Spatial Attributes and Patterns of Use in Household-Related Information and Communications Technology Activity

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Information and communications technologies (ICTs) are affecting an ever-increasing array of household activities. Although considerable research has documented patterns of ICT use and sociodemographic profiles of ICT users, surprisingly little research has examined the role of spatial attributes such as accessibility, ICT availability, and levels of congestion in ICT-related activities. This paper aims to answer questions related to the propensity of residents in metropolitan areas to use the Internet for e-commerce, e-banking, and other financial transactions and how such use is affected by spatial attributes of retail and bank accessibility and traffic congestion. First, a snapshot of aggregate patterns of ICT use in the United States is provided, and past theories are described. Next, the methodology is described for administering a mail-out and mail-back survey of households in the spring of 2003 (including Seattle, Washington; Kansas City, Kansas and Missouri; and Pittsburgh, Pennsylvania). The survey measured participation in ICT-based activities in the form of shopping on the Internet (referred to as e-shopping), electronic banking, and other financial transactions. Finally, analyses are presented that focus on the degree to which the use of such activities is shaped by factors of accessibility, ICT availability, and traffic congestion. Contrary to expectations, the results suggest that, for the most part, spatial attributes do not appear to play a significant or substantive role in affecting rates of ICT use.

Information and communications technologies (ICT) are affecting an ever-increasing array of household activities. The penetration of the Internet alone expanded from roughly 86 million Americans in March 2000 to 126 million in August 2003 (*1*). A reported 63% of all Americans now use the Internet, suggesting that this medium alone has the potential to shape radically not only the manner in which information is transmitted but also the ways in which households meet their needs for a wide variety of activities. Because the Internet offers the potential to eliminate physical travel traditionally associated with activities such as work, shopping, and entertainment, the extent to which households use the Internet for such activities may depend on spatial attributes of the communities where they are located. For example, households in rural areas with limited access to retail outlets may depend more on online shopping than households in metropolitan areas. On the other hand, residents of metropolitan areas may prefer shopping online to facing traffic congestion at the regional mall.

Although there has been considerable research documenting patterns of ICT use and sociodemographic profiles of ICT users, surprisingly little of it researches ICT in a spatial context. Now that ICT rates have had several years to mature, the time is ripe to investigate in detail such relationships and to explore possible variations in different geographic areas. The research summarized in this paper provides an initial analysis of this issue. First, a snapshot of aggregate patterns of ICT use in the United States is provided and past theories on the matter are described. Next, the methodology for surveying hundreds of households in three different metropolitan areas is described. Finally, survey data are analyzed and the results of this analysis are discussed. The survey measured participation in ICT-based activities in the form of shopping on the Internet (hereafter referred to as e-shopping), electronic banking, and other financial transactions; the analysis focuses on the degree to which spatial elements—such as retail accessibility—shape ICT use. The results suggest that, for the most part, spatial attributes do not appear to play a significant or substantive role in affecting rates of ICT use.

OVERVIEW

Trends of Household-Related ICT Activities

This research focuses on household use of three categories of ICT-based activity: e-commerce, electronic banking, and other financial transactions. The three categories likely have distinct patterns of use and are affected by spatial attributes in different ways. Therefore, the analysis focuses on each and begins by briefly describing general trends with respect to each category.

For the purposes of this paper, e-commerce refers to the purchase of commercial goods or services over the Internet; its rise comes as little surprise to most. The Boston Consulting Group (*2*) estimates that online retailing in North America alone totaled $27 billion in 1999 and $45 billion in 2000. Although this dollar figure still comprises a relatively insignificant margin of total retail sales (1.7%), its amount has increased by more than 67% since 1999. Whereas most e-commerce forecasters anticipate that the shear growth in proportion of sales will likely subside, the availability of such services is likely to be of increasing impact. One need only examine trends in personal use. Among U.S. Internet users alone, those who had ever bought online has grown from 48% (about 41 million Americans) in 2000 to 61% (about 67 million Americans) in 2002—an increase of 63% (*1*). It remains unclear, however, who such shoppers are in terms

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of demographics and computer experience; furthermore, it is unclear whether such e-commerce shopping is substituting or replacing in-store shopping.

The second category is electronic banking, defined as using automatic teller machines (ATMs), a telephone, or the Internet to engage in transactions with one's principle bank (e.g., cashing checks, deposits, transferring money, and making withdrawals). In some cases, such a banking transaction still requires a physical trip to the ATM. For this reason and because it was desirable to ensure comparability of this activity with a similar survey instrument from a previous application, it has its own category. The rise in electronic banking is interesting if for no other reason than its reported surge in growth in recent years. Looking at trends dating back to 2000, for example, the Pew Center survey estimates that online banking increased by 23 million Americans between 2000 and 2002, amounting to about 20% of the population. These proportions are generally consistent with other surveys where Gartner reported that 17% of Americans used online banking services by the end of 2002 (*3*) and Celent Communications reported online banking penetration at 22% in 2002 (*4*). Overall, slightly less than a quarter of the population uses some form of electronic banking.

The last category distinguishes online financial transactions from electronic banking. The former is defined as completing any array of financial activities over the Internet such as buying and selling stocks, trading commodities, paying mortgages, and paying other bills. Few national surveys separate this category from online banking. It is done here primarily for two reasons. The first is that traditional financial transactions (e.g., paying utility bills or credit card statements) typically did not involve a physical trip; they were mostly completed by using U.S. mail. Second, these types of transactions represent a burgeoning array of activities that previously have not been empirically researched. Available evidence indicates that this specialized ICT activity is also rising, although certainly not as rapidly as the other categories of ICT activities. According to Jupiter Research, 18.9 million U.S. households viewed and paid bills online during 2003, increasing from 12.2 million in 2002. In addition, they reported that, among those that bank online, 50% also paid their bills online in 2003 (*5*).

Review of Past Literature and Expected Relationships

How might spatial attributes affect the use of these categories of ICT activities? Prevailing theory suggests two contradictory hypotheses about this relationship. One theory is guided by what is commonly referred to as a variation of the innovation diffusion hypothesis (*6*). In a metropolitan setting, this theory postulates that urban centers, by virtue of being at the center of innovation (intellectually or technically), exhibit a higher tendency to engage in practices or thoughts enabled by the innovation (*7, 8*). Using this logic, urbanites are more likely to adopt such ICT behavior because such services (e.g., online banking) first became available in urban settings. The currently "spotty" nature of where high-speed Internet service is available throughout the United States is consistent with this theory. On the flip side, others argue that, in most metropolitan areas, different areas [i.e., central business district (CBD), first- and second-ring suburbs, and exurbs] all more or less enjoy similar levels of access to technology, thereby eliminating any noticeable differences due to geography.

A counter theory is driven by what has loosely been referred to as the "efficiency hypothesis" (*9*), which suggests that individuals aim to save time by combining trips (*10*)—or, in this case, save the additional cost associated with physical travel (*11*) (e.g., online shopping and banking). Such costs may derive from a variety of attributes, be it lower levels of accessibility (therefore longer travel distances) or having to fight traffic congestion in areas more urban in nature (therefore longer travel times). Virtual travel, it is argued, would more likely be used by residents in those situations to avert such costs.

Most previous work on ICT use is unable to shed direct light on these hypotheses because it has been devoid of a spatial context. Existing studies most often treat residents in metropolitan areas as a single population where spatial attributes are theorized to play little role in affecting the propensity of e-commerce or e-banking type activities. Studies that have addressed spatial attributes have often used flawed measures of those attributes; they are often measured at extremely aggregate scales (e.g., city versus rural) or are not precisely defined. Furthermore, where previous research has specifically aimed to tackle such questions, researchers have found contradictory results. For example, Farag (*11*) empirically tested the preceding two hypotheses with data from the Netherlands (1996–2001) and found that people living in urbanized areas were more likely to engage in e-shopping. On the other hand, however, it was found that people who do not have easy access to shops (defined as having fewer shops for nondaily goods that can be reached by car from the person's home in a certain time span) also tended to shop more online.

This paper aims to understand the degree to which residents use the Internet for e-commerce, e-banking, and other financial transactions and how such use is affected by spatial attributes such as retail and bank accessibility and traffic congestion. Controlling for a host of confounding variables, the analysis measures spatial attributes at two different scales: intermetropolitan and intrametropolitan. The intermetropolitan analysis examines aggregate use patterns among three cities, using general levels of congestion as a spatial attribute. A metropolitan area with high traffic congestion is expected to exhibit higher rates of ICT use because of the increased burden of traveling to activities. The intrametropolitan analysis uses individual households as the unit of analysis and examines relationships to nearby retail, the CBD, or banks. For these relationships, theory suggests that spatial attributes may both increase and decrease ICT use; as a result, it is difficult to posit specific hypotheses about the directions of the relationships. The hypothesized relationships examined in this paper together with the spatial units of analysis are presented in Table 1.

DESCRIPTION OF SURVEY AND SAMPLE

To examine the preceding dimensions, a mail-out and mail-back survey of households was administered in the spring of 2003. The survey sample was drawn randomly from the population in three metropolitan statistical areas: Seattle, Washington; Kansas City, Kansas and Missouri; and Pittsburgh, Pennsylvania. Several criteria guided the selection of these cities. First, a sample of residents representative of relatively large U.S. urban areas from the Midwest and the East and West coasts was desired. Next, the basic hypotheses about spatial attributes and information technology (IT) availability were instrumental in stratifying the sample by balancing among two other criteria: level of traffic congestion for large cities and rates of Internet penetration. Using Texas Transportation

TABLE 1 Hypothesized Relationships Between ICT Use and Spatial Attributes

Scale of Analysis	Spatial Measure	Outcome Variable: Online Shopping	Outcome Variable: Electronic Banking	Outcome Variable: Other Online Financial Transactions
Metro area	Higher level of traffic congestion	+	+	+
Household	Urban versus suburban residence	+/–	+/–	+/–
Household	Distance to CBD	+/–	+/–	+/–
Household	Proximity of retail activity (home)	+/–	+/–	+/–
Household	Proximity of ATM machine (work or home)	+/–	+/–	+/–

Institute's measures of traffic congestion in U.S. urbanized areas in 1990–1999 (*12*), candidate cities representing both high and low levels of traffic congestion were identified. Next, this criterion was balanced by controlling for IT availability in each city, as measured by rates of Internet penetration by Scarborough Research (2002). The final selection included Seattle, representing a high-congestion/high-technology city (Seattle rates second on the congestion list and among the highest of cities in IT availability). Kansas City represented a low-congestion/high-technology city, and Pittsburgh was selected to represent a low-congestion/low-technology city.

After pilot testing, the survey was mailed to 800 households in each of the three cities in May 2003. The households were selected at random from an address database maintained by Survey Sampling International. The primary source of their database listings is telephone directories, which were supplemented with other sources, such as state ID cards. A cover letter explained the purpose of the survey and invited a household member 18 years or older to complete it. Following the Dillman (*13*) method, reminder postcards were mailed to the 2,400 households 1 week later and a third mailing (with the complete survey) was sent out 3 weeks later to each household that had not yet replied. The overall response rate is 31%, including 32% from Seattle, 30% from Kansas City, and 30% from Pittsburgh. After comparing sociodemographics with 2000 census data for each metropolitan area, it was found that the characteristics of the survey respondents differ only slightly from the overall populations in the three cities. Most notable is the fact that the survey respondents are substantially older than the general population in the three cities (60% to 70% are more than 50 years old, in contrast to 30% to 40% in the overall population; 36% to 37% are more than 60 years old, in contrast to 18% to 28% in the overall population). Other differences showed the sample to have a slightly higher percentage of males, to be more educated, and to have slightly higher household incomes than the general population. On the one hand, higher income levels would suggest a bias in terms of use of ICT-related services. Given that older populations are probably less likely to be using the Internet for services, this would likely sway the bias in the opposite direction.

RESULTS AND DISCUSSION

The results of the analysis are now considered by describing relationships between ICT use and spatial attributes of urban environments. The focus is on three different ICT behaviors: online purchases, e-banking, and on-line financial transactions. In each case, the focus was primarily on the behavior in a binary manner, capturing whether the survey respondent performed the activity, generally within the past 6 months. This research is therefore less about measuring the frequency of the behavior and more about detecting its use. The following discussion is divided as follows. First, rates are described in which the three dimensions of ICT are used to glean a better understanding of general patterns. This is followed by an overview of how such patterns differ by level of IT availability and levels of congestion; this part represents the intrametropolitan analysis. Then, moving to a fuller discussion of the specific effects of various accessibilities, statistics are presented revealing penetration rates, how such rates vary by geographic area, and other descriptive information. To investigate the impact of spatial variables on e-shopping while controlling for a variety of other factors, three multivariate models were used. Doing so controls for mediating factors and therefore serves to better isolate the impact of specific measures.

General Patterns and Relative Independence of Activities

The first look at the data aims to identify general patterns of ICT use in the aggregate. This analysis provides background information about general levels of ICT among the sample and highlights the need for separate analyses for each category of ICT activity.

Examining rates of use across the three activities reveals the following. As indicated in Table 2, shopping online has the highest penetration (around 47%), with e-bankers making up a considerably smaller share of the sample (about 31%). It is also interesting to look at the degree to which the use of the different categories of ICT overlaps within individual households; 20% of the sample have completed all three activities least once; 21% reported ever completing two activities, 16% reported ever completing only one of the activities. Finally, 43% of respondents reported never having engaged in any of the three activities.

These results suggest overlap among the three activities; a fair number of individuals appear partial to one of the activities. Whereas online shopping is the most popular activity among the three, this does not necessarily suggest that all e-shoppers are also e-bankers or that they make financial transactions online (Table 3). Among those who e-bank, 23% have never shopped online and 21% have never made a financial transaction online. And among those who ever made other financial transactions online, about 20% have never shopped

TABLE 2 ICT Activities in Three Metropolitan Areas

	Ever Shopped Online (% yes)	Ever Use E-Banking (% yes)*	Ever Made Other Online Financial Transactions (% yes)	Average (% yes)	Ever Completed at Least Two of the Activities (% yes)
Overall	342 (46.6%)	232 (31.2%)	303 (41.2%)	292 (39.7%)	306 (41.7%)
Seattle	390 (53.1%)	113 (44.2%)	128 (50.2%)	126 (49.2%)	123 (51.0%)
Kansas City	120 (50.0%)	66 (27.7%)	100 (41.5%)	95 (39.7%)	102 (42.7%)
Pittsburgh	87 (36.4%)***	50 (20.7%)***	75 (31.2%)***	71 (29.4%)	74 (30.8%)
Pearson χ^2 *p*-value	.000***	.000***	.000***		

Among those that *never* banked online, about one third does not have the option of online banking, while the rest choose not to use online banking even though the option is offered by their banks.

* = $p < 0.1$.
** = $p < 0.05$.
*** = $p < 0.01$.

online. This suggests that there does not appear to be a sequential relationship between e-shopping and the other two activities. If there were a sequential relationship, then whoever had completed the other two activities would have e-shopped as well. It is therefore difficult to say that people shop online first, and then some of them go on to use online banking or do other financial transactions online. The picture of household ICT use appears to get murky very quickly. Most important for the subsequent analysis, it suggests that household use of ICT activity is complex and it is helpful to break it down to analyze the different types of ICT activities separately.

Intermetropolitan Differences

The next look at the data examines spatial dimensions by seeing how ICT use differs across each of the three metropolitan areas. Table 4 indicates that, consistent with the initial hypotheses, ICT use differs across the three metropolitan areas and appears to be correlated with ICT availability or congestion. Seattle (high technology, high congestion) appears to have the highest ICT use and Pittsburgh (low technology, low congestion) has the lowest ICT use. Seattle clearly stands out in all three activity categories (e-shopping, e-banking, other financial) with more than half the Seattle sample having experience in at least two of the three activities. In contrast, Pittsburgh is the least penetrated by ICT activities. Only 31% of the population have ever done at least two of the three activities online. Specifically, only 36% have ever shopped online, only 21% have ever banked online, and only 31% have ever made other financial transactions online. This is consistent with what would be expected given the relatively low level of IT and low level of congestion in the Pittsburgh area. Expectedly, Kansas City falls between the two with an average of 43% of the sample ever having completed at least two of the activities. About 50% have ever e-shopped, 28% have ever e-banked, and 42% have ever engaged in other financial transactions online.

Table 3 also indicates that the percentage who ever e-banked is remarkably lower than the percentages who ever completed the other two activities in both Kansas City and Pittsburgh, whereas the difference is less apparent in Seattle. In terms of e-banking, Kansas City is more like Pittsburgh than Seattle. This suggests that e-banking might be more strongly related to levels of congestion. It is plausible that, because of security concerns, people with high technology available (like those in Kansas City) are still reluctant to bank online if their traffic remains tolerable. When congestion is an issue, it appears that respondents are more likely to take advantage of e-banking. Although these findings certainly support the notion that technology and congestion appear to play a role in ICT activities, it is important not to overstate their impact. For example, it remains inconclusive whether such a coarse measure of IT penetration (i.e., provided by Scarborough Research) is accurate for more specific ICT-based services. That is, is a high-technology rating (as measured by rates of Internet penetration) synonymous with rates of ATM card ownership, cell phone ownership, home computer ownership, and home Internet access?

In response to this question, Table 4 shows each of the cities and possession of five different technologies as measured in the survey: ATM card ownership, a home computer, home Internet access, fast

TABLE 3 Relationships Between ICT Activities and Users

	Of Those That . . .	Ever Shopped Online	Ever Banked Online	Ever Made Other Financial Transactions Online
They have . . .	Never shopped online	na	53 (23%)	60 (20%)
	Never banked online	164 (48%)	na	121 (40%)
	Never made other financial transactions online	102 (30%)	49 (21%)	na

TABLE 4 Availability of IT-Related Services

Sampling Stratification			Do You Have . . .				
			. . . An ATM Card	. . . A Home Computer	. . . Home Internet Access	. . . Fast Home Internet Access	. . . A Cell Phone
Low tech	Pittsburgh	Yes	175 (74%)	163 (69%)	157 (67%)	67 (46%)	156 (65%)
High tech	Seattle	Yes	198 (78%)	220 (87%)	208 (82%)	78 (40%)	167 (66%)
	Kansas City	Yes	161 (70%)	184 (79%)	171 (73%)	72 (44%)	154 (66%)
Total within high tech		Yes	359 (74%)	404 (83%)***	379 (77%)***	150 (42%)	321 (66%)
Pearson χ^2 p-value			.888	.000***	.002***	.426	.893

* = $p < 0.1$ ** = $p < 0.05$ *** = $p < 0.01$.
Seattle and Kansas City are groups because both metropolitan areas were deemed technology friendly in the sampling stratification.
Fast home Internet column provides percentage based on only 75%(S), 69%(KC), and 60%(P) of survey sample who have home Internet in each city. The question on Internet type branches after "Does your household have access to Internet?" Those answering no to the Internet access question are not led to answering the question regarding the type of Internet they are using.

home Internet access, and cell phone. Seattle and Kansas City are grouped because both metropolitan areas were deemed technology friendly in the sampling stratification. As expected, those dimensions on which sample selection was based appear to show up as statistically significant. Seattle and Kansas City live up to their high-technology classification for computer- and Internet-related activities. However, the distinction is not as noticeable as one would expect. Across the remaining three services, statistically significant differences are not observed across high-technology versus low-technology cities.

Intrametropolitan Differences

Having described general relationships between each of the cities, now the relationships between ICT use and spatial attributes are described as they vary within metropolitan areas. This is done to better understand matters related to accessibility of different services (e.g., shops, ATMs). Measures representing two different levels of geography and attributes are used, each of which is derived by the hypotheses of interest and described later. The first measure aims to represent relatively coarse distinctions between areas with high levels of retail activity and shops versus those with lower levels. This dimension is captured through two measures. The first is a self-reported measure, asking respondents how far they live from the CBD. The second measure is an objective one gleaned from the census zip code business patterns data, quantifying the number of establishments in the retail trade category (Industry Code 44xxxx in the North American Industry Classification System) for the respondent's zip code. The second group primarily applies to the electronic banking category and aims to get at the degree to which there are ATMs within close proximity that are either available or used by the respondent. Both are binary variables and self-reported from the survey, which asked if there is an ATM close to the person's residence or workplace and if there is a bank close to the person's residence or workplace (i.e., within walking distance).

In Table 5, some preliminary relationships emerge. First, there appears to be a higher propensity for people living farther from the CBD to engage in ICT-based activities. Self-reported city residents are less likely to shop online than suburbanites. In addition, almost 60% of those living more than 10 mi from the CBD have shopped online (versus 40% for those living less than 5 mi from the CBD) and almost half of those beyond 10 mi have ever made financial transactions online. Second, the relationship between the availability of nearby retail and online shopping is not statistically significant, suggesting that the proximity of retail (within one's zip code) does not appear to affect one's propensity for online shopping. Examining the effects of having a neighborhood ATM produces expected results: an ATM near one's home or workplace is more likely to be used. Those respondents who do not have banks within walking distance of home or work are slightly more likely to have ever banked online (31.8%) as opposed to 30.1% among those who have banks within walking distance. However, the distinction is not statistically significant.

The relationships thus far have been examined primarily through simple correlations of ICT use and various explanatory variables. Although some statistically significant relationships were uncovered, the bivariate analysis precludes an understanding of such phenomena in a multivariate context. Introducing control variables in the analysis and modeling such behavior at the individual level can better discern the explanatory power of the spatial attributes.

In the multivariate analysis, five categories of variables thought to contribute to higher levels of ICT were used. The first category is sociodemographic variables including age in years, sex (male = 1), education (low, high), household income (low, high), two-plus vehicles, household structure (households without teenage children, households with teenage children), and whether the respondent is employed (yes = 1). Measures in the second category, reflecting the availability of IT-related infrastructure, were gathered at the metropolitan level and at the household level, each described previously. The metropolitan level measures are rates of Internet penetration where Seattle and Kansas City were deemed high and Pittsburgh was deemed low. The household measures were gleaned from the survey and captured ATM card ownership (yes = 1), cell phone ownership (yes = 1), home computer ownership (yes = 1), and home Internet access (yes = 1). The third category comprises behavioral variables, including frequency of nongrocery shopping (more than five times in the last 30 days = frequent, otherwise = infrequent) and frequency of bank visits (one to three times per month or more = frequent, otherwise = infrequent). The fourth category captures attitudinal variables that were gleaned from a dozen or so attitudinal questions

TABLE 5 ICT Activity and Intrametropolitan Spatial Attributes

Spatial Attribute	Percent of Respondents Within Each Category of the Spatial Attribute	Ever Shopped Online (% yes)	Ever Electronic Banked (% yes)*	Ever Made Other Financial Transactions Online (% yes)
City/suburban	City (38.2%)	40.8%	31.4%	40.1%
	Suburban (61.8%)	50.7%	31.3%	42%
	Pearson χ^2 *p*-value	0.01**	0.964	0.604
Distance to CBD	<=5 mi (42.8%)	40.3%	28.4%	36.1%
	5–10 mi (25%)	44.8%	31.5%	39.3%
	>10 mi (32.2%)	58.4%	36.1%	50.9%
	Pearson χ^2 *p*-value	0.000***	0.164	0.002***
Availability of nearby retail	>100 retail (32.8%)	49.6%		
	50–100 retail (33.3%)	47.1%		
	<=50 retail (33.9%)	44.3%		
	Pearson χ^2 *p*-value	0.506		
ATM availability	Within walk distance (53.5%)		37%	
	Not within walk distance (46.5%)		24.5%	
	Pearson χ^2 *p*-value		0.000***	
Bank availability	Within walk distance (36%)		30.1%	
	Not within walk distance (64%)		31.8%	
	Pearson χ^2 *p*-value		0.631	

* = p < 0.1 ** = p < 0.05 *** = p < 0.01.

answered by the respondents; examples include "I feel comfortable using computers," "technology makes my life easier," "traffic makes me crazy," and "I think shopping in stores is a hassle." The responses on a 5-point Likert scale were used as input into a *K*-means factor analysis procedure yielding four factors (all with an eigenvalue greater than 1). These factors were subsequently titled protechnology, antitravel, concerned about Internet security, and outgoing/gregarious; each respondent's score for each factor was used as a dependent variable.

The last category of measures—spatial attributes—comprises the heart of this investigation. Levels of congestion (at the metropolitan-wide level) were captured using dummies of the city variable (Seattle = 1). Other measures are self-reported from the survey and include whether the respondent's home is in the city versus suburb, miles from the CBD (less than 5 mi, 5 to 10 mi, more than 10 mi), whether there was an ATM close to work or home (yes = 1, no = 0), whether there was a bank close to work or home (yes = 1, no = 0), and number of retail businesses in the immediate zip code area of the home (gathered from U.S. employment statistics). The dependent variable in three of the models was dichotomized as having ever completed the activity. However, the frequency of online purchases was examined as frequent (defined as answering two times per month and more often) versus infrequent (once per month, less than monthly, and never). The final binomial logistic regression models were constructed by performing log likelihood tests to determine whether the statistical significance of the model deteriorates when insignificant variables are eliminated from the model. The results for statistically significant variables are presented in Table 6.

The models produce interesting findings about attributes of individuals and metropolitan areas. The first observation is that only one measure of spatial attributes appears to be statistically significant—being a high-congestion city—and this was for only one of the models, the model for ever banked electronically. Thus, whereas significant spatial relationships emerged in bivariate contexts, other factors in fact explain the variation; simply put, spatial attributes, by themselves, do not appear to play a significant role in affecting levels of ICT use. In the e-shopping model, the dummy variable for low-technology city (Pittsburgh) is significant and in the expected direction. This finding indicates that households in cities with relatively low rates of Internet penetration are less likely to have ever shopped online. Similar relationships are observed in the logistic regression model for other financial transactions online. The distinction between the electronic banking model and the other two models corresponds to the descriptive findings: congestion influences only levels of electronic banking.

The results also indicate that IT availability on the household level positively affects an individual's propensity for adopting ICT activities. Understandably, individuals with ATM cards and home Internet access are more likely to engage in ICT activities. Not only is this relationship statistically robust across all four activities but the odds ratio calculations show this factor as having considerable impact. Cell phone ownership is also significant in the other financial transaction model. However, the direction of causality cannot be determined from these models. Although it is logical that having access to IT increases engagement in ICT activities, it is also possible that engaging in ICT activities leads to an increase in access to IT. For example, households that enjoy shopping online may be more likely to opt for high-speed Internet access.

Control variables were also significant in the regression results. Similar sociodemographic and attitudinal variables affect all four activities, despite some minor differences. Being young and highly educated relates positively to ICT use in all three activities. In addition, owning two or more vehicles contributes positively to adopting online banking behavior, whereas having teenage children in the household contributes positively to engaging in online financial transactions. Furthermore, people who are protechnology are more likely to adopt ICT activities, a trend that holds true for all three categories of ICT activities. Besides, people who are

TABLE 6 Multivariate Analysis of ICT Activity

Independent Variable	Dependent Variables (Logistic Regression)							
	Frequency of Online Purchases		Ever Bought Online		Ever Electronic Banked		Ever Completed Internet Financial Transaction Other Than Banking	
	B	Odds Ratio	B	Odds Ratio	B	Odds Ratio	B	Odds Ratio
Sociodemographic variable								
Age in years	−.025***	.975	−.035***	.966	−.033***	.968	−.028***	.972
High education			.445**	1.560	.492**	1.636	.486**	1.626
High income	.584**	1.793						
Two vehicles or more					.572**	1.772		
Teenage children in household							.573**	1.774
IT availability at household level								
ATM card ownership			.560*	1.751	.698*	2.010	.751**	2.119
Cell phone ownership							.453*	1.573
Home Internet access	2.495**	12.122	2.377***	10.773	1.786***	5.966	1.217***	3.377
Low technology			−.698***	.498			−.731***	.481
Behavioral variable								
Visit bank frequently					−.458**	.633		
Frequently shop for nongrocery items	.471*	1.602						
Attitudinal variable								
Pro-technology	.909***	2.482	.901***	2.462	.762***	2.143	.819***	2.268
Anti-travel	.244*	1.276						
Concerned about Internet security	−.467***	.627					−.285**	.752
Gregarious/social			−.266**	.766	−.192*	.825		
Spatial attribute								
High congestion					.984***	2.675		
Constant	−3.439	.032	−.640	.527	−2.086	.124	−.981	.375
Number of cases	538		538		538		535	
Df	7		7		9		9	
χ^2	128.934		238.523		199.179		213.152	
−2 log likelihood	424.137		505.153		509.793		526.479	
Nagelkerke R^2	.332		0.478		0.423		.439	

*Significant at 0.1 level, **significant at 0.05 level, ***significant at 0.01 level.

gregarious and who like to socialize with others are less likely to have ever used e-banking or e-shopping. The results also suggest that concern about Internet security is a significant factor that deters some people from having ever completed other financial transactions online.

SUMMARY AND CONCLUSIONS

The hypotheses that spatial attributes would influence the use of ICT for selected activities was not entirely borne out by this analysis. The intermetropolitan comparisons indicate that the high-technology and high-congestion city was associated with greater penetration of at least some ICT-based activities. Within metropolitan areas, residents who live in the suburbs or live further from the CBD were more likely to engage in e-shopping than residents who live in the city or close to the CBD. However, the lack of significance of these attributes in the multivariate analyses suggested the bivariate relationships are explained by other factors: high-technology status, high-congestion status, suburban location, and location relative to the CBD are all associated with other factors that more directly explain ICT use. The multivariate analyses suggest that IT availability at the household level, sociodemographic characteristics, and attitudinal factors are more important than spatial variables in explaining ICT use. If spatial attributes are not a factor in deciding to use ICT, as these results suggest, then a desire to reduce travel may not be a primary motivation for using ICT. Other studies have shown that ICT use does not always substitute for travel (*14*, *15*, p. 51). Nevertheless, ICT-based activities offer the option of reducing travel, and an improved understanding of the factors that do and do not influence the choice to use ICT is important for transportation planning.

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