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## **Consumer E-Commerce, Virtual Accessibility and Sustainable Transport**

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Jane Gould <sup>1</sup>  
Thomas F. Golob <sup>2</sup>

<sup>1</sup> Future Media Programme, London Business School, United Kingdom and  
Transportation Services, University of California, Los Angeles  
Los Angeles, CA 90024, U.S.A., jgould@ts.ucla.edu

<sup>2</sup> Institute of Transportation Studies  
University of California, Irvine, tgolob@uci.edu

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Institute of Transportation Studies  
University of California, Irvine  
Irvine, CA 92697-3600, U.S.A.  
<http://www.its.uci.edu>

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The growth of the Internet has rekindled interest in the relationship between communications and travel. New communication technologies have expanded the range, the type, and the number of transactions that can take place without travel. A number of promotions capture the new tradeoffs between communications and travel: initially, the Internet was referred to as "the information superhighway" and Microsoft ran an ad campaign dubbed "where do you want to go today?" The connection between travel and bytes has been summed up as "The Death of Distance" (Cairncross, 1997).

A parallel evolution in telecommunication and transportation was envisioned more than 150 years ago with the inventions of the telegraph and telephone. The telephone was expected to "speed the movement of perishable goods," "reduce the travels of salesmen," and "let (itinerant) workers stay at home to be phoned for jobs" (Pool, 1983).

Today, the Internet has fueled similar expectations, and many of them center on travel-related issues. The Internet might relieve demand for new road capacity, slow down the rate of new vehicle ownership, and divert existing travel trips to less congested times. The Internet might help create more sustainable growth in transportation, by providing virtual accessibility. In this paper, we explore the transportation aspects of consumer electronic commerce (e-commerce). Shopping activities are currently automobile-intensive in many countries, and increases in e-commerce could portend important changes in transportation patterns and activities.

### **The Growth of Consumer E-Commerce**

Currently, consumer e-commerce represents a small but rapidly growing proportion of retail sales. In 1999, it is estimated that 17 million U.S. households shopped online (Forrester, 2000), and consumer e-commerce revenues in the U.S. were estimated to be US\$ 20 billion, up dramatically from US\$ 4 billion in 1997 (IDC, 1999). Europe and the rest of the world are catching up to the U.S. in terms of online shopping, and there are forecasts of worldwide consumer e-commerce revenues of US\$ 200 billion by 2002 (IDC, 1999). Growth in e-commerce will be driven by anticipated advances in Information technology. Some of these advances (discussed in Golob, 2000) include:

(1) improvements in Internet speed and capacity involving the next generation Internet Protocol, (2) wide-band and satellite home Internet connections, (3) handheld Internet devices ("smart phones"), (4) television set-top Internet devices and other simplified "Internet appliances," (5) Extensible Markup Language (XML), (6) smart agents (software "bots") for comparing products and prices, and (7) voice over Internet Protocol (VoIP) for multimedia and human-assisted shopping.

Consumer e-commerce today is concentrated in items like books, software, music, travel (e.g., airline tickets), hardware, clothing, and electronics. In the U.S., most of the online sales take place at the holiday season. However, there is also a developing e-commerce sector in groceries and household goods. It is estimated that this part of e-commerce might reach US\$ 11 billion in sales by 2003, but this will still only be 2% of the total grocery market (Forrester, 2000). Restricted geographic location, high development and maintenance costs of online inventory display, and high delivery costs are cited as factors impeding the growth of grocery e-commerce. E-merchants in this sector are attempting to establish one of two types of markets: household replenishment or specialty luxury items (Forrester, 2000).

Online shopping for groceries and household goods is of particular interest to transportation planners, because this activity is much more repetitive than other types of shopping and many shopping trips are linked to trips for other purposes. More sustainable transportation networks might be developed if e-commerce substituted for certain types of trips. For example, there might be less demand for new suburban centers with acres of parking, and e-commerce could reduce congestion during peak shopping periods (Golob, 2000). E-commerce could also radically change both the location of transshipment centers, and patterns of vehicle movement for physical goods distribution.

Another benefit for sustainable transportation is that e-commerce might induce more neighborhood, pedestrian based commerce, particularly in Europe (ESRC, 1995). Local corner shops, village center, or high-street stores could serve as pick-up points, with regular scheduled deliveries by truck of e-commerce ordered perishables and

drygoods.<sup>1</sup> This would reduce the difficulty of making day-time deliveries to working households, and provide new opportunities for small shopkeepers. The opportunity has not been overlooked by oil companies and operators of gasoline stations, who envision existing neighborhood gasoline/food courts as pick-up centers.

Although electronic commerce will not eliminate travel trips for shopping, it could impact the type and number of vehicles on the road. The need for advanced logistics and delivery vans will surely increase, and household transportation needs might change. Fewer shopping trips might reduce demand for personal vehicles that are capacious, being designed to accommodate both passengers and shopping cargo. There might be a gradual shift towards smaller, alternative-fuel vehicles, since there could be less reliance on personal vehicles for transporting groceries, boxes, and bulky durable goods. A growth in electronic commerce might also slow a trend to acquire a second, and in some cases, a third, household vehicle.

The aim of this paper is to explore the interrelationships between personal shopping trips and transportation. We begin by examining the role of the personal vehicle for shopping trips, with an emphasis upon fully employed workers, in both the U.S. and the U.K. We choose to look at fully employed workers because they have opportunities to access e-commerce from work and home computers. We also know that many of these workers, particularly female heads of households, have very busy activity schedules (Golob and McNally, 1997, Gould and Golob, 1997).

### **Research into Demand for Shopping Travel**

It is estimated that shopping trips comprised one out of every five person trips and one out of every seven person miles traveled in the U.S. (NPTS, 2000). Shopping trips in the U.S. account annually for 1700 miles per car, a figure which has increased by 88 percent since 1969 (Edmondson, 1994, citing the 1990 U.S. Nationwide Personal Transportation Survey). Travel trips by women are of particular note. Between 1983 and 1990, the number of miles driven by women increased by 49 percent, with women

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<sup>1</sup> McKinnon and Woodburn (1994) estimate that the contents of one single lorry (i.e. truck) will dispense

ages 20 to 34, driving the most. This is explained, in part, by the overall increase of women in the labor force. Pisarski (1992) notes the dependence of working women on cars, and observes that in Los Angeles, working women have a *multiple-function commute*, which, in addition to work, includes dropping off children at school or daycare, stops at the grocery stores, pharmacies, and so forth.

It is likely that conditions in the UK, and throughout Europe are similar for women workers, although the distances they drive are not as large, due to different land use. The National Travel Survey for the U.K. indicates that there has also been a steady gain in the number of personal journeys where shopping is defined as the main purpose (Table 1). In 1965, about 13% of all trips were for this purpose, and it had risen to about 1 in 5 trips around 1995.. These data are not broken down by gender. For both the US and UK, shopping accounts for about 20% of the average household's annual trips by vehicle, and the majority of these trips are probably made by women.

However, even today, many aspects of shopping do not involve travel and evoke other levels of involvement. For example, Salomon and Koppelman (1988) observed that purchasing goods is just one aspect of the shopping visit. Gould (1998) and Salomon and Mokhtarian (1998) noted that there can be a recreational aspect to shopping related travel. Gould and Golob (1997) broke shopping activities down into two components, the time engaged in the shopping activity, and the time to travel to and from the shopping sites. Using a structural equation model of activity patterns, they found that the need to recoup time spent in travel for shopping purposes would be particularly useful among busy working women with families. For these women, the time to travel could be transferred to other pressing activities or demands. This result is consistent with earlier NPTS (1994) data, which suggests a pattern of increasing complexity in women's travel trips. In order to explore the future role of e-commerce, it is useful to understand more about the travel patterns of busy working women: when do they schedule their shopping, to what extent do they chain their shopping trips to work and other activities? For many reasons, working women are likely to be one of the first groups to adopt e-commerce because they are technologically adept, they must make

continual tradeoffs between in-home and out-of-home activities, and they make the majority of household purchases and transactions.

Table I: Trends in UK Shopping Trips

	Shopping trips per person per year	Average miles per trip	Annual mileage*	Percent of households owning cars	Number of shopping centers	Real consumer expenditure (billion £)
1965	77	3.5	268	42%	50	218.3
1975	115	3.8	440	53%	300	270.2
1985	125	4.6	557	62%	500	323.4
1995	145	5.2	747	68%	990 (1992)	405.6 (1993)

\*excludes shopping trips < 1 miles. Sources: Social Trends (1997), UK DOT (1996)

\*\* British Council Shopping Centre data. Numbers rounded up

Transportation researchers are beginning to explore the impacts of e-commerce (e.g., Kilpapa, *et al.*, 2000, Marker and Goulias, 2000, Martens and Korver, 2000). These recent studies are guided by a series of earlier works that predated the Internet as we know it today (e.g., Koppelman, *et al.*, 1991, Salomon, 1985, 1990, Salomon and Koppelman, 1988, 1992, and Salomon and Schofer, 1988). But it is difficult for travel behavior researchers to keep up with the pace of development. Studies of consumer e-commerce are outdated in that they are relevant to virtual opportunities that are obsolete before the studies are completed. Lacking relevant up-to-date e-commerce data, here we explore what can be learned from investigating existing activity patterns.

### Shopping Chained with the Work-trip

An activity and travel study with a large and representative sample was conducted for the Portland Metropolitan Area in 1994-95. This is the only recent multi-day travel diary in the U.S. with a spatial distribution of stores and households. The spatial distribution is a key variable for studying the influence of virtual accessibility. The survey, of 3,891 households, achieved a distribution of households similar to the 1990 Census although

there was a tendency for low-income households to be underrepresented. There are 6,919 persons in the sample, age 16 or over, and of these, 1669 are women who work out-of-home for four hours or more on one of the survey diary days. This segment represents 46.7% of the 3573 women in the full data set.

We first examine the frequency with which workers engage in a work tour that includes at least one shopping trip. More specifically, we count as a work/shop tour any journey to/ from work that is broken by at least one shopping activity. As expected, women are far more likely than men to engage in work/shopping tours. Less than 10% of all the male workers engage in combined work/shopping trips, compared to about 15% of all women. We did not find much indication that women in lower status professions ran a greater number of errands, or engaged in more work related shopping tours than women in higher status jobs (Table 2). Across all job categories, women shopped more than their male counterparts.

We constructed a logistic regression model that distinguishes between two types of home-based trip chains involving away-from-home work destinations: (1) any chain not involving shopping, and (2) any chain involving shopping. There are 6790 work-involved trip chains, 12.1% (822) of which involve at least one shopping sojourn.

Table 2: Percent of Workers in Select Professions Engaging in Work/Shop Tours

Occupation	Gender	
	Men	Women
Managerial/Professional	10.5	16.4
Sales/ Administration	9.3	16.3
Service	7.6	11.8
Laborers/ Manuf./ Repair	17.3	-
Factory	6.3	16.4

The logit model results are listed in Table 3. The strongest predictors of shopping attached to work trips are possession of a driving license and gender. Female workers

are more likely to shop on the way home from work or during breaks in the work day. Household size, as measured by number of small children, number of older children and number of drivers in the household are negative indicators of work-related shopping. The maximum value of the non-linear age function occurs at age forty-eight.

Table 3: Is a Shopping Sojourn Included in The Home-based Work Trip Chain? (0 = shopping not included / 1 = shopping included)

<b>Exogenous Variable</b>	<b>Coefficient</b>	<b>z-statistic</b>
Gender (+ = female)	.561	6.71
Age	.066	3.00
Age <sup>2</sup>	-.000692	-2.74
Possession of driving license	.634	2.41
Annual household Income > \$60,000	.358	3.69
Number of children in household under 6 years old	-.403	-3.55
Number of children 12 to 17 without license	-.287	-2.44
Number of drivers	-.227	-3.34
Constant	-4.44	-8.59
Initial -2 log likelihood	4079.9	
Final -2 log likelihood	3969.0	
Model Chi-square (degrees of freedom)	110.97 (8)	

We next tested whether accessibility associated with household location affected shopping attached to work trips. Four different accessibility indices were used. Two of the indices are based on detailed land use and transportation network data compiled in a geographical information system (GIS) database maintained by Metro, the metropolitan planning organization responsible for the Portland Metropolitan Area. For each household location, GIS was used to compute total employment and total retail employment within one mile of the household. These indices are at the neighborhood level, capturing accessibility by walking or bicycling or by using personal vehicles for short trips.

The other two accessibility indices are derived from destination choice models used in a traditional (four-step) urban transportation planning system. These measures are



computed for every traffic analysis zone and assigned to the households that reside in that zone. They are the travel time-weighted sums over all zones of logs of attractions from multinomial logit destination choice models. One index used total employment as the attraction, and the second index used total households as the attraction. These indices capture accessibility on a broader scale utilizing the arterial road and mass transit networks. Two of these accessibility indices added significant explanatory power to the logit model shown in Table 3. The expanded model is shown in Table 4.

Table 4: Is a Shopping Sojourn Included in the Home-based Work Trip Chain, with consideration of spatial factors (0 = shopping not included / 1 = shopping included)

<b>Exogenous Variable</b>	<b>Coefficient</b>	<b>z-statistic</b>
Gender (+ = female)	.568	6.76
Age	.0709	3.17
Age Squared	-.000716	-2.82
Possession of driving license	.627	2.39
Annual household Income > \$60,000	.343	3.53
Number of children in household under 6 years old	-.371	-3.26
Number of children 12 to 17 without license	-.269	-2.28
Number of drivers	-.166	-2.35
Accessibility to zonal employment weighted by auto travel times (from destination choice models)	.0068	4.00
Accessibility to total employment within 1 mile of home location (GIS data)	-.0059	-1.90
Constant	-5.06	-9.15
Initial -2 log likelihood	4079.9	
Final -2 log likelihood	3952.8	
Model Chi-square (degrees of freedom)	127.13 (10)	

The improvement in model goodness of fit, as measured by the -2 log likelihood chi-square, is 16.2 with 2 degrees of freedom, which is significant at any reasonable confidence level. The index with the greatest explanatory power was the one that measures access to total regional employment from the home zone. This accessibility is positively related to the propensity to shop when going to or from work. The second

index, total employment within one mile of the home location is marginally negatively significant. That is, controlling for all other effects, persons living in denser areas with mixed land uses are less likely to chain their shopping with their work trips.

## **Discussion**

Our results have implications for the future location of stores (land/use planning issues) and for the choice of transportation to reach these stores. As a baseline, the Portland data establishes that people who live in higher-density areas engage in fewer chained shopping trips. Presumably, these people can make relatively short shopping trips from home, thus avoiding the need to shop on their way home from work.

E-commerce could be channeled as a virtual substitute for the high-density neighborhood. This has important implications for environmental policies which promote mixed development and greater residential densities. In residential areas with fewer stores and outlets, the local gas station or corner shop could become an afternoon pick-up site for groceries, and sundries, ordered earlier in the day. This virtual substitute is dependent, however, on reasonably priced, efficient, and timely package delivery.

The development of localized e-commerce could provide more opportunity for sustainable transport. Commuters could become less car-dependent if personal vehicles were not needed to make multiple after-work stops, and carry goods home. These commuters might also find that they might be able to use public transport or carpools more readily.

For working women, e-commerce holds the greatest promise, providing that there is growth of a reasonable, timely and efficient package distribution system. Working women run more errands on the way home than others; one can imagine that in addition to shopping trips, women might be picking up young children from school or daycare, or going to after-school activities. E-commerce is one aspect of the multi-stop commute, but it might make the number of stops fewer, and less frequent.

It is worth mentioning that the type of merchandise available through e-commerce will also determine whether it evolves as a virtual alternative for the high-density neighborhood. Currently, the majority of Internet purchases are one-off items, or goods such as books, software, and music. Rather, it is the more routine things of daily commerce -- postage stamps, dry-cleaning, fill-in groceries, diapers, and pharmacy runs -- that can usefully be consolidated in a single drop-off. For the most part, these must be provided by local fulfillment centers or middle-men, in order to meet same-day delivery requirements.

### **Agenda for Future Research**

Transportation planners should reopen the issue of what defines accessibility, in view of growing e-commerce. Can accessibility gains be attained by entirely new electronic means? Salomon and Mokhtarian (1998) question whether accessibility attained through (traditional) land use planning or temporal policies (like alternate work schedules) should be considered socially efficient.

Policy makers may wish to consider to what extent the development of e-commerce is socially desirable: will it help to reduce congestion, lessen the need for new roads, and perhaps provide greater flexibility for workers to use mass transit for work tours? If e-commerce is considered to be socially desirable, what actions and policies can facilitate it? Relatedly, we need to examine the logistics delivery system in various countries to determine what are the issues for enhancing the on-demand delivery service.

E-commerce can also be a catalyst in breaking the dependence of the car for shopping, particularly in the US (Handy, 1993). Potentially, those who use mass transit will be among the first group to benefit from e-commerce and virtual accessibility. Commuters who favor mass transit and carpool or vanpools might be studied to see if their travel patterns and activity space are enhanced by travel-less shopping.

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## References

- Cairncross, F. (1997) *The Death of Distance*, Orion Publishing Group, London.
- Edmondson, B. (1994) Alone in the Car, *American Demographics*, June.
- ESRC Transport Studies Unit (1995) *Car Dependence*. A report for the RAC Foundation.
- Forrester (2000). *B2B Insights: eMarketplaces*. Forrester Research, Cambridge MA.  
<http://www.forrester.com/>
- Golob, T.F. (2000) TravelBehavior.Com: Activity approaches to modeling the effects of information technology on personal travel behavior. To be presented at the 9<sup>th</sup> International Association for Travel Behavior Research (IATBR) Conference, Gold Coast, Australia, 2-7 July, 2000.
- Golob, T.F. and M.G. McNally (1997). A model of household interactions in activity participation and the derived demand for travel. *Transportation Research, Part B*, 31: 177-194.
- Gould, J. (1998) Driven to shop? The role of transportation in future home shopping. *Transportation Research Record*, Number 1617: 149-156.
- Gould, J. and Golob, T.F. (1997) Shopping without travel or travel without shopping? An investigation of electronic home shopping. *Transport Reviews*, 17: 355-376.
- Handy, S. (1993) A cycle of dependence: automobiles, accessibility and the evolution of the transportation and retail hierarchies. *Berkeley Planning Journal*, 8: 21-43.

- IDC (1999). *The State of the Internet Economy – Trends Forecast 1998-2003*. International Data Corp, Framingham, MA.
- Kilpala, H.K., P.N. Seneviratne and S.M. Pekkarinen (2000). Electronic grocery shopping and its impact on transportation and logistics with special reference to Finland. Presented at Annual Meeting of the Transportation Research Board, January 9-13, Washington, DC.
- Koppelman, F., I. Salomon and K. Proussalogou (1991). Teleshopping or store shopping? A choice model for forecasting the use of new telecommunications - based services. *Environment and Planning B*, 18: 473-489.
- McKinnon, A. and Woodburn, A. (1994) The Consolidation of Retail Deliveries; Its Effect on CO<sub>2</sub> Emissions, *Transport Policy*, 1(2) 125-136.
- Koppelman, F., Salomon, I. and Proussaloglou (1991) Teleshopping or store shopping? A choice model for forecasting the use of new telecommunications-based services. *Environment and Planning B.*, Vol. 18, pp. 473-489.
- Marker, J.T. and K. Goulias (2000). A framework for the analysis of grocery teleshopping. Presented at 79<sup>th</sup> Annual Meeting of the Transportation Research Board, January 9-13, Washington, DC.
- Martens, M.J. and W. Korver (2000). Forecasting the mobility effects of teleservices using a scenario approach. Presented at Annual Meeting of the Transportation Research Board, January 9-13, Washington, DC.
- Mokhtarian, P.L. (1997) Now that Travel Can be Virtual, Will Congestion Virtually Disappear? *Scientific American*. October. <http://www/sciam.com/1097issue>.
- NPTS (1994) *NPTS Urban Travel Patterns*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC.
- NPTS (2000). *Our Nation's travel: 1995 NPTS Early results Report*. National Personal Transportation Survey, U.S. Department of Transportation, Washington. <http://www-cta.ornl.gov/npts/1995/Doc/publications.shtml>.

- Pisarski, A. E. (1992) *New Perspectives on Commuting*. Report prepared for U.S. DOT, FHWA. Office of Highway Information Management, Washington, D.C.
- Pool, I. de Sola, (1983) *Forecasting the Telephone: A Retrospective Technology Assessment*. Ablex Publishing Corporation. Norwood, N.J.
- Salomon, I. (1985). Telecommunications and travel: substitution or modified mobility. *Journal of Transport Economics and Policy*, 19: 219-235.
- Salomon, I. (1990). Telematics and personal travel behavior, with special emphasis on telecommuting and teleshopping. In H.H. Soekka, et al., eds., *Telematics, Transportation and Spatial Development*, 67-89. VSP, Utrecht.
- Salomon, I. and Koppelman, F. (1988) A Framework for studying teleshopping versus store shopping, *Transportation Research, Part A*, 22: 247-255.
- Salomon, I. and F. Koppelman (1992) Teleshopping or going shopping: an information acquisition perspective. *Behaviour and Information Technology*, 11: 189-198.
- Salomon, I. and Mokhtarian, P.L. (1998) What happens when mobility-Inclined market segments face accessibility-enhancing policies? *Transportation Research, Part D*, 3: 129-140.
- Salomon I. and J. Schofer (1988). Forecasting telecommunications-travel interactions: the transportation manager's perspective, *Transportation Research, Part A*, 22: 219-229.
- U.K. Office for National Statistics (1997). *Social Trends 27*. The Stationery Office. London.
- U.K. Department of Transport (1996) *Transport Statistics*. The Stationary Office, London.