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Online shopping habits and the potential for reductions in carbon dioxide emissions from passenger transport

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ABSTRACT

Opportunities for online shopping are transforming travel behaviour related to shopping, and they have the potential to reduce overall travel demands. This paper analyses the potential for reductions in carbon dioxide (CO_2) emissions from passenger transport due to an increased use of online shopping in Sweden and adds to the broader picture of what potential growing online shopping might have on transport sustainability. This paper shows that there is a sustainability potential related to more sustainable travel habits by those who shop online more frequently. Calculations indicate that the predicted increase in online shopping behaviour together with the predicted increase of the Swedish population in 2030 would give a 22% decrease in CO_2 emissions related to shopping trips compared to 2012. Furthermore, if all travel is taken into account this would result in a 2% reduction in 2030 compared to total CO_2 emissions 2012. The paper furthermore discusses how these results might influence transport sustainability ambitions and policies. The discussion suggests that online shopping might facilitate reductions in CO_2 emissions but above all, it could act as a facilitator for implementing other policies promoting a less car dependent planning regime including shopping localisation.

1. Introduction

Increasing transport as a means for economic growth is often taken for granted (Essebo, 2013), and “curbing mobility is not an option” according to the 2011 EU Transport White Paper (European Commission, 2011). Transport is, however, the source of many environmental problems, and there is largely a consensus among transport researchers on the need for levels of transport to be reduced in order for the sector to contribute to more sustainable development (Johansson, 2009; Åkerman, 2011; Gudmundsson, 2008). It is important to note that it is not only the technical aspects of the transport infrastructure that need to change, but also transport behaviour (Nilsson and Khan, 2013; Moriarty and Honnery, 2013; Nissinen et al., 2015). Transport is responsible for almost 25% of global energy-related greenhouse gas emissions (IPCC, 2007). In Sweden, this share is even higher (33%) primarily due to the fact that electricity generation and heating in Sweden is less dependent on fossil fuels (The Swedish Environmental Protection Agency, 2015). Both in Sweden and globally, transport is increasing its share of emissions (The Swedish Environmental Protection Agency, 2015; the European Environment Agency, 2015).

Much effort has been put into finding solutions and measures to reduce the environmental impact of the transport sector (European Commission, 2013). The Swedish Commission on Fossil-Free Road Transport was recently tasked with identifying possible courses of action to reduce the emissions and the fossil fuel dependence of the transport sector in line with the national vision of Sweden to achieve zero net emissions of greenhouse gases by 2050 (Swedish Government Official Reports, 2013). Examples of the measures published by this commission for the Swedish context are presented in Table 1. This table includes the estimated impacts of the measures on the number of vehicle kilometres driven by car.

In Sweden, the CO_2 emissions from passenger transport are considerably greater than CO_2 emissions from freight transport (Swedish Transport Administration, 2013). Shopping trips account for approximately 20% of all trips and for approximately 10% of the total passenger mileage according to data from Sweden and other European countries (Trivector, 2011). More than one third of shopping trips are made by car (Winslott Hiselius et al., 2015). If the number and/or length of shopping trips made by car can be reduced, this would provide an interesting potential for increasing sustainability in the transport sector. Studies focusing on the

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Table 1
Estimated reduction in number of car kilometres in Sweden by 2030 and 2050 compared to a reference scenario (Swedish Government Official Reports, 2013).

	2030	2050
Planning	7–10%	15–20%
Fees and taxes	5%	6%
ITS	>0.3%	>0.3%
Car sharing	5%	7%
Travel free meetings	4%	6%

location of retailers and shopping centres in Sweden indicate a potential reduction of CO_2 emissions. The location of retailers (e.g. consumer electronics, pet shops, key cutting) can reduce CO_2 emissions from customer travel by 22% (Carling et al., 2013) while the location of shopping centres can lead to a reduction of 8–9% (Jia et al., 2013). A recent example of a study for the mid-European context is Seebauer et al. (2015) in which the impact on CO_2 emissions of restricting shopping and supporting neighbourhood stores and online shopping is analysed in Austria, indicating similar reduction levels.

It has been suggested that the growing trend of online shopping might lead the transport sector to become more efficient with regard to energy use and CO_2 emissions. Rotem-Mindali and Weltevreden (2013) have published an extensive and interesting review of studies on how business-to-consumer online shopping affects mobility. There have been many conceptual studies presenting theories and assumptions on the possible impacts of online shopping (Salomon, 1985, 1986; Mokhtarian, 2004), and since the establishment and expansion of the online market, many empirical studies have also been undertaken. In many empirical studies, the results indicate that online shopping acts as a substitute for personal shopping travel (Corpuz and Peachman, 2003; Weltevreden and van Rietbergen, 2007). However, there are also empirical results which indicate that online shopping will have a limited or even no impact on the number of trips and total distance travelled for shopping (Keskinen et al., 2002; Visser and Lanzendorf, 2004; Weltevreden, 2007). With a focus on online searching, there are studies which claim that there can even be a positive effect between online shopping and mobility behaviour resulting in additional travel due to the online options and accessibility (Farag et al., 2006, 2007). Finally, there are studies reporting empirical evidence for both substitution and complementarity behaviour within different groups in the sample population. This is, for instance, shown in Tonn and Hemrick (2004) where the use of e-mail and/or the Internet resulted in some respondents substituting one or more trips to a bookstore while some made more trips to bookstores.

With regard to the total number of passenger trips, one must recognise that online shopping could very well result in no reduction at all or even an increase in trips in line with findings on the effects of telecommuting. In the mid-seventies, telecommuting was predicted to be substitute for traditional forms of transport for commuting (Niles and Gray, 1975). However, the empirical results from, e.g., Niles (2001), De Graaff (2004), and Choo and Mokhtarian (2007), among many other authors, suggest that telecommunications and travel are complementary and even increase total travel. Gould and Golob (1997) argue that, analogous to the finding that saved travel for work is converted into new trips, saved shopping travel might be converted into other types of travel. Thus, the combination of substitution and the complementary effects of travel lead to a very complicated picture of the overall effect of online shopping. Even if there is a substitution effect in the number of trips for shopping, there might be a rebound effect in trips for other purposes. This increase in other types of trips might, of course, occur even if the number of physical shopping trips is unaffected or increases.

To understand the complicated impact of online shopping requires study designs that look at total travel over a national level, e.g., Casas et al. (2001), Ferrell (2005), and Zhou and Wang (2014). Winslott Hiselius et al. (2015) presented a study designed to include all daily travel over a representative sample of the Swedish population. Analysis of the travel survey data indicated that there are some mobility pattern differences between frequent online shoppers and those with less frequent online shopping behaviour, although there were no simple and conclusive overall differences in total travel patterns. However, a significant overall difference in mode choice could be seen between frequent regular online shoppers and those who do not shop regularly online.

The latter result is interesting since if online shopping increases the use of more sustainable modes of transport, then online shopping might – even on a short-term basis – provide a sustainability potential for the transport sector. For instance, in Van Loon et al. (2015) and Seebauer et al. (2015) the authors argue that consumer behaviour regarding the number of trips and mode choice are critical factors for determining the sustainability effects of online shopping.

However since these studies mostly use cross-sectional datasets, conclusions regarding the causal effects of online shopping behaviour are difficult to draw, since the estimated effect may also be due to self-selection, which refers to individuals selecting themselves into preferred choices rather than being randomly distributed (Hong et al., 2014). The presence of self-selection might then lead to a bias in the estimated effect of online shopping on travel behaviour much in the same way as has been discussed for walkability in different residential areas, e.g. Bohte et al. (2009). The use of longitudinal data (rather than cross-sectional data) provides a better way to begin to understand underlying causalities.

The aim of this paper is to further discuss the potential for reductions in passenger transport CO_2 emissions as a result of an increased use of online shopping on the national level in Sweden. The discussion is based on estimates of CO_2 emissions for the typical travel behaviour of different categories of online shoppers in Sweden today as recorded by Winslott Hiselius et al. (2015). However, because online shopping is currently growing very rapidly, and estimates for the future present a continuous rise in online shopping (GSI, 2013), this investigation also estimates possible reductions in CO_2 emissions in 2030 based on the predicted growth in online shopping. The analysis also acknowledges, in line with Crocco et al. (2013), that an increasing share of online shopping will likely lead to changes not only in travel behaviour but also in the use of transport systems and how shopping locations are distributed. Consequently, this paper also analyses trip length and transport modes for various trip purposes as the basis for discussion of the total potential regarding passenger transport CO_2 efficiency. This is used as the basis for a discussion as to whether emissions reduction potentials can be realised solely by the expected growth in e-shopping, or whether other conditions for the transport system and supportive actions for a less car-dependent lifestyle are also required.

2. Method

2.1. Method overview

This paper aims to provide an overall picture of the potential for passenger transport CO_2 emission reductions due to increased use of online shopping in Sweden. This is done by presenting estimates of:

1. CO_2 emissions for the typical travel behaviour of different categories of current online shoppers;
2. possible reductions in CO_2 emissions supported by an increase in online shopping according to the trade industry's predictions of e-shopping growth;
3. possible reductions in CO_2 emissions in 2030 compared to 2012 levels of CO_2 emissions provided by increases in use of online shopping and population growth predicted for 2030; and
4. the importance of shopping location when discussing future reductions in CO_2 emissions for online shopping.

The study thus seeks to isolate the effect on CO_2 emissions of an increased use of e-shopping, taking into account growth in the population until 2030. Exogenous factor such changes in the transport system and shop locations are consequently assumed to be constant.

2.2. e-shopping and travel behaviour in 2012

Estimates of CO_2 emissions for categories of online and non-online shoppers can be collected from travel survey data. In this paper, the travel survey from Winslott Hiselius et al. (2015) was used and provided data on online shopping habits as well as daily travel behaviour. The questionnaire consisted of an individual one-day travel survey diary that recorded the purpose, mode, and distance for all trips (for shopping as well as for other purposes) that were made on a specified day. The questionnaire also included questions on online shopping habits and demographic data, including place of residence.

The study was performed as a web-based survey distributed to a representative panel of the Swedish population aged 18 and over. A total of 4148 out of the 7650 persons who received an invitation to participate answered the survey, giving a response rate of 54%.

The respondents were classified into one of three different groups of online shoppers based on their stated online shopping habits for groceries and other purchases.

- Frequent online shoppers: shop online for groceries or other purchases at least once a week
- Regular online shoppers: shop online for groceries or other purchases about once a month
- Not or non-regular online shoppers: shop online for groceries or other purchases once every six months or less

Background data for the data set is presented in Table 2. In the dataset, 9% of the respondents shop online frequently, 34% do so regularly, and 57% do so seldom or never. The distribution of the observation corresponds to statistics presented by the Swedish Retail Institute (2013).

Table 2
Background data for different categories of online shoppers (Winslott Hiselius et al., 2015).

Typology	Frequent	Regular	Not or non-regular
Number of respondents	321	1400	2427
Share of total sample	9%	34%	57%
Place of residence			
Centrally in main town	44%	41%	34%
Suburbs of main town	35%	35%	37%
In village	15%	12%	15%
In the countryside	6%	12%	14%
Access to a car			
Always	48%	54%	59%
Most of the time	24%	21%	19%

2.3. Emission factors in 2012 and 2030

CO_2 emissions from passenger transport per person per day were calculated using the standard Swedish emissions factors for cars and public transport and by assuming that walking and cycling do not produce any emissions. The emission factor for cars in 2012 is 144 g/km per person assuming an occupancy rate of 1.2 people per car for each journey (Transport Administration, 2009). Because the data for public transport are not subdivided into different modes of public transport, the emission factor used for 'public transport' was calculated as a weighted average of the emission factors based on the mode share of different public transport modes in 2011 from the Swedish National Travel Survey. This gave an emission factor of 33 g/km per person for an average journey by public transport. The emission factors for train, bus, and tram/metro are 0.002 g/km, 62.1 g/km, and 0.002 g/km per person, respectively (The Network for Transport and Environment, 2013).

The predicted emission factors for 2030 are based on Swedish Government Official Reports (2013). These emission factors include the Transport Administration forecasts of the development and introduction of more efficient vehicles and fuels. The emission factor for cars in 2030 is assumed to be 120 g/km per person (Transport Administration, 2009) assuming an occupancy rate of 1.2 people per car for each journey, and the average emission factor for public transport is assumed to be the same as in 2012 because the forecast assumes no improvements for these vehicles.

2.4. Share of customer categories for the estimated population in 2030

The scenarios for increased online shopping frequency among the population in 2030 are presented in Swedish Government Official Reports (2013) and based on the Swedish Trade Federation's e-shopping reports together with a specific estimation of expected growth in e-shopping up to 2022 (GS1 Sweden and the Swedish Trade Federation Research, 2013). The estimates of the share of categories of different online shopping habits in 2030 are based on a prediction of increased online shopping turnover and an increase in its share of total shopping turnover.

The shopping habit categories as presented in Section 2.2 and the distribution of the population in these categories is assumed to change in the future. Based on the predictions of the growth of online shopping, the average share of frequent online shoppers in the population is estimated to be 60% in 2030, the share that regularly shops online is estimated to be 40%, and the share of those who seldom or rarely shop online is estimated to be 0% in 2030. Also taking the predicted future population by 2030 into account (Statistics Sweden, 2012), the distribution over the Swedish population is calculated, see Table 3.

3. Results

3.1. CO_2 per person per day 2012

Table 4 presents the travel patterns in Winslott Hiselius et al. (2015) translated into CO_2 emissions using conversion factors from the Swedish Transport Administration as explained in Section 2.3.

Starting with comparing the CO_2 emissions produced by trips for shopping purposes we can conclude that both the categories of customers who frequently, as well as the ones who regularly shop online have only about half the CO_2 emissions compared to the other category who never or seldom shop online. Frequent online shoppers' CO_2 emissions are 55% of the emissions of those who

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Table 3
Swedish population in 2012 and 2030 distributed according to predicted online shopping frequency.

	Shopping online…			
	Frequently	Regularly	Never or seldom	Total
In 2012	941 557	3 295 450	5 178 564	9 415 570
In 2030	6 396 206	4 264 138	0	10 660 344

seldom or never shop online and for those regularly shopping online this figure is 54%.

Naturally, those who frequently shop online have higher CO_2 emissions for the purpose of collecting online purchases adding to the total emission from shopping trips. For this errand, the differences are statistically significant (at the 5% level). When comparing other specific sub-characteristics, there are statistically significant differences at the 5% level with respect to online shopping habit (frequent, regular, or not or non-regular online shoppers).

The results further reveal that the higher number of trips, but fewer total kilometres, by car for those who frequently shop online also gives considerably lower CO_2 emissions for the rest of the trips made. For errands other than shopping there is also a difference between those who frequently and those who regularly shop online.

Looking at the total daily travel, frequent online shoppers' CO_2 emissions are 76% of the emissions of those who seldom or never shop online. This is considerably less of a difference than when only looking at shopping errands in total. Nevertheless, the pattern of frequent online shoppers using the car less and travelling shorter distances becomes clear when using CO_2 emissions as an indicator for the travel patterns. This also means that there is no rebound effect regarding increased CO_2 emissions for other errands when reducing car use and distances for shopping while shopping online.

These results show a 45% reduction in CO_2 emissions for shopping purposes (from 100% to 55% according to Table 4) and a 24% reduction for all trips (from 100% to 76% in Table 4) for frequent online shoppers. These are considered to be significant reductions, and in what follows, we investigate what might be the overall potential if online shopping were to grow in the population of Sweden according to estimates of expected growth in e-shopping as described in Section 2.4.

3.2. CO_2 emissions 2012 with predicted e-shopping trends

In order to further investigate the total sustainability potential of increased e-shopping behaviour, we calculate the total CO_2 emissions for the Swedish population for the year 2012, using the distribution of online shopping habits for 2012 and corresponding travel behaviour for these categories as recorded in Winslott Hiselius et al. (2015). The result is presented in Table 5.

In order to analyse the effect of a future change in the distribution of online shopping frequency as discussed in Section 2.4, the total CO_2 emissions for the Swedish population for the year 2012 is also calculated assuming an increased share of those who shop online frequently and regularly as predicted for the year 2030. This result is presented in Table 6 together with figures on the estimated difference compared to the e-shopping frequency of 2012.

The result in Table 6 shows that for shopping purposes, the calculated reduction in CO_2 emissions is 31% if the 2012 population would have the distribution of online shopping habits predicted for 2030 with the corresponding travel behaviour. This reduction (682 551 tonnes) corresponds to a 4% reduction of 2012 total CO_2 emissions (16 993 494 tons in Table 5) only for shopping trips.

The result in Table 6 also indicates that if the 2012 population shopped online according to the 2030 prediction (and had the corresponding travel behaviour), the overall reduction in total CO_2 emissions from all trips would be 14% for all trips made.

In these calculations, there is an underlying assumption that individuals when increasing their frequency of e-shopping in 2030 (and changing category of online shopping behaviour) also gain the same travel behaviour as individuals belonging to this new online shopping category. The data set indicate however that individuals who never or seldom shop online today (and are likely to e-shop more frequently in the future) tend to live in rural areas (see Table 2) with less accessibility to public transport and infrastructure for walking and biking. These future frequent online shoppers may thus have a wider geographical distribution of residence than frequent online shoppers of today with fewer possibilities for travelling more sustainably. Also, if those who frequently shop online do so due to a preference for a more sustainable travel behaviour (or other reasons) then the calculations are likely to lead to an overestimation. The figures in Table 6 should therefore be seen as indicative values for the maximum CO_2 emission reduction potentials.

3.3. CO_2 emissions 2030 with predicted e-shopping trends and population growth

In order to analyse the maximum potential further, the CO_2 emissions in Sweden are calculated considering both the predicted increase in the e-shopping frequency and the growth in the Swedish population until 2030. These results together with the difference in total tonnes of CO_2 emissions per day 2030 compared to the situation of 2012 are presented in Table 7.

The calculation indicates that the increase in the predicted e-shopping behaviour together with the increase in the Swedish population in 2030 would give a 22% decrease in CO_2 emissions for shopping purposes compared to 2012. Furthermore, if all travel is taken into account this would result in a 2% reduction in 2030 compared to total CO_2 emissions 2012.

Table 4
CO_2 emissions per day (grams) for passenger transport per person according to e-shopping frequency and trip purpose in 2012.

	Shopping online …, frequency of 2012				CO2 emission for shopping online…. compared to those never or seldom	
Errand	Frequently	Regularly	Never or seldom	Average all	Frequently	Regularly
By trip purpose						
Shopping purpose (total)	$440^{F,N}$	$430^{R,N}$	$800^{F,R,N}$	601	55%	54%
Groceries	198	$192^{R,N}$	$324^{R,N}$	253	61%	59%
Other	$173^{F,N}$	$217^{R,N}$	$440^{F,R,N}$	313	39%	49%
Pick-up online purchases	$48^{F,R,N}$	$6^{F,R}$	$11^{F,N}$	14	443%	52%
Other purposes	3310	3874	4143	3919	80%	94%
Total travel	$4015^{F,N}$	4636	$5310^{F,N}$	4862	76%	87%

F: Frequent, R: Regular, N: Never or seldom. These indicate that there are significant differences between these groups at the 5% level.

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Table 5
CO_2 emissions per year (tonnes) in Sweden in 2012 based on the e-shopping frequency recorded in 2012.

Errand	Shopping online ..., frequency of 2012			
	Frequently	Regularly	Never or seldom	All
By trip purpose				
Shopping purposes (total)	151 172	517 684	1 512 367	2 181 224
Groceries	68 128	231 351	612 726	912 205
Other	59 447	260 443	831 805	1 151 694
Pick-up online goods	16 606	6 828	20 618	44 052
Other purposes	1 137 555	4 659 707	7 830 104	13 627 365
Total travel	1 379 822	5 576 277	10 037 394	16 993 494

Table 6
CO_2 emission per year (tonnes) in Sweden for the 2012 population based on predicted e-shopping frequency for 2030.

Errand	Shopping online ..., predicted e-shopping frequency of 2030				Comparison with e-shopping frequency of 2012	
	Frequently	Regularly	Never or seldom	All		
By trip purpose						
Shopping purposes (total)	2485	1621	0	4106	−682 551	−31%
Groceries	1120	724	0	1844	−239 034	−26%
Other	977	815	0	1793	−497 365	−43%
Pick-up online goods	273	21	0	294	63 389	144%
Other purposes	18 700	14 590	0	33 290	−1 476 656	−11%
Total travel	22 682	17 460	0	40 142	−2 341 672	−14%

3.4. *Trip distance and modal split in 2012*

According to the literature e.g. Crocco et al. (2013) and Zhou and Wang (2014), the long-term effects on travel habits of online shopping will be affected by the localisation of shopping facilities and the logistics structure of the retail business in the future (and vice versa). Differences in trip distances and modal split between groups of customers may then help us to understand and discuss the future potential, giving us a deeper understanding of the results summarised in Tables 3–7. In Table 8, the average trip distance based on the data set of Winslott Hiselius et al. (2015) is presented, separated by trip purpose and online shopping frequency.

The result indicates that shopping trips in 2012 by car are almost twice as long per trip for those who seldom or never shop online compared to frequent online shoppers. This may of course be a result of geographical differences, since those who shop online frequently tend to live more centrally than those who seldom or never shop online, see Table 2. However, if looking at the trip distance by car only for grocery shopping, the difference between those who shop online frequently/regularly and those who seldom or never shop online is not as large. The trip distance for other errands than shopping also does not differ much between these two groups (the regular/frequent online shoppers and those who seldom/never shop online).

The result indicates that the choice to use the car has a larger impact on trip length when it comes to shopping purposes (especially other purchases than groceries) than for other errands. This leads us to believe that shopping trips are more affected by localisation than other activities, and specifically so for trips made by car. This is in line with the effect of shop location investigated and reported in e.g. Seebauer et al. (2015) reporting notable reducing effects on total distance travelled by car through encouraging neighbourhood stores or restricting externally located shopping centres. The result indicates that in the case of shopping trips (and especially non-grocery shopping), the *location* of shops affects trip length for car users more than for other errands. This could be due to the prevalence of out-of-town shopping centres which are generally most accessible by car. Other errands do not have an out-of-town equivalent in most cases (e.g. school, university, workplace, nursery, etc).

4. Discussion

This paper explores to what extent online shopping might present a potential for reduction in passenger transport CO2 emissions. The focus is on passenger transport emissions, since these are considerably greater than CO2 emissions from freight transport in Sweden (Swedish Transport Administration, 2013). However, there is a methodological problem in drawing conclusions regarding the causal effects for passenger transport emissions based on the set of cross-sectional data used here, i.e. whether online shopping leads those shopping online to travel the way they

Table 7
CO_2 emissions per year (tonnes) in Sweden based on the predicted e-shopping frequency and population for 2030.

Errand	Shopping online ..., predicted e-shopping frequency and population of 2030				Comparison with e-shopping frequency and population of 2012	
	Frequently	Regularly	Never or seldom	All		
By trip purpose						
Shopping purposes (total)	1 026 947	669 856	0	1 696 803	−484 421	−22%
Groceries	462 811	299 356	0	762 167	−150 038	−16%
Other	403 835	336 999	0	740 834	−410 860	−36%
Pick-up online goods	112 811	8835	0	121 645	77 593	176%
Other purposes	7 727 665	6 029 414	0	13 757 079	129 714	1%
Total travel	9 373 440	7 215 408	0	16 588 849	−404 645	−2%

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Table 8
Trip distance (km) by trip purpose and transport mode.

	Trips by car for those who shop online…			Trips by another mode than car for those who shop online…		
	Frequently	Regularly	Never or seldom	Frequently	Regularly	Never or seldom
Shopping trips (total)	7500	7436	13 750	2222	2857	3846
By shopping errand:						
Groceries	6667	5417	8462	2500	2500	2857
Other purchases	8000	10 714	21 429	3333	4000	3333
Pick-up online goods[a]	–	–	–	–	–	–
Other errands	19 533	23 211	25 327	19 432	17 349	20 000

[a] Limited number of observations.

do or if online shopping today attracts those who practice more sustainable travel behaviour to start with. In order to analyse the presence of self-selection, it would be necessary to include various questions regarding preferences for sustainable transport modes in the questionnaire. Analyses of subgroups such as people living in cities or in the main metropolitan areas in Sweden from Winslott Hiselius et al. (2015) (not presented in this article) do indicate, however, that the pattern of travel behaviour is persistent when also looking at such subgroups.

This paper shows that there is an overall sustainability potential for online shopping that is related to more sustainable travel habits by those who shop online more frequently. The calculations indicate that the predicted increase in e-shopping frequency (and correspondingly more sustainable travel behaviour) together with an anticipated growth in the Swedish population would give a 22% reduction in CO2 emissions for shopping purposes (including pick-up of goods purchased online) in 2030 compared to 2012. The estimated reduction when not considering a growth in population is 31%. The second figure is comparable to the result of Carling et al. (2013) who found a CO2 emission reduction potential of 22% through locating retailers (e.g. consumer electronics, pet shops, key cutters) in such a way to minimise CO2 emissions from consumer travel in Sweden today, whereas Jia et al. (2013) found a reduction of 8–9% in CO2 emissions through optimal locations of shopping centres.

The results on trip distances and modal split highlight the important impact location of shops has on trip distances – and especially so for trips made by car. This adds to the importance of a less car-dependent planning to support the emission reduction potential of online shopping. If all trip purposes are taken into account, the result of this study indicates a reduction of 2% in CO2 emissions in 2030 compared to total emissions in 2012. The estimated impact for total travel is comparable to the figures of Swedish Government Official Reports (2013) suggesting that the number of car kilometres in Sweden 2030 compared to a reference scenario could be reduced by 4–5% through implementation of transport demand measures e.g. car sharing, congestion charging, fees and taxes.

In summary the results indicate an impact on CO2 emissions due to increased e-shopping that could and should not be ignored. Online shopping is a growing market and will no doubt continue to grow no matter what research has to say about its effects. The most urgent question might not be the exact effects that increased online shopping frequency will have on travel behaviour and resulting CO2 emissions but how any potential reduction can best be realised. Based on the current situation and policies, an important question is what is needed in order to make online shopping contribute to a transport system that supports a sustainable future. At best, online shopping can be used to support less car-dependent planning and to encourage policies for enhancing the transition towards a society with zero emissions.

Some of the benefits of online shopping might develop on their own, but the urgency and extent of change needed for a transition towards zero emissions suggest that planning and policies – especially regarding long-lasting structures – should support and facilitate a less car-dependent lifestyle. Although not statistically significant, there is a persistent pattern in our data suggesting that frequent online shoppers seem more inclined to use other transport modes than a car. Holding a driving licence and having access to a car are often pointed out as important factors for transport sustainability in terms of mileage travelled by car (Frändberg and Vilhelmson, 2011; Sivak and Schoettle, 2012). It is, however, interesting to explore the relationship between having a driving licence and using the car as a transport mode, and an important question to ask is whether the trend of less car mileage in younger people as found by Frändberg and Vilhelmson (2011) is a result of a reduced proportion of younger adults holding a driving licence or if the reduced proportion of younger adults holding a driving license is a result of reduced demand for car travel. Online shopping also provides a potential reduction in travel mileage because the need to have a car to transport purchases from the shop to home is reduced. This could reduce the need to have a car or might increase the demand for smaller cars or car sharing.

5. Conclusions

In order to analyse the complicated impact of online shopping, this study looks at travel at the national level in Sweden and considers effects on number of trips, trip length and modal choice including predicted growth in population as well as predicted uptake of online shopping by 2030. The result adds to the knowledge base on the potential effects of an increased online shopping behaviour with a focus on net CO_2 emissions from passenger transport.

The result shows that there is a sustainability potential related to more sustainable travel habits by those who shop online more frequently. Calculations indicate that the predicted increase in online shopping behaviour together with the predicted increase of the Swedish population in 2030 would give a 22% decrease in CO_2 emissions related to shopping trips compared to 2012. Furthermore, if all travel is taken into account this would result in a reduction in CO_2 emissions by 2% in 2030, in size comparable with various transport demand measures. The study furthermore shows that car use has a general larger impact on trip length for shopping (irrespective of online shopping behaviour) than for other errands, underlining the impact of shopping locations.

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