor times, counties comprised market towns often with a population of 600-1,000, together with one or two shire towns with several thousand inhabitants. Market places and the taverns and inns that sprung up around them were the meeting places of producers and traders. Craftsmen such as carpenters, wheelwrights and ploughwrights based in these towns mainly served the needs of the surrounding villages and countryside. By the 16th century approximately one-third of larger towns specialised in particular products such as corn, cattle, horses and sheep, cheeses and butter, poultry, fish or cloth. Shire towns were major regional centres of distribution and consumption and had grown from market towns due to a range of factors including their surrounding road infrastructure, their extensive hinterland, the presence of a sizeable, navigable river, and their topographical suitability (especially in terms of space and width of their market place) (Everitt, 1967).

By 1500 communities had become increasingly less self-sustaining than they had previously been. In the 16th century two types of trading were prevalent: i) town markets; and ii) private bargaining. The former had continued to be highly regulated, whereas the latter often took place beyond the control of town

officials. In addition, by this time, town markets were struggling to cope with the growing logistics requirements of selling, especially in terms of space requirements. During the 17th and 18th centuries the relative importance of the market place declined (Chartres, 1985).

Retailing is concerned with breaking bulk and selling individual items to private individuals. Retailing traditionally took place among both resident and itinerant retailers. Resident retailers began as stallholders at markets and fairs and not until the 17th century did they begin to retail from what we now think of as shops (Davis, 1966). 'Shop' in some contexts meant any place where selling took place including a tray round a hawkers neck, or a market stall, or a merchant's warehouse. What we would call a shop now was often called a "standing shop", while an "open shop" meant a shop built onto the front of a house. The commonest kind of retail shop occupied the ground floor of a house and by the end of the 17th century this was what the word had come to mean (Davis, 1966). It was common for these early shops to sell an extremely wide range of products including groceries, ironmongery, haberdashery, linen and woollen draperies, and giftware and much else (Spufford, 1984; Cox, 2000). Markets continued to flourish after the appearance of the first shops in the 17th century, and the two could often be found side-by-side. In London, the traditional markets remained important well into the 19th century (Smith, 2002).

Alongside markets and emerging shops, itinerant retailers included pedlars, petty chapmen, hawkers and street sellers who appear in written records from the 12th century; they also provided customers with products, but, in many cases, visited their customers' homes selling door-to-door. By the 18th century they were joined by Scotch Drapers, who specialised in selling cheap textiles that the new mills were producing door-to-door on foot but, unlike the others, sold on credit and visited the same areas on a regular basis to collect payments in instalments (Davis, 1966). By 1685 there were enough chapmen in the country to justify the publication of an almanac especially for them, and by 1697/8 there were over 2,500 pedlars licensed to sell goods in locations all over England (Spufford, 1984).

Little changed in the retail trade up to the mid-19th century in terms of the size of shops, the kinds of people who ran them, and the methods they used for buying and selling goods (Davis, 1966). However, two key changes in retailing occurred between the mid-19th and mid- 20th centuries. First, the process of retail selling became much simpler and less skilled – the more difficult tasks (such as sourcing, selecting and pricing goods) were taken over by the manufacturer who considered advertising and marketing their concern. Second, retail chains began to emerge and to replace sole traders. This resulted in customers dealing with employees rather than owners and took several forms including: multiple stores, co-operatives, and department stores (Davis, 1966).

The doorstep retail services of itinerant retailers as well as the delivery services of retailers trading from fixed shops proved popular with their customers for hundreds of years. Such doorstep services suited many customers without access to suitable and affordable transport technology. Even during the second half of the twentieth century, when some forms of door-to-door sales and last-mile deliveries were in decline due to the growth in retail outlets and car ownership, other forms of last-mile deliveries persisted (such as doorstep milk delivery which remained the dominant sales method for household milk until the late 1980s and still exists on a much reduced scale today). Mail order selling by catalogue first appeared on any scale in the mid-19th century, making use of the lower priced postal services that had been introduced and the rise of a national rail network. By the mid-20th century mail order catalogue shopping had become increasingly popular. The widespread affordability of household technology during the 20th century (such as motor cars, refrigerators, freezers, washing machines, and televisions) also brought about major changes in shopping behaviour, in terms of types of product wanted, shopping locations used, shopping frequency and quantities purchased.

From the 1980s, the increasing dominance of major grocery chains and non-food multiple retailers, together with new propositions concerning the experience offered to shoppers and changes to public planning policy for retailing led to the relocation and decentralisation of retailing activities away from high streets to stand-alone supermarkets, retail parks and out-of-town shopping centres. This caused further changes to the geographical destinations, transport modes and trip patterns of consumers, in particular greater use of personal car travel.

In this sense the advent of the internet, which has brought about new methods of digital retailing is just another stage in technological innovation and geographical change in the history of retailing in the UK, which has also altered where and how shopping takes place and shoppers' travel patterns.

6.4 Potential impacts of online retailing on personal travel

Online retailing can influence consumer shopping travel through one of three mechanisms: substitution, complementarity, or modification. Neutrality (i.e. no impact) is also possible (Mokhtarian, 2002). Substitution occurs when online shopping reduces the total number of shopping trips and/or the distances travelled per shopping trip, resulting in a reduction in overall shopping travel. Complementarity refers to online shopping leading to an increase in the total number of shopping trips and/or the distances travelled per shopping trip, resulting in an increase in overall shopping travel (such as if shopping for an item online resulted in a trip to the retail store to examine or test the product, or if online consumers used savings in online shopping time or money to carry out additional shopping trips). Modification and neutrality refer to online shopping having little or no effect on overall shopping travel (even if it does alter some component of shopping trips in a minor way (such as if a consumer made the trip at a different time of day) (Rotem-Mindali, 2014; Lee et al., 2017).

On first consideration, it may seem that online shopping will result in consumers no longer making shopping trips to acquire goods (i.e. complete substitution); however, in practice this is seldom the case, especially across the range of products a person may buy online. In order to consider the impact of online retailing on consumer shopping trips it is necessary to take account of several factors: i) the different types of shopping trips that consumers make; ii) the type of product involved; iii) how the consumer previously acquired the product; and iv) the attributes of the consumer.

Different types of shopping trips that consumers make

Shopping does not only consist of purchasing products. It can involve many additional activities that are part of the retailing function. These can include (Couclelis, 2004): i) identifying/becoming aware of a need or desire for a product; ii) gathering information about options; iii) searching and browsing; iv) seeking help and advice about products; v) inspecting products, vi) deciding which product to purchase, vii) deciding which retailer to buy the product from; viii) purchasing the product (order/pay for it); ix) tracking the status of the product (if it has been ordered); x) getting the product to home (or other location); xi) returning products (if they are not wanted or have a defect); xii) acquiring after-sales service for a product (if required).

This can be simplified into five main shopping stages (Hoogendoorn‑Lanser et al., 2019):

- Browsing for potential products (including becoming aware of a need or want)
- Selecting a specific product (seeking advice and inspecting the alternatives between products and vendors)
- Purchasing the selected product (including the activities of ordering and paying)
- Obtaining the purchased product (including tracking the order status, if ordered), and
- (Possibly) returning the purchased product.

Each of these five tasks may make use of computing and can also involve shopping-related travel. In addition, shopping-related travel can also take place as a leisure activity or as a means of exercise with no particular purpose in mind.

When a consumer makes use of online shopping, they decide how many of these purposes and activities they will conduct over the internet and how many they would like to carry out in-person in a store by making trips. This will be determined by a consumer's motives, preferences and resources. It is therefore by no means necessarily the case that online shopping results in the consumer no longer making shopping trips.

In a UK survey of approximately 2,000 consumers who had purchased non-food items online in the previous twelve months, which was carried out in 2019, 23% of respondents stated that they had travelled to stores to view products before ordering online (Mintel, 2019a).

Type of product involved

Some researchers have divided products into two categories based on their impacts on consumer shopping travel. These are 'experience' products and 'switch' products. Experience products are those that tend to vary in quality and pricing, and which consumers cannot easily obtain all the information about via the internet that they require prior to making a purchase. This can result in consumers making trips to physical stores to view, touch, test and compare them. Such products include clothing, shoes, and household electrical items. Switch products tend to have relatively few if any quality differences and/or do not require touching and testing in-person prior to purchase. Examples of switch goods include books, music, groceries, and ready-to-eat meals. In addition, some switch products are only available through online shopping such as e-books and music streaming and film services (Zhai et al., 2017).

How the consumer previously acquired the product

When a consumer decides to shop online for a product, in determining the effect that this has on their shopping travel, it is also necessary to consider how they previously acquired the product. If it was previously acquired in a physical shop, then online shopping may result in a reduction or complete removal of shopping trips related to the product acquisition. However, if the product was previously purchased via another form of remote shopping (such as catalogue shopping, or door-to-door sales) then there may have already been little or no shopping travel associated with the acquisition.

Attributes of the consumer

There are many shopper attributes that play a part in determining a consumer's shopping behaviour and related travel activity. These include: age; income and wealth; gender; ethnicity and race; level of education; household size and composition; location of residence in relation to physical shopping facilities; car and other vehicle ownership; employment status and working hours; lifestyle; political, social, environmental and other attitudes and preferences. Therefore, there are no two consumers who are exactly alike in their shopping behaviour and related travel activity.

Wider considerations

Various aspects of a consumer's travel behaviour and shopping transport may change due to online shopping. These include:

- Frequency of shopping trips
- Location and distance of shopping trips (based on shopping location and store choice)
- And therefore, based on the two factors above, total shopping travel (in terms of total distance travelled)
- Transport mode choice for shopping travel
- Trip-chaining
- Whether consumers use travel time savings resulting from online shopping to make additional trips for other purposes and/or to carry out additional shopping.

Trip-chaining, listed above, has two different meanings. It can refer to the extent to which a consumer includes other trip purposes together with their shopping trips. If, for example, a person combines their commute home with a visit to a supermarket, buying their groceries online may only fractionally reduce the distance of their trip home. Trip-chaining can also refer to a consumer purchasing multiple items from various shops or a single shop as part of a single shopping trip. If this person switches to buying some of these items online but continues to travel to the shops to purchase the others with the same frequency, there will be no net effect on their shopping travel.

If online shopping reduces the amount of visits that consumers make to physical stores to view and purchase goods this is liable to affect land use patterns and strategies and plans for the built environment (see section 2.6 on the high street and retail land-use patterns). As well as having implications for personal travel patterns, such a change in retail land-use will also alter logistics activities in terms of where goods are stored, and the extent of last-mile deliveries taking place.

Physical shops have traditionally 'anchored' the buying and providing of products (and their related personal and commercial transport activities) in space and time. Online shopping alters the nature and timing of retailing activities. The spatial 'de-tethering of shopping and its temporal fragmentation have further consequences for the geographies and temporalities' of retailing, shopping travel and last-mile deliveries (Cass and Shoe, 2017). As discussed above, the extent, nature and timing of consumers' shopping travel patterns may alter considerably. The form that last-mile deliveries take vary by retailer, product type, and delivery lead-time, with some items delivered by a major parcel carrier using a laden van performing multi-stop deliveries, while others are made using a bicycle, scooter, or car delivering a single item.

Consumers engaging in online shopping may also opt to collect their products from a collection point or locker bank rather than have the item delivered to their home, as they do not want to wait in for the delivery, or are aware they may not be at home when the delivery is made. In this instance, the consumer will engage in a new form of shopping travel, which they may carry out on its own, or may be able to trip-chain by incorporating it into a trip for another purpose (such as commuting).

6.5 Summary

In terms of recent studies into shopping travel of online shoppers, a study in which 1,700 Dutch users of online shopping were surveyed, found that 50% of respondents did not change their shopping-related travel behaviour since they started shopping online, while 50% did. Of the latter, some shopped less often, while others shopped more often. Some of them reported that they shopped further from home. Analysis indicated that the use of online shopping influences trip distances for non-food, but not grocery shopping trip distance (Hoogendoorn-Lanser et al., 2019). Meanwhile structured interviews with 710 online shoppers in Chengdu, China, found that almost half (44%) of respondents stated that they had reduced their shopping trips due to online shopping, while 15% stated that they had increased their shopping trips due to online shopping (Shia et al., 2019).

Research into the impacts of online shopping on consumer shopping behaviour in terms of whether it reduces or adds to shopping frequency and total distance travelled has so far failed to identify clear findings; instead the outcomes of studies are often 'diverse and sometimes contradictory' (Suel and Polak, 2018). A review of studies that had attempted to address this question found that although online shopping seems to have a complementarity relationship with in-store shopping (i.e. that online shopping is associated with higher in-store shopping frequency), it is difficult to determine the causality (i.e. which causes which: whether seeing an item advertised online leads to a shopping trip, or whether visits to physical stores lead to consumers shopping online) (Cao et al., 2012; Lee et al., 2017). It has been suggested that 'differences in sample sizes and measurement of the dependent variables are likely responsible for some of the inconsistencies' (Lee et al., 2017).

The product type is likely to play an important role in the relationship between online retailing and shopping travel, with the online purchase of so-called search products such as groceries and books resulting in far fewer shopping trips than so-called experience items which are more expensive, purchased less frequently and which are less uniform in terms of price and characteristics (such as washing machines, smartphones and cars) (Rotem-Mindali and Salomon, 2009; Weltevreden, 2007). Time savings related to online shopping may also lead to individuals engaging in other activities that generate travel, or may use these time savings to carry out additional shopping (Farag et al., 2006; Farag et al., 2007; Ferrell, 2005; Gould and Golob, 1997).

7. Impacts of online shopping and last-mile deliveries

At the same time that online retailers have been providing ever-faster and often free delivery services in their efforts to attract customers, there has been increasing concern among scientists, politicians and the public about a range of issues related to environmental sustainability including carbon emissions and their impact on flooding, famine, biodiversity and species loss. Retailing and transport activity are two activities that generate carbon emissions, and the faster the speed and the lower the price of last-mile delivery services, the potentially greater the demand for frequent, small shipment of last-mile deliveries becomes.

Survey work indicates that consumers are aware of the environmental impact of online shopping and last-mile delivery services. One international survey (with 36,000 respondents in 41 countries who had engaged in cross-border online shopping) indicates that 45% of consumers who responded either agree or strongly agree with the statement that they would prefer the delivery activity involved in parcels to be carbon-neutral. In addition, 47% of respondents either agree or strongly agree with the statement that they are willing to receive a package a few days later to reduce the environmental impact International Post Corporation, 2019). In the same survey, 66% of respondents either agree or strongly agree with the statement that they would like the packaging of their parcels purchased online to be recyclable, while 64% either agree or strongly agree with the statement that they would like the packaging of their parcels purchased online to be reusable (International Post Corporation, 2019).

Another survey of approximately 500 consumers in the UK found that 52% of respondents were conscious of the environmental impact of their online deliveries and a further 25% said they cared a great deal about how their online deliveries contribute to traffic and carbon emissions, and 94% said they would opt for consolidated delivery if ordering more than one item (i.e. be prepared to wait for all items to be delivered in a single consignment) as it was greener and more convenient. However, 66% expected standard delivery to be free (Metapack, 2018). Another survey of UK consumers found that, in 2019, approximately 70% of respondents stated they would choose a carbon-friendly delivery option over the standard delivery for online parcel orders if one was available. However, when asked if they would pay more for this option only 33% said they would (IMRG, 2020b). Another survey of consumers in the UK found that only 3% of consumers said they were offered a ‘green’ delivery option when ordering (Barrie, 2020).

The results of these UK consumer surveys indicate public concern about negative environmental impacts on online retailing and deliveries and a desire to reduce these impacts, but that consumers aren’t often provided with environmentally sustainable delivery option when placing their orders. However, the willingness for these outcomes to be reflected in delivery charges are typically met with less support, and whether there would be a substantial uptake of sustainable delivery options by consumers when placing orders remains to be seen.

Online shopping and last-mile deliveries are related to transport activity, kerbside use, carbon emissions and operating costs. The specific, direct impacts of last-mile delivery activity have been considered in chapter 4. In order to understand the full effects of online shopping and last-mile delivery it is necessary to compare it with conventional shopping (in-store) and its associated consumer shopping transport in terms of all of its direct and indirect impacts. This is covered in sections 7.1-7.4.

One study that considered the carbon impacts of online shopping and last-mile delivery classified the effects of online shopping into three types: first order (production and use of ICT), second order (supply chain and freight transport processes) and third order (changes in consumer behaviour and habits) (Van Loon et al., 2014, using a classification system devised by Fichter, 2003). This approach has been extended in Table 7.1 to take account of other factors and other impacts in addition to carbon emissions, together with an indication of in which section they are addressed.

Table 7.1: Full listing of potential impacts of online shopping and last-mile deliveries

Impacts	Section to refer to in report
First-order impacts	
Computing and related electricity use for online ordering	Section 7.6
Second order impacts (supply chain and freight transport processes)	
Last-mile delivery activity	Chapter 4 and section 7.5
Packaging use and waste	Section 7.7
Storage and order picking for online retailing	Section 7.8
More international sourcing of small items and use of air freight	Section 7.9
Behaviour of last-mile delivery workers	Section 7.10
The safety and wellbeing of couriers	Section 7.11
Social inclusion and exclusion due to online shopping	Section 7.12
Casualisation of labour in last-mile delivery operations	Section 7.13
Third order impacts (changes in consumer behaviour and habits)	
Consumer shopping travel	Chapters 5 and 6 and section 7.4
Overall life cycle analysis of online shopping	Section 7.14

7.1 The importance of consumer transport in retail transport activity

Research that has analysed the consumer transport component of the retail supply chain for various grocery and clothing products has shown that, on a per item basis, shopping using a conventional car has a considerable energy consumption and carbon emissions footprint. Various factors are important in the scale of this impact including: the mode of transport, the quantity of goods purchased, the extent to which the consumer trip is dedicated to shopping or involves other purposes, and the travel distances for shopping and in product supply chains. Depending on these factors, the consumer shopping trip can be responsible for a considerable proportion of total retail logistics energy use and related emissions.

A study of commercial and consumer transport activity for rye bread in Denmark indicated that consumer activity by car per unit of weight carried was greater than all the commercial transport activity in the production and distribution of the bread from farm to shop (Jespersen, 2004). A study of jeans sold in a UK retail store found that the consumer transport trip to the shop by car uses one third of the energy per kg of jeans transported in the total international commercial freight transport stages from cotton field to shop. This shopping trip by car also uses approximately 50% more energy than that used in transporting the jeans from the UK port to the retail outlet. In the case of yoghurt, it was found that the energy used in the car trip per kg of yoghurt was approximately the same as the total commercial freight transport energy from farm to retail outlet (Browne et al., 2005; Browne et al., 2006).

7.2 Last-mile deliveries compared with deliveries by larger goods vehicles

Analysis of data from survey work and interviews with managers and drivers in the non-food, grocery and ready-to-eat meal delivery sectors in London indicates that these last-mile deliveries have far greater traffic and environmental impacts than general freight deliveries using larger, heavier goods vehicles carrying greater quantities of goods. The results indicate that the traffic intensity (in terms of the distance travelled per unit weight of goods transported) and greenhouse gas emissions per unit weight of goods transported are far greater for each of these types of last-mile operations than for conventional freight transport operations using rigid and articulated vehicles.

Ready-to-eat meal deliveries were found to generate by far the greatest vehicle kilometres per tonne of goods transported of these last-mile delivery operations. This form of last-mile operation was estimated to result in approximately 100 times more vehicle kilometres per tonne transported than non-food parcel deliveries, 40 times more than grocery next-day deliveries, and 2.5 times more than same-day grocery deliveries. In terms of carbon emissions per unit weight transported, ready-to-eat meal deliveries by moped were estimated to generate approximately 30 times more than next-day parcel deliveries by van, and 10 times more than grocery next-day delivery by van (Allen et al., 2020).

Even the least transport-intensive form of last-mile delivery, next-day parcel operations, were estimated to result in four times more vehicle kilometres per tonne transported than general freight operations using rigid vehicles, and 11 times more than articulated goods vehicles.

7.3 Comparing transport activity and CO_2 emissions in store-based and online shopping

Various studies have attempted to quantify the impact of last-mile deliveries compared with consumers travelling to physical shops to buy goods in person.

A 2010 study found that purchasing a book online and having it delivered to home rather than making a personal trip by car or bus to the shops could substantially reduce last-mile CO_2 emissions. If only one book was purchased and assuming average UK values for distance travelled, fuel efficiency and vehicle loading, shopping by car would emit 4,274 g CO_2 per book, by bus 1,265 g CO_2, and delivery by van 181 g CO_2 (i.e. shopping by car and by bus would result in respectively 24 and 7 times more CO_2 than a last-mile delivery by van). The analysis showed that the differential between retail methods and vehicle modes reduced as the number of items purchased increased (Edwards et al., 2009; Edwards et al., 2010a; McKinnon, 2018).

The same 2010 study considered the impact on the total CO_2 emissions generated by consumer shopping transport of: i) the quantity of items purchased; ii) shopping trips made for browsing and acquiring information rather than buying; and iii) trip-chaining. This showed that the CO_2 emissions on a per item basis were directly inversely proportional to the number of items purchased. It also reflected that a dedicated shopping trip for browsing results in the same amount of CO_2 emissions as a shopping trip using the same mode of travel in which an item is purchased. It also demonstrated that the number of activities incorporated in an overall transport journey (e.g. shopping combined with commuting, visiting friends or a leisure trip) without required additional, diversionary distance is inversely related to the distance attributed to the shopping trip (Edwards et al., 2010a).

A case study of the purchase of electronic goods (such as a desktop computer or small stereo) by consumers in the Dalecarlia region in central Sweden (a region chosen for its representativeness of the country as a whole, containing mountains that limit road transport routes in and out, and with rural locations resulting in some people living far from electronics shops), showed that, on average, consumer buying online (and collecting from a local postal collection point) consume only 14% of the transport CO_2 emissions of those buying at a store (Carling et al., 2015). This assumes that consumers do not visit a store to view the item, instead doing all their research and order placement online. The analysis showed that if 71% (or more) of these online orders also involved a consumer trip to a store to view the item before buying online, then the CO_2 benefits of online shopping would be offset. In the base case, the goods vehicle delivering the online order to the collection point was assumed to be 60% full. Further analysis showed that if the vehicle is only loaded to 30% of its capacity, this only modestly worsens the CO_2 emissions produced by shopping online compared with buying in a store, and the CO_2 benefits of buying online remained large (Carling et al., 2015).

A comparison of store-based and online clothes retailing in Germany from the retailer's central warehouse to store or customer's home, which took account of the mode used by consumers when buying from store, estimated that store-based retailing results in ten times more CO2 emissions per item purchased than online shopping (2.4 kg of CO_2 compared with 0.2 kg), and six times more CO2 emissions per transaction (4.2 kg of CO_2 compared with 0.7 kg) (Wiese et al., 2012).

Research has shown that if online grocery shopping involves the complete substitution of consumer transport with a van last-mile delivery making multiple drops (as may also be the case for the online

purchase of a single book), the total shopping vehicle kilometres (i.e. personal travel plus last-mile trip) can be reduced, depending on drop-density, by 60%-80% (Cairns, 1999, 2005). A case study of online grocery shopping in Seattle, USA, showed potential vehicle kilometres reductions of 85%-95% and CO_2 emissions reductions of 80%-90% compared to consumers making dedicated car journeys to and from grocery supermarkets (Wygonik and Goodchild, 2012). However, for many products and consumers, even when use is made of online shopping, it often does not necessarily result in the entire cessation of shopping trips (Rotem-Mindali, 2014 – see **section 6.4** for further discussion).

'Bewust Bezorgd' ('Consciously Delivered') is a carbon emissions calculation tool intended to assist online retailer members to understand the CO_2 emissions associated with last-mile parcel deliveries (from the point of despatch to the delivery point - see section 8.7 for further details). Results provided by the tool show that: (i) same-day deliveries generate more CO_2 emissions than next-day deliveries (due to the parcel load carried), (ii) customers collecting parcels by car from click and collection facilities generates more CO_2 emissions than a parcel carrier delivering to the customer's home (based on the respective parcel loads of the two vehicles), (iii) same-day deliveries are far better than those by van in terms of CO_2 emissions (Bewust Bezorgd, 2020a).

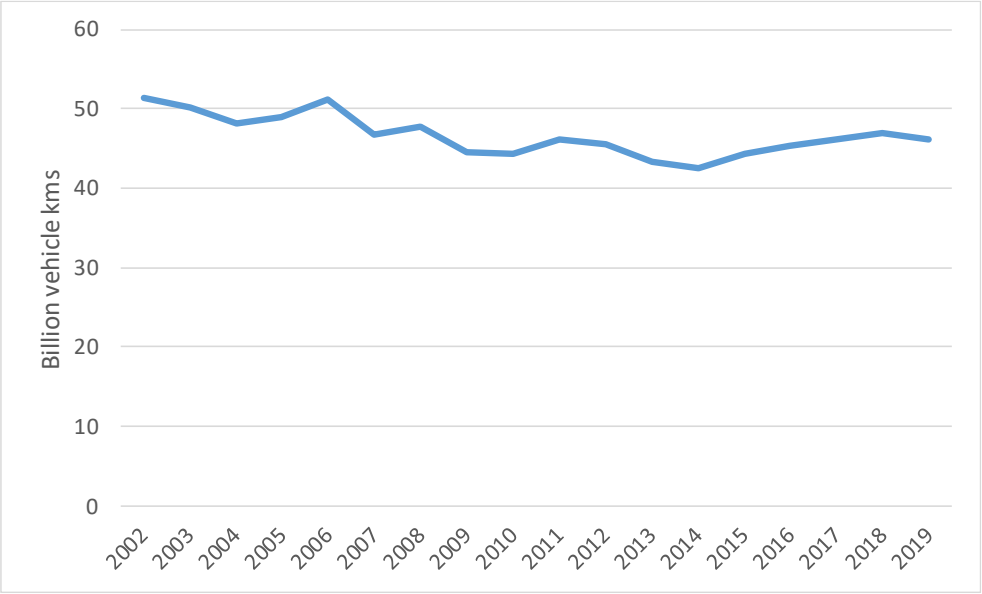
Studies such as those summarised above are subject to various methodological, study boundary and data availability difficulties (Edwards et al., 2011). They often take no account of: failed delivery and product return rates involved in online shopping, the personal shopping trips that online shopping can result in to search for and gain information about products, trip-chaining by consumers when shopping, the fact that some shoppers walk or use bicycles for store-based shopping, and any wider changes in consumer shopping behaviour as a result of online shopping (Edwards et al., 2010a). The international nature of some online shopping transactions is also ignored in many transport studies, which can have considerable upstream carbon implications (see section 7.6). There is therefore no current consensus concerning the transport and related carbon implications of online shopping compared to store-based retailing (Mangiaracina, 2015).

7.4 Analysis of consumer shopping and last-mile deliveries in the UK using government transport statistics

The car is by far the most commonly used means by which consumer shopping takes place in the UK. Cars and taxis accounted, on average, for 86% of shopping distance travelled per person in 2019 in England, buses accounted for 6%, trains for 3%, walking for 4%, motorcycles for 0.1%, and bicycles for 0.5% (Department for Transport, 2020b - see section 5). In terms of motorised road transport, shopping accounted for 11% of total car and taxi kilometres per person per year, 4% of total motorcycle kilometres, and 20% of total bus kilometres in England in 2019 (based on an analysis of National Travel Survey data - Department for Transport, 2020b).

Using National Travel Survey data for England about shopping by car and taxi in England between 2002 and 2019 and applying this to government car traffic data for Britain as a whole it is possible to estimate the total car and taxi traffic in Britain over this period (Department for Transport, 2020b and 2020c - see Figure 7.1). This indicates that 5.2 billion fewer car and taxi traffic kilometres were travelled for the purpose of shopping in Britain in 2019 than in 2002 (a reduction of 10%).

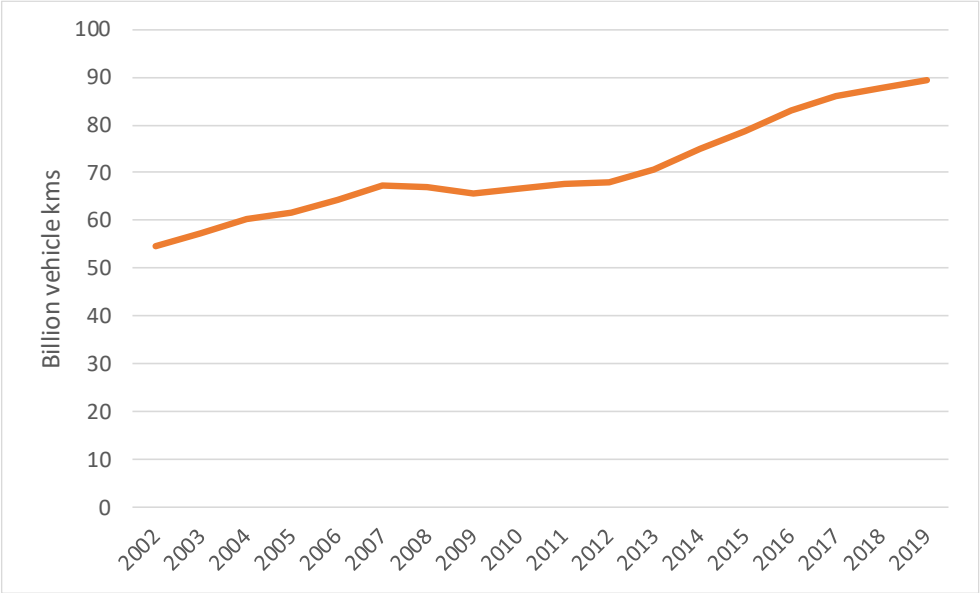
Figure 7.1: Car and taxi shopping activity in Britain, 2002-2019



Source: Calculated using Department for Transport NTS data and road traffic statistics (Department for Transport, 2020b and 2020c).

As explained in section 3, vans are the most commonly used vehicles for last-mile deliveries (especially for grocery and small, non-food purchases). Figure 7.2 shows total van activity in Britain over the period 2002-2019, which has increased by 63% over this period. This comprises van activity for all purposes including last-mile deliveries of online shopping.

Figure 7.2: Total van activity in Britain, 2002-2019



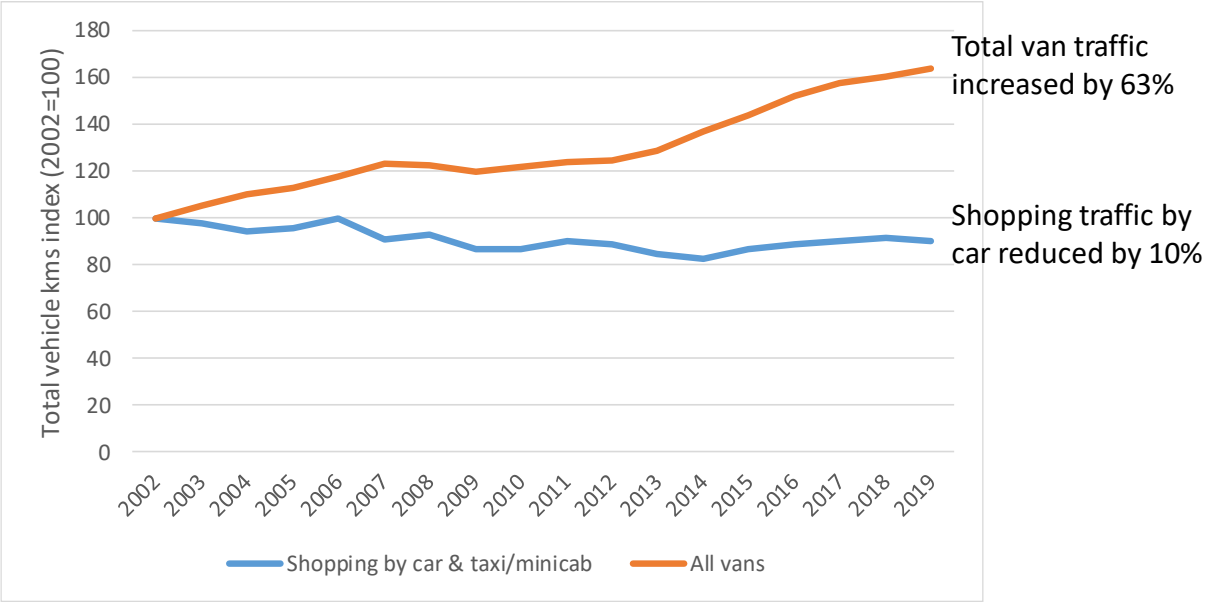
Source: Department for Transport, 2020c.

Previous research has shown that vans are used for many purposes: the collection and delivery of goods (including last-mile deliveries), the carrying of equipment and tools to enable the provision of a service (such as utility and computing engineers, builders, electricians and plumbers), travel to and from work, and private use (Allen et al. 2018; Braithwaite, 2017; CfIT, 2010). A survey of the registered keeper of 17,600 vans (both registered to private individuals and companies) in 2019/20 was carried out. The provisional results indicate the most important uses of vans in terms of the proportion of total van vehicle kilometres travelled in Britain that they account for (in order of importance): the carrying of equipment

and tools to enable the provision of a service (48%), the delivery/collection of goods (23%), private use including travel to/from work (10%), providing transport to others (4%), and recreational/leisure and holidays (3%). Twelve percent of van travel was not ascribed to a specific purpose in the survey (Department for Transport, 2020d). Although this survey indicates that the delivery/collection of goods accounted for 23% of the total vehicle kilometres travelled by vans in 2019/20, it does not sub-divide this into various types of delivery and collection work, one of which is the delivery of online shopping.

Figure 7.3 shows the relative change in total van activity and shopping by car and taxi traffic in Britain between 2002 and 2018.

Figure 7.3: Change in total van activity and shopping by car and taxi in Britain 2002-2019



Source: calculated from Department for Transport National Travel Survey and Road Traffic Statistics (Department for Transport, 2020b and 2020c).

Comparing this growth in van traffic and the reduction in car-based shopping since 2002 (2002 being the earliest year for which this NTS car travel data is available and also a period when little online shopping took place in Britain), the data suggests that last-mile van traffic would have to account for no more than 6% of total van activity in Britain in 2019 for there to have been no net increase in the total distance travelled by cars, taxis and vans for shopping purposes compared with 2002.

There are few estimates of the proportion of van activity in Britain accounted for by the deliveries of online shopping. However, it has been estimated that approximately 300,000 vans are used in the parcels and mail sector in Britain (which was equivalent to approximately 8% of the total van fleet at the time) (FTA, 2016). Another study estimated that online shopping accounted for 7-10% of total van activity in Britain (Braithwaite, 2017). Based on a small-scale survey, Transport for London estimated that last-mile parcel deliveries accounted for 5-10% of van kilometres in London (Transport for London, 2016b).

Obviously, this analysis takes no consideration of last-mile deliveries by other motorised vehicles (i.e. the use of motorcycles and mopeds for meal, grocery and parcel deliveries and the use of HGVs for large item non-food deliveries). However, it provides some insight into the overall effect on motorised traffic of online shopping taking account of shopper and company delivery activity.

7.5 Failed last-mile deliveries and carbon emissions

A study examined the carbon emissions impact of failed last-mile deliveries (Edwards et al., 2010b). The spreadsheet-based analysis indicated that CO_2 resulting from a failed delivery increases the emissions per item by 9% to 75% (depending on the number of times the carrier has to attempt redelivery). If it is

necessary for the consumer to subsequently collect the item from the carrier's depot themselves this results in far greater increases in CO_2 per item. It was calculated that using a car to make a 25 mile round trip to collect and bring back a missed delivery produces the equivalent of 26 redelivery attempts by van. The study went on to analyse the potential carbon benefits in the case of failed deliveries that could arise from the use of collection points and locker banks located closer to the consumer than the carrier's depot (at places such as supermarkets, post offices, and railway stations). The results indicate that the use of such collection points or locker banks for failed deliveries would result in only 14%-73% of the CO_2 produced by a failed delivery leading to a consumer collection by car from a local parcel depot (Edwards et al., 2010b).

As previously discussed (see section 4.5), a study of using agnostics lockers to serve online deliveries to a block of residential flats in Seattle entirely removed the problem of failed deliveries and also resulted in a 78% time saving for carriers (Urban Freight Lab, 2018a). If the trail had involved deliveries to houses rather than a single block of flats it would also have resulted in substantial reductions in the distance travelled and CO_2 emissions of the delivery van.

7.6 International retailing and the use of air freight

Online shopping can result in consumers purchasing non-food products directly from overseas retailers, and in retailers advertising products that are only stocked overseas. These cases of international online retailing commonly take place on retail platforms such as eBay and Amazon Marketplace, in which international sellers can readily advertise and sell items in different countries and continents to those in which they are based. The items sold are them transported long-distance as individual parcels in non-unitised loads, and make use of aviation or maritime transport. Both of these modes involve considerable fossil fuel consumption and hence carbon emissions, but aviation is far greater per unit of goods handled than maritime. These two modes offer marked differences in journey time. For example, whereas air freight from China to the UK may take approximately take 2-10 days depending on the service level requested, maritime journeys are likely to take 6-8 weeks (i.e. as much as eight times longer door-to-door – McKinnon, 2019).

According to parcel carrier data, international parcels represent approximately 20% of total parcels handled in the UK. Meanwhile, data from 200 retailers indicates that international parcels account for approximately 30% of total online orders (Ofcom, 2019; IMRG and Metapack, 2019). Data on inbound international parcel flows to the UK shows that volumes grew year-on-year by 11% in 2016/17, 30% in 2017/18, and 15% in 2018/19. This is a considerably stronger rate of growth than for domestic parcels over this same period (which was 7%, 9% and 9% respectively) (Ofcom, 2017; Ofcom, 2018; Ofcom, 2019). Therefore, both relative and absolute growth is taking place in international parcel flows to the UK. Survey work in the UK in 2018 with 500 consumers indicated that approximately 30% of respondents had made 2-5 international online purchases in the previous 12 months, while 10% had made 6-10 such purchases (Metapack, 2018).

It has been noted by the UK's communications regulator that the key factor in this growth in cross-border parcel traffic is likely to be increases in cross-border online shopping purchases, especially from China (Ofcom, 2019). A survey by the International Post Corporation (IPC) found that Chinese parcels accounted for 38% of all global cross-border parcels in 2018. This IPC survey also showed that, in 2018, 50% of international online shoppers in the UK had bought their most recent cross-border purchase from China, with the next highest proportion (19%) being purchases from the USA (International Post Corporation, 2018). A total of 51 billion parcels were handled in China in 2018, an annual increase of 26%, while parcels shipped from China internationally increased by 34% year-on-year (State Post Bureau of The People's Republic of China, 2019a).

International express freight (i.e. parcel traffic) by air accounted for approximately 18% of total air cargo in 2016, and is growing at a faster rate than other air cargo sectors. Express freight accounts for approximately 60% of all cargo by revenue in the US domestic air cargo market, 50% in the intra-European air cargo market, and 30% of the total Asia to North America cargo market (Malighetti, 2019a). There are three main international parcel carriers that offer aviation in addition to road transport services: DHL, FedEx/TNT, and UPS, and it has been calculated that their relative market shares of the

international aviation parcel market to, from and within Europe are 45%, 29% and 24% respectively (in terms of available freight capacity - Malighetti, 2019b).

Amazon makes use of air freight to transport goods ordered by customers domestically between distribution centres for final last-mile delivery by road. It previously made use of third-party carriers for these aviation services but in 2015 established its own aviation division, Amazon Air, for in-house transport within its supply chain. It has a fleet of 60 planes (Boeing 737 and 767 freighters) which it intends to increase to 70 by 2021 (Herrera and Qian, 2019).

Air freight is by far the most carbon-intensive freight transport mode. It has an average CO_2/tonne-kilometres that is 8-10 times that of a heavy truck, and 80-100 times that of shipping (McKinnon and Piecyk, 2011; Sims and Schaeffer, 2014 quoted in McKinnon, 2019). However, it is important to note that the CO_2/tonne-kilometres for diesel vans used for last-mile deliveries is far higher than a heavy truck, at approximately 6-8 times greater (Sims and Schaeffer, 2014).

7.7 Online orders, computing electricity and emissions

The technology used to facilitate online shopping is responsible for energy consumption and hence carbon emissions. UK national statistics show that, in 2018, computing as a whole was responsible for 4% of total domestic electricity consumption in the UK, and consumer electronics (computers, TVs, DVDs, set-top boxes and games consoles was responsible for 28% of non-heating or cooling domestic electricity consumption (BEIS, 2019a,b).

Google has estimated that a typical internet search using its search engine requires as the same electricity as illuminating a 60-watt light bulb for 17 seconds and is responsible for 0.2 grams of CO_2 emissions. Based on this, a typical car in the EU driven for one kilometre produces as much greenhouse gas emissions as a thousand Google searches (Google, 2009). An internet connection using a W-Fi network is approximately 50-60% more energy efficient than using 3G and 4G connections (Zou et al., 2017). Due to its greater transmission speed, 5G networks could consume far more electricity than 4G if energy efficiency is not improved (Bronk, 2019).

Due to differences in methodologies and where system boundaries are drawn, there is no single, definitive figure for how much electricity is consumed by the internet. Research since 2010 has estimated the electricity consumed by the various equipment that powers the internet (including digital devices such as computers and smartphones as well as the supporting infrastructures of communication networks and data centres) to account for approximately 3-5% of global electricity consumption; and approximately 7-10% if other equipment including TVs, audio/visual equipment and broadcast infrastructures were included (Andrae and Edler, 2015; Malmodin et al., 2010; Molmodin and Lunden, 2018; Morley et al., 2018; Van Heddeghem et al., 2014). Global internet data traffic has increased approximately five-fold between 2010 and 2015, has continued to increase since, and is forecast to continue growing over the coming years (Aslan et al., 2017).

A study into data centres suggests that, despite an expected tripling of data centre workloads between 2014 and 2020, global data centre electricity demand is expected to grow by only 3% up to 2030 due to efficiency improvements in IT hardware and data centre infrastructure, and a shift to hyperscale data centres (IEA, 2017). By contrast, an analysis of the estimated global electricity consumption that Communication Technology (CT) could be responsible for between 2010 and 2030, found that in the worst-case scenario, CT could account for up to 51% of global electricity in 2030 if there is insufficient improvement in the efficiency of wireless access networks and data centres. The analysis reported that by 2030 there is likely to be substantial renewable electricity generation, but even given this, in the worst-case scenario CT electricity could account for up to 23% of the global GHG emissions in 2030 (Andrae and Edler, 2015).

7.8 Packaging use and waste

Online shopping for non-food items is associated with the use of substantial packaging, especially cardboard and plastic polybag packaging. Primary packaging for non-food products sold online is typically greater than for those sold in store, as it is necessary to prevent damage to them as they are handled and transported to the customer. Meanwhile, non-food items sold online are associated with less secondary packaging than goods sold in store (for example, cases and crates that unitise and prevent damage to loads during handling and transport to the store). Goods sold in store also require merchandising packaging (to attract customers to purchase them), whereas online orders do not, and their packaging can potentially be more functional. However, the same merchandising packaging is often used by retailers for products regardless of whether they are sold online or in-store. Given that non-food goods sold online are moved in far smaller quantities than those sold in-store, and are not capable of being efficiently unitised on transport trips between central hubs and local depots and on last-mile delivery trips, more packaging is typically required in total for the same quantity of goods sold online compared with if they had been sold in store.

One study of last-mile deliveries versus conventional shopping found that cardboard packaging can account for a significant portion of the greenhouse gas emissions generated through last-mile deliveries (100 g of corrugated cardboard plus 33 g of filling material was found to result in 181 g CO_2-eq per item). By comparison, the use of plastic bags in last-mile deliveries and conventional consumer shopping trips results in less than 11 g CO_2-eq (due to the lower quantity and weight of plastic packaging (Van Loon et al., 2015). In addition, the returns of non-food products purchased online by consumers require repackaging, which can involve the use of additional packaging materials. Ready-to-eat delivered meals are also responsible for substantial packaging use, with pizzas delivered in cardboard boxes, and other foods and drinks in cardboard or plastic containers, together with the use of plastic or paper bags.

In-store shopping in the UK has been the subject of a plastic bag tax introduced in 2015 in order to stimulate their reuse by customers. As a result, in 2017/18 plastic bag sales in the seven largest supermarkets fell by 86% compared with the year prior to the introduction of the tax, a decrease of approximately 300 million bags, which is equivalent to 19 bags per person, compared to 140 bags prior to the tax (DEFRA, 2018). More than 100 UK retailers and manufacturers, including all major grocery retailers, have signed up to the UK Plastics Pact launched in 2018, which has resulted in, among other things, them not using plastic fruit and vegetable punnets and trays where possible in-store, allowing customers to use their own containers at delicatessen counters in store, stopping the use of disposable coffee cups in their stores, and pledging to remove unnecessary plastic packaging from their supermarket shelves by 2025 (WRAP, 2019).

The vast majority of online clothing retailers use polybags, which are made from polyethylene film (plastic film #4 or LPDE film), which are not commonly recyclable by domestic refuse collection services. In 2014, one online and store clothes retailer, the outdoor clothing company Patagonia, investigated what could be done to reduce the use of plastic bags in response to customer complaints about each item being delivered in its own polybag. Finished goods are packed into polybags at the factory to prevent dirt, moisture and damage. In a study, the company experimented with eliminating the use of polybags and simply using paper ties to hold individual products in a fixed shape as they passed along the conveyor system in the picking process for despatch to customer. It was found that approximately 30% of these garments were damaged beyond being sellable even before leaving the distribution centre. In another trial the company tried used recyclable paper packaging instead of plastic polybags, but found that these bags were damaged during the picking process on the conveyors in the distribution centre (Cohen, 2014).

Relatively little attention has been paid by retailers and government to packaging use and waste in online shopping and last-mile deliveries, even though there appears to be a sizeable proportion of consumers who would like to see changes. Market research in the UK in 2017 found that approximately half (47%) of respondents who used online shopping felt that too much packaging is used, and two-thirds (67%) said they avoid buying products online that they know use substantial packaging either some or all of the time (Mintel, 2017).

There is scope for online retailers to ensure that they reduce packaging waste, and make use of reusable and recyclable packaging. This includes ensuring that orders consisting of multiple items are packaged

together rather than individually, using packaging that is appropriately sized for the items concerned to prevent unnecessary overuse of packaging, and providing reusable bags for customers to return items in.

The Dutch online retailing trade association, thuiswinkel.org, established a Packaging Sustainability Plan for the period 2018-2022 which involved meeting with the packaging industry to gain insight into packaging innovations and established a working group with online retailers to implement them. It provided a comprehensive set of objectives and research targets. The targets are summarised in Table 7.2.

Table 7.2: Summary of packaging objectives and research targets 2018-2022

Reduce (materials)	Objective	Only to use shipping packaging where it is required to protect the product, not for marketing reasons.
		Not to use filling materials inside packaging unless this is essential for product protection.
	Research	Investigate whether collective agreements can be reached with suppliers about primary packaging used in online retailing.
Reduce (volume)	Objective	Reduce the quantity of air in packaging by 10% compared to 2018 (especially for items packaged by hand as machines are already capable of removing unnecessary air.
	Research	Investigate the extent to air reduction instead of packaging standardization can help to reduce the CO2 impact of logistics.
		Research the most sustainable materials and solutions for shipping bags, such as paper, (recycled) plastic and other materials.
Reuse (Reusable packaging)	Objective	10% of eligible products will be shipped in reusable packaging (assuming a successful pilot project).
	Research	Run a pilot project with online retailers into the application of reusable packaging.
Recyclability	Objective	All shipping bags are resealable.
		100% of consumers are informed about how to separate the packaging. In the case of printed packaging, the logos can be printed from the disposal guide.
Recycled material	Objective	For Plastic Packaging: 100% recycled plastic in case of manual packing, provided there is sufficient supply. 50% recycled plastic in case of machine packing, provided there is sufficient supply.
		For Cardboard Packaging: All cardboard packaging is made of FSC / PEFC material and contains the highest possible percentage of recycled fibres.

Source: Translated from thuiswinkel.org, 2018.

7.9 Storage and order picking for online retailing

Estimates suggest that warehousing accounts for approximately 10% of carbon emissions in the UK (two estimates put it at 11% while another put it at 13% - AEA, 2012; Baker and Marchant, 2015; World Economic Forum/Accenture, 2009). Lighting is the major source of energy consumption within an ambient warehouse, accounting for 65%-95% of total energy consumed (Carbon Trust, 2019).

Warehouse picking and packing tend to result in less lighting and heating energy use than in store (with warehouses using less energy per unit of space than a store, especially if a manual warehouse) (Lovins, 2001). Changes in upstream warehousing locations/strategies – for example, holding goods in fewer, more-centralised, larger facilities results in reductions in stockholding levels (due to the square root law) but increases the distances over which goods need to be transported (Romm et al., 1999). Thus, holding goods in fewer locations reduces warehousing energy but increases transport energy. Given that transport energy is typically nine times greater than warehouse energy consumption in a supply chain, the overall effect can be an increase in net energy / carbon intensity of the upstream supply chain. This

is dependent on the efficiency of transport operations from the storage location (World Economic Forum and Accenture, 2009). By contrast, picking and packing in more local fulfilment centres, closer to the customer, can increase warehouse energy but reduce transport energy.

In the case of online shopping, warehouses tend to be large, which can help to reduce total inventory levels compared with the use of a greater number of smaller facilities, and hence lower carbon emissions. However, the small order sizes and the scale of returned products can result in additional warehousing operations, and thereby greater carbon emissions per order (Mangiaracina et al., 2015). However, there is no existing research that has analysed the net effect of these factors (Pålsson et al., 2017).

No overall comprehensive analysis of the warehousing and order picking supply chain effects of online retailing on energy use and CO_2 was identified during this literature review.

As part of its decarbonisation strategy, An Post, the national mail and parcel carrier in the Republic of Ireland, achieved 100% use of renewable electricity in its buildings by 2019. The company has set targets to reduce electricity use within buildings by 40% by 2022 from a 2009 baseline and to replace all lighting with energy efficient lighting by 2022 (An Post, 2019a).

7.10 Behaviour of last-mile delivery workers

Same-day couriers on bicycles, cargo cycles, and motorcycles working in dense urban areas often drive/ride fast and endanger themselves, other road users and pedestrians in their haste to complete work and earn more pay. This can involve weaving in and out of the traffic, and even riding on pavements. This partially stems from their typical self-employed status, as a result of which, the faster that jobs can be carried out, the more the courier can earn. Other factors likely to have a bearing on the road behaviour of some couriers include the lack of driver/rider training available in many companies, especially when couriers are self-employed, and the lack of driving qualifications and experience among many moped and motorcycle couriers, especially in the meal delivery sector (Allen et al., 2018).

Some residents living near to the restaurants where couriers wait to collect meals ordered online have been affected by noise disturbance and other nuisances. In the case of one restaurant selling delivered takeaway meals online in Westminster, London the council received approximately 25 complaints from residents living close to the outlet. These complaints included: 3-4 mopeds being parked up outside the restaurant at any one time after 19:00; several hundred delivery trips being generated over the course of a weekend; poor driving behaviour and risk of traffic collisions with pedestrians; couriers often congregating in the street in the evening in good weather and creating substantial noise; verbal and physical abuse directed at residents when they asked couriers and customers keep the noise down; litter dropped by couriers; and customers and couriers eating food on residents' steps (Hexter, 2017).

7.11 The safety and wellbeing of couriers

Meal and parcel workers operating at night (or even during the daytime) making deliveries to residential addresses may be confronted by aggressive or drunken customers. Working alone after dark and sometimes handling money can also make such work dangerous (European Agency for Health and Safety at Work, 2010). In the last couple of years, attempts to steal workers' motorcycles, mopeds and bicycles have led to acid attacks on some couriers that have resulted in life-changing injuries (McGoogan, 2017). The road-worthiness of the vehicles used also plays an important role in road safety. Couriers on two-wheeled vehicles are exposed to the elements and are subject to poor air quality, especially in dense, congested urban areas. In addition, the physical strain of cycling requires a higher and more intense rate of breathing. This results in cyclists being more exposed to polluted air. Chronic exposure to air pollutants can reduce lung function permanently (Hendry, 1999).

A study of last-mile couriers and taxi drivers in the 'gig' economy in the UK found that pressures associated with the work and self-employment may significantly increase the risk of being involved in a traffic collision. Sixty three per cent of survey respondents stated that they were not provided with safety training on managing risks on the road, while 65% said that they were not given any safety equipment. Sixty seven per cent reported that the company did not suggest they had rest breaks and did not give

advice about using their phone whilst driving or riding. Across both two and four-wheeled couriers, only 25 per cent agreed that the company cared about their safety whilst working (Christie, Ward and Helman, 2018).

Self-employed couriers are usually required to provide their own vehicles (be it a bicycle, moped, motorbike, car or van). Some companies will rent or lease vehicles to their couriers. In the case of couriers who are employed by a carrier, they are typically provided with a vehicle by the carrier.

7.12 Online shopping and social inclusion/exclusion

For some consumers with physical disabilities online retailing has improved their ability to shop, as they do not need to visit stores in person. Instead the product search, viewing and transaction and delivery can all be facilitated from the consumer's home with the use of a computer or smartphone. Online shopping can also be advantageous to consumers living in remote communities and locations that are based substantial distances from retail centres.

However, those who are not computer- or smartphone literate or who do not have the financial standing to afford these technologies or broadband access can be excluded from online shopping (as well as from other services that depend on access to these technologies). In the UK, 20% of the adult population were non-internet users; however, this had fallen to 10% by 2018 (Office for National Statistics, 2019). Many of those without the prerequisite knowledge to make use of online shopping are in older age categories who grew up without the technology. In the UK, 55% of those aged 75 or over and 24% of those aged 65 to 74 were non-internet users in 2018 (Office for National Statistics, 2019). This may be largely a one-off situation that will not continue to this extent in the future. However, some with low-educational status are likely to continue to be excluded. In terms of those excluded due to low financial means, the price of technology has fallen considerably over time. However, the price of broadband contracts remains relatively high. This has been addressed to some extent by the availability of free broadband services in public libraries and some pubs and restaurants.

Working with charities and local authority housing departments, An Post, the national mail and parcel carrier in the Republic of Ireland, launched a free service in 2019 called 'Address Point' which provides a personal postal address and letter collection service for people who are homeless or living in temporary accommodation. These people choose a local post office, which then becomes their collection point for mail and parcels (An Post, 2019a).

7.13 Casualisation of labour in last-mile delivery operations

Many parcel carriers have, for a long time, made use of self-employed drivers (so-called 'independent contractors') (Scott, 2016). An industry survey found that all parcel carriers surveyed made at least some use of self-employed couriers/drivers. Carriers in the same-day sector were found to be more likely to offer self-employment rather than employed status to couriers/drivers (Institute of Couriers, 2017).

The companies offering self-employed status to couriers/drivers argue that this approach helps to match the demand for services with the supply of workers. It also means that the companies are not responsible for paying minimum wages or national insurance on behalf of the couriers, the couriers are not entitled to holiday pay, sick pay, or maternity/paternity leave, and the company can choose not to use couriers as it wishes. The only securities offered by law to these self-employed couriers is in the form of basic health and safety rights and a right not to be discriminated against.

With the rise of the so-called 'gig-economy' (including online shopping), this self-employed method of hiring drivers has been growing rapidly for last-mile non-food and ready-to-eat meal delivery services (for example among Amazon – with its Amazon Flex drivers, and Deliveroo (Allen et al., 2018)). By contrast major grocery retailers making last-mile deliveries tend to offer employed posts. Whilst these methods of work and remuneration suit some people who like to work for just a few hours when they choose, and to have flexibility in their working arrangements, others are less happy and would prefer to have 'worker' or 'employee' status.

Some working as couriers/drivers in the last-mile delivery sector argue they cannot refuse work or set their own hours, can be asked to wear uniforms and identification, and need company permission to take holidays and that therefore they should be reclassified as 'dependent workers' (Chakrabortty, 2016; Ainsworth, 2018; Field and Forsey, 2016). This is not equivalent to full employee status, but provides workers with additional rights to the self-employed including the right to the National Living Wage (NLW) or National Minimum Wage (NMW), protection against unlawful deduction from wages, minimum levels of paid holiday and rest breaks, protection against discrimination, and the right not to be treated less favourably if they work part-time (House of Commons Work and Pensions and Business, Energy and Industrial Strategy Committees, 2017).

Self-employed couriers/drivers are typically only paid when they are actively carrying out a task, whereas employed couriers are paid regardless of whether they are working or not (Kidder, 2009). The issue of whether or not these couriers and drivers are employees has an important bearing on UK tax payments (including national insurance and income tax in the UK), and also on legal rights (such as holiday pay, sick pay and annual leave entitlement). In addition, the self-employed are often responsible for providing vehicles, and vehicle maintenance and repair. Some companies require that self-employed couriers/drivers who are unable to work due to illness or holiday provide alternative labour cover until they return.

The employment status of couriers and drivers making last-mile deliveries has received substantial political scrutiny in the UK in the last couple of years (along with other sectors of the 'gig economy' that also make use of self-employed, especially manual, workers). The same situation has also been noted in France (Dablanc et al., 2017). This has resulted in industrial action by some self-employed drivers (Lomas, 2018; Siddique, 2018; IWW, 2018).

Existing employment law provides little detail about the differences in the three categories of work that currently exist in the UK, namely i) employee; ii) dependent contractor (also referred to as 'limb (b) worker'); and iii) self-employment (also referred to as independent contractor). Several cases have been brought by couriers and drivers against their self-employed status in recent years (see Allen et al., 2018 for a review of these cases). The majority of these recent employment tribunal cases have resulted in couriers and drivers successfully challenging the companies they work for that had argued they were self-employed (e.g. CitySprint, Excel, and Addison Lee). As a result these drivers were given dependent contractor status, gaining several important employment rights. However, these rulings only apply to the named workers bringing these cases and their companies; they did not result in any automatic consequences for other companies with similar business models.

A government-commissioned independent review of the UK labour market considered the changing nature of working in the country, including the status of those working in the 'gig' economy, those on zero-hours contracts, agency workers, and those who are self-employed, and made suggestions and recommendations to government (Taylor Review, 2017). The UK Government responded to the Taylor Review by saying that it would, "therefore consult to explore the best way to improve clarity for those on the boundary between employment and self-employment, including options for legislative reform" (HM Government, 2018). This resulted in the 'Good Work Plan' published at the end of 2018, in which the government accepted the majority of the Taylor Review recommendations (BEIS, 2018). However, this plan did not clarify the law on employment status (i.e. did not provide greater definition, or remove the 'worker' or 'self-employed' employment categories), or provide workers with a presumption of employee status, thereby placing the onus on employers to prove that the worker is not entitled to employment rights; these were the two key recommendations of the Taylor Review. Instead, the government said that it would introduce legislation to clarify the law, as well as commissioning further research.

The Taylor Review resulted in some companies in the logistics and transport sector changing their practices. For instance, Deliveroo and Uber put in place measures to improve various aspects of the services they make available to their drivers including insurance schemes (Fioretti, 2017; Lomas, 2017; Makortoff, 2017; Deliveroo, 2018; Roberg, 2018; Tassinari, 2018).

Concerns have also been raised about the under-representation of women in senior management positions and gender pay gaps between men and women. An Post, the mail and parcel carrier in the Republic of Ireland, has made active efforts to address this situation. In 2016, its management board

comprised all men, by 2019 it was made up of four men and four women. The company is now seeking to achieve a better gender balance in senior management roles and across the organisation as a whole. In 2019, it also had a gender pay gap of 3.7% compared to the gap of 13.9% nationally (An Post, 2019b).

7.14 Life Cycle Analysis of online shopping and deliveries

Three studies have attempted to include consideration of transport and several other activities that involve carbon emissions due to online shopping into a single analysis and then compare these findings with conventional shopping. These are summarised below. However, it should be noted that they do not attempt to take account of all the potential impacts of online shopping and last-mile delivery reviewed in this chapter.

A 2015 study used Life Cycle Analysis (LCA) to investigate the GHG emissions associated with the use of different last-mile fulfilment systems for an item purchased online and compared this with conventional shopping in the UK. The fulfilment systems studied included the use of an online retailer making deliveries through a parcel network, online deliveries made from local shops, click and collect deliveries to local stores for customer collection, and conventional consumer shopping in a local supermarket. The results indicate that the consumers' behaviour in terms of related transport trips they make (to collect and return these goods), the choice of the e-fulfilment method and the basket size (i.e. number of items purchased and then delivered jointly) are critical factors in determining the environmental sustainability of shopping. Pre-arranged delivery time-slots, leading to lower requirements for consumers to travel to collect their goods from a depot or shop, are shown to result in far lower average emissions per item (with the location/distance that consumers have to travel in such cases being another important factor). Basket size is also shown to be an important factor, with the emissions per item increasing inversely with basket size. When a single item is ordered online, transport operations (be they by consumers or by retailers/carriers) are shown to contribute far more GHG emissions per item than the operation of stores, fulfilment centres, packaging and electricity used for order placement. This indicates the importance of not splitting an order into multiple packages or deliveries. The results indicate that the placement of larger orders by consumers substantially reduces the number of deliveries and the environmental impact of online shopping – so encouragement of such behaviour is desirable. The amount and type of packaging used, and the energy efficiency of shop and e-fulfilment centre operations, are also shown to be substantial contributors to GHG emissions. As with any such study, the authors note that the results are limited by the assumptions and system boundaries applied. They also note that in some countries, such as the Netherlands, a far greater proportion of consumers walk or cycle to the shop than in the UK, which results in lower GHG emissions for consumer shopping transport (Van Loon et al., 2015).

A lifecycle assessment was carried out to analyse the energy use and CO_2 emissions involved in supplying a USB memory stick from wholesale warehouse to consumer via both retail physical store sale and online sale with last-mile delivery. The study took account of: freight transportation from the manufacturer to the retail store or local distribution centre, last mile transport from the local distribution centre to the customer, customer travel to and from the physical store to their home, energy use in the warehouse and the physical store, electricity use to place the order using a home computer and at the data centre, and packaging for both retail options. Energy associated with product manufacture and product use were excluded from the study (Weber et al., 2011). The results indicated that the online retailing and last-mile delivery resulted in less CO_2 emissions than for in-store shopping and consumer transport by car (2200 g CO_2/delivery compared to 2800 g CO_2/delivery). Major contributors to CO_2 emissions were found to be consumer transport (65% of CO_2 emissions in the case of store-based sales), wholesale warehousing (26% of CO_2 in-store sales and 31% of online sales), cardboard packaging for online sales (22% of CO_2 in the case of online sales), and last-mile delivery (32% of CO_2 in online sales). Several activities accounted for only small contributions to CO_2 emissions, namely: freight transport between wholesale warehouse and store or distribution centre, energy use in the retail store, electricity used in placing the order (i.e. the consumer home computer and network use, and the data centre servers). An online order that required long-distance international transport by air was also investigated. This resulted in total CO_2 emissions for online shopping of 2500 g CO_2/delivery. Further analysis of uncertainty and variability in these results for online and in-store shopping and delivery indicated that, if all transport was carried out by road, there was only a 20% likelihood that store-based retailing would generate lower emissions than online shopping. If online shopping also included long haul air freight, they

found that the likelihood of store-based retailing generating lower emissions rose to 50% (Weber et al., 2011).

A 2013 study in the USA compared the carbon emissions associated with online and in-store shopping for three non-food products: a laptop computer, a toy doll, and a T-shirt (Weideli, 2013). These were chosen as they differ in terms of product category, price, packaging requirements and return rates. The analysis took account of energy used in consumer transport and upstream freight transport to the shop or warehouse and last-mile delivery transport, electricity used by computing equipment and data centres used to place orders, lighting and heating warehouses and shops, packaging, and printed labels used to trace the product through the supply chain. Production of the product and its disposal were not included. The study also took account of different consumer online shopping behaviours including those who use cars to browse in store and then order online, those who collect and return online orders at stores by car, and those who make no car trips as part of their online shopping or returns. The results for the toy doll show that carbon emissions resulting from online shopping by a person who makes no transport journeys (to browse, collect or return the product) are approximately half those for the same product if it is browsed for, purchased and returned in-store by car. However, a store-based shopper who browses online but purchases in-store by car produces approximately the same carbon emissions as an online shopper who makes no car journeys. If an online shopper carries out a car trip to browse products in store before ordering online, this generates approximately the same carbon emissions as a traditional in-store purchase. For in-store doll purchases, customer transport by car was calculated to account for the vast majority of all carbon emissions. For online doll shopping, customer transport by car (if used), packaging, and freight transport (upstream and last-mile) were calculated to account for the greatest proportion of the carbon emissions involved in supplying the product. The carbon emissions resulting from purchasing a T-shirt were found to be similar to those of the doll. However, the laptop computer was found to be responsible for greater carbon emissions (Weideli, 2013).

A 2019 study used stochastic modelling to compare the CO_2 emissions of the upstream transport (i.e. from factory to point of despatch to store or customer), last-mile delivery transport operations and warehousing operations associated with the purchase of fast-moving consumer goods (FMCG) in the UK (Shahmohammadi et al, 2020). Three retail channels were compared: 'brick and mortar' (i.e. shopper travelling to a store to make the purchase), 'bricks and clicks' (i.e. shopper buying online and the goods delivered from a physical store), and 'pure players' (i.e. shopper buying online and the goods being delivered from a distribution centre). The CO_2 emissions resulting from last-mile delivery packaging were also accounted for in the case of 'pure players' delivering to the customer (but were excluded from the 'bricks and clicks' retail channel as it was argued that they did not occur in this case). The analysis indicated that 'pure play' purchases resulted in a median total of 0.18 kg CO_2eq/item compared with 0.10 kg CO_2eq/item for traditional bricks and mortar retailing and 0.07 kg CO_2eq/item for 'bricks and clicks' retailing. Upstream and last-mile transport activity was found to account for the majority of the total CO_2 emissions, with the last-mile delivery emissions exhibiting the highest variability, depending on factors including the number of items purchased, journey distance and mode. The work and its findings indicated the many factors involved in carrying out such analysis, and the variability of the findings in relation to the related assumptions (Shahmohammadi et al, 2020).

A review study identified 11 projects involving 16 cases that compared the energy consumption of retailers with stores also carrying out last-mile deliveries that took account of transport (retailer and consumer), building, packaging, and product waste energy use (not all of these factors were taken account of in all studies; for instance building energy was only included in half of the cases). Books, DVDs and CDs comprised 80% of the products studied in these projects. Five of the projects only considered road transport, while five also considered upstream air freight. Ten of the 16 cases only considered car travel for consumer transport, five cases included other consumer transport modes, but only one case included a biking or walking only option. Ten of these cases found that energy consumption was greater in the store-based operations than in online shopping/last-mile delivery sales, five cases found that online shopping/last-mile deliveries were more energy intensive and one case found both retail channels resulted in similar energy consumption. Packaging was the reason for the five online shopping/last-mile delivery cases being more energy intensive than store-based sales (Pålsson et al., 2017). However, it is important to note that the projects reviewed in this study focused on a narrow range of product types, some of the projects did not include consideration of product return rates, and, in those that did, the

products studied tend to have low return rates and they did not consider the means by which the product was returned, successful first-time deliveries were assumed (Pålsson et al., 2017).

As discussed above, the overall impact on transport activity, related energy use and carbon emissions are dependent on many factors including vehicles modes and types used, freight transport operating patterns and consumer shopping travel behaviour (and how and to what extent this changes when a person shops online), the drop density of last-mile delivery orders, the amount purchased per order, product return and product wastage rates, the type of packaging used, and energy use in buildings. The results from existing studies indicate that online shopping could potentially result in an overall reduction in last-mile vehicle kilometres and carbon emissions but more comprehensive analysis that takes account of all of these factors is required. Analysis of the transport component of online shopping indicates that a reduction in consumer shopping travel by car is required if carbon emissions reduction and associated environmental benefits are to be achieved.

7.15 Summary

Table 7.2 provides an assessment of the potential links between the issues identified in this chapter as being associated with online shopping and last-mile deliveries that generate transport, GHG emissions and other impacts.

Table 7.2: Other potential factors involved in the impacts of online shopping and last-mile delivery

Potential factors involved in impacts of online shopping and last-mile delivery	Explanation	Transport intensity	GHG emissions	Other impacts	Online shopping sectors related to this impact
International online shopping	Non-food online shopping that is despatched as an individual packaged item from overseas to the customer using either airfreight or seafreight. International parcels represent approximately 20-30% of total parcels handled in the UK.	✓	✓		P
Electricity and computing energy use for online shopping	The computing technology used to facilitate online shopping is responsible for energy consumption and carbon emissions. Estimates suggest that all the various equipment that powers the internet accounts for 3-10% of global electricity consumption.		✓		G,P,L,M
Packaging use and waste	Online shopping is associated with the use of substantial packaging, especially cardboard and plastic polybags. Many of the polybags used are made from materials that are not commonly recyclable. Packaging waste requires collection by refuse vehicles.	✓	✓		G,P,L,M
The energy use of warehouses and fulfilment centres rather than shops	Online shopping often involves the despatch of products from buildings other than shops (i.e. warehouses, fulfilment centres, dark kitchens) which may require less lighting and heating than shops and may be larger than an average shop resulting in lower energy consumption per item handled. However, small order sizes and the scale of non-food returned products can result in additional warehousing operations. Existing research has not analysed the net energy impact of buildings used in online shopping.		✓		G,P,L,M
Health and safety and wellbeing of last-mile delivery workers	Delivery personnel using bicycles and mopeds are exposed to the elements and are subject to poor air quality, especially in dense, congested urban areas. Those using these vehicles are more prone to road injury in adverse weather conditions. Solo night delivery work, especially meal deliveries involving cash payments, can place delivery personnel at risk of confrontation or theft.			✓	G,P,M
Casualisation of delivery personnel and possible link to road risk	Many parcel and meal delivery workers are self-employed, working in the so-called 'gig economy' without the sick pay, holiday pay, insurance and training entitlements of employees and often also having to provide their own vehicles. This employment status can adversely affect their on-road performance in terms of speed of travel and behaviour, as they are often paid on a per delivery basis, placing themselves and other road users at risk.			✓	P,M
Impact on local shopping area and community	High street shop closures and vacancy rates, one of the contributing factors to which is online shopping, leads to local job losses, an unattractive shopping area and can be linked to anti-social behaviour. Meal deliverers waiting for meal collections can lead to traffic generation, noise disturbance and other impacts for residents living near takeaway restaurants and dark kitchens.			✓	G,P,L,M
Online shopping and social inclusion / exclusion	Online shopping facilitates shopping among those too physically disabled to visit shops in person. However, it can exclude those without the necessary skills and/or computing equipment, reducing their choices and barring them from prices available online.				G,P,L,M

Key: G = grocery delivery; P = parcel delivery; L = large, non-food two-person delivery (e.g. white goods or furniture); M = ready-to-eat meal delivery
✓ - indicate a links between factor and impact
Source: authors' own judgement based on review of research evidence.

8. Efforts to reduce online retailing transport impacts: company initiatives, policy measures and research findings

8.1 Reducing product returns and their impacts

As noted earlier in this report, ASOS, the online fashion retailer has trialled technology tools to help reduce product return rates. These include a tool which recommends the correct size of item to order based on the consumer's weight, height, and style of fit preference, and also providing improved all-round photographic images of footwear. In April 2019, ASOS also announced changes to its return policy: the time allowed for returns was extended from 28 days to 45 days, but it was also stipulated that customers deemed to be misusing the returns system may have their account suspended (BBC, 2019a).

The fashion retailer Next also altered its returns service in 2018. Originally customers paid £3.99 for a parcel carrier to collect their product return but had this fee deducted from their next order; under the revised arrangement customers are charged £1 for each carrier collection or return to a Hermes parcel shop, with returns to store remaining free (Clark, 2018).

In 2014 House of Fraser teamed up with Caffé Nero to trial a shop in Cambridge with a ground floor café and first floor store with some product display together with collection point for online orders and changing rooms to try and return goods before leaving the shop (Rigby, 2015). A Czech online-only retailer, ZOOT, implemented a new approach in which clothing ordered by customers can be delivered to a 'Try & Buy' store. Goods ordered by consumers are delivered to the Try & Buy facility which the customer visits to try on the clothes and decide if they are suitable. Half of all orders are delivered to the Try & Buy facility within 24 hours of the order being placed and some deliveries take as little as three hours, with customers only having to buy the goods after trying them (Mintel, 2016).

In October 2020, Royal Mail introduced a service called Parcel Collect' in the UK. This allows consumers to return online orders via the postmen and postwomen who make daily deliveries from Monday to Saturday, either from collecting the parcel from the consumer's doors or a nominated safe place. This collection service costs £0.72 per item, in addition to postage charges (or for £0.60 for pre-paid return items) and is available for up to five parcels per address per collection. This collection service needs to be pre-booked online (Royal Mail, 2020).

8.2 Sustainable delivery time slots

Last-mile deliveries that are required to be made at pre-specified times without any reduction in lead time will result in greater distances being travelled than if the deliveries are unconstrained in terms of time of delivery (Manerba et al., 2018; Nyugen et al., 2019). Similarly, greater lead time for the carrier in making the delivery (i.e. the time between order placement and despatch) and the removal of specified delivery times will permit carriers to achieve higher levels of drop density, as well as offering the potential to consolidate multiple items ordered at the same time into a single delivery. However, this runs counter to what many consumers are increasingly seeking in terms of last-mile delivery services to their home. In a Royal Mail survey of 1,500 shoppers in 2019, 47% of respondents expected an estimated day or time of delivery, 32% expected a 1-2 hour delivery slot. In terms of when they expect to receive this delivery timing information, one third said on the day of the delivery, a third said the day before the delivery and another third said within 24 hours of ordering online (Royal Mail, 2019a).

Sainsbury and Ocado offer so-called 'green' delivery time slots in selected locations. This service allows customers to select a time and day slot at which a delivery vehicle will already be in their neighbourhood making another delivery. This helps to reduce the inter-drop distance for the delivery, and thereby reduce the transport, carbon and air quality impacts associated with it (Ocado, 2020; Sainsbury, 2020). John Lewis is trialling this same approach for non-food deliveries

(Sword, 2019). Research has investigated how carriers can also use pricing to influence consumers' delivery time choices and thereby reduce carrier operating costs as well as distance travelled (Klein et al., 2017). Transport for London has used newspaper advertising to encourage consumers to opt for less rapid delivery services when ordering goods online (i.e. not to select instant or same-day delivery) (Transport for London, 2019a).

8.3 Reducing failed deliveries – providing delivery notifications

In order to improve customer service, and reduce the number of failed deliveries, some parcel carriers provide advance notification systems by text message to customers to tell them the day of delivery (and in some cases even an expected arrival time). Some carriers allow the customer to track the vehicle's progress on the day of delivery and provide an expected time of arrival. For example the DPD 'Follow My Parcel' service provides customers with a one hour delivery timeslot, a real-time vehicle tracking facility which shows the vehicle's progress on a map, the position of the customer's delivery in the driver's current parcel delivery queue, a further notification when the driver is 15 minutes from making the delivery, and an option to reschedule their delivery or have their goods delivered to a neighbour. These services are made possible by DPD's 'Predict' vehicle routeing and scheduling system (DPD, 2020a). DPD estimates that this system has prevented 4.5 million extra journeys and 3.5 million miles of travel (DPD, 2020b). Further recent enhancements to this system by DPD comprise the inclusion of driver profiles so consumers know more about the person making their delivery and can provide ratings (DPD, 2020c). In a survey by Royal Mail in 2019 of 1,500 UK shoppers, 63% of respondents said they would track all of their online orders if the service was available, 58% wanted tracking progress throughout the entire delivery journey (i.e. not just the last-mile delivery stage), and 78% considered it important to receive information regarding the progress of their deliveries (Royal Mail, 2019a).

Waitrose has been carrying out a grocery delivery trial in south London in which customers can select to have their deliveries made while they are out. Customers in the trial are provided with a smart door lock which uses a temporary access code sent via a secure app to provide the Waitrose driver access to the property. Drivers will then enter the home and put the groceries into the fridge, freezer and work surfaces. Drivers also wear a camera to record the entire delivery process (BBC, 2018).

8.4 Reducing failed deliveries – alternative delivery addresses

Failed deliveries can delay consumers receiving their goods, are costly for retailers and carriers, and result in greater transport intensity and environmental impacts in making the deliveries. Delivering orders to places other than customers' homes can help to eliminate failed home deliveries, thereby removing a cause of delay in consumers receiving their goods and costly redeliveries for retailers / carriers. Referred to as 'unattended' deliveries, these solutions include the use of click and collect services (from shops, other collection points and locker banks) as well as leaving deliveries with neighbours. In addition, a goods vehicle delivers far more items to a single location items when these unattended delivery options are used than in the case of deliveries to consumers' homes. This helps to reduce the distance travelled per item delivered and the associated environmental impacts. However, the overall transport and CO_2 impacts will depend on the customer's travel choices in collecting their goods. It is also important to note that unattended delivery systems result in additional freight and passenger transport trip generation at the places where these facilities are located.

As previously discussed (see **section 7.5**) an academic study using spreadsheet-based analysis indicated that the use of collection points and locker banks (located at places such as supermarkets, post offices, and railway stations) result in only 14%-73% of the CO_2 produced by a failed delivery that leads to a consumer collection by car from a carrier's local depot (Edwards et al., 2010b).

Some online shoppers opt to have personal deliveries (typically of packages and parcels) delivered to their workplace, to avoid missing the delivery as they know they will not be at home to receive it. Whilst this helps to reduce delivery failure rates, it can have negative consequences for the organisation. These include the detrimental impact of these product flows on their delivery bays, internal building logistics and post-rooms (requiring staff employed to perform these activities to use their time for non-company work), which is a hindrance to the efficient flow of essential business deliveries within the building. It can also add to the total number of deliveries made to the building, which can be especially problematic in terms of adding to traffic levels if the building is sited in a busy location. Research in central London suggests that personal parcel deliveries can represent up to 40%-60% of parcel throughput in medium-large sized multi-tenanted offices, and up to 90% of parcel throughput at these buildings during the Christmas peak (Browne et al., 2016). As a result of these issues, a few organisations have decided to ban personal deliveries among their staff (either due to the impact on the efficiency of their internal building logistics, or as part of their sustainability agendas. However, some other employers see personal deliveries to the building as a staff perk. Survey work in offices in London indicates that 3% of offices ban staff from receiving personal deliveries at their workplace and these deliveries do not take place, 5% of offices ban staff from receiving personal deliveries at workplace but these deliveries do take place, 17% of offices discourage staff from receiving personal deliveries at their workplace, but staff can receive them if they wish, and 75% of offices allow staff to have personal deliveries sent to their workplace (Transport for London, 2015). In a survey of 500 UK online consumers, 26% of respondents had opted to have their order delivered to their workplace on at least one occasion (Metapack, 2018).

It remains to be seen whether the number of organisations banning personal deliveries from the workplace will increase in future, but this is an action called for by London Assembly in its report on traffic congestion in London and by Transport for London (London Assembly, 2017). Transport for London banned personal deliveries at six of its main office sites (Transport for London, 2019b). Transport for London has produced a toolkit for organisations that are planning to discourage or ban personal deliveries to the workplace. This includes the following ideas: carrying out a communications campaign, charging employees to pay a small fee to receive workplace deliveries, and promoting the use of collection points and locker banks near the workplace or the employee's home (Transport for London, 2018).

A project initiative by Cross River Partnership has established a website to assist companies and their staff to determine suitable click and collect facilities from which personal online shopping can be collected instead of from a workplace (Cross River Partnership, 2016). Transport for London has also encouraged the use of collection points and locker banks through the use of a newspaper advert (Transport for London, 2019a).

Transport for London is also carrying out research and discussions with the industry with an ambition to reorganise parcel deliveries in London in order to reduce the carbon emissions, air pollutants and traffic congestion associated with them. It intends to achieve this by changing consumer behaviour and improving business opportunities for the suppliers of 'green' delivery solutions including clean vehicles, locker banks and collection point sites. TfL has a vision to change the current delivery locations for parcels, in which deliveries from click and collect points in physical stores, collection points and locker banks only account for 13% of parcel deliveries, to a situation by 2030 in which these delivery locations account for 50% of deliveries, thereby substantially reducing the deliveries made to homes and workplaces. This aim would be achieved through a substantial increase in the provision and use of locker banks and collection points, which would be operated on an agnostic basis thereby making collaborative use by carriers possible. In addition, electric vans, cycles and on-foot porters would be used to make last-mile deliveries. Achieving these ambitions will require substantial change by retailers, carriers and consumers. Industry partners working with Transport for London on this work includes DPD, Hermes, John Lewis Partnership, the Post Office, inPost, Quadient and Delivering London (Barrie, 2020; Transport for London, 2019c).

While locker banks are not very common in the UK, they are far more common in some other European countries including Germany, Denmark and Poland (Apex Insight, 2019).

Research among consumers in New Zealand has indicated that key factors influencing consumers' use of unattended delivery collection points and locker banks include: the density and location of the network, parking availability at these facilities, the safety and security of these facilities, and the hours of operation of CDPs (Kedia et al., 2017). Decision-making in determining appropriate locations for locker banks from a city and transport planning perspective involves assessment of site characteristics, proximity to consumers and parcel carrier depots (Lachapelle, 2018). Consumer research carried out in Singapore indicates the most important factors in increasing customers' intention to use CDPs is to integrate self-collection into consumers' lifestyle and values while marketing these services in a way that provides them with a clear advantage over other last-mile delivery methods (Yuen et al, 2018; 2019). Brazilian consumer research has indicated that the most desirable locations for collection points and locker banks are stores, supermarkets and shopping centres, each of which proved far more popular with survey respondents than other locations. Approximately 60% of Brazilian respondents stated that they would use cars to collect their deliveries, which is less desirable than walking and public transport options (in terms of reducing private motorised transport), but which may be coupled with other car-based shopping trips that were taking place anyway, thereby resulting in no additional car travel (Oliviera et al., 2017). The price charged for the use of collection points and locker banks together with the extent to which they are agnostic or dedicated to one or several retailers/carriers are likely to play an important role in their potential use by consumers. A consumer survey in Germany, China and the USA found that approximately 50 per cent of consumers surveyed expressed willingness to switch to locker banks but only when deliveries to home (or workplace) cost EUR 3 (or USD 3 or RMB 20) more than self-collection services (Joerss et al., 2016).

Design considerations in the development of locker banks are important with regard to how efficiently they are used, in terms of achieving high levels of use and product throughput as well as customer satisfaction, especially given the scarcity and cost of land in urban areas. This includes decisions about whether to use fixed-configuration locker banks or locker banks that can be modified in terms of locker unit size in the immediate or longer term (Faugère and Montreuil, 2020).

An alternative solution to collection points/locker banks for overcoming parcel delivery failures has been proposed in research, which expands the traditional alternative delivery solution of the immediate neighbour. It involves using all the consumers in a retailer's/carrier's network as local neighbours to whom the delivery can be made instead if the customer is not at home. The customer can then pick up the parcel from their neighbour at a mutually convenient time. If the network of consumers is sufficiently large, resulting in parcels being left with very nearby neighbours, then this collection can be made on foot, without the need for car journeys (Akeb et al., 2019).

In terms of collection services for rural communities, An Post, the national mail and parcel carrier in the Republic of Ireland, has ensured that 95% of the population is within 15 km of at least one Post Office, that there is a post office in every community of over 500 people, and that eight offshore islands will retain their Post Offices (An Post, 2019a).

8.5 Increasing the operational efficiency of delivery workers

Last-mile delivery workers have to carry out many tasks each day in the course of their work, each of which influences their operational efficiency. These tasks include (Bates et al., 2018):

- Vehicle routeing decisions.
- Picking the best vehicle stopping location

- Optimizing walking routes – from the parked vehicle to the delivery/collection point
- Locating point of entry to the building – which may not correspond with the delivery/collection address
- The journey inside the building to the point of delivery/collection – and gaining whatever proof of delivery/collection is required
- Make decisions about what to do when no-one is available to receive the delivery/provide the collection.

In addition, multi-drop parcel delivery drivers have to decide how to group deliveries together in walking tours. All of these tasks are highly challenging and the latter is an under-researched optimisation task which the FTC2050 research team has been investigating. Results for the next-day parcel delivery sector suggest that the total time taken for delivery work may be reduced by making fewer vehicle stops than at present and making a greater number of deliveries and collections on foot each time the vehicle is parked. Such a solution is capable of reducing the total round time by approximately 25% and the total driving time (and distance) in the delivery area by approximately 50% but with a 20% increase in parking time and an up to 50% increase in walking time and distance (Allen et al., 2018).

Finding the entry point to the building to make a collection or delivery when this is not the front door or address registered on the paperwork or computer system issued to the courier can result in lost time and additional driving distance. A trial conducted by a provider of a precise geographical location tool involved working with a carrier to test the benefits of using their tool in a situation in which the precise delivery point location had been logged using their tool. Two couriers were despatched to carry out exactly the same delivery round involving visiting 20 addresses in London. One of the couriers used the tool, called what3words, to immediately locate the precise delivery point, whereas the other courier was issued with only the street address of the building. Both couriers successfully completed their delivery rounds but the first driver using the tool was 30% faster than the other, which equated to approximately 6 minutes on average per building delivered to and therefore two hours in terms of total time savings over the course of the entire 20 deliveries (what3words, 2017).

Research from the FTC 2050 project has indicated that there are major differences in operational performance between couriers of very different levels of experience working on the same next-day multi-drop delivery round on different days. In one such case, an experienced driver was found to drive 44% less distance per parcel, spend 35% less total time per parcel, and 39% less parking time per parcel than the inexperienced driver. The variation in effectiveness of the couriers related to better route planning and exploitation of accumulated knowledge (Bates et al., 2018). Providing couriers, especially novices, with computer-based tools to assist vehicle routeing, vehicle parking and driver walking strategies, and locating the building entry point for deliveries/collections can improve their efficiency and thereby reduce their traffic and environmental impacts. Providing inexperienced couriers with training programmes can also assist in raising operational performance as well as road safety.

In delivering to consignees, couriers often have to ascend and descend staircases and lifts. This can be the case for both commercial consignees, especially those in multi-tenanted office blocks, and residential consignees in block of flats. This results in couriers spending substantial periods of time inside buildings (e.g. waiting for lifts to different floors, climbing and descending stairs), thus increasing vehicle kerbside dwell time and total working time taken. Research in the City of London suggests that parcel delivery workers had to travel vertically to reach approximately 15% of consignees whilst serving their rounds (this includes consignees not located in multi-tenanted buildings, so the proportion of multi-tenanted, multi-storey buildings in which this is necessary is considerably higher) (Clarke et al., 2018). In the case of large and multi-tenanted buildings, providing the facility for drivers to deliver tenants' items to a single mail room, reception desk or loading bay can reduce the time that vehicles are parked on-street while deliveries take place.

8.6 Vehicle fuel sources

Several policy measures have been implemented in the UK by national and local government that target carbon emissions and/or air pollutants associated road freight transport which will have an impact on last-mile deliveries. New van CO_2 emission regulations were introduced by the UK government at the beginning of 2020 which set CO_2 emission reduction targets for new vans of 15% by 2025 and 31% by 2030 (based on a 2021 baseline). Specified types of alternatively fuelled vans are currently permitted to operate up to a maximum weight of 4.25 tonnes (rather than 3.5 tonnes) with those holding car driving licences permitted to drive them. The UK government has already announced that all new cars and vans sold after 2035 will have to be powered by renewable fuel sources rather than by petrol or diesel. HGVs are harder to decarbonise given existing technologies. However, the UK government has established an industry-wide voluntary target for reducing HGV GHG emissions by 15% by 2025, from 2015 levels. It has also made grants available for plug-in van and HGV purchases and for electric cargo bikes trials and is funding charge point infrastructures on streets and at homes and workplaces (Department for Transport, 2020e).

The Mayor of London has committed the capital to becoming a zero-carbon city by 2050 and has already implemented several initial policy measures towards this target. An Ultra-Low Emission Zone has been introduced in central London that will be increased in size and vehicle compliance standards over time, a public network of rapid EV chargers is being funded, and new buildings will have to be zero carbon. A Low Emission Zone already covers the whole of Greater London to reduce local air pollutants from vehicles (Mayor of London, 2018).

Some London boroughs are also implementing targets and strategies to reduce carbon emissions and improve local air quality and road safety that will affect road freight transport. For instance, in the City of London road traffic will be reduced by 25% by 2030 and 50% by 2044, with much parcel freight having to be delivered by electric vehicles, cargo bikes and on-foot porters (Corporation of London, 2019). An experimental Zero Emissions Scheme was also introduced in March 2020 on Beech Street, Bridgewater Street and Golden Lane in the City of London with the aim of reducing air pollution. This scheme requires that road freight conveyed through these streets is carried by zero-emission vehicles or cargo cycles (Corporation of London, 2020). While in the London Borough of Hackney, two Ultra Low Emission zones have been introduced that, during peak hours, restrict travel to low emission vehicles cycling and walking, with no petrol and diesel vehicles permitted (London Borough of Hackney, 2019).

Clean Air Zones will be introduced in other urban areas in the UK to ensure that local air quality levels meet EU standards (Department for Environment, Food and Rural Affairs and Department for Transport, 2020).

Several last-mile delivery companies have switched from using diesel-powered to electric vans for grocery and parcel deliveries. Examples include Gnewt, the first UK parcel carrier to use an all-electric fleet. Meanwhile, in the grocery sector Ocado, Sainsbury and Waitrose have all begun trials with electric vans (Commercial Fleet, 2019; Post&Parcel, 2019; Ocado, 2019; Sainsbury, 2019).

The parcel carrier DPD opened its first all-electric parcel micro-depots in Westminster, central London in 2018, followed by additional London sites in Shoreditch, and Hyde Park, and another in Hull. These sites include an electric vehicle recharging system. Further micro-depots in London and the rest of the UK are planned as sites become available (DPD, 2020b). In the case of the Westminster micro-depot, parcels are brought to the site in the early morning by 7.5 tonne electric vehicles; last-mile deliveries to customers are then made using Nissan e-NV200 all-electric vans and Paxster micro-vehicles (DPD 2018). In 2019, DPD had 139 electric vehicles; by July 2020 it achieved its target early that by the end of 2020, 10% of its fleet of about 8,000 vehicles would have zero-tailpipe emissions (DPD, 2020d). This meant that in 2019, one million parcels were delivered by electric vehicle, while in 2020 this rose to one million parcels per month. DPD has set

a target that by 2025 it will be delivering from 25 towns and cities in the UK by electric vehicle to 25% of the UK population comprising 100 million deliveries per year (DPD, 2020e). Electric delivery vehicles operated by DPD comprise cargo bikes, Paxsters, and vans including Nissan e-NV200, Peugeot ePartner, Mercedes eVito, MAN eTGE, and the 7.5 tonne Mitsubishi Fuso eCanter (DPD, 2020b; DPD, 2020f).

Another major parcel carrier UPS is working with the vehicle manufacturer Arrival to design and produce fully electric delivery vans to be trialled in London, as well as working with Tevva Motors to design an extended range of hybrid diesel-electric vehicles for use within and beyond the urban area (Cork, 2019). UPS has also carried out a project in which an electric power-assisted delivery trailer can be used for parcel delivery in a central urban area by bicycle or on foot and this is being trialled and assessed in Seattle (UPS, 2017a; Urban Freight Lab, 2018c). The company has also worked on a project with UK Power Networks to design, implement and operate a smart-grid solution to electrify its 170-vehicle depot fleet at its Kentish Town depot in London (UK Power Networks, 2020).

An Post, the state-owned provider of mail and parcel services in the Republic of Ireland, has set several targets in relation to decarbonisation. These include to reduce its carbon emissions by 50% by 2025 (compared to 2009), and to net zero from own operations by 2030. By 2019, it had achieved a 30% reduction in carbon emissions since 2009. This was achieved through the implementation of electric vehicles and the use of renewable electricity usage in buildings (by 2019, all electricity used in its buildings was from renewable sources). During 2019, An Post became the first postal service provider in the world to achieve zero carbon emissions in its deliveries in a capital city when it achieved this in Dublin. It is aiming to achieve the same in five more cities by the end of 2020. This has been achieved through the acquisition and use of electric vehicles and the implementation of recharging points (An Post, 2019a).

A survey has shown that commercial cycle logistics businesses are operating in many towns and cities across Europe. Median daily distances travelled per bike/cargo bike were 30-50 kilometres (Amsterdam University of Applied Sciences, 2016). Electrically-assisted 2-4 wheeled cargo cycles do not emit any emissions at the point of use and are capable of transporting 50-250 kg of goods, with a distance range limit of approximately 50-80 kilometres per day on a full charge (Schier et al., 2016). Urban authorities have been identified as having a key role in the uptake of cargo cycles by companies, through the implementation of policy measures aimed at reducing the environmental impact of freight traffic (Rudolph and Gruber, 2017). A study in Rotterdam investigated the market for cargo cycles in the city, existing regulations and policies that govern their use, and opportunities for their use on specific streets and localities within the city, taking into account design issues that can help ensure that urban distribution by cargo bike can take place in a high-quality and safe way (Hoogendoorn et al., 2018). A modelling study found that electrically-assisted cargo cycles were more cost effective than motorised goods vehicles for situations in which deliveries are in close proximity to the distribution centre from which they are despatched (the cargo cycles provided a lower cost solution when the distance from the depot to the delivery area is less than 2 miles, and the inter-stop distance is 0.2 miles with eight stopping locations) (Sheth et al., 2019). Transport for London has published a toolkit for cargo bike use in London (Transport for London, 2020a).

Some companies have set targets regarding the vehicles they use for their last-mile deliveries. For instance, as part of its overall corporate strategy to be ‘climate positive’ by 2030, IKEA has pledged to use electric vehicles or other zero-emission solutions for all last-mile deliveries by 2025, and to have achieved this in five cities (Amsterdam, Los Angeles, New York, Paris, and Shanghai) by 2020 (IKEA, 2019). UPS has pledged that 25% of annual vehicle purchases will be alternative fuel and advanced technology vehicles by 2020 (UPS, 2018). Meanwhile, the online clothes retailer ASOS signed a new five-year contract with parcel carrier DPD, under which at least 50% of deliveries within the London Ultra Low Emission Zone will be carried out by electric vehicles (DPD, 2019).

The International Post Corporation (IPC) is a cooperative association of 25 member national postal operators in North America, Europe and Asia Pacific. These companies handle letters and parcels, and the IPC works to develop solutions and services to improve the quality and service of national and international postal operations. Between 2008 and 2018 the 19 IPC member companies of the Environmental Measurement and Monitoring System (EMMS) reduced their overall annual carbon emissions by 27% (2.3 million tonnes – compared with the IPC's original target for 20% reductions by 2020). They also reduced carbon emissions from their own buildings (Scope 2 emissions) by 46% over the same period in 2008, with seven of the IPC members using 100% renewable electricity. IPC members also reported that 24% of the total vehicle fleet (148,000 vehicles) operated by members was alternatively-fuelled in 2018. Of these, 55% are electric bikes, mopeds and vans, 28% run on ethanol fuel blends, and 17% run on compressed natural gas, liquid propane gas or are hybrids (The International Post Corporation, 2019). However, it is important to note that between 2017 and 2018 the total annual carbon emissions from IPC EMMS members' own vehicles and buildings actually rose by 3% following ten years of steady decline (International Post Corporation, 2019a). This indicates the difficulty in continuing to achieve carbon reductions now that the easiest actions have been taken.

IPC EMMS members set themselves a new target in 2014 which includes outsourced as well as in-house transport and building emissions. This target is to achieve a 20% reduction in carbon emissions per letter mail and per parcel by 2025, from a 2013 baseline year. In 2018 carbon emissions were 486 g CO_2 per parcel, which represents a reduction of 14% since 2013. However, this figure has remained relatively unchanged since 2015. Between 2015 and 2018 the total amount of parcels handled rose by 58%, while total carbon emissions increased by 36% (International Post Corporation, 2019a).

In 2019, the IPC launched its Sustainability Measurement and Management System (SMMS) to continue and extend the sustainability work carried out in the EMMS beyond just carbon emissions. It is aligned with the UN Sustainable Development Goals and covers seven sustainability topics of relevance to the postal sector. These are: health and safety, learning and development, resource efficiency, climate change, air quality, circular economy and sustainable procurement. The IPC is currently defining targets for the SMMS programme (International Post Corporation, 2020).

The use of electric vans, electric cargo bikes and manual bicycles rather than fossil-fuel powered vehicles will help to reduce fossil fuel consumption, carbon emissions and local air pollutants at the point of use when carrying out last-mile deliveries (Rudolph and Gruber, 2017). Bicycles have very small carrying capacity, but cargo bikes can carry far greater weights and volumes of products. However, the van has a far greater carrying capacity than the cargo cycle. Although a cargo cycle has a smaller vehicle footprint (i.e. the physical space it occupies in terms of the amount of road- and kerbside space that the vehicle uses) than a van, its use can contribute to the number of trips that have to be made and the overall vehicle kilometres travelled. Therefore, appropriate vehicle selection to minimise the traffic and environmental impact will depend on key factors including: the type of product to be transported, the quantity to be carried on any given trip, and the distance to be covered.

8.7 CO_2 emissions calculator for retailers in Dutch last-mile delivery operations

In 2018 several Dutch organisations developed and launched a tool called 'Bewust Bezorgd' ('Consciously Delivered'). It is a carbon emissions calculation tool intended to assist online retailers and carriers understand the CO_2 emissions associated with last-mile parcel deliveries (from the final point of despatch in a warehouse or fulfilment centre to the delivery point). The work was led by Thuiswinkel, a trade association that provides support, advice and a 'quality' trademark that online retailers can subscribe to; Connekt, a sustainability mobility organisation; and Topsector Logistiek, a logistics organisation that brings together industry, government and researchers; and TNO, a transport and logistics research organisation (Bewust Bezorgd, 2020b).

The tool is intended to help online retailers and carriers to achieve a 50% reduction in their 2018 last-mile delivery CO_2 emissions by 2025 by implementing necessary measures. Online retail members can also display the 'Conscious Delivery' logo on their online retail websites. Initially, the tool is intended to be used by online retailers and parcel carriers to assess current CO_2 emissions based on their operations and identify operational changes that can be made to reduce these emissions. At a later date it is intended that consumers will be able to use the tool to check the CO_2 impacts of the delivery options available to them, with online retailers able to provide the tool on their website checkout.

The tool's calculations are based on several factors including: the number of parcels transported, the vehicle load factor, the mode/vehicle used and its fuel economy, the distance travelled, the failed delivery rate, and the delivery service provided (such as same-day or next-day and use of collection points). The tool is based on operational data provided by Dutch parcel carriers which is updated annually. This Dutch last-mile delivery CO_2 emissions calculator is the first such tool developed in Europe to be commercially applied. The tool is marketed to online retailers as a means by which to demonstrate to prospective customers that they are committed to carbon reduction, and thereby differentiate themselves from their competitors (Bewust Bezorgd, 2020b).

8.8 Portering

In 2016, DHL opened a 1,200 square foot 'walking courier' facility in New York's lower Manhattan financial district, employing approximately a dozen 'foot couriers' who delivered parcels in five ZIP codes (DC Velocity, 2016; DHL, 2016). UPS uses what it describes as 'air walkers', often operating from a mobile UPS vehicle to pick up and deliver letters, documents and parcels on foot in central business districts of some American cities (UPS, 2017b).

Portering solutions, in which the last-mile leg of next-day urban parcel deliveries are made by on-foot porters rather than delivery drivers, have been trialled as part of the FTC 2050 project (Clarke et al., 2018). Porters are provided with bag loads of parcels by drivers at the kerbside. These solutions show considerable promise in terms of reducing vehicle kerbside stopping durations as well as the total vehicle distance travelled, together with potential financial viability from a carrier perspective, including vehicle parking time savings of approximately 80%, and vehicle driving time and distance savings of approximately 35% (Clarke, et al., 2018). Such portering solutions could also be used in future in conjunction with autonomous vehicles when these become available for general use in urban areas, and would overcome the safety, security and operational challenges associated with the proposed use of aerial drones and pavement droids in urban environments.

8.9 Collaboration and consolidation

The sharing of vehicle capacity to transport more than one carrier's goods (often referred to as 'horizontal collaboration') can help to improve the efficiency and hence reduce the costs of freight transport operations by improving vehicle fill and reducing vehicle distance travelled (Cruijssen, 2012). In the case of last-mile deliveries such collaboration can lead to reductions in vehicle traffic, reductions in transport fossil fuel consumption and associated reductions in carbon emissions and local air pollution, as well as reduction in the demand for kerbside parking by delivery vehicles (Park et al., 2016; Allen et al, 2018c).

However, achieving successful horizontal collaboration between freight operators requires a well-specified and organised operational model that functions to the mutual benefit of the participants, addressing all of their concerns about data confidentiality and security and privacy, no preferential treatment, fair and transparent pricing, and a data handling system that can be integrated with the existing IT systems of the carriers involved. Given these concerns from carriers, together with prevailing competition law, it is often most satisfactory for such a collaborative delivery system to

function via a neutral logistics provider (Lietner et al., 2011). Such a last-mile parcel delivery system, co-ordinated and managed by a neutral consolidator currently exists in the Scottish Highlands and Islands. Via this collaborative operation, Menzies Distribution carries out deliveries on behalf of other carriers including many national parcel carriers (McLeod and MacLean, 2019). An urban trial (called KoMoDo) is currently under way in Berlin in which several national parcel carriers provide their goods to a neutral consolidator that delivers by cargo cycle (Berlin.de, 2018)

A case study carried out as part of the FTC 2050 project of next-day parcel operations indicated that the merging of the parcel flows from three London depots into a single delivery operation could lead to a 14% reduction in total distance travelled on delivery operations in the urban area. Given that this case study only included three depots, which represented a small proportion of the total next-day parcel delivery market, and did not consider altering vehicle size used, there is clearly great scope for traffic reduction and related environmental benefits from such collaborative working (Freight Traffic Control 2050, 2017). Research in Seoul, South Korea, indicated that the consolidation of the parcel flows of nine parcel carriers destined for a major high-rise housing complex, with the last-mile delivery handled by a single carrier, would reduce the distance travelled by vehicles by approximately 70%, and the time taken for vertical delivery within buildings by approximately 35%. This collaborative consolidated delivery of parcels was calculated to be financially feasible for 10%-20% of all apartments in the city (Park et al., 2016).

While some click and collect collection points and locker bank networks remain dedicated to specific retailers and carriers (such as Amazon, Royal Mail, DPD, DHL and Hermes collection points and locker banks, and many retailers' with in-house collection services in their shops), some collaboration exists in those click and collect facilities that provide so-called 'agnostics' services with more than one retailer or carrier able to use these facilities. For instance, the third-party collection point services Collect + and Doddle allow multiple commercial users, as do InPost's locker banks. Some retailers with in-store collection points also allow other commercial organisations to make use of their facilities such as Asda with its 'To You' service which allows customers of approximately 100 other retailers (including Sports Direct, ASOS and River Island) to collect and return parcels at Asda stores (Asda, 2020). Similarly, Waitrose allows Boden customers to collect and return items at selected stores (John Lewis Partnership, 2019). Such sharing of click and collect facilities and services helps to consolidate the flow of products through fewer points of collection, and thereby offers the potential for better vehicle utilisation on goods vehicles and for customers to collect several orders from a single location.

Amazon offers its Amazon Prime members (who pay a subscription fee) their so-called 'One-Day Delivery' service. Depending on the time that Prime consumers place their orders, if the goods are in stock, they will be delivered the next day. This 'One-Day Delivery' service is offered as the default delivery option for Amazon Prime customers and is offered without any additional charge beyond the Primer subscription fee. To counter criticism that such service levels lead to the proliferation of deliveries, as well as to enhance customer service, Amazon has introduced a couple of additional delivery options for its Amazon prime members that can help to alleviate delivery proliferation. Its so-called 'No-Rush' delivery service provides Prime members with the option to forgo next-day delivery on selected items over £10 that they order, and in return to receive a £1 discount on their next eligible order. No-Rush deliveries are made within six working days (Amazon, 2020b). Another delivery option called 'Amazon Day' allows Amazon Prime members to select a day of the week (except Sunday) which best suits them to receive a single delivery of all of the orders they have placed each week (rather than receiving a separate delivery of each individual order as soon as it is available). Where possible, Amazon also endeavours to group these orders together to reduce packaging where possible. This Amazon Day option is available on selected products that are for Amazon Prime 'free 2-day shipping' and shipped by Amazon (Amazon, 2020c). Both of these delivery options have been made available to Prime members at no additional cost. No information is available about the usage levels of No-Rush and Amazon Day delivery services among Prime customers.

Transport for London supported a project organised by the BEE Midtown Business Improvement District (BiD) in central London in which local businesses could sign up for the personal deliveries of their staff to be delivered to their buildings via a consolidation centre, thereby potentially reducing the last-mile vehicle activity associated with these deliveries and their impact on the post rooms at the buildings. However, signing up companies to participate in this project proved difficult (Transport for London, 2019b). In another project to consolidate personal deliveries to workplaces, Grosvenor Estates implemented a scheme whereby stationery orders and staff's personal deliveries destined for Grosvenor's head office were consolidated at a hub in east London and then delivered by a single vehicle delivery (Transport for London, 2019b).

Transport for London has also supported work that focuses on improving goods consolidation on their freight vehicle journeys, as well as producing a freight transport toolkit that encourages businesses to think about retiming their delivery activity in general (Peter Brett Associates and WYG, 2019; Transport for London, 2019b, Transport for London, 2020b).

8.10 Crowdshipping

Crowdshipping involves, 'enlisting people who are already travelling from points A to B to take a package along with them, making a stop along the way to drop it off' (US Postal Service, 2014). It therefore makes use of members of the public who are already making trips for other purposes to act as couriers for the distribution of parcels and other small items, thereby creating new informal logistics networks (McKinnon, 2016; Le et al., 2019). Crowdshipping is intended to make use of the spare delivery capacity of courier-passengers to deliver parcels and items that are travelling between the same locations as the courier-passenger already intended to travel to for their own purposes. Therefore, the crowdshipped item will not create any more transport activity than would have been generated by the courier-passenger anyway (or possibly only slightly more as the dispatch and delivery collections differ a little from the courier-passenger's starting and ending locations for their own journey). In addition, crowdshipping does not require additional transport vehicles than those already used by the courier-passenger for their own trip that they intended to make anyway, regardless of whether or not they had a parcel or other goods to transport. The courier-passengers who collect and deliver the parcels only provide this service on a part-time basis in accordance and conjunction with their already planned passenger trips.

Uber, the online taxi business, entered the American crowdshipping market with a service called UberRUSH in 2014, thereby allowing its existing drivers to transport parcels as well as passengers. This changed the shape and direction of crowdshipping, as it was originally aimed primarily at those looking to move goods for a living rather than as part of an existing passenger trip. At the launch of this service, the general manager of Uber in New York described UberRUSH as, 'an Uber for things' (Prigg, 2014).

An example of crowdshipping is provided by Nimber which provides an online matching service between those who needs items transported and those willing to do so (called "bringers"). Bringers log regular trips they make online, and Nimber then notifies them when potentially suitable delivery opportunities become available. The company was founded in Norway in 2010, and commenced operations in the UK in 2015. Nimber describes itself as a "collaborative peer-to-peer service that connects people who need to send something from one place to another with people going that way anyway. Whether they are on the road, taking the train or traveling by other means, they can use their mobile phone to pick up and deliver, make some money and maybe save the environment as well" (Nimber, 2018). It was reported in 2015, shortly after Nimber commenced its UK operations, that 3,000 bringers had signed up in this country. Many of the items sent via Nimber are large and bulky and would attract high prices from standard parcel carriers. Nimber provides £500 insurance per item shipped via its service. However, Nimber it is not a 'pure' crowdshipper (i.e. with private individuals already making trips acting as bringers). The company has reported that in Norway, where it began, approximately 40% of bringers do fall into this category, while the

other 60% are commercial operators such as courier companies, or individuals with a vehicle looking for dedicated transport work (Hickey, 2015).

Crowdshipping is intended to provide an alternative freight distribution model for parcels and small items to that offered by professional carriers (such as parcel companies). Given that the trips involved were taking place anyway, crowdshipping is intended to reduce logistics costs, especially those associated with the last-mile delivery, particularly in congested urban areas or remote rural locations which are expensive to service. These potential logistics cost reductions are associated with the lack of need for warehouses, employed vehicle drivers, and vehicles. The potential traffic and environmental benefits of crowdshipping are derived from the use of a single trip for both passenger and goods transport, rather than both trips being made in separate vehicles, potentially resulting in reduced total vehicle travel, energy use and emissions.

There are several risks and challenges associated with crowdshipping. These include: (i) reliability concerns (i.e. that the courier/passenger may be less reliable than professional carrier companies, and courier/passenger turnover rates at crowdshipping companies are very high); (ii) safety concerns (that theft, fraud, damage of parcels and late delivery may occur); (iii) privacy and security concerns (due to potential problems that may arise from giving couriers/passengers information concerning private individuals, their home addresses and preferred delivery times); and (iv) there may be additional costs arising from factors including insurance, lawsuits and training of part-time couriers/passengers.

There is no evidence that this type of 'pure' crowdshipping is growing and becoming widespread. This is likely to be due to the potential problems that it raises including: safety and privacy issues, legal issues, questions concerning liability, and reputational risks to companies using these services. In addition, the demand for such services and hence their financial viability and profitability, are currently uncertain. Whether or not the supply of couriers/passengers can meet current and future demand patterns in terms of times and locations at which customers require services also remains unclear. Likewise, the traffic and environmental impacts of crowdshipping, in terms of whether or not it will alter transport activity in a positive way (Fung Business Intelligence Centre, 2015). Three main issues affect the overall environmental sustainability of 'pure' crowdshipping: (i) the extent of professional third-party involvement; (ii) crowd motivation; and (iii) modal choice of the crowdshipper (car and other petrol motorised private transport versus public transportation versus clean vehicles/modes) (Buldeo Rai et al., 2017).

Instead of the emergence of this 'pure' crowdshipping on a wider scale, the fastest growing form of the status of delivery personnel in last-mile deliveries has been that of the self-employed courier who is provided with jobs and deliveries to carry out by a meal delivery or parcel delivery company on a casual basis (i.e. being paid on a per item delivered basis). However, rather than carrying out these deliveries as part of a trip they were already making for another purpose, these delivery workers are solely dedicated to making these last-mile deliveries. Therefore, this type of delivery arrangement offers none of the transport and environmental benefits of using trips for more than one purpose that is offered by 'pure' crowdshipping. These workers are typically not offered any guaranteed quantity of work during their chosen shifts, and are only paid for the work they perform. Such work has become commonplace in the parcel and meal delivery sectors, and has resulted in many legal challenges by delivery personnel who would prefer the benefits associated with being dependent contractors or employees rather than self-employed contractors (see section 7.13 for further discussion).

8.11 Online versus high street retailers

While the first Grimsey Review in 2013 presented means by which physical store retailing could be promoted and saved, the second Grimsey Review in 2018 argues that this is no longer possible given what has happened in the intervening five years, and the lack of action by policy makers (The Grimsey Review, 2013; The Grimsey Review, 2018). Although the latest Grimsey review

outlines measures that could help support the remaining physical high street retailers, it argues that: “There is a need for all towns to develop plans that are business-like and focused on transforming the place into a complete community hub incorporating health, housing, arts, education, entertainment, leisure, business/office space, as well as some shops.” It goes on to argue that the key to a successful future high street in the UK is outstanding and committed leadership from either elected mayors, or plans that, while co-ordinated by local government, reflect the views of all stakeholders, including the community (The Grimsey Review, 2018).

The House of Commons Housing, Communities and Local Government Committee recommended that, in order to assist store-based retailers, the UK Government should urgently assess new taxation regimes for retailing, including a new ratings methodology for warehouses of online retailers based on turnover above a certain threshold, an online sales tax, an increase in VAT, a revenue-based tax for online retailers where 80% of turnover is generated online, and ‘green taxes’ on deliveries and packaging (Housing, Communities and Local Government Committee, 2019). The Government responded to this report by agreeing that changing consumer behaviour presents a major challenge for store-based retailers. However, it argued that a new ratings methodology for online retailers’ warehouses would be unlikely to be feasible and would raise State aid issues; and that it would be likely that new taxes on deliveries would “would feed through to consumers and detract from the benefits of deliveries. In addition, we would have to consider the overall incentives and impact on pollution and congestion” (UK Government, 2019). The Government also noted that the Digital Services Tax announced at 2018 Budget is intended to respond to failures in international tax rules to “ensure digital platform businesses make a fair contribution to the public finances. The Government is not introducing the DST to address issues facing high streets or to change the balance of taxation between different types of retail business models” (UK Government, 2019). In July 2019, the government published a policy paper in which it confirmed plans to introduce from April 2020 a digital services tax of 2% on “the revenues of search engines, social media platforms and online marketplaces which derive value from UK users”, when the company’s “worldwide revenues from these digital activities are more than £500m and more than £25m of these revenues are derived from UK users” (HM Revenue and Customs, 2019). This introduction of the Digital Services Tax went ahead as planned in April 2020. In July 2020, HM Treasury launched a consultation into Business Rates. The consultation document explained that some believe that the current system of business rates, a tax on the rental value of non-domestic property, favours online retailers that can trade without expensive retail properties. It went on to explain that an online sales tax could provide a meaningful revenue source for the government. and could be “focused on sales in direct competition with those carried out through physical premises”. It noted that opinion on this idea was divided, with some arguing it would result in higher prices charged to consumers, could result in the bundling together of online purchases of goods and services, and would penalise innovative businesses (HM Treasury, 2020).

The continued contraction in physical store-based retailing in the UK that is expected in the coming years and the related rise in online shopping is likely to further increase the demand for last-mile deliveries. However, the demise of physical shops will result in the loss of important logistics space from which last-mile deliveries can be fulfilled. Therefore, in designing the future use of high streets it is important to take account of the logistics space required for last-mile deliveries and how to make the use of such space affordable.

8.12 Aerial drones and pavement droids

Delivery companies and engineers have been developing aerial drones and self-piloted pavement drones for use in last-mile deliveries. In 2014, Amazon obtained a patent for what it called an ‘airborne fulfilment centre, which consisted of airships used as flying warehouses equipped with fleets of drones for final delivery to consumers. Additional airships would be used to replenish stock at the ‘fulfilment centre’ airship. It was stated that such a concept could be used to serve sporting events or festivals (BBC, 2016b). In a trial in December 2016, Amazon made its first, fully-autonomous delivery by drone, which consisted of a tablet computer and a packet of popcorn,

from one of its fulfilment centres to a customer in a rural part of Cambridgeshire. The delivery was completed 13 minutes after the order was placed (Slide, 2016). Drones are already being used for small machinery parts and medical samples to be successfully moved by drone between fixed locations in remote locations that are difficult to access and which have poor road infrastructure, such as with the DHL Parcelcopter and the Matternet Station (DHL, 2020; Matternet, 2019). A study by the University of Southampton looked into patient sample movements from seven central clinics to a main hospital, suggesting time and emissions savings of up to 61% and 93% respectively over the conventional courier operation (Orda, 2017). Modelling of last-mile deliveries by road vehicle making multistep journeys and aerial drones that can only carry one order at a time and then return to the depot to pick up the next indicates that road vehicle use results in 98% less vehicle kilometres than drone use, but the former is road based and the latter airborne. In terms of CO_2 emissions, this same modelling study reported that drones with an average electricity charging requirement of "40 Wh/mile will generally have a net positive impact in most delivery situations (compared to delivery by road vehicles), while drones at an 80 Wh/mi average energy requirement will not". The number of customers to serve, their population density, and distance from the depot are also important factors in drone CO_2 emissions (Goodchild and Toy, 2018).

Some commentators are of the opinion that droids and drones will soon be playing a major role in last-mile deliveries of online shopping (Schröder, 2018; Hausmann, 2019). However, both technologies face various legal, regulatory and operational hurdles to their widespread use in the UK for freight transport, and especially in urban areas. In the case of drones these are concerned with safety and security risks associated with their use, and include the current prevention of drone use outside of the pilot's direct sight at all times, not being able to fly it more than 400ft above the ground (including over hills), and not being permitted to fly within the Flight Restriction Zone of a protected aerodrome (Civil Aviation Authority, 2020). Drones also require substantial landing spaces at delivery locations and also have the operational limitation of the delivery being made to an area outside of a delivery point rather than to a door or a location inside the building.

Similarly, pavement droids developed by Starship Technologies have been trialled by Just Eats in south London (Wader, 2016; Warren, 2017). However, droids also face several operational difficulties when tasked with tackling last-mile urban deliveries including: delivering to entrance to a building or inside the building rather than outside it, struggling to climb stairs of various depths and layouts, ringing doorbells, negotiating complex road crossing and other types of road and pavement infrastructure, ensuring that the goods being transported are secure (i.e. preventing theft and vandalism), and preventing being responsible for pedestrian and other road user collisions and injuries, especially in busy urban areas. At this point in time, droids appear to be more likely to be used for freight operations inside buildings rather than on-street operations, and have already been deployed within factories and hospitals for moving goods over relatively short distances. For example, Aethon TUG autonomous mobile robots have been deployed in American hospitals to transport medicines, equipment, meals, linen, and waste, and are able to open doors and call lifts (Aethon, 2020).

The wider deployment of drones and droids for last-mile deliveries on any scale would be likely to also require the extensive redesign of delivery reception facilities at commercial and residential buildings. Given this constraint, together with the safety and security concerns they currently face, these technologies are unlikely to play a large-scale role in urban last-mile deliveries in the near future.

8.13 Packaging initiatives

Some online clothing retailers take their items out of polybags (which are non-recyclable in domestic waste services) and putting them in recyclable packaging before despatching them to the consumer and repackaging them in recyclable packaging. Two such retailers are Patagonia and United by Blue. Patagonia bales its used polybags and ships them to a company that use them to make recycled decking and outdoor furniture. United by Blue passes its used polybags to

a recycling company that is storing them until a use can be found for them (which is proving difficult at present due to the scale of polybag supply). Some other sustainable retailers have switched to using biodegradable bags rather than polybags but these still require customers to dispose of them separately from conventional domestic plastic recycling services. Patagonia is now replacing all polybags in its supply chain with recyclable plastic bags made from fully recycled content (Wicker, 2019).

The packaging sustainability plan implemented by the Dutch online retailing trade association, thuiswinkel.org, which includes targets and research to reduce, reuse and recycle the packaging used in online shopping indicates the scope for change if companies are prepared to adopt such an approach (thuiswinkel.org, 2018 - see section 7.11).

8.14 Amazon case study

The online retailer Amazon delivers approximately 10 billion items a year, has a substantial transportation and data centre footprint, and has faced criticism from within its own workforce (Kearney, 2020). It has been investing heavily in its logistics operations in its efforts to provide one-day shipping to its Amazon Prime members (BBC News, 2019a). It operates and contracts substantial vehicle operations between its many distribution centres, local fulfilment centres and customers' home worldwide (known as Amazon Logistics). Globally, the company has 390 distribution centres and 20,000 delivery vehicles (World Economic Forum, 2020). It also began operating its own air cargo operations in the USA in 2015 for domestic freight movements between its distribution centres (known as Amazon Air). It is also developing aerial drones, and in 2019 applied for permission to use these in the USA (known as Amazon Prime Air – FAA, 2019), as well as developing pavement droids for urban deliveries (Scott, 2019).

In September 2019, Amazon made the following pledges: to use 80% renewable energy across its businesses by 2024 and 100% by 2030; to make 50% of its shipments net zero carbon by 2030; and to become net zero carbon across its business operations by 2040 (so-called 'Shipment Zero' - this covers the operations from the fulfilment centre where an item is picked, the materials used to package the item, and the vehicles that transport the package to the customer). Amazon intends to achieve these targets through the adoption of sustainable processes, the use of recycled materials, together with investments in electrification, and renewable energy initiatives. In terms of road transport vehicles this will include the use of electric last-mile delivery vehicles, as well as improving the energy efficiency of the existing upstream fleet through aerodynamics, automatic tyre monitoring and inflation, and the use of double-deck trailers (Amazon, 2020d, 2020e, 2020f).

Amazon is making efforts to implement solar and wind farms, to improve and reduce its packaging and minimise waste, and ensuring more packaging is recycled by making it easier for customers to recycle packaging through local collection schemes (Clarke, 2017; Amazon, 2018; Day One Staff, 2018).

In February 2020, Amazon's Chief Executive Officer Jeff Bezos committed $10 billion to environmental protection and addressing climate change. The so-called 'Bezos Earth Fund' will issue grants to scientists, non-profit organisations and other individuals and groups to support their research and work (Kearney, 2020).

9. The effect of the Covid-19 pandemic on online shopping in the UK

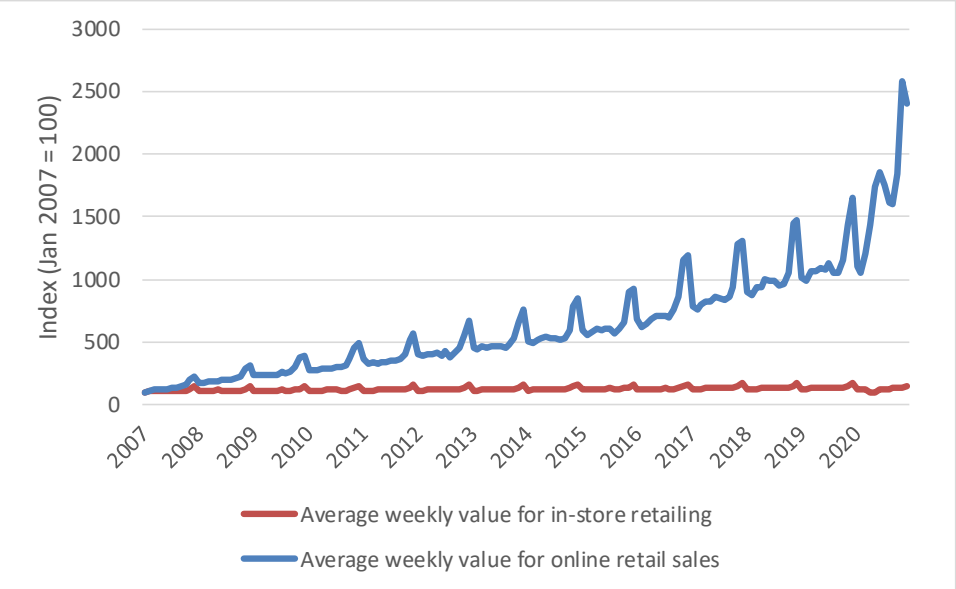
9.1 Introduction

The Covid-19 pandemic resulted in the UK Government telling the public that from 23rd March 2020 there were only four reasons for leaving their homes: i) shopping for basic necessities as infrequently as possible; ii) taking one form of exercise per day; iii) a medical need, or to escape risk of injury or harm, and iv) travelling for work purposes for those in jobs deemed to be essential (UK Government, 2020a).

Food shops and takeaway restaurants, deemed essential by government, remained open during the pandemic. However, non-food shops, eat-in restaurants, pubs and bars were deemed non-essential and ordered to close from 23rd March (with the exception that eat-in restaurants were allowed to make and sell takeaway meals if they wished). Some non-food retail chains already struggling before the onset of Covid-19 went into administration during the epidemic including Debenhams, Cath Kidston, Laura Ashley, Oasis and Warehouse.

Figure 9.1 shows the comparison between changes in total UK store-based retail sales (including online sales) and total UK online sales since 2007. The Covid-19 epidemic during 2020 can be seen to have further exacerbated the difference between retail sales growth between online and store-based sales.

Figure 9.1: Change in UK store-based and online retail sales, Jan 2007 – Dec 2020 (Index Jan 2007 = 100)



Note: Based on average weekly sales data for each month.
Non-seasonally adjusted data.
These figures do not take account of price inflation.
Does not include restaurant and online meal delivery sales.
Source: Calculated from data in Office for National Statistics, 2021a.

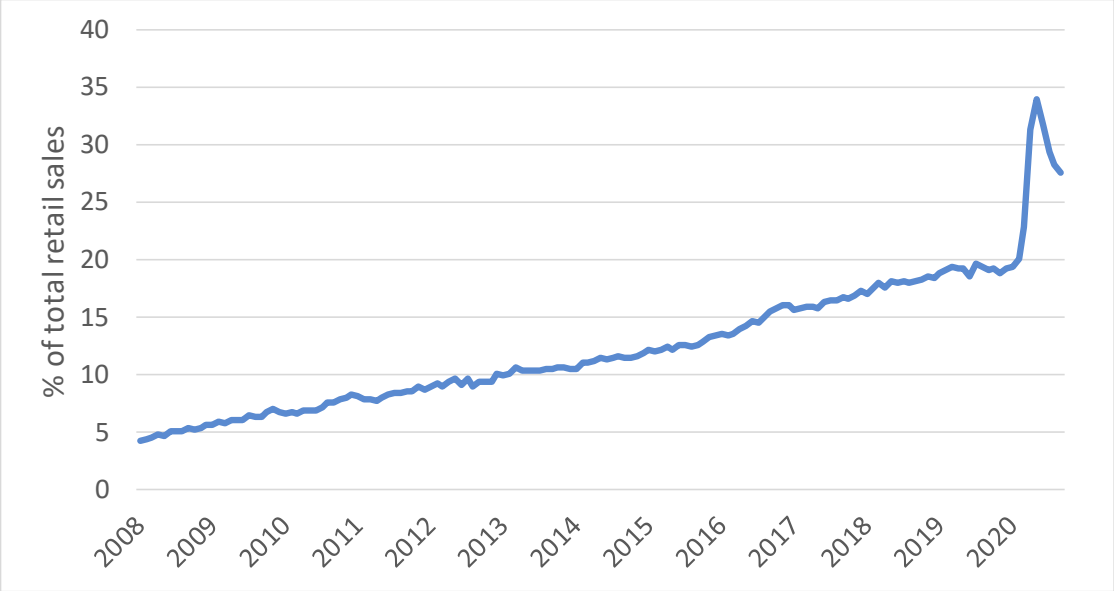
Last-mile delivery workers were deemed to be essential workers during the Covid-19 epidemic in the UK. They continued to deliver groceries, non-food and meal online orders to consumers' homes.

As a result of Covid-19 and its impact on retailing and consumer retail behaviour, total retail sales in the UK decreased by 1.9% in 2020. This is the largest annual fall in retail sales since records

began in 1997, and the first year of declining annual retail sales since 2011 (Office for National Statistics, 2021b).

All online retail sales (including non-food and grocery sales by store-based and online-only retailers) increased from 20% of total retail sales in January 2020 to 34% of all retail sales in May 2020 before falling back a little to 30% in December 2020 (see Figure 9.2 - Office for National Statistics, 2021a). The annual amount spent in online retail sales in the UK in 2020 increased by 46.1% compared with 2019 as a whole – this represented the largest annual increase in online sales since 2008 Office for National Statistics, 2021b). The growth in the retail penetration rate of online shopping during 2020 epidemic is equivalent to at least the growth rate over the preceding five years.

Figure 9.2: Online sales as a percentage of total retail sales in the UK (Jan 2008 -Dec 2020)



Note: Seasonally adjusted monthly data.
Source: Office for National Statistics, 2021a.

9.2 Grocery shopping

In-store grocery shopping

News of the restrictions imposed by government on 23rd March, resulted in initial 'panic buying' by consumers in grocery stores, with many items deemed essential by consumers (such as tinned and other long-life products, fresh fruit and vegetables, bread, rice, pasta, milk, eggs, flour, frozen foods, alcohol, soap, hand sanitiser, toilet roll) purchased in substantial quantity as some people stockpiled goods. Tesco, the largest grocery retailer in the UK, reported that in the peak week of consumer stockpiling sales of liquid soap increased by 363% compared to a typical week, tinned bean sales increased by more than 100%, tinned tomatoes sales were up by 115%, and toilet roll sales were up by 76%. By contrast, Tesco sales of clothing and vehicle fuel both fell by 70% (BBC, 2020a). After several days of this consumer reaction, leading grocery chains imposed restrictions on the quantity of items deemed essential that consumers could purchase (typically 2-4 of each essential item). This consumer reaction continued for approximately three weeks until shoppers became assured that shops would not run out of these essential items, after which limits on how much any shopper could buy were gradually relaxed.

Approximately two weeks after the 23rd March restrictions, grocery retailers began to put in place additional arrangements in their stores to try to ensure that customers were not in close proximity to each other (through the installation of screens at checkouts, deployment of additional grocery

and security workers, and queuing systems to limit the number of customers in the shop at any one time). Retailers also worked with their suppliers to reduce the number of product varieties available on the shelf and thereby increase production and availability levels in store.

Sainsbury's and Tesco both revealed by the end of April 2020 that customers were visiting stores on a less frequent basis than normal and buying about twice as much when they did shop (BBC, 2020b; BBC, 2020c).The Chief Executive of Sainsbury's announced at the end of April that customers in its stores should expect to experience queuing and delays for the foreseeable future due to social distancing measures (BBC, 2020b). In fact, queuing and delays for in-store shoppers mostly ceased by the end of May 2020.

Online grocery shopping

On 23rd March 2020, the day the Covid-19 restrictions were imposed in the UK, the Prime Minister Boris Johnson told the public that they should use place their grocery orders online rather than visiting stores as a means by which to limit the spread of the virus (BBC, 2020d). This indicated a lack of understanding among the government about the existing scale of online grocery sales and the extent to which this could be rapidly increased at short notice (especially in terms of the necessary warehouse capacity and refrigerated last-mile delivery vehicle fleet). Online grocers reported enormous increases in their website traffic as people tried to follow this advice, resulting in some grocer's websites crashing and people finding themselves in extremely long digital queues. Many people found themselves unable to place online orders or being told that no delivery slots were available for several weeks.

Retailers recruited more last-mile delivery workers to pick orders and make deliveries. For example, Tesco, the largest online grocer in the UK, doubled its online ordering slots to 1.2 million per week between March and May 2020 (Tesco, 2020a) and other retailers increased theirs by approximately 50% over a similar period. However, a sizeable proportion of this expansion was met by increasing in-house click and collect services, with customers collecting their ready-bagged up orders from store carparks in their cars. Many retailers prioritised these last-mile deliveries for elderly and vulnerable customers. In August 2020, Tesco announced that it was handling 1.5 million online orders per week and would create 16,000 new permanent jobs in order picking and making deliveries, as it expects the increased demand for online grocery ordering to continue in the long-term (Tesco, 2020b).

In order to expand last-mile deliveries to meet the demand since the Covid-19 epidemic began, some grocery retailers (including Morrisons and Marks and Spencer) have been teaming up with meal platform providers such as Deliveroo to offer same-day deliveries of limited product ranges and quantities via their rider networks (IGD, 2020a; Morrisons, 2020a; Shennan, 2020). Sainsbury's reintroduced its instant/same-day delivery service 'Chop Chop' which it had cancelled prior to the onset of Covid-19, which allows customers to receive deliveries of small numbers of items from a limited range via deliverers using bicycles and mopeds.

Grocemania, which enables consumers to buy groceries from local grocery and convenience food chain stores including branches of Budgens, Nisa, Londis and Costcutter (which have no online shopping capability) and have them delivered within a couple of hours by delivery personnel, expanded the shops signed up to its online platform during Covid-19. The service already existed in London and Brighton but was rolled out to stores in Newcastle in May 2020, with plans for stores in Manchester and Birmingham by July (Wells, 2020). Amazon announced in April 2020 that it was retrofitting existing UK depots to fulfil grocery orders on a same-day basis, which would be made available to approximately 40% of households before the end of 2020 (Sibson, 2020).

Some major grocery chains, including Morrisons, Marks and Spencer and Aldi began selling food boxes that were delivered to customers' homes during the Covid-19 pandemic. Aldi had never previously offered last-mile grocery deliveries and teamed up with the parcel carrier Hermes to

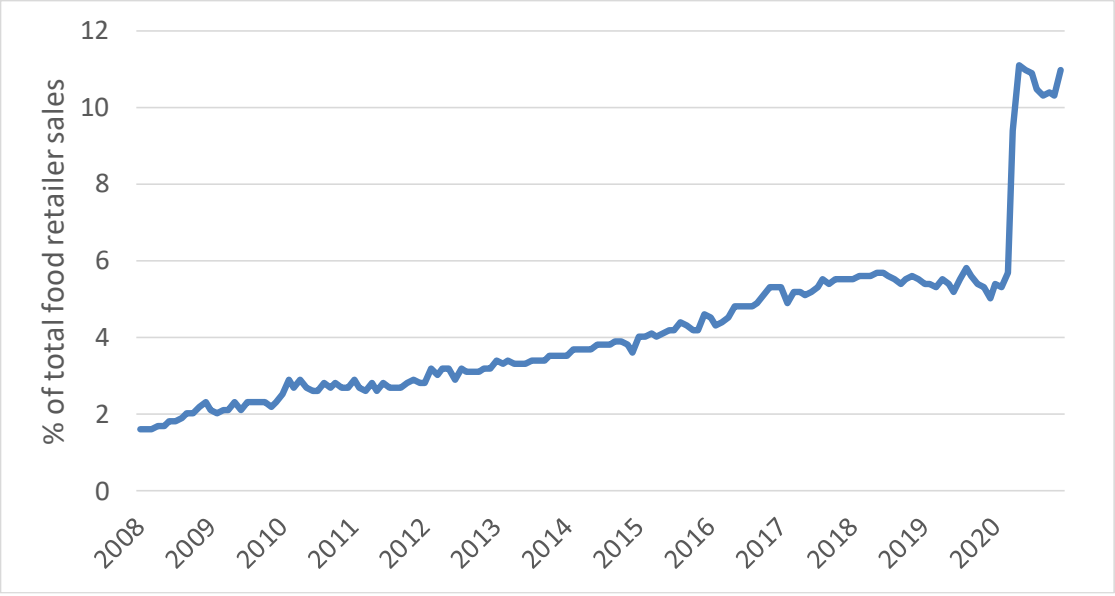
offer this service. Morrisons also put in place a telephone-based ordering service for those without computers (Farrell, 2020; Morrisons, 2020b).

During the Covid-19 crisis, grocery delivery drivers (and non-food and ready-to-eat delivery workers) used a new delivery protocol. They knocked at the door on arrival, left the goods on the floor and stepped back 2 metres (rather than handing them over in person, or entering the property with them to take them to the kitchen, as is normally the case for some grocery customers requiring this service).

For individuals deemed by government to be at risk of the most extreme illness from the virus who were advised to stay at home, the national government put in place an essential food box delivery scheme operated by two major food wholesalers (Brakes and Bidfood). Rather than having to place orders, these recipients received a weekly selection of groceries, soap and toilet roll in a large cardboard box left on their doorstep. This service was provided free of charge. These two companies were chosen because of their combined national network of 52 depots and hubs across the country and both had spare capacity to carry out this work as a result of the reduction in orders from the restaurant and hospitality trade that they serve. The scheme had the capacity to deliver up to 400,000 food boxes per week if required (Bidfood, 2020; Butler et al., 2020). Local government and charities put in place similar food box schemes for other vulnerable people.

In total, food retail sales in the UK experienced annual growth of 4.3% in 2020, which is the highest annual growth since 2001 (Office for National Statistics, 2021b). This was due to the increase in people eating at home rather than eating out, as well as some people who were able to afford it purchasing more expensive items than normal as a treat, at a time when few other treats were possible.

Figure 9.3: Online sales as a percentage of total food retailer sales in the UK (Jan 2008 - Dec 2020)



Note: Seasonally adjusted monthly data.
Source: Office for National Statistics, 2021aa.

Online grocery sales in the UK increased substantially during the Covid-19 epidemic from 5% to 11% of multichannel grocery sales between January and May 2020 and have remained at this level right through to December 2020 (Office for National Statistics, 2021a – see Figure 9.3). Despite physical food stores remaining open for business throughout the Covid-19 epidemic, this data reflects some customers' choice to avoid having to shop in store. Total online food sales in

the UK increased by 79% in the year compared with 2019 (Office for National Statistics, 2021b). Demand for grocery deliveries far outstripped supply, and retailers reported that orders would have been even greater than they were if they had been able to expand their fulfilment centres and delivery van fleets more quickly.

9.3 Food producers, wholesalers and online-only specialist retailers selling direct to consumers

While for some food and drink producers, especially those who normally supply the restaurant and hospitality trade, Covid-19 has presented extremely difficult trading conditions, others have generated sales and even flourished by selling to consumers online. These include artisan cheese providers such as Baron Bigod (Farming Today, 2020). Brewers of craft beer have also reported substantial increases in online sales (Clark, 2020). Bidfood, one of the wholesalers that won a government contract to deliver food boxes to vulnerable people during the Covid-19 crisis also began selling this service to the general public.

Hotel Chocolat the maker and retailer of luxury chocolate had to close its 125 retail stores during the Covid-19 crisis. It returned to its roots as an online-only retailer and sold a reduced product range consisting of thirty various chocolate box bundles that made warehouse picking and packing far easier to manage, and faster. The company reported that its sales were higher than the previous Easter (Russon, 2020). Given this experience, the company is now planning to focus more heavily on its online sales in future.

Specialist online-only retailers such as the wine retailer Laithwaite's also reported increases in new customers and sales during the Covid-19 crisis. The company has experienced a 300% increase in new customers year-on-year in March and April, and its prosecco sales were up 117% year-on-year during April 2020, with half-bottle and quarter-bottle sizes proving most popular (Plummer, 2020).

Online meal kit sellers which provide customers with all the ingredients and instructions needed to cook a meal for themselves, and which are marketed as being more healthy than standard takeaway meals, increased their advertising and sales during the Covid-19 crisis. These sellers provide options for customers from various cuisines of the world and with dietary requirements, such as vegan, vegetarian, gluten-free and dairy-free. Sellers include companies such as Hello Fresh, Mindful Chef, Gousto, Pasta Evangelists, SimplyCook, AllPlants, Abel & Cole Recipe Box, Riverford Recipe Box, and Recipe Box. Deliveries are made via parcel post with boxes packed with ice to ensure freshness. Many of these services are offered on a regular subscription basis.

Therefore, the Covid-19 pandemic is resulting is some signs of increasing disintermediation in the grocery and food sector, with producers and wholesalers that sell online direct to customers experiencing growth in customers and sales. This has provided some of these companies with a source of income at a time when their sales to the hospitality trade have fallen substantially. Some specialist online food and drink and meal kit sellers have also increased their sales during Covid-19. Therefore, the Covid-19 pandemic may mark the start of a substantial period of change and innovation in grocery retailing channels, as well as an increase in grocery online shopping penetration rates.

9.4 Ready-to-eat meals

All restaurants, bars and pubs were ordered by government to cease dine-in and drink-in services from 23 March 2020, but they could choose to serve takeaway meals if they wished and were able to comply with distancing requirements in their kitchens. However, many restaurant owners decided that the operating costs of running the kitchen were not viable while generating only takeaway meal sales, and therefore closed anyway (Tan, 2020). Others struggled to comply with

distancing rules and closed shortly after 23 March. Major chains to announce temporary closure of all branches included McDonalds, Kentucky Fried Chicken, Wagamama, Nandos, Costa Coffee, Subway, Pizza Express and Greggs. Takeaway-only outlets were allowed to continue trading as long as they were able to comply with physical distancing requirements in their kitchens.

Just Eat, Deliveroo and Uber Eats, the major platform providers in the UK, continued to offer online meal orders during the Covid-19 crisis. Just Eat reported that two-thirds of the restaurant and takeaway users that are members of its UK platform continued to trade during the epidemic. However, it reported that order volumes were reduced in the initial weeks following the 23 March lockdown, and the times of day and the day of week of orders became more unpredictable with more weekday lunchtime orders than normal, and less demand in the usual evening and weekend peak periods (The Food Programme, 2020). Reduced order volumes resulted in delivery couriers travelling further between restaurants and delivery locations. However, as restaurants began to re-open and offer takeaway meals and deliveries and households used up their food supplies, demand for meal deliveries began to grow again. Just Eat and Deliveroo both experienced higher order levels in April 2020 than in April 2019, and Deliveroo's order levels in May and June 2020 were above its pre Covid-19 crisis budget forecast for those months (which had been set in February 2020) (Competition and Markets Authority, 2020). Despite the epidemic, Just Eat reported an increase in orders of 18% and revenue of 28% in the UK in the first six months of 2020 compared to same period in 2019 (Just Eat Takeaway.com, 2020).

As previously mentioned, Deliveroo and Uber Eats had already begun to offer customers the opportunity to purchase groceries via their platforms prior to the Covid-19 pandemic with couriers collecting items from grocery stores. However, they experienced growth in demand for this service during the pandemic, especially for essential food stuffs such as milk, bread and eggs (The Food Programme, 2020). During Covid-19 Deliveroo signed deals with several major grocery retailers to commence instant deliveries of small order quantities on their behalf. Deliveroo began working with Marks and Spencer, Aldi, McColl's and Budgens during the epidemic to facilitate deliveries as these retailers had no existing delivery operations of their own (IGD, 2020b and 2020c). Deliveroo made deliveries from approximately 150 Marks and Spencer outlets (IGD, 2020a). Deliveroo also worked with Co-op and Morrisons (IGD, 2020d; Morrisons, 2020a). In the case of Morrisons, Deliveroo made deliveries from 130 of its stores in geographical areas in which either the retailer had no existing last-mile delivery operations presence or to help it increase its delivery slot availability. Morrisons and Deliveroo offered customers a range of 110 products with ordering permitted until 21:30 for instant delivery as quickly as 30 minutes from order placement (Morrisons, 2020a).

The use of Deliveroo by a far greater number of grocery retailers during the Covid-19 epidemic may lead to a longer-term partnership between Deliveroo and grocers who either have no last-mile delivery operations of their own, or who want to expand their existing last-mile services by offering instant delivery services.

Major fast food outlets such as Kentucky Fried Chicken, Burger King and Pret A Manger began to gradually reopen some of their branches from late April but for takeaway meals and deliveries only (BBC, 2020e). Restaurants, bars and pubs in certain parts of the country were subject to further bans on dine-in and drink-in services in the UK from October 2020, and another almost nationwide lockdown on restaurants, bars and pubs for dine-in services commenced on 19 December 2020. Takeaway meal services and meal deliveries were permitted to continue.

9.5 Non-food shopping

All non-food shops were ordered to close by government, with the exception of corner shops and newsagents, off-licences, chemists, petrol stations, Post offices, retail bank and building society branches, pet shops, laundrettes and dry cleaners, bicycle shops, hardware shops, plant and tool hire shops, and agricultural supplies shops (UK Government, 2020a).

In addition, some non-food online retailers closed their businesses in the first few weeks of the epidemic following the 23rd March 2020 lockdown; some of these closures were self-imposed as retailers safeguarded their workers and installed safe working practices, while others were enforced by Environmental Health Officers due to physical distancing concerns (Davey, 2020). Online clothing and footwear retailers that took the voluntary decision to initially close their operations included Next, River Island, Net-a-Porter, Tk Maxx and Schuh. These companies put in place measures in their warehouses and fulfilment centres to ensure that staff were working at safe distances from each other by reorganising picking systems and, in some cases reducing product range in order to recommence their operations. The time they temporarily ceased trading ranged from approximately two to six weeks.

Delivery lead times increased for many non-food orders due to the greater time taken to pick and pack orders, and due to increased order volumes. Availability of some products was also affected due to production and distribution difficulties upstream of the fulfilment centre. International online orders faced particular challenges given the delays at border crossings and the roads leading to them, especially in the initial weeks following the UK lockdown (and production shutdowns in China and other countries that preceded this).

Products in many non-food sectors experienced substantial increases in sales during the Covid-19 pandemic as a result of shop closures. However, the online clothing sector suffered a decline in sales which was associated with consumers not requiring new outfits due to the lack of social events (Ecommerce Europe, 2020).

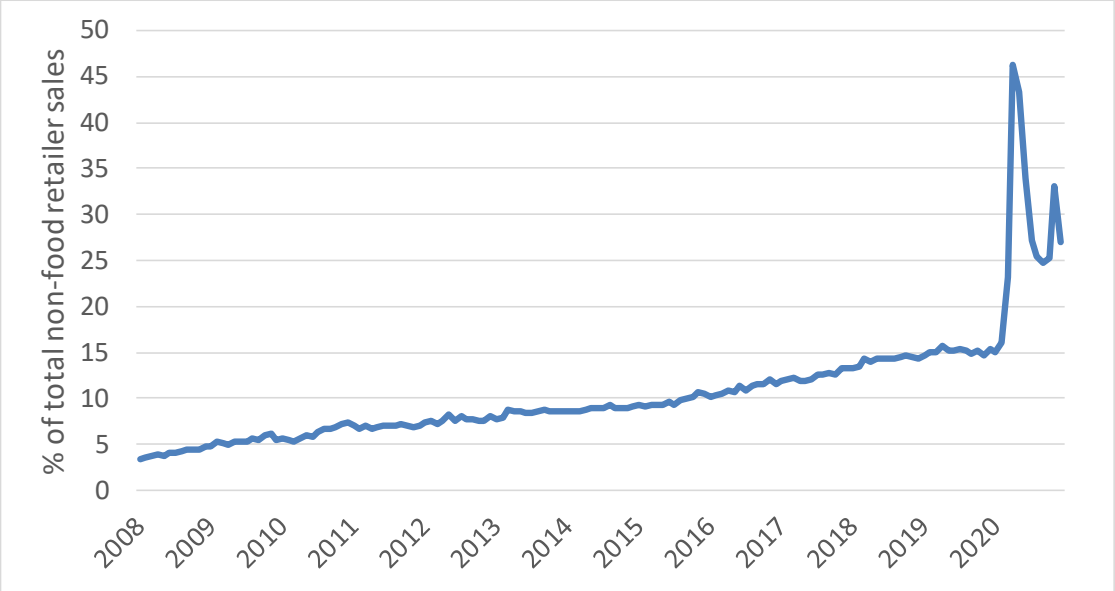
As would be expected, online non-food retailing in the UK increased substantially as a proportion of all non-food retail sales during the period when non-essential, non-food shops were closed. These stores were not permitted to reopen until 15 June 2020 in England, 22 June in Wales, and between 29 June and 15 July in Scotland (where different dates were imposed for those in highs streets and inside shopping centres). Following their reopening, shops were required to put in place measures to ensure distancing between people and other safety measures. Even once non-food stores reopened, the number of customers using shops remained well below pre Covid-19 epidemic levels. The British Retail Consortium reported that footfall on high streets in July 2020 was 47% lower than in July 2019 (British Retail Consortium, 2020). Many store-based non-food retailers, including John Lewis, Marks and Spencer, Boots and Debenhams have announced job losses since the onset of the epidemic, with several retailers also announcing store closure programmes. Further closures of non-food physical shops took place in areas worst affected by Covid-19 from October 2020, and another almost nationwide lockdown on non-essential shops (i.e. most non-food stores) commenced from 19 December 2020.

The economic impacts of Covid-19 on non-food store-based retailers has been substantial resulting, in some shops being closed on a permanent basis. Data indicates that the permanent closure down of physical shops was almost twice as great in the period January to June 2020 than it was in 2019, with approximately 11,000 chain stores closing and 5,000 opening, resulting in a net loss of 6,000 chain shops (in an analysis of 210,000 stores). Types of retail that showed the greatest resilience in physical shop numbers included: takeaways and coffee shops, supermarkets and DIY/building product store. Meanwhile, those showing the greatest net increase in physical shop numbers included: fashion retailers, electrical stores, mobile phone stores, convenience stores and betting shops. It is likely that the net decline during the Covid-19 epidemic will be greater than this given that other chains have announced closures and entered into company voluntary arrangements that have yet to take effect and are not therefore reflected in this data (PwC UK and the Local Data Company, 2020).

Retail sales in 2020 have been very poor for many non-food retailers in the UK due to the Covid-19 epidemic. Overall, clothing store retailers, department store retailers and "other" store retailers (which includes jewellers, cosmetics and toys) experienced annual decreases in sales in 2020 compared with 2019 of 25%, 5% and 12%, respectively.

However, online sales by non-food retailers fared better than their shop sales increasing from 15% in January 2020 to 46% of their total sales in April 2020, before falling back to 27% of sales by July 2020 as physical shops reopened (Office for National Statistics, 2021a – see Figure 9.4). Various sectors of non-food retailing which offer both in-store and online sales experienced substantial growth in online sales in 2020. For example, department store retailers, household goods store retailers and "other" store retailers experienced increases in annual online sales in 2020 compared with 2019 of 66%, 74% and 73%, respectively. Non-store non-food retailers (i.e. retailers that use no physical shops are that are primarily selling online including online-only clothing retailers) experienced an annual sales increase of 32% in 2020 compared with 2019 (Office for National Statistics, 2021b).

Figure 9.4: Online sales as a percentage of total non-food retailer sales in the UK (Jan 2008 - Dec 2020)



Note: Seasonally adjusted monthly data.
Source: Office for National Statistics, 2021aa.

Amazon, the largest online-only retailer in the UK, recruited an additional 3,000 permanent staff (a 10% increase in its permanent staffing levels) as well as many temporary staff to help cope with the increased demand during the Covid-19 epidemic. In September 2020 it announced its plan to recruit an additional 7,000 permanent staff by the end of the year (BBC, 2020e). Clothing has been the worst affected non-food retail sector both in-store and online, due the lack of business and social interactions and the closures of shops and changing rooms resulting in a reduced demand for garments.

It has been estimated that 93,000 retail jobs were lost in the UK in 2020, compared with 79,000 retail job losses in 2019. These extra job losses in 2020 are mostly as a result of store-based non-food retailers going into administration and Company Voluntary Arrangement (CVAs) as a result the trading difficulties caused by the Covid-19 epidemic (Centre for Retail Research, 2020b). It is not yet known how many retail businesses will re-open once Covid-19 has been brought under control and shop-based retailing can return to normal practices. It has been forecast that there will be a further 200,000 retail job losses in the UK in 2021 (Centre for Retail Research, 2020b).

Major increases in total parcel volumes during the Covid-19 crisis may translate into a long-term increase if consumer behaviour change takes place, with a permanent step change increase in online shopping. The epidemic may also lead to other important changes in non-food online shopping that are discussed below.

Online retailing has increased substantially during the epidemic with existing online retailers selling far more, as well as many smaller new retailers entering the market. While online retailing and the parcel flows it generates have grown rapidly during the epidemic, business-to-business parcel flows have fallen considerably, given that many employees are no longer working from offices in central urban locations. Given that B2B parcels attract higher charges than B2C parcels, this is likely to further affect the profitability of some carriers that were heavily involved in the B2B parcel market. At the same time, Covid-19 has accelerated the decline in letter traffic (PostEurop, 2020). This has negatively affected the income of national postal carriers, who are relying of the growing parcel flows to compensate for this loss of business. This is making the parcel market ever-more competitive, as more companies are viewing it as a crucial element of their future business and success. The major global online retailers (such as Amazon, Alibaba and JD.com) have been increasing their last-mile delivery capability during the epidemic, both in terms of road-based and air-based resources, and this poses a further challenge and threat to the traditional parcel carriers.

While this growth in demand for non-food online shopping and parcel volumes offers a business opportunity, some parcel carriers may face capacity constraints that cannot be overcome without major investment in more sortation hubs and automated handling equipment. It will be important for these carriers to decide which retail customers' additional parcel flows to accept, as not all of this additional work will necessarily suit their existing infrastructure or prove profitable for them. It is also important for carriers to decide the scale of expansion they should aim for as not all retail customers and types of online product will necessarily continue to grow rapidly in the longer-term.

Growth in total quantity and frequency of non-food online orders placed by consumers are resulting in more deliveries to the same addresses and a general increase in parcel drop density. This, together with potential increases in carrier costs due to investment needs and the possible imposition of further restrictions and requirements on urban road freight transport operations, may further encourage carriers to consider collaborating with each other to prevent them replicating the work of each other, and thereby reduce their operating costs. However, there are several hurdles to overcome before this happens, most importantly traditional resistance to it from the carriers themselves, together with commercial and legal considerations.

Some in the last-mile delivery industry believe that the health concerns associated with receiving deliveries on the doorstep during the Covid-19 epidemic, together with the growing quantity of parcels, will result in greater use of locker banks in future. Carriers would potentially benefit from such an outcome as the use of lockers removes delivery failures, as there is no need for the consumer to be present to receive the delivery. In addition, deliveries to locker banks result in more parcels being delivered in a shorter space of time. Both of these factors increase delivery efficiency and thereby reduce the cost per parcel delivered. Policy makers are also of the opinion that such an outcome would thereby reduce the van distance travelled per parcel delivered and thereby the greenhouse gas emissions and other negative impacts. However, traditionally the UK consumer has not been keen on the use of locker banks. In addition, to prove efficient, existing locker bank networks that are dedicated to a single carrier or retailer would need to become opened to use by many different companies. Also, to extend the locker bank network is likely to be a slow and expensive process. This is likely to be easiest in the case of new build apartments, but is far harder to achieve at scale in locations away from new properties such as high streets and railway stations. Also, traffic and sustainability benefits would depend on the siting of these locker banks and consumers' travel behaviour to and from them.

Given that at present during the epidemic, the demand for parcel shipping and last-mile delivery is exceeding supply, and is likely to require carriers to make expensive infrastructure investments, this could result in parcel delivery charges increasing. If this were to happen, it is possible that retailers may have to reconsider the 'free' delivery and return propositions they make to consumers. More explicit charging for these delivery and return services would potentially result in more environmentally sustainable operations.

The Covid-19 epidemic has probably brought the requirement for obtaining physical signatures at the doorstep to a faster end than would otherwise have been the case, driven by health advice not to request signatures together with consumer unwillingness to sign in person. These signatures are being replaced by electronic geographical data and the use of photographs as proof of delivery.

Consumers affected by delivery delays on international online orders during the epidemic may opt to purchase less from international retailers and more from national retailers in future to avoid these problems, while these delays may also encourage online retailers to source products from less distant producers.

The epidemic also reduced the provision of airfreight capacity, as a substantial quantity of parcel traffic is usually carried on passenger flights which were severely reduced. This led to greater use of long-distance shipping by sea. Producers and online retailers may not return to shipping by air to the same extent in future as they did previously, given the price differentials between these modes. They may decide that a slower, but reliable service by sea is acceptable for these orders.

10. Summary of research findings

The review of research and publications carried out has identified a range of factors that contribute to transport, carbon and other impacts of online shopping and last-mile deliveries. The authors have used this information together with their own insights and judgement to produce Figure 10.1 which summarises these factors and their impacts for the three key growth sectors in online shopping namely: non-food (delivered as parcels and packages), grocery, and ready-to-eat meals. The type of factor is shown (i.e. whether it is operational – related to company behaviour, consumer behaviour, or technological), as well as the impact related to each of these factors (i.e. transport intensity and carbon emissions, carbon emissions only, and worker wellbeing). Figure 10.1 also groups these factors into the timescale within which they could be extensively altered (i.e. can be altered now, can be altered within the next ten years, or will take more than ten years to alter).

In terms of decarbonising online shopping and last-mile deliveries, the most important factor is likely to involve switching delivery vans from fossil fuels to zero emissions energy, most notably electricity generated from renewable sources. However, as illustrated in Figure 10.1 this is likely to take a considerable time to achieve on a large scale given the barriers that currently exist such as vehicle availability, current operating cost differences with fossil-fuelled vehicles, and recharging infrastructure requirements at depots.

In addition, while switching the fuel source of the vehicle can eliminate carbon exhaust emissions (and air pollutants) from the delivery locations served, it will not alter the road transport intensity of last-mile deliveries. Reducing the transport intensity is an important goal given the growing traffic congestion in urban areas and the need to make more safe space available for cycling and walking, together with public transport.

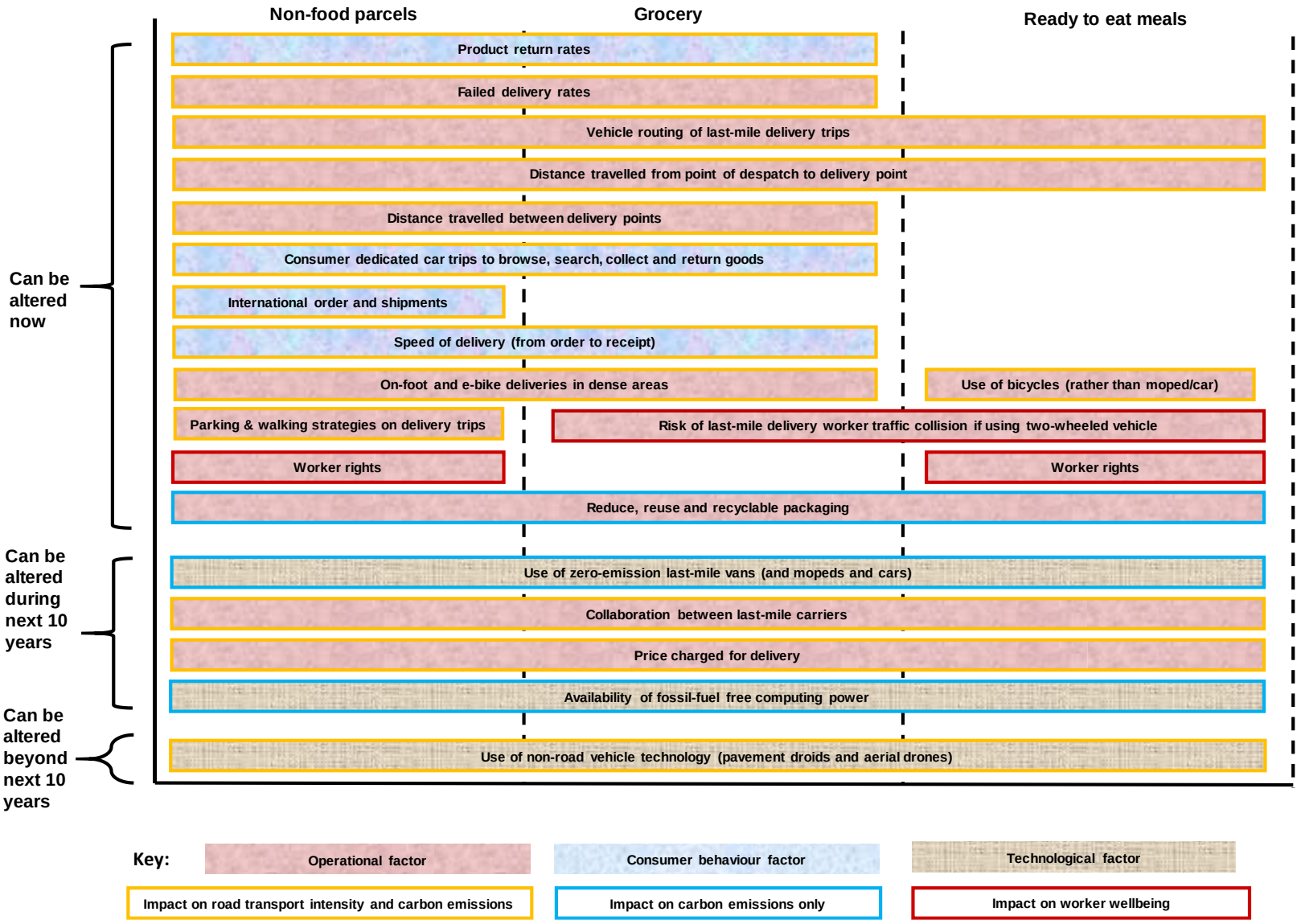
Fortunately, as depicted in Figure 10.1, there are many other factors that contribute to the impacts of online shopping and last-mile deliveries that can be more quickly addressed through changes to both company and consumer behaviour, and which would result in reductions in both the road transport intensity and carbon emissions. These include both changes to how consumers behave and the choices they make when placing online orders as well as the services made available by retailers and how they and carriers plan their delivery operations.

Figure 10.1 also illustrates that there are fewer factors that can be influenced to reduce the transport intensity and carbon emissions of ready-to-eat meals compared to the other sectors. However, the single most important factor in this sector is the use of bicycles to make these deliveries rather than fossil-fuelled cars and mopeds and this is achievable now.

As discussed in previous chapters, consumer shopping travel by car makes an important contribution to road transport intensity, carbon emissions and air pollution. Even when consumers make use of online shopping for non-food or grocery products this does not necessarily result in them ceasing their car-based shopping trips. Some consumers continue to make dedicated car trips to browse and search items prior to placing online orders and also collect online orders and return items at shops and locker banks using cars. Consumers' decisions about how quickly they want their online orders delivered, the size and frequency of their orders, the extent to which they order more than they intend to keep, and hence return goods, and whether or not they order goods that are shipped direct internationally also play important roles in transport intensity and related carbon emissions. Therefore, consumers have an important role to play alongside other stakeholders in reducing the negative impacts of online shopping.

Electrically-powered pavement droids and aerial drones may play an important role in last-mile deliveries in the future, but have many technological, safety and security issues to address before they become viable. In addition to transport-related factors, the extent to which the electricity used to power computing technology and commercial buildings is fossil-fuel free and the type and extent of packaging used to shop orders are also important.

Figure 10.1: Factors that lead to impacts in online shopping and last-mile deliveries



Source: Based on authors' own judgement from the review work carried out.

11. Conclusions

The review of online shopping and last-mile delivery carried out and the analysis of the findings of the material reviewed leads to the following conclusions:

- Online shopping has grown rapidly since its inception and is forecast to continue to do so.

- The Covid-19 epidemic has significantly increased the uptake and penetration of online shopping as a retailing channel both in relative and absolute terms, as it removed the need for people to take the risk of visiting shop in person and provided a retail channel when physical shops were closed. It has also led to more direct online selling by manufacturers, farmers and wholesalers.

- It is currently unclear whether these much greater levels of online shopping seen during the Covid-19 crisis will persist beyond the epidemic, but the longer the virus exists and poses a risk, the greater the likelihood that consumer shopping patterns will experience substantial long-term change.

- The transport of goods by consumers using cars from shops to their home is typically the most carbon-intensive stage of the retail supply chain (on a per item basis) despite the short distance involved.

- Van delivery to customers can be less transport- and carbon-intensive than consumers' shopping trips by car as the vanload of parcels or groceries carries many customers' orders in a single trip.

- However, the transport and carbon benefits of van deliveries compared to consumers' car trips are eroded by factors including failed delivery rates (i.e. when the customer is not at home to collect the parcel) and the provision and desire for ever-faster delivery.

- Same-day and instant last-mile deliveries are typically more transport and carbon intensive than next-day or slower ones due to the smaller loads carried and the distance between deliveries.

- Several other aspects of some consumers' behaviour when shopping online also diminish the potential comparative transport and carbon benefits such as ordering more than they require (especially in relation to clothing) and then returning what they decide they don't want.

- In addition, some consumers continue to make car trips to shops to browse and view items prior to placing online orders, and choose to buy some of their grocery requirements online while still driving to shops for other items. Therefore, the use of online shopping does not necessarily result in the complete substitution of a consumer shopping trip with a last-mile delivery.

- For online shopping to result in reduced total traffic levels and transport-related environmental impacts than conventional shopping there has to be a sizeable reduction in consumer shopping trips by car.

- Online shopping provides consumers with the opportunity to order goods from remote retailers, including internationally, which has consequences for the distance over which individual orders are transported, the potential use of air and sea freight, and the related environmental impacts of this upstream distribution activity.

- The last-mile delivery of online shopping has resulted in an increase in total commercial freight transport between shops/depots and homes (with a related reduction in car trips and other modes of consumer shopping transport).

- A wide range of vehicles are associated with last-mile deliveries: the van is the most commonly used, but mopeds, motorbikes, bicycles and cargo cycles (electrically and manually powered) are also used (as well as rigid HGVs for large, heavy items).

- Last-mile freight transport is typically more transport- and energy-intensive per unit of goods transported than other more traditional forms of freight transport. This is due to the relatively small carrying capacity of last-mile delivery vehicles (and cars), and the characteristics and efficiency of these delivery operations.

- Of all types of last-mile delivery, ready-to-eat meal deliveries by fossil-fuel powered mopeds and cars result in the greatest transport and carbon impacts per unit of product transported.

- Key factors that directly affect the transport-related environmental impacts of last-mile deliveries include: the rate of failed deliveries, amount purchased per order, product return rates, delivery lead times, drop densities, vehicle carrying capacities, vehicle type and fuel source, vehicle (and walking) routeing decisions, and driver knowledge and experience.

- Official data showing the scale of transport activity associated with online shopping (by companies and consumers) does not currently exist to make it possible to assess the overall traffic and carbon impacts of online shopping.

- In addition to the transport-related environmental impacts of online shopping there are other environmental impacts related to online shopping that need to be taken into account in understanding its overall impact. These include: packaging waste; computing energy use; goods storage locations and their energy consumption; the behaviour, safety and wellbeing of last-mile delivery workers; casualisation of labour in last-mile delivery operations; and social inclusion/exclusion issues related to consumers' access to online shopping.

- Some retailers, carriers and academics have developed trials and operational schemes that can help to reduce the traffic and environmental impacts of online shopping and last-mile delivery.

- The action that will produce the greatest reduction in last-mile delivery GHG emissions is the uptake and use of zero-emission delivery vehicles. However, it will take time for the use of these clean vehicles to become widespread, and even when they are, their use will still result in transport impacts.

- There are other logistics actions that stakeholders (retailers, carriers, those responsible for logistics land ownership and property management, policy makers and consumers) can take to reduce the negative transport and environmental impacts of online shopping and last-mile delivery. All of these actions are provided in chapter 12.

- If consumers and companies are unable to implement the necessary changes to online shopping and last-mile delivery behaviour to reduce its negative transport and environmental impacts then policy makers may have to intervene more directly if existing targets for net-zero carbon emissions in the UK are to be met.

12. Recommendations

Recommended actions have been devised with respect to online shopping and last-mile delivery, based on the review and analysis carried out as part of this review (see Tables 12.1 to 12.5). These actions have been categorised according to the stakeholder groups to which they apply. These stakeholders are:

- Online retailers
- Delivery companies (who may also be retailers)
- Consumers
- Policy makers
- Land owners, property developers and building managers.

These recommended actions have been categorised in terms of the aspects of last-mile delivery operations on which they will positively impact:

- Transport intensity (last-mile delivery vehicle kilometres travelled).
- GHG emissions (due to online shopping and last-mile delivery activity).
- Wellbeing and safety of last-mile delivery workers (including their working conditions and health).

Some of these recommended actions are also expected to result in improvements in last-mile delivery operating costs, while at the same time reducing these negative impacts.

These recommended actions have been sub-divided into those that could potentially be implemented in the short term (with 18 months), medium term (18-36 months) and long term (more than 36 months). A tick mark denotes a positive link between the recommended action and potential improvements in the sustainability of delivery operations (in terms of transport intensity, GHG emissions and/or worker wellbeing and safety). Those recommended actions that are also expected to have a positive impact on operating costs have also been shown with a tick mark.

The online shopping and last-mile delivery sectors to which these recommended actions apply have also been indicated, using the same key as in previous tables:

G = grocery delivery
P = parcel delivery
L = large, non-food two-person delivery (e.g. white goods or furniture)
M = ready-to-eat meal delivery

The impacts of these actions have been assessed by the authors using their expert judgement, drawing on the results of research reviewed in carrying out this work.

Table 12.1: Possible actions for online retailers

Initiatives and measures	Potential impacts				
	Transport intensity of last-mile deliveries	GHG emissions	Wellbeing and safety of last-mile workers	Last-mile delivery operating costs	Online shopping sectors related to this action
Short-term					
Reconsider the provision of free returns	✓	✓		✓	P
Sanction customers who regularly return large volumes	✓	✓		✓	P
Offer 'green' checkout option to consolidate items into single consignment (delaying delivery)	✓	✓		✓	P
Group delivery time slots offered based on inter-drop distances between them ('green option')	✓	✓		✓	G
Request alternative delivery address details (in case needed)	✓	✓		✓	P
Medium-term					
Devise sustainability and decarbonisation plans for last-mile delivery	✓	✓	✓		G,P,L,M
Make online tools and product information available to help customers select the correct item	✓	✓		✓	P
Incentivise consumers to ensure returned items are in good condition				✓	P
Implement delivery charges that reflect operating and external costs (including removal of 'free' deliveries)	✓	✓		✓	G,P,L,M
Obtain grid coordinates of entrance point at delivery location from customers	✓	✓		✓	G,P,L,M
Refrain from offering or at least make clear to customers items that involve direct deliveries from overseas	✓	✓		✓	P
Reconsider whether offering same day and instant delivery is appropriate	✓	✓		✓	G,P,L
Develop and implement packaging reduction, reuse and recycling plans		✓			G,P,L,M
Offer and promote agnostic locker banks and collection points (especially in locations easily reached by non-car modes)	✓	✓		✓	P
Long-term					
Use vacant shop space for last-mile logistics services: collection, returns, showrooms/fitting rooms etc.	✓	✓		✓	P
Join sustainable last-mile delivery certification schemes (if/when they exist in UK)	✓	✓	✓		G,P,L,M

Table 12.2: Possible actions for last-mile delivery operators (retailers and carriers)

Initiatives and measures	Potential impacts				
	Transport intensity of last-mile deliveries	GHG emissions	Wellbeing and safety of last-mile workers	Last-mile delivery operating costs	Online shopping sectors related to this action
Short-term					
Refrain from instant and same-day delivery services where possible	✓	✓		✓	G,P,L
Provide consumers with real-time delivery information and expected time of arrival	✓	✓		✓	G,P,L
Provide training to inexperienced multi-drop parcel drivers (for vehicle loading, vehicle driving/walking strategies, suitable kerbside stopping locations)	✓	✓		✓	P
The use of bicycles rather than fossil-fuelled mopeds and cars for ready-to-eat meal deliveries	✓	✓	✓	✓	M
Medium-term					
Devise sustainability and decarbonisation plans for last-mile delivery	✓	✓	✓		G,P,L,M
Use zero emissions vans and other vehicles where possible (electric vehicles etc.)		✓	✓		G,P,L,M
Use walking porters and electric cargo bikes in dense urban areas to decouple delivery personnel and vehicles	✓	✓			G,P
Use micro logistics hubs to facilitate use of clean vehicles and walking porters	✓	✓	✓		G,P
Use IT-based routeing and scheduling for drivers	✓	✓		✓	G,P,L,M
Make use of delivery point grid coordinates for entrance door at delivery location routeing	✓	✓		✓	G,P,L,M
Develop agnostic locker banks and collection points (especially in locations easily reached by non-car modes)	✓	✓		✓	P
Provide more training to last-mile delivery workers (including driving style)	✓	✓		✓	P,M
Pay self-employed/contractors by time period rather than per delivery to ensure at least the minimum wage	✓	✓			P,M
Long-term					
Continue investigation of pavement drones and aerial droids for last-mile deliveries	✓	✓		✓	G,P,M
Collaborate with other carriers to share loads and micro hubs / depot facilities	✓	✓		✓	G,P,L
Improve working conditions for pickers/packers and drivers (insurance, sick pay, holiday entitlement, protective clothing, vehicle)	✓	✓	✓		P,M
Join/provide operational data to sustainable last-mile delivery certification schemes (if/when they exist in UK)	✓	✓	✓		G,P,L,M

Table 12.3: Possible actions for consumers

Initiatives and measures	Potential impacts				
	Transport intensity of last-mile deliveries	GHG emissions	Wellbeing and safety of last-mile workers	Last-mile delivery operating costs	Online shopping sectors related to this action
Short-term					
Make use of 'green' delivery options provided on online retailer's checkouts where available (including time slots where delivery vehicles will be in your vicinity, and slower delivery options to improve consolidation of deliveries in your area)	✓	✓		✓	G,P,L
Do not select same-day / instant delivery options where possible	✓	✓		✓	G,P,L
Agree for items in order to be consolidated into single delivery on online retailer's checkouts	✓	✓		✓	P
Do not order individual items from retailers if possible (wait until several items are required or use fewer retailers)	✓	✓		✓	G,P
Place combined orders with others in the household	✓	✓		✓	G,P,M
Refrain from ordering multiple similar items and then returning those unwanted (particularly clothing)	✓	✓		✓	P
Ensure you are available to receive goods if having them delivered to your home via a service that provides expected time of arrival (and notify them in advance if for some reason you cannot be at home)	✓	✓		✓	G,P,L
Provide alternative delivery location details (such as friends and neighbours in case you are not home) if permitted at the time of ordering	✓	✓		✓	P
Pick up goods from shops and lockers as part of existing trips (e.g. commute to work) avoiding use of car where possible	✓	✓		✓	G,P
Refrain from making trips to shops by car to view and study items and gain staff knowledge before placing orders online	✓	✓			G,P,L
Return goods as part of trips already being made for other purposes (avoiding use of car where possible)	✓	✓			P
Reconsider ordering items where it is apparent they are delivered directly from overseas	✓	✓		✓	P
Reconsider need for and impacts of 'fast fashion' and food before placing orders to prevent waste arising	✓	✓			G,P
Long-term					
Use online retailers signed up to sustainable last-mile delivery certification schemes (if/when they exist in UK)	✓	✓	✓		G,P,L,M

Table 12.4: Possible actions for policy makers

Initiatives and measures	Potential impacts				
	Transport intensity of last-mile deliveries	GHG emissions	Wellbeing and safety of last-mile workers	Last-mile delivery operating costs	Online shopping sectors related to this action
Short-term					
Encourage and promote greater use of non-car modes for personal shopping trips	✓	✓			G,P,L
Provide information/education on impacts of product disposability and waste (fast fashion and food waste)	✓	✓			G,P
In cases of noise disturbance & nuisance to residents check planning conditions permit takeaway meals	✓				M
Medium-term					
Disseminate last-mile information and advice to stakeholders including consumers	✓	✓		✓	G,P,L,M
Work with retailers and delivery operators to develop agnostic locker banks and collection points (especially in locations easily reached by non-car modes)	✓	✓		✓	P
Carry out strategic assessment of logistics land provision and location to prevent logistics depot sprawl	✓	✓			G,P,L
Safeguard / protect existing last-mile delivery sites / land	✓	✓			G,P,L
Consider requirement of inclusion of micro logistics hubs to serve local area in major building development	✓	✓			P
Provide micro logistics hub sites / land in dense urban areas to facilitate use of cargo cycles and walking porters and rapid EV recharging (i.e. former car parks etc.)	✓	✓			P
Implement training requirements for last-mile delivery workers	✓	✓	✓		P,M
Review competition law to ensure that last-mile collaboration between delivery companies is permissible	✓	✓		✓	G,P,L
Clarify law on employment status (i.e. greater definition, or remove the 'worker' or 'self-employed' employment categories)			✓		P,M
Increase requirements for uptake of renewable electricity (for vehicles and computing)		✓			G,P,L,M
Increase requirements for energy saving technology for computers and smartphones		✓			G,P,L,M
Long-term					
Consider implementing delivery tax/charges to prevent ‘free’ delivery / incentivise green delivery options	✓	✓			G,P,L,M
Use planning system to mandate internal logistics systems at large commercial buildings	✓			✓	P
Plan/provide energy infrastructure for zero emission vehicles (including last-mile delivery vehicles)		✓	✓		G,P,L,M
Require relocation of server farms to locations with cooler ambient temperatures		✓			G,P,L,M
Improve working conditions for drivers (insurance, sick pay, holiday entitlement, protective clothing, vehicle)	✓	✓	✓		R,P

Table 12.5: Possible actions for land owners, property developers and building managers

Initiatives and measures	Potential impacts				
	Transport intensity of last-mile deliveries	GHG emissions	Wellbeing and safety of last-mile workers	Last-mile delivery operating costs	Online shopping sectors related to this action
Short-term					
Ensure reception points and internal logistics systems so drivers can make deliveries to loading bay or front door rather than having to deliver to desk inside large buildings with single user such as hospitals and central/local government offices	✓			✓	P
Medium-term					
Design-in secure unattended delivery facilities (lockers) attached to houses in new builds	✓	✓		✓	G,P
Design-in secure unattended delivery facilities (lockers and concierge facilities) for residential apartment new builds to prevent failed deliveries	✓	✓		✓	G,P
Design micro logistics hubs and rapid recharging points in major new commercial and residential developments to facilitate use of walking porters, cargo cycles and electric vehicles	✓	✓	✓		G,P
Provide former high street retail sites for multi-user locker banks/collection points/showrooms/wardrobes	✓	✓		✓	P
Develop multi-story, multi-level logistics fulfilment sites in urban areas (i.e. intensification of logistics sites)	✓	✓		✓	G,P,L

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