Transport Reviews
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ttrv20

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Sharon Cullinane [a]

[a] School of Management and Languages, Heriot--Watt University, Edinburgh, UK

Available online: 21 Oct 2009

To cite this article: Sharon Cullinane (2009): From Bricks to Clicks: The Impact of Online Retailing on Transport and the Environment, Transport Reviews, 29:6, 759-776

To link to this article: http://dx.doi.org/10.1080/01441640902796364

Transport Reviews, Vol. 29, No. 6, 759–776, November 2009

From Bricks to Clicks: The Impact of Online Retailing on Transport and the Environment

SHARON CULLINANE

School of Management and Languages, Heriot-Watt University, Edinburgh, UK

(Received 6 December 2007; revised 20 January 2009; accepted 2 February 2009)

ABSTRACT *Online retailing is growing fast and claims are being made about its positive environmental impact relative to traditional shopping, particularly by the retailers themselves. There is, however, little concrete evidence to support the claims. Whilst there exists some research into the passenger travel implications of e-shopping, this paper seeks to analyse the issues involved in online shopping from both a passenger and freight transport perspective. The objectives of the paper are first, to set out the complex transport relationships involved in online shopping and in particular the interaction between the passenger and freight aspects and second, to shed some light on the environmental impact of online shopping. It concludes that as things currently stand, it cannot be stated with any degree of certainty that clicks are any more environmentally responsible than bricks. The paper is conceptual in nature and is the pre-cursor to an empirical study of the issue.*

Introduction

Various forecasts have been made over the years of the impact of improving information and communications technology (ICT) on travel demand. There has been (and still is), for instance, a great deal of interest in the area of telecommuting and its likely impact on travel and the environment. The subject of telecommuting has raised considerable debate about the need for travel and human behaviour in relation to it. As the wider, more indirect issues relating to telecommuting are discovered, the debate still continues as to its net impact on travel. Home shopping in general, and internet shopping in particular, presents additional complexities since not only do we need to consider consumers and their travel behaviour, but we must also consider the freight dimension in terms of the deliveries of goods ordered to homes. Much of the previous research into online retailing has focussed either on the consumer side or on the freight side of the last mile issue (an exception is the paper by Visser and Lanzendorf, 2004). This (conceptual) paper seeks to combine the two. It does not aim to determine a precise answer as to the impact of online retailing (sometimes

Correspondence Address: Sharon Cullinane, Senior Lecturer in Logistics, Logistics Research Centre, School of Management and Languages, Heriot-Watt University, Edinburgh EH14 4AS, Scotland, UK. Email: s.l.cullinane@hw.ac.uk

0144-1647 print/1464-5327 online/09/060759-18

DOI: 10.1080/01441640902796364

referred to as e-tailing) on the environment, but seeks to set out the complexity of the issues as a pre-cursor to a future empirical study. The literature review concentrates principally (but not exclusively) on publications since 2001 since evidence pre-2001 is thoroughly reviewed in Browne *et al*. (2001), the OECD/ECMT (2001) and the Retail Logistics Task Force (Chaired by Prof Alan McKinnon, 2001) as well as in the ROSETTA (www.trg.soton.ac.uk/rosetta) and STELLA European projects (www.stellaproject.org).

In common with most research dealing with environmental impacts, one of the difficulties is deciding where to set the boundaries of the research. This paper confines itself to the impacts from the shop to the consumer and does not take into consideration possible impacts arising from changes in either the retail structure itself or the supply chain configuration. Such changes could include the closure of shops, relocation of distribution centres, the building of purpose-built e-fulfilment centres, changes in picking and packing processes, in the sourcing of products, in inventory levels as well as in the number of stock-keeping units held. These are substantial and important changes which would require a separate paper to analyse and are, therefore, beyond the scope of this paper.

The Consumer Travel Dimension

Background

Shopping generates a great deal of travel. In GB, the average person aged 16+ makes 219 shopping trips[1] a year, accounting for 21% of total trips made per year (DfT, 2006). Of the 219 trips, 42% are made as car drivers and 21% as car passenger. In terms of mileage, an average person aged 16+ travels 926 miles per year on shopping trips, 82% of which is done in a car. Over the last ten years, the average number of shopping trips per person has dropped by 13%, but the average length of trip has increased by 10% as some people have changed from making frequent trips to local shops in favour of less frequent trips to edge-of-town or out-of-town centres. Overall shopping mileage has increased by 22% since the 1993/95 National Travel Survey (DfT, 1996, 2006).

The environmental impact of these trips is considerable. Defra (2007) has calculated that cars produce 54% of the CO_2 emissions of transport, which itself accounts for 28% of the domestic emissions of CO_2 by source.[2] Defra calculates that each medium-sized petrol car emits 216 grams of CO_2 per kilometre (or 348g per mile). Since vehicle miles travelled (VMT) is the main aggregate variable determining transport's carbon footprint, methods to reduce car use are constantly being sought. One potential candidate for this is online shopping.

Online Shopping

Home shopping has been happening for decades and is not confined to online shopping. In 2007, orders taken in store still account for just over 50% of the home-shopping market and this mode of shopping is particularly prevalent in the electrical goods sector (Verdict, 2007). Other home-shopping channels include television shopping, catalogue or mail-order shopping, telephone ordering and door-sales shopping. According to Verdict (2007) *online* retail spending in the UK in 2006 only accounted for 25% of the home-shopping spend. What is important, however, is that the £10.9 billion spent online, represented an increase of 33.4% over the previous year (compared to an average increase in home-shopping of 7.2%).

Online retail spending is one element of a larger e-commerce sector. In 2005, total internet sales to households amounted to £21.4 billion (ONS, 2005). This includes all internet sales including financial and other intangible goods. The £10.9 billion of internet *retail* sales represents approximately 4% of total retail sales and is roughly the same proportion as in the USA where e-tail sales amounted to $104 billion in 2006 (an increase of 18% over the 2005 figures) (Plunkett Research, 2007). Although this paper concentrates on consumers, it is interesting to note that B2B (business-to-business) online sales are nearly five times higher in the UK than B2C (business to consumer) sales; for every £100 of goods sold online in the UK, £21 represented B2C sales, the remainder being B2B sales. Proportionately, B2B online sales are also rising at a faster rate than B2C (ONS, 2005).

E-tailing is obviously dependent on household internet access. Across Europe (EU 27), household access to broadband internet has increased substantially from 14% in 2004 to 42% in 2007. Household access ranges from 7% in Greece to 74% in the Netherlands (Eurostat, 2008). In 2007, 61% of households in the UK had internet access and 84% of those had broadband (ONS, 2007). As Cairns *et al*. (2004) point out, household access to the internet is not necessarily a limiting factor as many people have access to it at work.

In 2006, just under half of all men and women used the internet to buy physical goods, but one in six did not use the internet at all. Of those aged 65+ only one in four has access to the internet and one in seven has bought online (Mintel, 2007). However, silver surfer clubs are encouraging older people to use the internet and in 2005, online spending by the 55+ age group rose by 47% to £458 million (RAC Foundation, 2006). The RAC Foundation survey of 1000 people found that of those who use the internet, the main reasons for doing so were: to search for a better price (75%), to save the hassle of getting out the car or catching a bus (75%), to save time (73%), to have a better choice (62%) and to save the cost of getting to the shops (51%).

In the UK, between January and April 2006, 42% of adults aged 16+ had purchased something online in the previous 12 months (ONS, 2007). The type of purchase made is shown in Table 1.

Table 1. Category of goods purchased on the internet

Category of good	% of respondents
Travel, accommodation or holidays	51
Films, videos or DVDs	42
Music or CDs	41
Clothes or sports goods	37
Books, magazines, e-learning, training material	37
Tickets for events	35
Computer software	29
Electronic equipment	25
Household goods	24
Computer hardware	22
Insurance	21
Food or groceries	20

Source: ONS (2007)

Home-delivered products can be divided into physical goods (i.e. those that require to be physically distributed to households) and digitally delivered goods (which are delivered down the wire) (Fernie and McKinnon, 2004). The most frequently purchased products are the digitally delivered ones (travel, music, etc.), whereas the physical goods are less frequently purchased online (ONS, 2007). The difference is a very important one as far as distribution is concerned in that there are usually no marginal freight trips generated by digitally delivered goods, whereas the physical goods require at least one freight trip to be delivered to the customer. In cases where goods are sent by post, there may be no marginal freight trips generated (except that if the volume of post increases greatly, at some stage additional post vans may be required). In terms of passenger trips, it makes less difference whether the goods concerned are digital or physical as it is possible that the purchase of a theatre ticket online could substitute for a physical journey to buy it at a box office in the same way as the purchase of a book online could substitute for a trip to the shops to buy it.

Mintel (2007) divides the e-tailing industry into five major sectors; catalogue and TV shopping companies (which have obviously changed their mode of retail to include online ordering) account for 29% of the market, non-food-based retailers 21%, grocery-store-based retailers 21%, offshore companies (i.e. companies based outside the UK) 16% and pure players (i.e. those who retail only online and have no physical store presence, such as Amazon) 13%. The largest online retailer in the UK is Tesco which reported online sales of nearly £1 billion in 2006, with Argos coming in second, with online sales of £183 million (Mintel, 2007). Online grocery sales are still rising fast in the UK and are forecast to increase from £2.4 billion in 2007 to £5 billion by 2012 (the Grocer, 13 October 2007). However, despite all the hype it receives, online grocery sales only account for 2% of the UK grocery market. It is interesting to note that in 2001, Browne *et al*. mentioned that forecasts for online grocery sales were that they would increase from £530 million in 2000 to £4.96 billion by 2005. Clearly this has not been achieved. In the USA, online retailing has in fact reported a downturn as people return to the high street (Daily Mail, 18 June 2007). This does not seem to be a pattern replicated in the UK, however, as the Interactive Media in Retail Group (IMRG) reported in October 2007 that growth in internet shopping in the nine months to September 2007 was 51.8% higher than for the same period the previous year (IMRG, 2007).

Consumer Shopping Behaviour

In order to gauge the importance and impact of online shopping, we need to have some understanding of consumer shopping behaviour in general. There is a large academic literature on this (see, e.g. Engel *et al*., 1995; Dubois, 2000; Solomon *et al*., 2002) which space does not allow us to pursue. We do need, however, to know something about consumer spending patterns. Table 2 shows the purchase profile of shoppers from a large survey by the CfIT of shopping trips (based on 22,885 responses).

Food and non-alcoholic drinks were the most frequently purchased goods, with publications and stationery (probably frequently amounting to a newspaper), second. It is interesting that the third most purchased type of good was 'nothing' (16% of cases). There are many possible reasons for this latter figure, including the desired products being out of stock, browsing activity, people shopping for social reasons and people accompanying others who are making a purchase.

Table 2. Type of Goods purchased on shopping trips

Type of goods purchased	% of cases
Food and non-alcoholic drinks	46
Publications and stationery	22
Nothing	16
Household goods	15
Alcohol and beverages	10
Clothing and footwear	10
Recreation and culture	8
Personal care	7
Restaurants and hotels	6
Medical goods	4
Personal effects	4
Transport related goods	3
Financial services	3
Other	2
Energy products and utilities	1
Returning unwanted goods	1
Housing	1

Source: CfIT (2006)

Table 3 shows how much was spent during the average shopping trip. It illustrates that average spend per trip to the shops is actually very low in many cases; less than £10 in 43% of cases. This might again support the notion of the social nature of shopping trips, but could also reflect the influence of any of the factors mentioned above.

Unfortunately, we know very little about how many products were bought on the same trip and in what combinations. This information might help us to determine the similarities and differences between physical and online shopping behaviours and the impact of online shopping on travel.

The extent of the take-up of online shopping depends greatly on consumer attitudes towards it. The shopping experience has changed a great deal over the past century, responding to consumer pressures and the technological capabilities of the retailers themselves. Parking constraints in town and city centres have

Table 3. Total spend per trip

Cost of goods purchased	% of cases
Up to £4.99	27
£5.00–£9.99	16
£10.00–£19.99	19
£20.00–£29.99	11
£30.00–£39.99	7
£40.00–£49.99	5
£50.00–£99.99	10
£100.00–£199.99	4
£200.00–£299.99	1
£300+	<1

Source: CfIT (2006)

increased the popularity of edge-of-town and out-of-town shopping. However, retailers have adapted and shopping has become more of a social experience. It has always been common for department stores to have their own cafes, but now this extends to book shops, clothes shops and others. In many ways, conventional shops are becoming more like showrooms where people browse and maybe order online later once they have inspected the goods physically.

The British Council of Shopping Centres (BCSC) conducts continuous research into consumer shopping behaviour. In a recent publication (BCSC, 2006, p. 8) aimed at their members, they state that owners and developers must "understand that shoppers are faced with a myriad of shopping opportunities, and they have to give them a reason to keep going to the shops rather than shopping online". The main way of achieving this, they state, is to put real emphasis on customer service in-store. A survey carried out for Accenture (Hoffman and Lowitt, 2007) of consumers in the USA showed that consumers were actually very dissatisfied with the service they received in stores. They state (p. 2) that "consumers continue to experience service annoyances and are responding by not making desired purchases, creating a revenue leak in retailers' business models". The main sources of these 'service annoyances' were 'too little attention' and 'too much attention'. Poor in-store service is likely to encourage more online shopping.

In the RAC Foundation (2006) survey, when asked to respond to the statement "In the future people will buy most things online and shops will just become showrooms for browsing", 50% disagreed and 39% agreed (with 9% neither agreeing nor disagreeing). The survey also found that nearly two thirds of 17- to 24-year olds enjoyed shopping as a leisure pursuit. However, there is also anecdotal evidence that young people regard shopping online as a leisure pursuit and do it with friends in a social way.

Cushman and Wakefield (2000) suggest that the retail transition from bricks to clicks will be as shown in Table 4. Rather than accessing products at the local store, purchases will be made online from specialist shops all over the world, at any time of the day from retailers that have a proven record of secure, on-time delivery. The physical store will become a showcase for products bought subsequently online, where people can feel and touch the products and find out any additional information required.

The main thrust of the difference between the traditional and the new mixed medium shopping formats, concerns the fragmentation of the shopping process. Social commentators suggest that we will be buying goods at any time of the day, including when we are at work. This might also include when we are using public

Table 4. The retail transition from bricks to clicks

From	To
Location	Access/popularity
Generalists	Specialists
Times when we do	Moments when we might
Store as a warehouse	Store as a showroom/theatre
Store as a transaction point	Store as an information point
Retailer power	Consumer/broker/distributor power
Convenience	Relationship and trust
Value for money	Value for time coupled with value for money

Source: Cushman and Wakefield (2000)

transport, waiting at airports and even climbing up mountains! The Blackberry and other such hand-held communication devices enable people to order goods online from any location where there is a network signal. Retailers are improving and simplifying their ordering formats in order to facilitate this move, although sales through this medium are likely to be quite low.

Online shopping and in-store shopping are not direct substitutes. They offer different experiences and the general consensus of opinion appears to be that most people will not buy exclusively from either mode but will combine the two formats. According to Mokhtarian (2004), the difference between in-store shopping and online shopping is as shown in Table 5.

We have already seen (Table 1) how there is a difference in the extent of online use according to the product being purchased. The same is the case with the type of person doing the shopping. The BCSC (2006) divides consumers into five groups with respect to their inclination to shop online. These are:

(1) *Net sceptic store shoppers*—the largest group and the least likely to shop online. These are not even likely to browse online.
(2) *Multi-channel shoppers*—like to shop around different channels. They may browse in shops and then buy online.
(3) *Net browsers store shoppers*—research goods online but like to see and feel the goods they are buying, so buy in shops.
(4) *e-shoppers*—see shopping as a chore and shop as much as possible online.
(5) *Internet café contenders*—not likely to shop online but might do if there were internet facilities in shopping centres.

In a similar vein, Couclelis (2001) divided the act of shopping into three phases; before purchase, the purchase itself and after purchase, for each of which there are two mode possibilities; local (i.e. physical) and remote (i.e. online). Based on these she divides people into particular kinds of shopper: the traditional shopper (local/local/local), the cybernaut (remote/remote/remote), the good citizen (remote/local/remote) and the free rider (local/remote/local). There also appears to be a gender issue too. Men are more likely to want to shop online than women (RAC Foundation, 2006).

The direct net impact on the environment, at least on the passenger transport level, will depend how many people fall into each of the above categories and how this changes in the future. The RAC Foundation (2006) suggests that for many goods bought online, almost 80% of purchasers will still travel to the shops

Table 5. The differences between e-shopping and store shopping

E-shopping	Store shopping
Large choice	Sensory information (touch and see)
Lower prices/search costs	Tangibility (familiarity with store)
Information easily accessible	Immediate possession (take goods away)
Personalisation to customer	Social interaction (meeting in store)
Convenience (not having to go out in rain, can be done at any time)	Entertainment (having coffee in bookstore)
Speed	Movement (people just want to get out)
	Trip chaining (linking shopping with other activities)

Source: Mokhtarian (2004)

to browse and compare. Some shoppers will buy online but collect from store (i.e. click and collect).What is clear is that the picture is not simple. If people browse online and shop in-store, some journeys may be saved, but if they browse in-store and shop online, then it is likely that additional mileage will be incurred (by the distribution company). However, in the latter case, if people have no intention of buying in-store when they have made the decision to purchase something, they may be more inclined to use public transport since they will not be carrying their purchases home. The CfIT (2006) found that the need to carry shopping is a significant influence in modal choice between private and public transport.

There are parallels between the online shopping debate (sometimes called teleshopping) and the telecommuting debate. It is to this that we now turn to see how far these parallels go.

Telecommuting and Its Relationship to Online Shopping

Online shopping is not the first telecommunications-enabled influence on travel. The widespread adoption of the telephone was predicted to have an impact on travel behaviour (Pool, 1983) as was teleworking. The notion of teleworking, or telecommuting, has parallels to the online shopping debate, as in its early days, it was viewed as being totally positive in its impact on travel (i.e. telecommuting would reduce travel). It has subsequently transpired that this simple relationship does not necessarily hold.

There is now a substantial literature on telecommuting and its impact on personal travel (for reviews, see, for instance, Hensher and Golob, 2000; Golob and Regan, 2001; Mokhtarian and Salomon, 2002; Zhang *et al*., 2005). Individual studies have their own specific objectives, but the overall theme of the literature is to determine to what extent the relationship is substitutional or complementary. Substitution refers to the extent to which ICT replaces physical travel, whereas complementarity refers to the extent to which use of ICT is *in addition to* physical travel. Hjorthol (2002, p. 438) refines this binary division slightly by suggesting that there are four ways in which new technology can interact with old:

(1) *Substitution or replacement*—when new technology replaces old transport (travel purpose) without any effects on the travel patterns of the individual or members of the household
(2) *Modification*—when new technology is used to conduct or change planned activities, which is likely to reduce travel
(3) *Generation*—when new technology gives new information, new acquaintances and new possibilities which induce more travel
(4) *Addition*—when new technology comes in addition to old and there is no specific relationship between them

In assessing the carbon footprint of e-tailing, it is the net effect of substitution/complementarity (i.e. after taking into account all the modification, generation, additional and substitutional effects) that we are interested in determining as it is this that determines the overall environmental impact.

Most studies of the *direct* impact of *telecommuting* on travel suggest that there *is* a net benefit but that the benefits are tempered by elements of complementarity. For instance, telecommuters may use their cars for shorter trips associated with

activities other than work on the days they are telecommuting, or the car that was previously used for commuting by one family member may be used by another family member for a different purpose. Complementarity effects are not always predictable. For instance, a study by Balepur *et al*. (1998) on the telecentres project in California found that although person and VMT decreased as a result of the telecentres, because people were not driving so far to work, they were coming home for lunch and carrying out other activities by car.

A thorough review of the telecommuting literature undertaken by Cairns *et al*. (2004) for the UK Department for Transport came to the conclusion that although much of the US literature on teleworking and telecommuting suggested that the complementarity effects either balanced or outweighed the substitutional effects, most of this literature was 'based on speculation rather than empirical evidence'. They go on to review a host of empirical studies, nearly all of which illustrate that although complementary car use reduced the overall impact of teleworking, total VMT reduced as a result of teleworking. Indeed, they found some evidence (from a study by Pendyala *et al*., 1991) that teleworkers chose to travel to non-work activities that were closer to home, exhibiting 'contracted action spaces'. A very similar conclusion was reached following a review of the literature for the DLTR (2002).

Not all research has reinforced the link between telecommuting and reductions in travel. Hjorthol's (2002) study of telecommuting in Norway concluded that "stationary communication seems to be a supplement to activities based on mobile technology but it gives people more spatial and temporal options" (p. 451). The stationary communication referred to here by Hjorthol is the computer and the mobile technology is the car. This study found that VMT actually increased as a result of telecommuting.

As stated above, much of the telecommuting literature is confined to determining the extent of substitution versus complementarity. In terms of the environmental impact, however, although number of VMT is probably the key overall variable, there are also important issues about the type of miles being driven. This has been the subject of a great deal of Mokhtarian's work in relation to telecommuting. In a paper by Koenig *et al*. (1996), the authors set out to model the environmental impact of telecommuting, but not simply by using the traditional variables such as VMT or number of trips because as they state:

> These traditional measures only partially explain vehicle emissions. The vehicle emission process is very complex involving the interaction of numerous other factors including: the vehicle types and pollution control technologies in the fleet; how the vehicles are operated (speeds, acceleration/deceleration etc.) other travel related indicators (such as number of cold and hot engine starts); and environmental conditions (including season and ambient temperature). (p. 14)

One of the benefits of telecommuting is that the number of cold starts is reduced since, although the car is still used during the day for other reasons, it is not necessarily being used first thing in the morning when starting the car creates the most emissions. Koenig *et al*. (1996) also found that telecommuting meant less freeway driving but more driving on small, residential roads, which is disproportionately more environmentally damaging.

Koenig *et al*. (1996, p. 18) state that air quality may be affected in three different ways as a result of telecommuting:

- *Direct transportation impacts* are the first order effects on travel patterns
- *Indirect transportation impacts* including changes in household travel, weekend travel and residential relocation
- *Indirect non-transportation impacts* from energy consumption changes elsewhere (e.g. if telecommuting takes place, heating in residential houses may increase)

Having briefly reviewed the debate on telecommuting and travel, we now return to online shopping and the question of whether it will ultimately be beneficial or detrimental to the environment. Many of the issues raised above concerning telecommuting are equally valid in relation to online shopping. It is important to determine to what extent the online shopping is substitutional and to what extent it is complementary and also to consider the direct and indirect effects. James and Hopkinson (2001) aptly describe the dichotomy as being between 'quieter roads and fuller baskets' as people stay at home and interact more with the local community, or 'e-road rage' where home shopping increases delivery van movements and people use their cars for other purposes instead.

In an early paper on the effect of electronic home shopping on travel, Gould and Golob (1997) investigated the complex relationship between e-shopping and personal travel. They carried out a multi-diary activity and travel survey in the Portland Metropolitan area of the USA. They concluded that the elimination of some shopping trips would probably lead to an increase in trips for other reasons, particularly in the case of women, where there was a latent demand for 'maintenance trips', e.g. eating meals, medical care, picking up or dropping off of passengers, taking care of household or personal obligations. They also investigated the relationship between teleworkers and their shopping habits. They considered the idea, for instance, that teleworkers may be less likely to shop online, since they may shop more locally. Additionally, they postulated that since many shopping trips are part of a trip-chain linked to the daily commute, teleworkers shopping-related VMT could be higher than conventional workers.

Cairns (2005) suggests that another complementarity effect of online shopping is that consumers who would previously have walked or cycled to the shops may choose to have home deliveries, thereby increasing the total VMT. Research in the Netherlands (Transport en Logistiek Nederland, 2000, quoted in Retail Logistics Task Force, 2001) supports this notion. They calculated that if 11.5% of total sales are purchased online and delivered to the home by 2005, there would be a 17% increase in VMT because of the substitution of walking and cycling trips by motorized deliveries. Cairns also suggests, however, that if online shopping became the norm, it might actually encourage some people to give up their cars altogether. A contrary view put forward by Visser and Lanzendorf (2004) is that the growth in online shopping may cause shops in more remote areas to close down, forcing people without cars in these areas to buy one, thereby increasing vehicle mileage.

One of the complexities suggested by Gould and Golob (1997) is that online shopping allows the shopper to expand their horizons in terms of their shopping location. For instance, if a person is looking for a specific item, rather than confining their search to the local town, they may search online and find it cheaper further afield and travel to purchase it. This notion is supported by Ferrell (2004)

who analysed data from an activity diary survey of residents in the San Francisco Bay area and found that "teleshopping households engage in more shopping trips, travel longer distances for shopping and chain more of their shopping trips" (p. 241) and that the benefits of the trip chaining "are being overwhelmed by the complementary effects of home shopping on shop travel" (p. 241). In contrast, Cairns *et al*. (2004, p. 316) after reviewing the small number of empirical studies on the complementarity effects of teleshopping, come to the conclusion that whilst it may generate some offsetting travel, teleshopping "is likely to reduce personal car use".

Mokhtarian (2004) sets out a conceptual analysis of the impact of online shopping on travel based on a more aggregate economic consideration of some of the indirect effects. On the personal travel side, she states that many shopping trips are made as part of a trip chain and the amount of travel reduced by ordering online is actually quite low. Browne *et al*. (2001, p. 44) suggest that grocery shopping "is typically carried out as a dedicated car trip, so home shopping and delivery in the grocery sector does often lead to the removal of an entire shopping trip". There appears to be little hard evidence for this assertion, however, and further research is required to validate it. There is still also the question of the second round effects concerning alternative uses of the car if it is not being used for shopping.

On the freight side, amongst other things, Mokhtarian addresses the possibility that because goods are cheaper online, more will be demanded and this in turn will increase the number of deliveries made. Additionally, online ordering increases the potential for goods to travel further as they can be ordered from anywhere in the world. She also looks at the changing demographics to assess likely influences on aggregate demand and therefore freight movements. Overall she comes to the conclusion that:

> The combined outcome of all factors does not appear to support any hope that e-shopping will reduce travel on net; to the contrary there may be negative impacts due to increased travel, even if those impacts are likely to be localised and/or small in magnitude for the most part (Mokhtarian, 2004, p. 257).

Similar arguments are raised by Hesse (2002, p. 229) who argues that e-tailing is just another step in the development of logistics structures which will not impinge on cultural mores. He suggests that shopping is a cultural experience and that "new technologies are deeply embedded in culture and in social practices, in daily routines and habits that are far from being rapidly changed by new order-and-delivery services". On the freight side, he argues that e-tailing will result in a greater propensity to use air transport (environmentally more damaging) because of both the time sensitive nature of e-tailing and the ability to order and source goods from further afield. He also argues that huge e-fulfilment and consolidation centres will need to be built (and that they will not replace the traditional warehouse, but will be in addition to them), often on greenfield sites, to cope with the distribution of products bought online.

A further, longer term impact of e-shopping is that on residential location. There is some evidence that telecommuting increases the distance from work that people are prepared to live (Pendyala *et al*., 1991; Hjorthol, 2002; White *et al*., 2007). If, on top of telecommuting, you can also shop online and have goods

delivered to your door, this might reinforce the decision to live in a more remote location. Shen (2000) modelled the impact of new telecommunications in general on residential location and found that "as the level of substitution of telecommunications for transportation increases substantially, the residential location flexibility of those households that have technological capabilities is significantly enhanced" (p. 1458). This would mean that the number of trips made might reduce, but their length would increase, perhaps substantially. Ironically, Shen suggested that it was the non-IT-enabled trips that reduced the possibility for locational flexibility (e.g. members of the household that relied on public transport to carry out activities). With shopping becoming an IT-enabled activity, according to Shen's logic, a substantial increase in locational flexibility might result.

Turning to the type of trip that is replaced by online shopping, in the UK, the majority (63%) of shopping trips by car take place between 1000 hours and 1600 hours, outside of the peak congestion time (ONS, 2007). The issue of cold starts, therefore, is less relevant. Furthermore, the marginal environmental benefit in reducing a shopping trip should be less than that of reducing a commuting trip because the shopping trip is less likely to take place in congested conditions. On the other hand, shopping trips are more likely to take place on smaller roads rather than on main roads, and this results in a marginal increase in environmental cost over the same length commuting trip.

So to what extent is online shopping a substitute for physical travel? The RAC Foundation (2006) found that 80% of online purchases still resulted in a physical journey. As Mokhtarian (2004, p. 6) puts it: in e-shopping "products are detached from the physical cues afforded by a bricks-and-mortar store". Consumers therefore are likely to browse before purchasing online. Returning to the discussion on shoppers behaviour, people are social beings. In the case of telecommuting, although telecommuters reduce their VMT on the commuting trip, they tend to use their car for other things during the telecommuting day. Mokhtarian (2004, p. 9) suggests that "It is likely that a number of shopping trips are 'invented' in order to justify (often subconsciously) an urge simply to get out and go somewhere".

The Freight Dimension: The Last Mile

The freight dimension of online shopping is also a complex issue. Cairns (2005) models the impact of home deliveries of groceries specifically on traffic and suggests that online grocery deliveries could reduce vehicle km by at least 70%. Although she briefly considers some of the indirect affects in her discussion of the validity of her and others' models, she still concludes that there will be a substantial reduction in traffic. She suggests that the grocery market is somewhat unique, however, in that it is "typically a trip least valued in its own right" (p. 53) and is highly car dependent because of the need to carry things. The implication is that there is less likelihood of complementarity in this sector than others.

Many retailers are making claims about the greenness of this method of distribution. Jonathan Faiman, co-founder of Ocado, the online supermarket which works in partnership with Waitrose, claimed for instance that "each Ocado van replaces up to 20 cars on the road which overall can result in huge savings of unnecessary car journeys" (Guardian, 2007, p. 9). The environmental section of the Tesco website (Tesco, 2008, www.tesco.com/greenerliving) boasts that each delivery van saves 6000 car journeys per year. The validity of these claims (and

the environmental benefits associated with them) are, however, questionable on several grounds and it is to these that we now turn.

Vans vs Cars

Online shopping is usually delivered to consumers in diesel vans.[3] Vehicle for vehicle, a van is more environmentally polluting than a car. Vans delivering goods ordered online are in most cases a total addition to the vehicle stock in the UK. In some cases they are replacing HGVs, but in the majority of cases they are performing a function that was previously not performed by a goods vehicle. Although not entirely a result of online shopping, the number of vans in the UK has increased substantially over the past ten years and there are now five times as many vans in GB as HGVs. They consume 25% of the total diesel and 3% of the total petrol used by all motorized vehicles in GB (Browne *et al*., 2007). According to Defra (2007), vans account for 13% of the CO_2 emissions of transport in the UK. Of course, not all of the vans on the road are used for home deliveries; the DfT (2004) calculates that freight transport only accounts for approximately 1/3 of van kilometres. McKinnon (2007) has pointed out, however, that a problem with GB van statistics is determining the number that are used for freight deliveries at all.

Delivery vans, by their very nature, are also continuously stop-starting. This type of vehicle operation is bad for the environment (although this type of operation with a high drop-density is better environmentally than the situation where each retail company makes its own deliveries, often with lower drop-densities). Additionally, they often have to park at the side of the road causing traffic obstruction and slowing the free-flow of traffic (adding further to the environmental problems).

Fragmentation of the Shopping Activity

The notion of fragmentation of the shopping activity and product flow which results from online shopping has been discussed above. This in itself causes its own problems. Cairns (2005) argues that for grocery shopping, in many cases, the online shop is likely to be a direct replacement for a physical shop. Even if this were to be the case, for the non-grocery shop the situation could be very different. Rather than one trip to the shops to buy a selection of things (e.g. clothes from several different shops, plus a few household goods), if bought online, each of these things would be ordered at a different time of the day, but more importantly, from a different company, sometimes requiring separate delivery (depending on the extent of load consolidation). If this is the case, the number of freight trips generated could be huge and although delivery companies obviously combine deliveries for many different people in one van, there is likely to be an overall increase in VMT by van.

'Not at Home' or Unattended Deliveries

One of the problems with online shopping is that, for non-letterbox size products, the customer often needs to be at home to receive the goods bought. For whatever reason, this is not always possible. The IMRG reckons that 11% of deliveries fail on first attempt and 2% fail altogether. McKinnon and Tallam (2003) found that in

cases where parcel carriers refuse to leave consignments unsecured, the level of failed deliveries exceeds 20%. The DTi (2001) suggests that in cases where no delivery time has been specified in advance, the failure to deliver rate is around 60%. The higher the number of failed deliveries, the greater the VMT by vans and the greater the pollution caused. McLeod *et al*. (2006) point out that failed deliveries also lead to increased car journeys as customers eventually need to pick up their deliveries from the carrier's depot (quite often located in an edge-of-town location, inaccessible by public transport).

Over-orders

There is also some evidence that when purchasing online, people actually over-order knowing that they will send some of it back. For instance, because it is impossible to try on clothes bought online, consumers may buy several sizes and even several colours and send back what they do not like. Fernie and McKinnon (2004) state that around 25% of goods purchased online are returned. Nairn (2003) suggests that this increases to 30% of non-food products, compared to 6–10% in the case of physical shops. Returns also add to the number of van trips made, although the overall impact on VMT depends on the returns policy of the company (some companies require customers to return goods through the postal service or through local agents) and the extent to which returns can be integrated with existing trips.

Delivery Windows

The customer requires as narrow a delivery slot as possible, preferably an hour, so that they are not waiting around for a delivery. For the distribution company, however, the wider the delivery window, the lower the cost of delivery. Nockold (2001) modelled the impact on transport costs of varying the window delivery width in the London area. He found that a reduction in the window width from 3 hours to 1.5 hours resulted in a cost increase of 17–24% and elimination of windows altogether resulted in savings of between 27% and 37%. In terms of the environment, wider windows also equate to reduced costs per delivery. Ocado customers can choose a green van delivery display when they are buying online which means that they can take advantage of a van already allocated to their area.

The Future

It must be recognized that online shopping is in its infancy and to date, the logistical systems developed to deal with it have often adapted on a piecemeal basis. Some have reached a high level of sophistication using routeing and scheduling software and picking and packing processes to minimize distance travelled and maximize drop-density. Dedicated home-delivery companies, consolidating products from a number of online retailers, have also emerged. However, anomalies still exist. Customers ordering multiple products from a single online retailer may not necessarily receive all their items in one delivery because of the picking system used. This can result in trip duplication (as well as customer dissatisfaction). In the future, aspects of online shopping could change significantly. Most of the major grocery retailers are experimenting with less environmentally damaging vans, such as electrically powered vans, vans powered by biofuels and others.

By 2010, it looks from the websites of the large grocery companies, like at least nearly all urban grocery deliveries will made in such vehicles. This obviates some of the problems alluded to above, but does not address all the issues (and there is still the issue of the upstream environmental effects of the power generation to be dealt with).

Research has been ongoing into the 'not at home' or unattended delivery issue, with solutions such as secure lockers, local drop-off and collection points and community delivery points all being considered (see Punakivi *et al*., 2001; McKinnon and Tallam, 2003; Fernie and McKinnon, 2004). The research centres around finding a solution which balances security (of products delivered and of the premises to which they are delivered), cost (of providing the solution) and practicality for both the customer and the carrier. Home-based reception boxes have been tried in several places but most experiments have been curtailed due to a combination of costs being too high and usage being too low (McKinnon and Tallam, 2003). In Helsinki, Punakivi and Tanskanen (2002) carried out research on shared reception boxes (which can be placed at petrol stations, tobacconists or elsewhere) and found that transport costs were 55–66% lower than with unattended delivery and two-hour delivery windows. However, the idea was not operationalized.

Unattended delivery possibilities would eliminate the return journeys problem outlined in points 4.3 and, to a certain extent, the problem alluded to in 4.5 above. They might also allow the delivery of goods overnight when congestion is lower (although the noise creation could be a problem). However, an important point here is the extent to which eliminating these problems might actually *stimulate* demand for online shopping. At present, it seems likely that many people would prefer to shop physically for some items because they cannot, or do not want to, be at home waiting for deliveries. In certain circumstances an increase in the proportion of online shopping could improve the situation for consumers as frequency of deliveries to any one area could improve as demand from that area increases.

The environmental consequences of a large increase in online shopping are even more highly debatable since this probably would require changes to the entire structure of the distribution system. On the positive side, an increase in the proportion of online shopping should improve both the drop densities and the vehicle loading percentages. For instance, if either more people in a specific area order goods online from a specific retailer, or each person ordering orders more, the distance travelled by each delivery vehicle should decrease and the vehicle utilization should increase. This would be environmentally beneficial.

There is also discussion about company collaboration on consignment consolidation, whereby consignments going to a specific geographical location from different companies might be consolidated at a convenient location for final delivery to the consumer. To some extent, use of parcel delivery services such as DHL and UPS are already performing this function, but many companies do not use such services. Collaboration requires a great deal of trust on behalf of the companies involved, particularly since the distribution company is the interface between the retailer and the customer. Customer service perception is very dependent on this final leg of the journey. Indeed, Esper *et al*. (2003) found that in the USA, perception of the carrier had a significant influence on the consumer decision as to whether or not to buy online. The Royal Mail (2007) home shopping tracker study survey also showed that 70% of respondents liked to know which company would be delivering their goods.

Consolidation has been a central feature of city logistics for many years and a whole academic literature has built up around it (see, for instance, Taniguchi *et al*., 2001; Browne *et al*., 2005; Visser and Hassal, 2005). It needs to be even more widely used, encompassing much more than logistics in urban areas, if online shopping is to be the environmentally responsible shopping option.

Conclusions

It is clear that, despite the claims of the major UK grocers, the impact of online shopping on the environment is not clear cut. Rather the issue is complex and dynamic, involving human behaviour as well as hard business decisions. If the only considerations taken into account are the direct and static ones, i.e. one van replaces 20 shopping journeys, then on balance, yes, it appears that online shopping could be environmentally responsible. However, when consumer behaviour and the subtle interactions between shopping and other activities as well as the dynamics of household travel patterns are taken into consideration, the whole issue becomes much more complex. Combining the passenger travel complexities together with those on the freight side and also adding into the pot the problem of where to set the boundaries in terms of looking at the travel and environmental impacts makes the whole agenda fraught with difficulties. What is clear, however, is that there is an over-riding need for further study, particularly in light of the projections for the future of online shopping.

Acknowledgements

The author wishes to thank Professor Alan McKinnon for his very helpful comments on an earlier draft and two anonymous referees for their very thorough reviews and suggestions.

Notes

1. A shopping trip is defined in the National Travel Survey as a trip to the shops or from the shops to home even if there is no intention to buy. A trip to the shops where there is no direct shop-home or home-shop element is not included in the statistics.
2. Source figures allocate emissions according to where the fuel is consumed and so do not attribute emissions arising from fuel refining or electricity generation to the transport sector but to the energy sector. Figures include all transport except international air and sea.
3. A van refers to a vehicle not exceeding 3.5 tonnes GVW and a HGV refers to a vehicle of >3.5 tonnes GVW.

References

Balepur, P. N., Varma, K. V. and Mokhtarian, P. L. (1998) Transportation impacts of centrebased telecommuting: interim findings from the neighbourhood telecentres project. *Transportation,* 25, pp. 287–386.

BCSC (British Council of Shopping Centres) (2006) Online retailing: the impact of click on brick. Available at: http://www.bcsc.org (accessed 23 February 2007).

Browne, M., Allen, J., Anderson, S. and Jackson, M. (2001) *Overview of Home Deliveries in the UK.* Project Report (London: University of Westminster and the Freight Transport Association, a study for the DTI).

Browne, M., Allen, J., Woodburn, A. and Piotrowska, M. (2007) Light goods vehicles in urban areas. Literature review carried out as part of work module 1 of the Green logistics module. Available at: http://www.greenlogistics.org (accessed 16 May 2007).

Browne, M., Sweet, M. and Allen, J. (2005) *Urban Freight Consolidation Centres* (Final report prepared for the Department for Transport) (London: Department for Transport).
Cairns, S. (2005) Delivering supermarket shopping: more or less shopping? *Transport Reviews,* 25(1), pp. 51–84.
Cairns, S., Sloman, L., Newson, C., Anable, J., Kirkbride, A. and Goodwin, P. (2004) *Smarter Choices: Changing the Way We Travel* (Final report to the Department for Transport) (London: Department for Transport).
CfIT (Commission for Integrated Transport) (2006) *Sustainable Transport Choices and the Retail Sector* (London: HSO).
Couclelis, H. (2001) Pizza over the internet: e-commerce, the fragmentation of activity, and the tyranny of the region. Paper presented at the workshop on Entrepreneurship, ICT and the Region, Amsterdam, The Netherlands, 7–8 June 2001 (cited in Mokhtarian, 2004).
Cushman and Wakefield (2000) Global e-tailing (BCSC). Available at: http://www.bcrc.org.uk (accessed 18 May 2007).
Defra (2007) The environment in your pocket. Available at: http://www.defra.gov.uk/environment/statistics/eiyp/index.htm (accessed 12 February 2008).
DfT (1996) *Transport Statistics* (London: TSO).
DfT (2004) *Survey of Van Activity* (London: TSO).
DfT (2006) *National Travel Survey: 2006* (London: TSO).
DLTR (2002) The impact of information and communications technology on travel and freight distribution patterns. Review and Assessment of the literature. Report written by HOP Associates and the Transportation Research Group at the University of Southampton, UK.
DTi (2001) *@ Your Home: New Markets for Customer Service and Delivery* (London: DTi Foresight).
Dubois, B. (2000) *Understanding the Consumer* (Dorchester: Prentice Hall).
Engel, J. F., Blackwell, R. A. and Miniard, P. (1995) *Consumer Behaviour* (New York: Dryden Press).
Esper, T. I., Jensen, T. D., Turnipseed, F. L. and Burton, S. (2003) The last mile: an examination of effects of online retail delivery strategies on consumers, *Journal of Business Logistics,* 24(2), pp. 177–204.
Eurostat (2008) Households having access to the Internet. Available at: http://ec.europa.eu/eurostat/ (accessed 22 August 2008).
Fernie, J. and McKinnon, A. C. (2004) The development of e-tail logistics, in: J. Fernie and L. Sparks (Eds) *Logistics and Retail Management,* 2nd ed., pp. 164–187 (London: Kogan Page).
Ferrell, C. E. (2004) Home-based teleshoppers and shopping travel: do teleshoppers travel less. Paper presented at the 83rd annual meeting of the Transportation Research Board, Washington DC, January 2004.
Golob, T. F. and Regan, A. 2001. Impacts of information technology on personal travel and commercial vehicle operations: research challenges and opportunities, *Transportation Research C,* 9, pp. 87–121.
Gould, J. and Golob, T. F. (1997) Shopping without travel or travel without shopping? An investigation of electronic home shopping, *Transport Reviews,* 17, pp. 355–371.
Guardian (2007) Supermarket home delivery service promotes its green credentials. Available at: http://www.guardian.co.uk/environment/2007/sep/12 (accessed 18 August 2007).
Hensher, D. A. and Golob, J. M. (2000) Travel-telecommunications interactions, in: H. Mahmassani (Ed.) *Recent Developments in Travel Behaviour Research,* pp. 209–221 (Oxford: Pergamon).
Hesse, M. (2002) Shipping news: the implications of electronic commerce for logistics and freight transport, *Resources, Conservation and Recycling,* 36, pp. 211–240.
Hjorthol, R. J. (2002) The relation between daily travel and use of the home computer, *Transportation Research A,* 36, pp. 437–452.
Hoffman, J. and Lowitt, E. M. (2007) *Act Now! Customers are Limited* (Accenture Research Note) (New York: Accenture Institute for High Performance Business).
IMRG (2007) E-retail sales index. Available at: http://www.imrg.org (accessed 2 November 2007).
James, P. and Hopkinson, P. (2001) Virtual traffic: e-commerce, transport and distribution, in: J. Wilsdon (Ed.) *Digital Futures: Living in a Dot-Com World,* chap. 7 (London: Earthscan).
Koenig, B., Henderson, D. and Mokhtarian, P. L. (1996) The travel emissions impacts of telecommuting for the State of California Pilot Project, *Transportation Research C,* 4(1) pp. 13–32.
McKinnon, A. (2007) CO_2 *Emissions from Freight Transport in the UK* (Report for the DfT) (London: CfIT).
McKinnon, A. C. and Tallam, D. (2003) Unattended delivery to the home: an assessment of the security implications, *International Journal of Retail and Distribution Management,* 31(1), pp. 30–41.
McLeod, F., Cherrett, T. and Song, L. (2006) Transport impacts of local collection/delivery points, *International Journal of Logistics Research and Applications,* 9(3), pp. 307–317.

Mintel (2007) Home shopping UK. Available at: http://www.mintel.co.uk (accessed 16 November 2007).
Mokhtarian, P. L. (2004) A conceptual analysis of the transportation impacts of B2C e-commerce, *Transportation,* 31(3), pp. 257–284.
Mokhtarian, P. L. and Saloman, I. (2002) Emerging travel patterns: do telecommunications make a difference? in: H. S. Mahmassani (Ed.) *Perpetual Motion: Travel Behaviour Research Opportunities and Application Changes,* pp. 143–182, chap. 7 (Oxford: Pergamon).
Nairn, G. (2003). Not many happy returns, *Financial Times,* 5 February, p. 17.
Nockold, C. (2001). Identifying the real costs of home delivery, *Logistics and Transport Focus,* 3(10), pp. 70–71.
OECD/ECMT (2001) *Summary of Discussions of the Joint OECD/ECMT Seminar on the Impact of E-commerce on Transport* (Paris: OECD).
ONS (2005) ICT: activity of UK businesses 2005. Available at: http://www.statistics.gov.uk/downloads/theme_economy/ecommerce_report_2005.pdf (accessed 3 December 2007).
ONS (2007) *Social Trends* (London: HSO).
Pendyala, R. M., Goulias, K. and Kitamura, R. (1991) Impact of telecommuting on spatial and temporal patterns of household travel, *Transportation,* 18, pp. 411–432.
Plunkett Research (2007) Retailing overview. Available at: http://www.plunkettresearch.com/industries/retailing/retailingstatistics/tabid/268/default.aspx (accessed 04 July 2007).
Pool, I. (1983) *Forecasting the Telephone* (Norwood, NJ: Ablex).
Punakivi, M. and Tanskanen, K. (2002) Increasing the cost efficiency of e-fulfilment using shred reception boxes, *International Journal of Retail and Distribution Management,* 30(10), pp. 498–507.
Punakivi, M., Yrjola, H. and Holmstrom, J. (2001) Solving the last mile issue: reception box or delivery box, *International Journal of Physical Distribution and Logistics Management,* 31(6), pp. 427–439.
RAC Foundation (2006) *Motoring towards 2050: Shopping and Transport Policy* (London: RAC).
Retail Logistics Task Force (2001) *@ Your Home: New Markets for Customer Service and Delivery* (Foresight Programme) (London: DTI).
Royal Mail (2007) *Home Shopping Tracker Study* (London: Royal Mail Group Ltd).
Shen, Q. 2000. New telecommunications and residential location flexibility, *Environment and Planning A,* 32, pp. 1445–1463.
Solomon, M., Bamossy, G. and Askegaard, S. 2002. *Consumer Behaviour: A European Perspective* (London: Prentice Hall).
Taniguchi, E, Thompson, R, Yamada, T. and van Duin, R. (2001) *City Logistics* (Oxford: Pergamon).
Verdict (2007) *UK Home Delivery and Fulfilment 2007* (London: Verdict Research Ltd.).
Visser, J. and Hassal, K. (2005) The future of city logistics: estimating the demand for home delivery in urban areas. Paper presented at the 4th international conference on City Logistics, Langkawi, Malaysia, 12–14 July 2005.
Visser, E. J. and Lanzendorf, M. (2004) Mobility and accessibility effects of B2C e-commerce: a literature review, *Tijdschrift voor Economische en Sociale Geographie,* 95(2), pp. 189–205.
White, P., Christodoulou, G., Mackett, R., Titheridge, H., Thoreau, R. and Polak, J. (2007) The role of teleworking in Britain: its implications for the transport system and economic evaluation, in: *Proceedings of the European Transport Conference,* 17–19 October 2007 (Leiden, The Netherlands: Association for European Transport).
Zhang, F., Clifton, K. and Shen, Q. (2005) Re-examining ICT on travel using the 2001 NHTS data for Baltimore Metropolitan Area, in: H. J. Miller (Ed.) *Societies and Cities in the Age of Instant Access,* pp. 153–166 (Dordrecht, The Netherlands: Springer).