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The verdict from Professor Alan McKinnon and Dr Julia Edwards is that in the case of small non-food items, the home delivery operation is likely to generate less CO_2 than a conventional trip to the shops

Shopping trip or home delivery: which has the smaller carbon footprint?

It has been a hotly debated subject – but at last the verdict is in. Rather than finding that online shopping is detrimental to the environment, when considering the last mile stage only, successful home delivery compares favourably with conventional shopping. Professor Alan McKinnon and Dr Julia Edwards reveal their findings.

The internet offers consumers the flexibility of round-the-clock shopping with delivery to the home. Online retail sales and home deliveries have enjoyed phenomenal growth in recent years, leading several to question the impact that the resulting increase in van activity is having on the environment.[1] At the same time, some internet retailers are now arguing that online shopping is better for the environment.[2] Consumers have been left with no real way of assessing the environmental effects of their shopping behaviour, as to date little research has been done on this subject.

The key to any environmental comparison is the treatment of the 'last mile' – that is, the final link in the supply chain to the home. Not only is this last link – from retailer/supplier to consumer – the most visible and highly variable, it is also the most energy intensive, and typically generates more CO_2 emissions than all the upstream logistical activities.[3,4] The question is: how do we realistically compare the level of carbon emissions from a conventional shopping trip with those of delivery to the home?

Two issues are central to the investigation:

- What is a typical home delivery or shopping trip?
- How do we account for complicating factors, such as people combining shopping and other trips – that is, trip chaining – and failed delivery, when no one is at home to receive the goods?

In this study, undertaken as part of a larger green logistics research project, we have addressed these issues and attempted to establish whether or not online retailing has a lower carbon footprint. The analysis has focused on the purchase of small, non-food items.

An average home delivery round for such items has been determined using primary data from one of the UK's largest home delivery companies and discussions with senior logistics managers and, crucially, delivery van drivers on the job. The average length of delivery round, drops per round, failed delivery rates and the treatment of returned, unwanted goods have all been established. Typically, a van-based home delivery round consists of 120 drops on a 50-mile round. For ease of comparison, we assume that each drop on this average round comprises one item.

Obtaining readily available information on typical consumer shopping habits proved more difficult. Our analysis has relied mainly on Government statistics available at the national level. The National Travel Survey (NTS) monitors consumer travel behaviour on shopping trips for food and non-food products. According to the most recent NTS data, the average distances travelled for non-food purchases are longer than for food shopping trips, at 6.4 miles for car travel – car driver – and 4.4 miles for bus travel.[5] These distances are used to represent average shopping trips in our calculation. Key parameters in the analysis are shown in Table 1.

The emission factors for home delivery operations by diesel and petrol-fuelled vans were obtained from four statistical sources – Defra, National Atmospheric Emissions Inventory, Road Haulage Association and Freight Transport Association – and averaged. For typical car and bus journeys to the shops, average Defra emission factors, expressed as CO_2/km travelled, have been used.

A 50-mile delivery round by van produces 21,665g of CO_2. When this is divided equally among the 120 drops, each drop is responsible for 181g of CO_2; a standard return shopping trip by car of 12.8 miles, however, generates 4,274g of CO_2, 24 times more than the average home delivery drop. A vehicle excise duty Band A vehicle, such as a Seat Ibiza or Toyota iQ – 99g of CO_2/km – produces 12 times more CO_2 than a typical home delivery drop, and a mid-range Band G vehicle, such as a Ford Focus or Peugeot 308 Estate, 31 times more CO_2. Bus passengers fare slightly better. Typically, when the bus has an average loading of just over nine passengers, each one of those passenger journeys produces 1,265g of CO_2, seven times that of an average home delivery.

The average drop calculations can be further refined. While some deliveries to the home do only contain one item – some online retailers send items individually regardless of order size – it would be more realistic to increase the items per drop variable. For small items, such as books, CDs and DVDs with an average content of 1.4 items per drop, each item is responsible for 137g of CO_2. For clothes and household goods, we have assumed an average home delivery drop of 2.5 items, with each item being allocated 72g of CO_2.

These findings, based on average values and supposing successful first-time delivery and single-purpose conventional shopping trips, do appear to support the view that online shopping is better for the environment. However, before we can make such a claim with confidence, other, complicating factors need to be assessed.

Failed deliveries and the collection of unwanted goods returned by customers impair the efficiency of parcel carriers' operations. High street shoppers often combine shopping trips with other activities and may make more than one trip to the shops before purchasing goods either in-store or online. The allocation of energy consumption related to the home delivery or consumer shopping trip needs to be adjusted accordingly. We examine three conditions:

Key parameters in the analysis

Parameter (average values)	Characteristics
Average home delivery round	120 drops on a 50-mile round trip
Average drop	1 item standard comparison
	1.4 items per drop for small items – for example, books and DVDs
	2.5 items per drop for larger goods – for example, clothes
Average first-time failure rate	10%
	30%
	50%
Average second-time failure rate	50%
Average distance to local depot to collect missed delivery	15km
	25km
	40km
Average shopping trip by car	12.8 miles (20.6km)
Average shopping trip by bus	8.8 miles (14.2km)
Average trip to post office to return items	1.5 miles (2.4km)
Average shopping-related mileage as part of a combined trip	25%

Table 1

Buying items such as books on the web is better for the environment. Make the most of it at www.ciltuk.org.uk/webshop

1. Failed delivery. This generally occurs when no one is at home to receive the goods. We considered three different first-time failure rates: 10%, 30% and 50%. Emissions per drop were also calculated for the second, redelivery attempt. As the two delivery attempts are usually on consecutive days, we assume that 50% of redelivery attempts also fail and involve the customer having to travel to the local depot 15km, 25km or 40km away to collect the missed package.

With a 50% first-time delivery failure rate and a – theoretical – 100% second delivery success rate, each home delivery drop would be allocated 271g of CO_2. This rises to 316g when half the second deliveries also fail, or approximately three-quarters more CO_2 per drop than a successful first-time delivery. However, after two failed delivery attempts, the package is returned to a local depot for a customer to collect. As these depots are often located on the outskirts of urban centres, we assumed that a customer will combine collecting a parcel with another activity, with the trip to the depot representing approximately 50% the overall trip mileage.

A 25km round-trip by car to pick-up a missed parcel emits 5,188g of CO_2 or the equivalent of 16 redelivery attempts by delivery van; collecting the item by bus is the equivalent of 11 redelivery attempts – 3,574g of CO_2.

2. Product returns. Typically, between 25% and 30% of all non-food goods bought online are returned.[6] While an individual may return unwanted items to a depot, it is not encouraged; more usually a delivery van driver collects returned items as part of his or her usual delivery round, when very little additional returns mileage is generated, or a customer takes the unwanted goods to a high street store or post office for return. Figure 1 shows the carbon implications of the various

Conventional shopping trip: g/CO_2 per consumer trip/activity

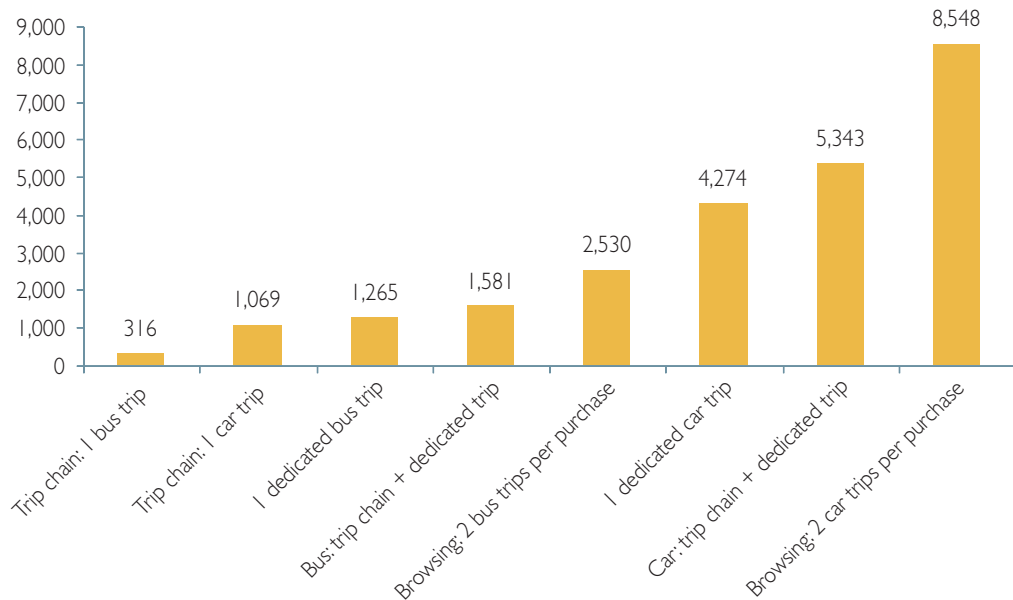| Activity	g/CO_2
Trip chain: 1 bus trip	316
Trip chain: 1 car trip	1,069
1 dedicated bus trip	1,265
Bus: trip chain + dedicated trip	1,581
Browsing: 2 bus trips per purchase	2,530
1 dedicated car trip	4,274
Car: trip chain + dedicated trip	5,343
Browsing: 2 car trips per purchase	8,548

Figure 1

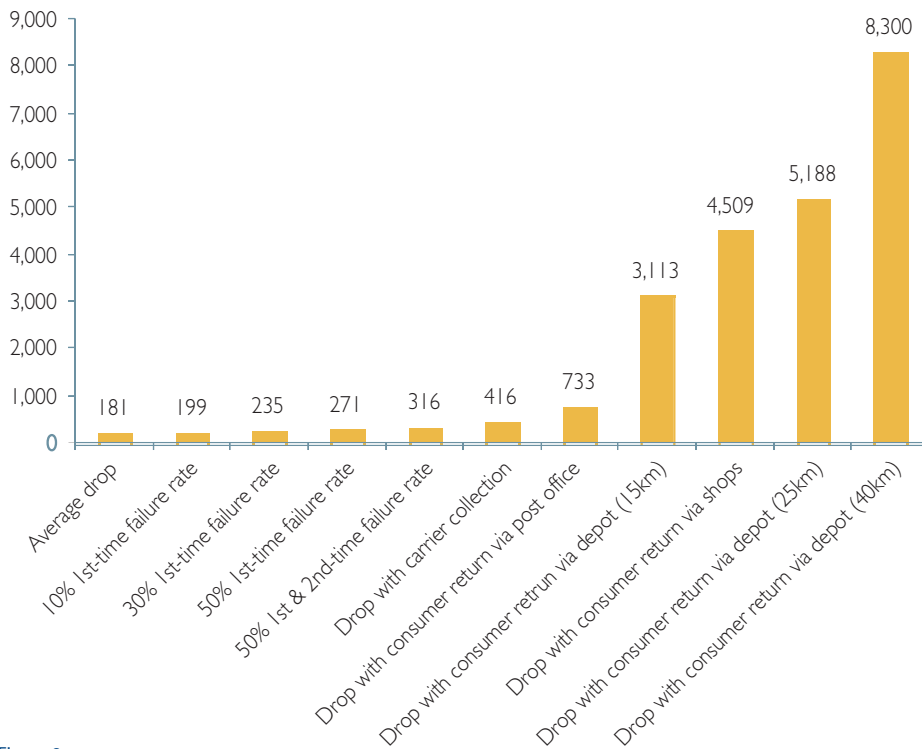Home delivery: g/CO_2 per drop/activity: assumes personal travel is undertaken by car

Figure 2

returns options. These range from 416g of CO_2 where the carrier collects the unwanted item on a subsequent delivery round to 4509g of CO_2 where the online shopper makes a separate car trip to return the item to a conventional shop. Again, where a home delivery has to be supplemented by personal car trip the amount of CO_2 emitted rises steeply.

3. Trip chaining and browsing trips. Shopping can be part of a wider combined trip and involve only a minor detour. We assume that where a shopper undertakes trip chaining, the shopping component of the trip makes up a quarter of the overall total mileage. An average combined car-based trip would then produce 1,069g of CO_2 of shopping-related emissions. While trip chaining helps to rationalise personal travel, making additional browsing trips prior to making a purchase has the opposite effect. This can effectively double or treble the carbon footprint of the shopping experience – see Figure 2.

Figures 1 and 2 show how the amount of CO_2 emitted by conventional and online purchases on the last link in the supply chain can vary enormously. This greatly complicates any comparison the transport-related CO_2 emissions associated with the two modes of shopping. Clearly, neither has an absolute environmental advantage. Some forms of conventional shopping behaviour emit less CO_2 than some home delivery operations. On balance, however, it appears that, in the case of small non-food items, the home delivery operation is likely to generate less CO_2 than a conventional trip to the shops. This environmental advantage can be reinforced in various ways if online retailers and their carriers alter some of their current operating practices.

The worst-case last mile scenarios for online retailing result from consumers at some stage in the process having to travel by car, mainly to collect undelivered products or return unwanted items. Unattended delivery

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options, such as the installation of a reception box at the home or the use of conveniently located collection points at post offices or public transport terminals, can greatly reduce the amount of supporting travel required and the associated CO_2 emissions. Rescheduling deliveries into the evening or weekends, narrowing delivery windows, keeping the consumer better informed and varying delivery rates by time of day can all help to make home delivery more CO_2 efficient, as well as improving the standard of service. The continuing growth of online retail sales is also likely to strengthen its environmental position, as it will tend to increase vehicle fill, raise delivery drop densities and thereby cut CO_2 emissions per package delivered.

Conclusion

This preliminary analysis suggests that online retailing can make a significant contribution to the development of a future low-carbon economy.

The vast majority of the CO_2 emissions associated with the last mile are generated by personal travel: either the consumer travelling to the shops to buy goods and/or return unwanted items or to a local depot to collect a missed delivery. While minimising these consumer-related emissions is the key to mitigating the overall environmental impact of shopping for either retail channel not all the onus is to be placed on the consumer.

There are a number of opportunities for parcel carriers to reduce the carbon footprint of home deliveries and to give themselves a clearer environmental advantage. Drop densities should be maximised and where possible the use of low-emissions delivery vehicles – for example, electric vehicles – encouraged. Equally, failed deliveries could be eliminated by the use of reception boxes at people's homes and separate, conveniently located collection points, possibly at shops passed as part of a daily routine journey. Over time, further efficiency measures could include the consolidation of orders to a particular address in a single delivery, thereby cutting vehicle-km and the promotion of off-peak/out-of-hours deliveries through variable delivery pricing, thus allowing delivery vans to run more of their mileage at fuel-efficient speeds.

Such measures would result in the delivery of environmental benefits to consumers.

Taking the bus can offset the carbon emissions of your journey, but is still unlikely to be greener than online shopping

About the author

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Further information

For more information about home delivery, why not join our Postal Services or The Last 50 Metres Forums? See our web site **www.ciltuk.org.uk** for more details.