

**ICT and Travel in the Twin Cities Metropolitan Area:  
Enacted Patterns Between Internet Use and Working and Shopping Trips**

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**ABSTRACT**

The relationship between travel and telecommunications is now viewed as multifaceted: telecommunications can substitute for trips, telecommunications can modify trips, and telecommunications can stimulate trips. While this complexity is recognized, there is less empirical evidence on the exact manners by which these various interrelationships occur. And in particular, there is a paucity of data on how new forms of telecommunications—particularly high bandwidth—affects the patterns of behavior between telecommunications use and travel.

This paper aims to further the discussion on the nature of information and communications technology (hereafter ICT), by focusing on work and shopping behavior at the household level. To do so, researchers examined the implications of home ICT access for residential travel behavior in and around Minneapolis, Minnesota. While targeted technologies included those that transmit voice and data (e.g. telephone and email), understanding how *home* Internet access via broadband, instead of slower dial-up connections, might influence repetitive travel behaviors (e.g. work commutes, shopping) is a key area of interest.

## ICT and Travel in the Twin Cities Metropolitan Area: Enacted Patterns Between Internet Use and Working and Shopping Trips

### PART I: BACKGROUND

The effect of technology, and more specifically ICT, has been examined on a number of levels in previous work (1). Toffler (2) suggested that ICT developments will make cities obsolete, and Lehman-Wilzig (3) projected that telecommunications might eliminate all travel. Indeed, several extensive discussions about how technology may impact urban life and land development patterns now exist (4-7).

In perusing the work that relates ICT and household travel (see, for example, 8 – 11) the central questions and issues associated with this line of inquiry begin to emerge. The bulk of the literature focuses on telecommuting, with a few studies (for example, 12-13) investigating e-shopping and its relationship with personal travel behavior. Many of the existing works regarding non-work commute impacts, however, are more hypothetical and theoretical. Most of the empirical shopping studies group e-shopping with shopping by catalogue, television, fax or telephone, rather than isolating it as an activity over the Internet. (14) Few studies have examined whether the speed of a household's connection to the Internet had an impact on their work or shopping travel behavior.

This study aims to contribute to the ICT-travel literature by empirically examining the implications of ICT for work and shopping trips, with a particular interest in the effects of broadband connections.. To frame the research, existing studies are reviewed, with emphasis on theoretical conceptualizations relating to this study's variables. Research questions are posed after the literature review. In the sections following, results of data collected via a residential survey and time use diary are analyzed before conclusions and suggestions for further research are presented in the final section.

### PART 2: PREVIOUS RESEARCH

#### A. ICT Activities and Their Effect on Travel

*Enacted Travel: A Conceptual Framework for Analyzing ICT's Relationship to Travel.*

Prior research (see, for example, 6, 20,) suggests individuals often engage in shopping and errand-running behavior concurrent with the work trip, and ideally, ICTs would replace these trips, which are often made by automobile and/or by single individuals. However, technology's influence appears to be more complex. Orlikowski and Iacono (54) therefore argue against more deterministic perspectives in favor of an "enacted" view of the relationship between technology, economic systems, and imbedded behaviors, such as trip making. In the former conceptualization, research attempts to measure and attempt to model the changes *caused* by technology or attempt to predict behaviors based upon strategic choice. Conceptualization of the relationship between ICTs and human behaviors, Orlikowski and Iacono argue, should adopt an enacted view, which targets analysis towards the patterns that emerge through the synergistic shaping of technology, human actions and contextual factors. This perspective allows consideration of the often unintended, nonlinear consequences of the relationship between technology and human activities and the questions posed extend beyond a purely substitutive effect of telecommunications technology on travel, instead exploring how such technologies might be integrated into and result in complex new and unforeseen behaviors.

This argument is paralleled in the transportation literature. Salomon provided the initial outline for this interaction (11, 41) by identifying four potential different types of interaction. First listing substitution, Solomon's framework expands to include more complex interactions including modification, enhancement, and neutrality. This typology frames subsequent discussion and analyses (15, 42, 43), and is employed here as a means to discuss the anticipated impacts of ICT on activities associated with trip-making. In brief:

- *Substitution* of travel refers to ICT improvements resulting in physical trips no longer being necessary. This interaction has been the focus of most ICT research, and the substitution of trips, by definition, is a phenomenon inherent in the term telecommuting. (10) Estimates of actual occurrences have been smaller than anticipated. (15, 47)
- *Modification* refers to travel that is altered by a shift in the timing and routing of trips. It may also refer to the manner in which trips are linked together (i.e. trip chaining) or even the mode of travel. The benefits of shifting even a small amount of peak hour travel to different times (through e-shopping and telecommuting)

are often strategies for reducing levels of congestion. While it is becoming clear that ICT will modify travel behavior (20, 44, 45), it is still unclear in what manner (e.g. more travel or less).

- *Generation* refers to any generation of travel that would not have occurred but for the existence of ICT. Little is known about how ICT may generate additional traffic, outside of a theoretical elasticity effects on discretionary travel. This lack of information is largely due to the difficulty in determining causality and a lack of time-series data before and after ICT enhancement and deployment.
- *Neutrality* refers to those instances in which ICT has no foreseeable effect on household travel behavior.

In keeping with the enacted view, one can envision how the potential to substitute telecommunications for travel is mediated by the circumstances and desire for travel. To help understand where substitution may have its strongest and weakest effects, researchers use the common conceptual distinctions between subsistence, maintenance and discretionary forms of travel. (16 - 19)

Subsistence activities, when viewed relative to ICT, refer to individuals working at home or other remote locations, or telecommuting. Interest in this relationship between ICT and the work trip stems from the potential of relieving peak hour traffic congestion by reducing or modifying people's work trip.

Maintenance activities include the purchase and consumption of convenience goods or personal services needed by an individual or household, but there is a lack of knowledge about how ICT affects them. The bulk of maintenance travel-related literature focuses on shopping, as opposed to other maintenance-type activities, such as banking or paying bills.

Leisure, or discretionary, activities comprise voluntary activities performed on free time, that is, time that is not allocated to work or maintenance activities. While this topic has received the least amount of study it may be among the most dynamic in terms of ICT travel tradeoffs.

### **B. E-Work: The ICT-Work-Travel Relationship**

Interest in this relationship between ICT and work travel stems from the potential of relieving peak hour traffic congestion by reducing or modifying people's work trip. This aspect of ICT has been the target of the overwhelming majority of all studies of ICT use (15, 20 – 30) for a number of reasons including: transportation planners and modelers have long focused on the work commute, and work related activities tend to be more stable and predictable.

Telecommuting has proven to be a more elusive topic for study than expected. Methodological issues, including a continued lack of consensus in defining telework, have complicated efforts. Across research, sampled respondents display a range of behaviors limiting the utility of cross-study comparisons. (9,31, 32) Several studies have attempted to gain a better understanding of which behaviors should be included under the telework construct, which may include salaried employees who work at home, paid employment from a telecenter, home-based businesses, distributed work teams, mobile work forms (e.g. mobile sales teams, on-site customer support), geographically dispersed work teams, after-hours work, and so forth. (See, for example, 21-23,33,34). Each of these forms could have broad ranging connotations for community growth and design, land use, economic growth telecommunications-facilitated service demand, and other community systems (6, 32).

Mokhtarian (24) has attempted to assemble the substantive findings to date under a unified framework by examining current knowledge in forecasting the demand for telecommuting and the resulting transportation impacts. While this information has settled that telecommuting does affect trips, it also shows that these effects are not uniform, and, in some cases, the results have been contradictory. Some studies have found that telecommuters reduce their number of trips and distance traveled on telecommute days (20, 45-47), on non-telecommute days (45, 46), or on net travel (see 24 for other reviews, 48), while others put forward evidence of travel stimulation or generation (8, 11, 15, 26), sometimes only on non-telecommute days, or for non-work trips (20, 47).

Wells et.al. (20) and Pratt (47) suggest that the actual impact may vary with the type of telecommuting in which one is engaged, that is, those that engage in full time work at home tend to demonstrate the most changed travel behavior, while those who telecommute a few days per week or less tend to maintain pre-telework behavior. Pratt summarized the results of telecommuting surveys to date as showing telecommuting has proven to be less effective trip reduction solution than hoped. (47) Failing a profound change on the current workplace environment, telecommuting's impact will be found in modification of trips, rather than direct substitution.

### **C. E-Shopping: The ICT-Shopping-Travel Relationship**

In examining the effect of ICT on shopping and related travel, Gould (49, 50) offered an overview of the transportation implication emerging from home shopping and on-line commerce, focusing on possible changes and

demands placed on delivery services, the possibility of goods with no physical delivery, and the possible growth of new retail venues. Marker and Goulias (42) outlined issues as they relate to the effects on traffic (e.g. substitution, consolidating loads, trip chaining), forms of delivery, and methods in modeling such activities as the developed a framework for understanding and estimating the use of ICT and grocery shopping. Lin and Mahmassani (51) also examined the grocery shopping relationship, including some suggestion as to why on-line grocery shopping firms were not succeeding. They concluded that this failure was due to accelerating delivery costs as the number of customers increased, and that a significant part of this cost increase was the need for more trucks to meet the tight time windows desired by customers. Intrinsic to this finding is that vehicle trips increase to the point that few physical trips to the grocery store are replaced.

A few empirical studies on ICT and maintenance travel have been carried out. Handy and Yantis (40) examined the potential substitutability of three different activities: movie watching, shopping (non-grocery) and banking, which were chosen to represent the spectrum of potential nonwork activities. The authors conducted a household survey in three different cities to explore individual use of and choices about each of the activities. The results suggest that the relationships are quite complex, and not conducive to substitution, since certain qualities of the physical trip were not duplicable by the ICT-facilitated in-home version.

Casas and colleagues (13) compared the travel behavior of e-shoppers with non-e-shoppers using data from a household travel survey of 3,931 households in Sacramento, CA. The survey concentrated on weekday travel, using interviews and one-day travel diaries, and the results showed that 37 percent of respondents had used the Internet to either search for product information or purchase a product. The study also showed that these shoppers made more shopping trips, as well as more trips of all kinds, than those shoppers that had not used the Internet to search for information or make a purchase. These high trip rates were also associated with income and age, which led the authors to attribute the increased Internet use to the more active lifestyle overall of these shoppers, leading the authors to conclude that e-shopping can ease the lifestyle of busy people, but it does not have a great impact upon whether the shopping trip itself is made.

To characterize the nature of study variables, researchers have developed (16) and employed (17, 18, 19) a broad typology of three travel activity behaviors. Salomon and Koppelman provided a theoretical framework to understand the relationship between home-based shopping and store-based shopping in 1988 (35); this framework was supported later by empirical investigation (36). While their work largely analyzed telephone shopping, which is distinguishable from shopping through ICT use (37), it still informs this work in two ways. First, they distinguished between the act of shopping (the acquisition of information) and purchasing an item, which is of growing importance to ICT activity. Second, they introduced the concept of dividing merchandise selection into a number of steps.

Couclelis (38) provided a more detailed task breakdown that is better tailored to ICT purchases, but several studies have instead focused on motives for engaging in these activities. Farag (14) found that convenience and timesaving are cited most often as reasons for on-line shopping and that these factors are tempered by individual and household characteristics, as well as product characteristics. "Search" goods, such as books and CDs are more suited to on-line purchase than "experience" goods, such as fresh vegetables. Farag concludes, however, that more detailed analysis of the role these personal and household characteristics play in online shopping behavior is necessary before reliable results are generated.

#### **D. Connection Speed and ICT Use**

As high-speed home connections are rather new opportunities for typical homeowners, most of the studies above assumed dial-up speeds. However, Pratt (47, 52) argues that broadband will help make ICT-enabled interactions more commonplace as it provides such advantages as an "always-on" connection, which reduces the time required for conducting business, more graphic-intensive content and potential for video and audio transfer as well as data.

Horan (6) suggests that increased connectivity will create new arrangements with a potential for altering trip making behavior, due to new opportunities for relocating institutions into more centralized locations. He suggests the possibility of new "enacted" interactions, in which homes function as part-time workplaces (due to telecommuting), schools provide a wider range of educational options (due to electronic content access), and stores would integrate e-commerce with traditional operations.

Hampton and Wellman (53) examined how broadband connectivity would impact the social dimension of communities by using a longitudinal survey and conducting interviews in a new development where residents had access to high speed Internet and related broadband-enabled technologies (telephone, entertainment, etc.). They found that the residents used their higher speed connections to access people and information that were "just out of

reach” geographically (50 – 500 km), suggesting that higher speed access may instead serve as an additional mode that allows people to expand the area used for their activities.

## E. Research Questions

This work revisits the real-world effects of ICT using a larger existing community setting as a context for an applied examination of the relationship between ICTs and travel. Recognizing the dynamism of the setting, this project draws upon the “enacted” perspective, paying attention to often-unintended results of the interaction between ICTs and activities. The questions posed explore the potential integration of telecommunications technologies into travel behavior and how they might result in complex new travel and travel-related behaviors. Questions include:

Research Question 1:

- What are the connections between e-work and (subsistence) travel behavior?

Research Question 2:

- What are the connections between e-shopping and (discretionary / maintenance) travel behavior?

Research Question 3:

- How does broadband access affect e-work and e-shopping?

These research questions were addressed through a multi-method data collection effort involving a general survey and in-depth travel diaries. After discussing the methodology, and the demographics for the each group, the first two questions are addressed, with the third question (broadband) addressed as a subset of each.

## PART 3: METHOD

### A. Design and Sampling

The study design calls for comparison of behaviors across three groups demarcated by differential access to telecommunications. Study groups include: (1) residents who do not have access to or use home Internet [no access], (2) those whose connection to the Internet is made via dial-up modem [slow access], and (3) residents who have access to broadband at home (principally DSL and cable) [high-speed access].

A 2001 Minnesota Department of Commerce study shows that Internet access is not ubiquitous, and that still fewer households have access to broadband. 45% of all telephone exchanges or wire centers in the state had DSL available and access to cable modem depended upon location whether one lives in a “metro” community (75% have access) or in a “non-metro” area (only 5%). (55). To identify the zip codes in the Twin Cities area that were likely to have households that connect to the Internet through DSL and cable modem, the researchers obtained data from an annual survey conducted by Claritas, Inc. Census data was then used to compare other aspects (size, location, etc.) of those communities, and four zip codes were selected: 55406 and 55407 in South Minneapolis and 55044 and 55124, which are located in Lakeville and Apple Valley, two 2<sup>nd</sup>-tier suburbs south of Minneapolis. Addresses were chosen using simple random sampling. Population size was similar across the four communities (55124 had 46,500, and the other three were between 33,000 and 37,000), and an equal number (500 residents) were selected from each cluster.

### B. Data Collection Procedure

Data were collected through a general survey and daily diary. First, a general survey instrument was mailed to 2000 residential addresses in the selected zip codes. It queried both specific behaviors (ICT access and use at home and work, travel behaviors related to shopping, work, and errands, and work characteristics amenable to ICT use, such as scheduling) and general attitudes (especially physical shopping versus ICT-enabled shopping). Heads of households were asked to complete the survey within three weeks, and a follow-up reminder postcard was mailed one week after the survey. Respondents received a University of Minnesota pen as a token for their efforts.

A second phase daily diary was developed in tandem with the general survey to provide a more in-depth look at the details and intricacies of the relationship between ICT and travel as they were enacted over a four-day period (Friday – Monday). Diary participants represented volunteers from the general survey. Respondents were contacted via email, provided a password, and every household member aged 18 and older was asked to describe his/her trip-making behavior for each day. Participating households received \$20.00 cash money.

## C. Participants

### *Survey Participant Characteristics*

Of the 2000 surveys mailed, 446 were returned, for a 22% response rate. Response rates were even across zip codes, with a low of 104 responses from 55124, and a high of 116 from 55406. Compared with 2000 Census figures, participants were older than the overall population in each zip code: median respondent ages ranged from 46 – 50, while median population ages ranged from 30 - 37. Men also were over-represented among respondents except in 55407 (only 41.5% of all respondents), and the percentage of respondents with incomes higher than \$50,000 per year was higher in 3 of the 4 zip codes. The only area where this was not the case was 55124, where 68.2% of the sample had the threshold income, and 69.6% of the population did.

### *Diary Participant Characteristics*

Of the 446 households that participated in the General Survey, 98 volunteered to participate in the diary. As the diary was addressed to persons and not households, an additional 72 members of the volunteering households also chose to participate in the diary, for a total of 170 respondents. This resulted in a more even balance between men (48%) and women (52%), with other basic demographics remaining similar to the survey.

## PART 4: RESULTS

### A. Respondent ICT Access

Access to both home and work computers is high (65%) across survey participants in general. Excluding non-workers (e.g. retirees), 80% of working participants have dual access. Most survey respondents do have access to home computers and the Internet, with nearly equal numbers accessing the Internet at home at work.

### B. Fast-Netters: Exploring the Use of Home Broadband

To initiate exploration of the impact of access to home broadband on daily activities, survey respondents who connected to the Internet were asked if they used dial-up modem, DSL, Cable or ISDN, T1 or faster, or other. Nearly half (47% or n=209) of those responding to this question selected dial-up modem. Approximately 20% indicated that they rely upon DSL, Cable or ISDN for their Internet connection.

More respondents with “fast” home Net connections in this sample were male (62%) than female (37%). Access to home broadband was positively related to income. Fast-netters also tended engage in professional/managerial and technical work. They also are well-educated with 32% college graduates, while 17% have earned a graduate or professional degree. A significant negative correlation between access to fast Net and age ( $r=-.208$ ,  $p < .001$ ) suggests that younger respondents are more willing to pay for faster home Net connections.

The diary results indicated that this group might also have different travel behaviors. Twenty-five percent of the diary participants had a broadband connection, and the results showed they made fewer trips than those with dial-up or no connection. (Average of 12.4 trips per day vs. 14.6) However, other factors, such as trip distance or number of shopping trips, did not vary significantly. These points will be further discussed in subsequent sections.

### C. Work, E-Work, and Travel

Keeping with the attitude of an enacted relationship between behaviors and ICTs, researchers included all forms of mobile work that are facilitated by access to telecommunications or that might allow strategic use of ICTs. These e-workers, or flexers, engage in *compressed work weeks* (work 40 hours over fewer than 5 days), *telecommuting* (work some portion of the work schedule from home or a satellite office), and/or *flexible arrival/departure schedules*.

#### *1. Profiling the E-Worker: Demographics, ICT Access and Use.*

34% of respondents (n=153) report that they participate in one of the three flexible work schedules described above. Those engaged in flexible arrival/departure times comprised the largest group (n=109). Participation in one form, however, did not seem to preclude engagement in another. For example, many telecommuters also engage in flex

schedules. Altogether, thirty-seven respondents telecommute; with a single exception these individuals worked from home.

Compared to those respondents not engaged in flexible work schedules (n=213), e-workers seem to have greater access to and be more frequent users of ICTs. More than 85% of e-workers indicated they use computers at home and at work, and access the Internet, compared with less than 42% of non-e-workers.

It may be that differences in ICT access and use evident between e-workers and their office-bound counterparts results from distinctions in occupations, as task demands and workplace policies restricting access were most often cited as reasons for not engaging in flexible work scheduling. In this study, a greater percentage of e-workers are indeed engaged in managerial or professional occupations as well as technical positions. More non-e-workers are involved in occupations that mandate their presence at work during specified time periods, including service, clerical/administrative, and farm/laborer work.

## 2. *Work Commutes and the E-Worker.*

As discussed in part 2, the expected influence of ICT on work trips is modification rather than substitution. The results from this study show that traffic is a significant consideration, and e-workers may be using new work paradigms to avoid the most congested travel. While results do not show that e-workers travel different distances, they may leave later, supporting the theory that ICT can contribute to spreading travel peaks.

Fifty-six percent of all respondents reported they travel to and from a primary workplace (or school in the case of students) an average of 5 days during a typical week, and most drive alone for this trip. In the survey, 198 indicated this mode was used 5 days per week, and diary results showed that in 89% of all trips, the respondent drove a car. Usage of alternative modes was sporadic: 26 indicating use of a mode other than driving alone. Use of alternate modes fewer than 5 days per week (e.g. in combination with driving alone) was even less common.

Survey respondents reported they travel an average of 13.2 miles, one-way, to work or school with the distribution peaking (around 145 participants) at 10 miles; with an overall average time of 47.6 minutes for the morning commute. Diary results indicate that respondents may be exaggerating their distance, however, as the weekday distances were recorded as between 15 and 20 miles per day (21.26 on Friday and 15.08 on Monday), even though total travel time was similar: 70-90 minutes (89.76 minutes on Friday and 71 minutes on Monday). Among the survey respondents who do engage in flexible work schedules (n=147) the mean one-way commute was reported as 13.73 miles. However, results of an independent samples t-test reveal this difference is not statistically significant [ $t(353) = .558, p = .577$ ].

When asked to select the reasons for engaging in a flexible work schedule, 2 of the 3 most common reasons were transportation-related: "To avoid rush hour (50/153)," and "Can take care of personal errands more easily (45/153)." In the morning departure hour, non-e-workers on average leave home 20 minutes earlier (7:00 a.m. while e-workers depart around 7:20 a.m.). Similar results are revealed in time for departure home where e-workers (5:30 p.m.) tend to leave the office an average of 21 minutes later than non-e-workers (5:09 p.m.). However, these results were not statistically significant, indicating that while e-workers are not yet impacting peak period travel.

## 3. *E-workers and "Overwork."*

A more intriguing relationship is shown between work behaviors and flexible work schedules in responses to a survey item that explores "overwork." Asked, "Do you ever do work for your job at home over the Internet?" Survey participants were presented with four items:

- I use the Internet to do work from home before work hours
- ...after work hours
- ...during the work day
- ...on the weekends

Respondents were asked to indicate with what frequency (using a scale of 1 = never to 6 = every work day) they engaged in any of the above behaviors and results show a positive and significant relationship with each overwork variable. Net use before work had a correlation of .209, after work, .207, and weekends .209, all of which were significant at the .01 level (2 tailed analysis). Combined with the suggestion that participants engage in flextime in part to avoid traffic, these findings suggest that e-workers may attempt to maintain or expand normal work hours while adjusting their commute time.

#### 4. *Fastnet and Work Travel.*

Sample fast-netters were in knowledge workers (e.g. professional or technical). Also, while a fast home Net connection is unrelated to engagement in flexible work schedules overall, it is related to telecommuting behavior in this sample ( $r = .193$ ,  $p = .05$ ).

**Overwork and Fast-netters.** Related to the type of work in which fast-netters are engaged, most of these knowledge workers also tend to “overwork.” That is, similar to flexers as group, high speed home Net connections are positively related to engagement in *work from home* before ( $r = .154$ ) and/or after ( $r = .125$ ) scheduled work hours and during the work day ( $r = .131$ ). These were significant at the .05 level in a 2-tailed analysis.

### D. Exploring the Relationship between ICT and Shopping

#### 1. *Profiling the E-Shopper: Demographics, ICT Use and Access*

Previous research (13 and 14) suggests that personal characteristics can influence whether one engages in e-shopping behavior. A number of differences emerge from a comparison of surveyed e-shoppers with non-e-shoppers. For example, in reported education level, a greater percentage of e-shoppers have a college degree (35.2% versus 28.9%) or a graduate degree (20.9% e-shoppers versus 17.1% non-e-shoppers). E-shoppers also are more likely to work full-time (77.6% versus 62.7%), be married (66.2% versus 59.2%) and have children living at home (52.1% versus 44.7%). While not statistically significant, the differences suggest an overall strategy, perhaps, toward employing ICTs as a tool to handle busy lives with multiple demands.

Analyses show that e-shoppers tend to have greater access and use ICTs to a greater extent than those who do not engage in on-line shopping. Not only were E-shoppers more likely to have access to ( $X^2(1, N=291) = 5.407$ ,  $p = .020$ , Cramer's  $V = .136$ ) and use ( $X^2(2, N=344) = 22.434$ ,  $p < .001$ , Cramer's  $V = .255$ ) a home computer, they were also more likely to have access to and use a computer in their jobs ( $X^2(2, N=356) = 21.57$ ,  $p < .001$ , Cramer's  $V = .246$ ). As suggested above, however, it may not be accurate to assume access to technology alone is the driving factor in e-shopping, as increased income seems to enable access to technology and new forms of shopping behavior.

#### 2. *Shopping-related Travel.*

Respondents were also asked about errand-running behavior. Most respondents indicated that they ran errands “on the weekends” ( $n=144$ ) followed by “during the day” ( $n=94$ ) and “while commuting to/from work” ( $n=72$ ) was a close third. A clear majority of participants ( $n=425$  or 95% of the sample) also selected “car” as the preferred mode for their errand running. Other possible forms included public transportation, and walk/run/bike.

To further explore the thought suggested in the literature review that Net shopping might not replace shopping trips, a number of survey items explored other possible and more complex interactions between ICTs and travel. These exploratory items probe:

1. on-line purchasing behavior (*substitution* for respondent travel)
2. browsing the Net before making a trip to shop (*substitution* for “exploration” trips)
3. use of the Net for item previews before making a trip to buy (*modification* – increasing trip efficiency)
4. extent to which Net browsing has led the respondent to make a shopping trip s/he would not otherwise have made (*generation*)
5. Net searches with the purpose of making shopping trips faster/more efficient (*modification*)

Survey results showed that respondents do engage in trip substitution behaviors as well as Net behaviors that might modify shopping-related travel. Of those that engage in some e-shopping behavior, 64% indicated that they had purchased items from on-line vendors, and 62% reported pre-purchase browsing on-line. However, on-line purchasing behavior was somewhat infrequent. When asked to indicate with what frequency they made on-line purchases, more participants noted doing so “several times per year” (48%).

Response patterns indicate more frequent browsing behavior than that revealed for actual on-line shopping. For example, more respondents indicated that they browse “every week” (14% vs. 3%) and “several times per month” (29% vs. 14%). Regarding whether browsing modified or generated shopping trips where a purchase was made, 52% of respondents indicated that they searched the net to make their shopping trip more efficient, and 32% perceived that their use of the Net for browsing generated a trip.

Two survey items explored whether nearby physical shopping areas might influence use of the Net as a shopping tool. The first explores maintenance shopping accessibility and appears as: *How close to your home are places where you can buy everyday convenience items (e.g. milk, bread, pharmaceuticals)*. A cross tabs evaluation reveals clustering of convenience shopping access along two response categories (within walking distance and a short drive). However, Net shopping was infrequent enough that there was not a statistically significant relationship between convenience (14.9% of all diary trips) shopping and Net purchasing frequency ( $X^2(4, N=281) = .687, p = .953$ , Cramer's  $V=.035$ ). Results of cross tab analysis describe a statistically non-significant relationship between "comparison" shopping and Net purchasing frequency and Net shopping frequency ( $X^2(6, N=282) = 2.348, p = .885$ , Cramer's  $V=.091$ ). The diary results further diminish the impact of comparison trips, comprising only 6.3 percent of all trips recorded.

### 3. Fast-netter Shopping and Errand-running Behavior.

In terms of home Internet connection speed, e-shoppers are more likely to have broadband (e.g. DSL, Cable) and non-e-shoppers tend to rely more upon slower dial-up modem ( $X^2(1, N=291) = 5.407, p = .020$ , Cramer's  $V=.136$ ). In terms of the possible substitution effect between ICT and shopping travel, results show a positive, significant correlation between frequency of net purchasing and Fast Net ( $r = .142$ ; significant at  $p = .05$ ). However, the effect is rather weak and Net shopping overall is infrequent. Instead, findings suggest high-speed access might modify and in some cases even stimulate shopping and errand-running forms of travel. A significant relationship was shown between all e-shopping behaviors and access to home broadband. The correlations between Fast-Net and the likelihood of respondents to browse the Internet before making a trip ( $r = .337$ ), preview an item before a trip (.343) and/or use an Internet search to increase travel efficiency (.239), suggest broadband users use the Net as a means of increasing trip efficiency. (All were significant  $p < .01$ ) A significant relationship was shown, however, with browsing the Internet leading to an *additional* shopping trip ( $r = .159, p < .01$ ) indicating that fast-netters may not only use the Net to balance work and home demands, but also as a recreational release, i.e. they may be engaging in virtual "window shopping."

**Fast-netters use of Net Services.** Beyond shopping, respondents were asked if they used the Internet to access other information and services. Survey results showed that *education* (school work, library access and online classes), *information acquisition* (read on-line news/magazines, information regarding community events, to access local government information/services), *entertainment* (chat, games, music), and *financial services access* (banking, bills, insurance) were related to household broadband access. Diary results further explained the potential of ICT to influence non-shopping or work travel behavior by showing that over one-third of the ICT-influenced trips were for "social / recreational" or "personal" purposes.

## PART 5: CONCLUSIONS AND FUTURE RESEARCH QUESTIONS

The impact of ICT on work and shopping trips is only beginning to be understood, and the influence of residential broadband connections is even less clear. However, the literature reviewed and data obtained in this study suggest a few lessons, especially for transportation planners.

First, e-workers take advantage of ICT to modify their commutes without impacting their workday. Many appear to use ICT before or after work to maintain contact with their office while leaving for or from work at times later than the common peak. While use of telecommuting as a direct substitute for the work commute is rare in this sample, most that do have broadband connections, indicating that the true telecommuting "boom" may yet occur, if broadband connections become more common.

However, these e-workers are a select group: managerial, professional or technical employees, where physical presence at specified times is less important. In areas where these workers do not make up a large percentage of the workforce, increased ICT connection speed and use may have little impact.

Second, e-shopping broadens the range of shopping activities from home. While direct substitution-type activities appear less frequent and seem to have little impact in this sample, people seem use the Internet to modify their shopping behavior, by either browsing for products before leaving home, or by using the Internet to make their trip more efficient. However, broadband users were more likely to use the Net to *generate* a trip than dial up uses, and income was correlated with both e-shopping behavior and broadband subscriptions. Taken together, these indicate that an improved economy and improved connectivity may have a significant multiplier effect on leisure or discretionary travel.

This research also raises new questions. Most important among these are the relationship between broadband use and the users: will younger people continue to be more likely to pay for this service, or will it become more ubiquitous? And, if it is the latter, will older people take advantage of the improved connections in different ways? Further, more work is needed to understand the products most conducive to e-shopping, attitudes and preferences of e-shoppers, as well as more empirical analyses of the travel implications of growth in these areas. Regardless, it continues to appear that the impacts of ICT on travel behavior are only beginning to be seen.

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**REFERENCES**

- (1) Golob, T., *TravelBehavior.com: Activity Approached to Modeling the Effects of Information Technology on Personal Travel*, Report Prepared for the Institute for Transportation Studies, University of California, Irvine, May 2000.
- (2) Toffler, A., *The Third Wave*. 1980 New York: Bantam Books.
- (3) Lehman-Wilzig, S., *Will Cities Become Obsolete?* Telecommunications Policy, 1981. **5**: p.326-328
- (4) Mitchell, W.J., *Electronic Cottages, Wired Neighborhoods and Smart Cities*, in *Smart Growth: Form and Consequences*, T.S. Szold and A. Caronel, Editors. 2002, Lincoln Institute of Land Policy: Cambridge, MA. P. 66-81
- (5) Moss, M.L. and A. Townsend, *How Telecommunications Systems are Transforming Urban Spaces*, in *Cities in the Telecommunication Age: The Fracturing of Geographies*, J.O. Wheeler, Y. Auyama, and B. Warf, Editors.2000, Routledge.
- (6) Horan, T. *Digital Places: Building Our City of Bits*. 2000 Washington, DC: Urban Land Institute
- (7) Henton, D. and Walesh, K. *Linking the New Economy to the Livable Community*1998 San Francisco: The James Irvine Foundation
- (8) Mokhtarian, P.L. and I. Salomon. *Emerging Travel Patterns: do Telecommunications Make a Difference*, in *Recent Developments in Travel Behavior Research*. 1997. Austin, TX: Oxford
- (9) Handy, S., and P. L. Mokhtarian. *Planning for Telecommuting*. Journal of the American Planning Association, 1995, **61**: pp. 99 – 112.
- (10) Golob, T.F. *Travelbehaviour.com: Activity Approaches to Modeling the Effects of Information Technology on Personal Travel Behaviour*, in *Travel Behavior Research, The Leading Edge*, D. Hensher, Editor. 2001, Elsevier Science/Pergamon: Kidlington, Oxford. pp. 145- 184
- (11) Salomon, I., *Telecommunications and Travel Relationships: A Review*. Transportation Research A, 1986 **20**(3): pp. 223-238
- (12) Golob, T.F. and A.C. Regan, *Impacts of Information Technology on Personal Travel and Commercial Vehicle Operations: Research Challenges and Opportunities*. Transportation Research C, 2001 **9**: pp. 87-121.
- (13) Casas, J., J. Zmund and S. Bricka, *Impact of shopping via Internet on Travel for Shopping Purposes*. Paper No. 01-3393 presented at the Transportation Research Board 80<sup>th</sup> Annual Meeting January 2001, Washington, D.C.
- (14) Farag, S. et. al. *Exploring the use of e-shopping and its impact on personal travel behaviour in the Netherlands*. Paper No. 03 – 3058 presented at the Transportation Research Board 82<sup>nd</sup> Annual Meeting January 2003, Washington, D.C.
- (15) Mokhtarian, P. L. *A Typology of Relationships Between Telecommunications and Transportation*. Transportation Research A, 1990. **24**(3): pp. 231- 242
- (16) Reichman, S., *Travel adjustments and lifestyles: A behavioral approach*, in *Behavioral Travel – Demand Models*, P. R. Stopher and A.H. Meyburg, Editors. 1976, Lexington Books: Lexington, MA pp. 143-152
- (17) Pas, E., *Analytically Derived Classifications of Daily Travel-Activity Behavior: Description, Evaluation, and Interpretation*. Transportation Research Record, 1982 **879**: pp. 9 - 15

- (18) Pas, E., *The effect of selected sociodemographic characteristics on daily travel-activity behavior*. Environment and Planning A, 1984. **16**: pp. 571-581
- (19) Bhat, C., and F. Koppelman *A Conceptual Framework of Individual Activity Program Generation*. Transportation Research, 1993. **27A**(6): pp. 433-446.
- (20) Wells, K., *et al.*, *Telecommuting Implications for Travel Behavior: Case Studies from Minnesota*. Transportation Research Record, 2001. **1752**: p. 148-156.
- (21) Mokhtarian, P.L. and I. Salomon, *Modeling the Choice of Telecommuting: Setting the Context*. Environment and Planning A, 1994. **26**: p. 749-766.
- (22) Mokhtarian, P.L. and I. Salomon, *Modeling the Choice of Telecommuting: 2. A Case of the Preferred Impossible Alternative*. Environment and Planning A, 1996. **28**: p. 1859-1876.
- (23) Mokhtarian, P.L. and I. Salomon, *Modeling the Choice of Telecommuting: 3. Identifying the Choice Set and Estimating Binary Choice Models for Technology-based Alternatives*. Environment and Planning A, 1996. **28**: p. 1877-1894.
- (24) Mokhtarian, P.L., *A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel*. Urban Studies, 1998. **35**(2): p. 215-241.
- (25) Nilles, J.M., *The Telecommunications-Transportation Tradeoff: Development of Policy*. 1976, New York City: Wiley. 196.
- (26) Niles, J., *Beyond Telecommuting: A New Paradigm For The Effect of Telecommunications on Travel*. 1994, Department of Energy: Washington DC.
- (27) Yen, J.-R., H.S. Mahmassani, and R. Herman, *Employer Attitudes and Stated Preferences Toward Telecommuting: An Exploratory Analysis*. Transportation Research Record, 1994. **1463**: p. 15-.
- (28) Kitamura, R., *et al.*, *Telecommuting as a Transportation Planning Measure: Initial Results of California Pilot Project*. Transportation Research Record, 1990. **1285**: p. 98-104.
- (29) Mokhtarian, P.L., *Telecommuting and Travel: State of the Practice, State of the Art*. Transportation, 1991. **18**: p. 319-342.
- (30) Kraut, R.E., *Telecommuting: The Trade-offs of Home Work*. Journal of Communication, 1989. **39**(3): p. 19-47.
- (31) Mokhtarian, P. L. and Salomon, I., *Modeling the Desire to Telecommute: The Importance of Attitudinal Factors in Behavioral Models*. Transportation Research A, 1997 **31**: pp. 35-50
- (32) Ellison, N. B., *Social Impacts: New Perspectives on Telework*. Social Science Computer Review, 1999 **17**: pp. 338-356
- (33) Davenport, T.H., and K. Pearlson, *Two cheers for the virtual office*, Sloan Management Review, 1998 **39**: pp. 51-65
- (34) National Research Council, *Research Recommendations to Facilitate Distributed Work*, 1994, Washington, D.C.: National Academy Press
- (35) Salomon, I. and F. Koppelman, *A Framework for Studying Teleshopping Versus Store Shopping*. Transportation Research A, 1988. **22**: pp. 247-255

- (36) Koppelman, F., I Salomon, and K. Prousaloglou, *Teleshopping or Store Shopping? A Choice Model for Forecasting the Use of New Telecommunications-Based Services*. Environment and Planning B, 1991. **18**(4): pp. 473-489
- (37) Sindav, B. and A.L. Balazs. *A Model of Factors Affecting the Growth of Retailing on the Internet*. Journal of Market Focused Management 1999 **4**: pp. 319-339
- (38) Couclelis, H., *Pizza over the Internet: E-commerce, the Fragmentation of Activity, and the Tyranny of the Region*. Entrepreneurship and Regional Development, *forthcoming*
- (39) Salomon, I., *Telecommunications and Travel*. Journal of Transport Economics and Policy, 1985 **19**(3): p. 219-235
- (40) Handy, S. and T. Yantis, *The Impacts of Telecommunications Technologies on Nonwork Travel Behavior*. 1997, Southwest Region University Transportation Center: Austin, TX p. 51.
- (41) Salomon, I., *Telecommunications and travel*. Journal of Transport Economics and Policy, 1985. **19**(3): pp. 219-235.
- (42) Marker, J.T. and K. Goulias. *A Framework for the Analysis of Grocery Teleshopping*, in *79th Annual Transportation Research Board*. 1999
- (43) Hjorthol, R.J., *The Relation Between Daily Travel and Use of the Home Computer*. Transportation Research A, 2002. **36**: pp. 437-452.
- (44) Viswanathan, K., and K.G. Goulias, *Travel Behavior Implications of Information and Communications Technology in Puget Sound Region*. Transportation Research Record, 2001. **1752**: pp. 157-165.
- (45) Pendyala, R.M., K.G. Goulias, and R. Kitamura, *Impact of Telecommuting on Spatial and Temporal Patterns of Household Travel*. Transportation 1991. **18**: pp. 383-409.
- (46) Nilles, J., *City of Los Angeles Telecommuting Project Final Report*, 1993, JALA International Inc.: Los Angeles. p. 89
- (47) Pratt, J., *Teleworkers, Trips and Telecommunications: Technology Drives Telework – But Does It Reduce Trips?* Transportation Research Record 2002 **1817**: pp. 58 - 66
- (48) Mokhtarian, P.L., S.L. Handy, and I. Salomon, *Methodological Issues in the Estimation of Travel, Energy and Air Quality Impacts of Telecommuting*. Transportation Research A, 1995. **29**(4): pp. 283- 302.
- (49) Gould, J. and T.F. Golob, *Shopping without travel or travel without shopping? An investigation of electronic home shopping*. Transport Reviews, 1997. **17**: pp. 355-376
- (50) Gould, J., *Driven to Shop? Role of Transportation in Future Home Shopping*. Transportation Research Record, 1998. **1617**: pp. 149-156
- (51) Lin, I. I., and H.S. Mahmassani, *Can Online Grocers Deliver? Some Logistics Considerations*, Transportation Research Record 2002 **1817**: pp. 17 – 24.
- (52) Pratt, J. *Teleworking Comes of Age with Broadband* International Telework Association and Council, April 2003. [http://www.workingfromanywhere.org/pdf/TWA2003\\_Executive\\_Summary.pdf](http://www.workingfromanywhere.org/pdf/TWA2003_Executive_Summary.pdf) Accessed July 31, 2003
- (53) Hampton, K. and B. Wellman, *Long Distance Community in the Network Society*, American Behavioral Scientist, November 2001 **45**: pp. 477 - 496

(54) Orlikowski, W.J. and C. S. Iacono, *The truth is not out there: An enacted view of the "Digital Economy,"* in *Understanding the Digital Economy: data, tools, and research*, E. Brynjolfsson and B. Kahlin, Editors, 2000, Massachusetts Institute of Technology.

(55) Minnesota State Government at Work (July 2002). Department Results: Department of Commerce. Available online: <http://www.departmentresults.state.mn.us/commerce/> Accessed July 30, 2003