IMPACTS OF ICT USE AND VIRTUAL IN-HOME ACTIVITIES ON DAILY ACTIVITY AND TRAVEL BEHAVIOR: A CASE STUDY OF CAIRO, EGYPT

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1. Introduction

According to the government of the Arab Republic of Egypt, number of home Internet users has increased by about 25-fold between 1999 and 2007. Similarly, the penetration of mobile telephones in Egypt population has increased from about 10% in 1999 to 37% in 2007. Projections suggest that technology improvements will further fuel the adoption and use of Internet and mobile communication devices by individuals and households in the future. The boom in telecommunications technologies is expected to have great impact on the lifestyles of the individuals and their households and also on transportation system. Recent advances in information and communication technologies (ICTs) make it possible to conduct activities virtually, thus obviating the need for physical travel, at least for some types of activities. Further, ICT use may contribute towards reducing urban congestion and air-quality problems (by replacing travel with virtual activities); on the other hand they may also generate significant additional and induced travel due to increased connectivity and access to resources. These potentials have motivated a great number of studies on the transportation impacts of ICT. Many studies focus on specific applications of ICT, such as telecommuting, teleshopping, teleconferencing, etc. (See Mokhtarian and Salomon, 2002; Lund and Mokhtarian, 1994; Salomon, 1996; Graham and Marvin, 1996). These studies have contributed a great deal to our knowledge about the direct impact of ICT on physical activity and travel. Nevertheless, by focusing on specific application, these studies fail to recognize the interrelationships among different forms of telecommunication and are not able to reveal the combined and holistic effects on daily activity and travel patterns. Further, to our knowledge, little attention has been directed to the understanding of how ICT affect activity participation and travel patterns of individuals in Egypt. The objective of this study is to investigate the effects of ICT on household members' daily activity-travel patterns using recent empirical activity and telecommunication dairy survey conducted in Greater Cairo Region, in Egypt. Structural equation models (SEMs) are developed to determine the structural relationship between ICT usage, virtual in-home activity participation, physical in-home and out-of-home activity participation, and observed travel dimensions. The information analyzed includes personal and household socio-demographic, ICT usage, and the role of constraints on time, and vehicle availability on activity patterns among household members. The organization of this paper is as follows. The next section provides a description of the data source and methodology. Modeling results are presented and explained in Section 3. Finally, Section 4 concludes the paper by highlighting the important findings from the research.

2. Data and research methodology

(1) Data and sample formation

The primary data source used for this analysis is the activity- travel and telecommunication diary survey spanned the period from December 2005 to January 2006. The survey collected original detailed information on all activity and travel episodes as well as daily telecommunications and Internet use for a two-day period from members of 150 households (459 respondents) in Cairo. The activity diary instrument consisted of 4 questionnaires parts, and two core diary parts. The first two parts concerned with various individual and household characteristics, the third part of the survey instrument aimed to collect general data about the physical activities of the respondents, the fourth part of the instrument concerned with daily and non-daily internet use and availability, the fifth part and one of the instrument cores concerned the actual activity diary. The core part of the instrument consists of two diaries; the physical and internet activities diary; and the telecommunication diary.

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The physical and internet activities diary, aimed to collect data about participants' all in-home and out-of-home activities. For each successive activity, respondents were asked to provide information about the type of activity (based on 42 pre-coded schemes of activities), the start and end times of activities, and location of participation. The information gathered on travel episodes included information on travel mode used, transfer location, and travel time. The telecommunication diary asked the respondents to record all of their daily communications over the two consecutive days. The communication modes were classified into four types: fixed location land line calls, mobile phone calls, short massages services (SMS), and e-mail. For each successive communication activity, respondents were asked to record timing of telecommunication, whether it was initiated or received, and purpose of each telecommunication activity. Respondents were asked to complete the diaries for two consecutive days (starting either on a Saturday or a Thursday so that data would be obtained for one weekend day and one weekday). After data cleaning and verification the final sample from the survey consisted of 459 respondents belong to 150 households, and contain a total of 15935 weekday and weekend activity and travel episodes.

The model developed in this study involves four constructs: socio-demographics, ICT usage, and time use for daily in-home and out of home physical and virtual activities and travel behavior. Long array of exogenous variables have been used in the analysis. These included household socio-demographics, individual socio-demographics, and zonal socio-demographic and density variables. As for the endogenous variables, the 42 activity type that were reported in the data set, were further grouped into the following six activity purpose typology: (1) work and school activities (such as work, work-related, school, school related), (2) physical maintenance (including: grocery shopping, non-daily shopping, shopping using delivery services, leisure window shopping, banking, purchasing bills, child care, housework. Preparing and eating meals, pick-up/drop-off passengers, and medical care), (3) physical recreational (including: restaurants, meals, reading , hobbies and exercising, cinema/theater/ library, listening to music, watching T.V/DVD'S, playing games, religious, visiting family/friends, and rest and relaxation), (4) in-home virtual maintenance activities (including: e-shopping, e-banking/paying bills, online restaurant/hotel/ cinema reservations, and e-government services), (5) in-home virtual recreational activities (including: web serving, downloading, and chatting, watching online movies, playing online games, etc.), and (6) travel activities. Work and school activities were treated as exogenous variables since they tend to be mandatory and inflexible. Further, physical maintenance and recreational activities were disaggregated based on the location of the activity into: out-of-home physical maintenance, in-home physical maintenance, out-of-home physical recreational and in-home physical recreational. For each of the four physical activities types, in-home virtual maintenance and recreational activities, and travel activity, total duration was computed over each individual two diary days. Number of trips was computed by summing the travel frequency for all activity types. Further, in order to assess the relationships between ICT usage, physical and virtual activity participation and travel behavior, one endogenous latent variable "use of ICT" was specified. This latent variable was measured by observed two days frequencies of land line calls, mobile phone calls, and SMS.

(2) Model specifications

The methodology of structural equation model (SEM) is applied in this research, because of our desire to estimate a simultaneous model of the interrelationships among ICT use, socio-demographics, and physical and virtual activity and travel participation. SEM has recently become a popular modeling tool in transport studies (Lu and Pas 1999; Van Wissen et al., 1991; Golob and McNally, 1997; Senbil and Kitamura, 2003). Moreover, SEM distinguishes between direct, indirect, and total effects (Bollen, 1989). The SEM used here consists of two equations: a measurement model and a structural model. In the measurement model, latent variables are explained by their indicators (observed variables). The structural model, relationships between the latent variables can be modeled. The structure model captures the regression effects of exogenous (independent) variables on endogenous (dependent variables), and the regression effects of endogenous variables on each other. We estimated a non-recursive structural equation model with latent variables using LISREL software version 8.8 (Jöreskog and Sörbom, 2001), using maximum likelihood estimation, was employed to obtain the results presented here. In addition to a covariance matrix, an asymptotic covariance matrix was calculated as input for the analysis. In this way, standard errors and chi-squares were corrected for non-normality (Jöreskog, 2001). The measurement model and the structural model were estimated simultaneously.

3. Modeling results

(1) Specification refinement and overall model fit

Similar to Lu and Pas, (1999), different specifications of the model, adding/deleting different direct effects between endogenous

variables, were tested in details. The independent model has a chi-square value of 782.581 with 136 degree of freedom. The final model indices of overall model fit show that the model fit very well. The model $\chi 2$ value was 141.519 with 99 degree of freedom, corresponding to probability value of 0.190. This indicates that the model cannot be rejected at the P =0.05 level.   Other measures of fit such as comparative fit index (CFI= 0.982), and root mean square error of approximation (RMSEA= 0.032) are also found to be acceptable by model fit criteria for structural equations models. The final model estimation results and their t-statistics are reported in Tables 1-3. In these tables standardized coefficients are given.   All the model coefficients are statistically significant at a p-value of 0.05 or lower, except in a few cases where excluding an insignificant variable degraded the interpretability of the rest of the model. Table 1 lists the estimates of the observed variables used to construct the latent use of ICT variable. Table 2 lists the effects among endogenous variables, i.e., the total, direct and indirect effects among the use of ICT, time use for in-home and out-of-home physical and virtual activities and travel behavior. Table 3 presents the effects of exogenous variables on endogenous variables.   The rest of this section will explain the results listed in these three tables. The sign of the relevant coefficient estimates indicate the direction of the effects.

(2)   The measurement model

   The measurement model describes how well the latent variable, "use of ICT" is measured by the frequency of land line calls, Mobile phone calls and SMS. Table 1 shows the standardized parameters estimates and t-values of the observed indicators, with the land line observed indicators were fixed to one. This is done to obtain a scale that can be interpreted for latent construct. As indicated by the t-statistics, all observed indicators for the latent "use of ICT" variable perform well.   Standardized observed indicators parameters (see Table 1) indicated the strengths of the contribution of each observed variable to the measurement of the "use of ICT' variable. The larger a parameter is, the more variances of the observed variable the latent constructs explain, and the more the observed variable contributes to the latent measurement.

Table 1: Standardized parameter estimates of the observed indicators of the use of ICT latent variable

Latent Variables	Parameters estimate	t-statistic
Use of ICT		
land line calls frequency*	0.781	
Within family mobile phone calls frequency	0.701	4.611
Within family SMS frequency	0.438	4.262

* Item fixed to one

(3)   Relationships between ICT usage, in-home and out-of-home activity participation and travel behavior

   The model results provide very consistent findings with our hypothesis. As expected, the strongest cause of ICT usage is the one from out-of-home recreational activity participation. Out-of-home recreational has positive and significant direct and total effects on use of ICT. This result may be a reflection of the higher propensity of out-of-home recreational activities to be pursued with non-family members or with a combination of family and non-family members, which in turn impose more pressure on ICT use in order to coordinate for possible joint activity participation. Additionally, positive direct and total effects of virtual in-home maintenance and recreational activities on use of ICT were found, with a higher positive total effect of virtual in-home recreational activity on use of ICT being observed. This reflects a "snowballing" effect; that is, the longer the time individuals engage in virtual in-home recreational activities, the greater the availability of information about recreational activity opportunities and people of interest, the more likely to participate in those activities and the more demand will be imposed on ICT. As indicated in Table 2, a significant negative direct effects of "use of ICT" on in-home and out-of-home maintenance activities were found, which tend to propose that ICT may reduce the time for maintenance activities.

   Noteworthy in the context of this paper, Table 2 shows that "use of ICT" have positive and significant direct and total effects on number of trips, whilst the indirect effect which is channeled though the effect of "use of ICT" on time use for out-of-home maintenance activities, is negative. In other words, the use of ICT directly induces individuals to make more trips. This is consistent to the findings of the study by Srinivasan and Athuru (2004). Although, no direct effect between "use of ICT" and travel time was found, the total and indirect effect are positive and highly significant, suggesting that ICT usage indirectly leads individuals to spend more time for daily travel. These are interesting results which apparently support the argument for complementary/generation effects of ICT on travel, which were speculated and found in previous studies (Mokhtarian 2003).

   Apart from the impacts of ICT on activity time use and travel behavior, Table 2 also lists the relations between time use for

in-home and out-of-home physical and virtual activities and travel behavior. Three distinct types of relations obtained for the final model are of interest. These are relations between time use for in-home and out-of-home physical activities, virtual in-home and physical in-home and out-of-home activity participations trade-offs, and relations between activity participations and travel behavior. First, consider the relations between physical activities participations. The model has clearly shown that there are a strong trade-offs between in-home and out-of-home physical maintenance and recreational activity engagement behavior. Durations of in-home physical maintenance and recreational activities are both found to have significant negative effects on the duration of out-of-home maintenance activities. The model appears to indicate that maintenance activities pursued in-home are generally not repeated out-of-home on the same day. Moreover, time use for in-home physical recreational activities negatively and significantly impacts on time use for out-of-home recreational activities. In other words, out-of-home recreational will decrease with an increase of in-home physical recreational activity duration. On the other hand, physical in-home recreational has a positive total (indirect) effect on physical in-home maintenance. In other words, there may be a complementary, but indirect, effect between physical in-home recreational and maintenance activity participation. Similarly, although there is no direct effect of out-of-home recreational duration on physical in-home maintenance duration, there appears a negative total (indirect) effect which is channeled through the negative direct effect of use of ICT on physical in-home maintenance duration.

Looking at the virtual-physical activity trade-offs, as expected, a significant substitution effect was found between virtual in-home and physical in-home recreational activities durations. This effect may be indication that individuals have a higher preference for virtual recreational activities over physical activities. That is individuals are more likely to perform recreational activities online compared to physical recreational activities. Further, the results show that virtual in-home recreational activity has a negative direct on out-of-home recreational activities. It does have, however, significant and positive indirect effect on time use for out-of-home recreational activities. This is largely in line with the findings presented above.

Finally, with respect to activity-travel interactions, the model results provide some very logical consistent finding with our hypothesis. The model shows that activity durations significantly affect trip generation. All of out-of-home duration variables are found to positively and significantly influence the number of trips. Travel time is also affected by out-of-home activities, and it increases as the amount of time spent on out-of-home activities increases (and vice versa). However, the more time spent on physical in-home, the less number of trips, and the less time is spent on travel, as would be expected. These findings are in support of previous studies (Lu and Pas 1999). On the other hand, the results show that virtual in-home activities have positive total (indirect) effects on number of trips. This is again a piece of evidence on the complementary impacts of virtual activities on trip making. Finally, as expected, total number of trips has a positive and significant impact on total travel time.

Table 2: Total, direct and indirect effects between endogenous variables given in standardized coefficients

		Telecommunication	Out-of-home activity		In-home physical activity		In-home virtual activity		Travel	
Affected variable		Use of ICT	Maintenance	Recreational	Maintenance	Recreational	Maintenance	Recreational	No. of Trips	Travel Time
Use of ICT	Total			0.689		-0.450	0.313	0.136		
	Direct			0.689			0.313	0.127		
	Indirect					-0.450		0.009		
Out-of-home activity										
Maintenance	Total	-0.038		-0.026	-0.272	-0.390	-0.012	0.048		
	Direct	-0.118			-0.272	-0.407				
	Indirect	0.080		-0.026		0.017	-0.012	0.048		
Recreational	Total					-0.654		0.013		
	Direct					-0.654		-0.072		
	Indirect							0.085		
In-home physical activity										
Maintenance	Total	-0.292		-0.201		0.132	-0.092	-0.040		
	Direct	-0.292								
	Indirect			-0.201		0.132	-0.092	-0.040		
Recreational	Total							-0.130		
	Direct							-0.130		
	Indirect									
Travel										
No. of Trips	Total	0.253	0.142	0.386	-0.039	-0.310	0.079	0.045		
	Direct	0.259	0.142	0.212						
	Indirect	-0.005		0.174	-0.039	-0.310	0.079	0.045		
Travel Time	Total	0.117	0.258	0.185	-0.070	-0.563	-0.086	0.075	0.492	
	Direct		0.188			-0.337	-0.123		0.492	
	Indirect	0.117	0.070	0.185	-0.070	-0.226	0.037	0.075		

(4) Effects of socio-demographics on ICT usage, time use and travel behavior

Table 3 lists the total, direct and indirect effects of socio-demographics on times uses for in-home and out-of-home physical and

virtual activity participations and travel behavior in terms of number of trips and travel time. The results indicate that adults in couple households are unlikely to participate in any of physical in-home activities, while they are very likely to pursue out-of-home activities and make more trips. However, they are more likely to participate in virtual in-home recreational activities. This is reasonable. Couple households have fewer household responsibilities than other household types which in turn increase the time available for them for out-of-home activities. As expected, number of children aged 6 or below appears to significantly increase the duration of physical in-home maintenance activities. On the other hand, it has a significant negative impact on physical in-home recreational. These results support the time-pressure hypothesis, which assume that the presence of children implies more maintenance activities and thus less time for recreational/social activities. As the number of adult females in the household increase, strong tendency away from out-of-home recreational activities participation was found. Number of adult females in the household was found to have significant and negative impacts on time use for out-of-home recreational. The negative signs of this coefficient may represent a tendency for households with higher number of adult females to be more oriented to in-home activities. This is also an evidence of the existence of strong traditional gender role effect in addition to that. Number of vehicles owned is found to have significant and negative impacts on time use for physical in-home activities, but positive impacts on time use for out-of-home activities and number of trips. Furthermore, number of vehicles was found to have significant positive impact on the use of ICT. This finding confirms our hypothesis that households with one car tend to engage in more out-of-home activities than zero-car households, due to greater mobility and access to activity locations. Being male has a significant negative impact on physical in-home maintenance. On the other hand, males spend more time for out-of-home maintenance and recreational activities, and spend more time for travel thank females do. Young coefficient has a negative impact on physical in-home recreational activities. On the other hand, younger individuals are more likely to participate in virtual in-home recreational activities. One possible explanation is that, younger individuals are better equipped with Internet knowledge and more willing to explore new Internet technologies.

Table 3: Total, direct and indirect effects of exogenous variables on endogenous variables given in standardized coefficients

Affected variable		Casual Variable					
		Couple household	Number of Kids	Total of adult females	Number of vehicles	Male	Young
Use of ICT	Total	0.033	0.113	-0.171	0.105	0.150	-0.017
	Direct					0.150	
	Indirect	0.033	0.113	-0.171	0.105		-0.017
Out-of-home activity							
Maintenance	Total	0.232	0.061	0.007	0.091	0.170	0.080
	Direct	0.183					
	Indirect	0.049	0.061	0.007	0.091	0.170	0.080
Recreational	Total	0.003	0.164	-0.248	0.153		-0.061
	Direct			-0.248			-0.175
	Indirect	0.003	0.164		0.153		0.114
In-home physical activity							
Maintenance	Total	-0.148	0.102	0.050	-0.031	-0.688	0.005
	Direct	-0.138	0.135			-0.645	
	Indirect	-0.010	-0.033	0.050	-0.031	-0.044	0.005
Recreational	Total	-0.032	-0.250		-0.234		-0.196
	Direct		-0.250		-0.234		-0.170
	Indirect	-0.032					-0.026
In-home virtual activity							
Recreational	Total	0.246					0.198
	Direct	0.246					0.198
	Indirect						
Travel							
No. of Trips	Total	0.249	0.337	-0.096	0.073	0.326	-0.006
	Direct	0.207	0.265			0.263	
	Indirect	0.042	0.072	-0.096	0.073	0.063	-0.006
Travel Time	Total	0.177	0.262	-0.046	0.132	0.340	0.078
	Direct					0.148	
	Indirect	0.177	0.262	-0.046	0.132	0.193	0.078

4. Conclusion

The study reported in this paper has thought to provide more insights into the relationships between ICT use, daily in-home and out-of-home physical and virtual activities, and travel behavior. Further, the analysis take account of factors known to affect the relations between ICT use, daily activity and travel patterns of individuals in Cairo, Egypt. Understanding the casual relationships is very important in Cairo because the adoption and use of ICTs continues to grow rapidly. Therefore, it is expected that the growing ICT use will have many reflections on individual activity and travel patterns as well as individuals life style in the near future. A non-recursive structural equation model with latent variable was proposed and estimated using data from recent two-day activity and travel diary survey conducted in the Greater Cairo Region. The observed endogenous variables are time uses for

in-home and out-of-home physical and virtual activity durations and number of trips and travel time. Further, in order to accommodate the possible endogeneity of ICT usage, an endogenous latent variable "use of ICT" was specified. This latent variable was measured by observed frequencies of land line calls, mobile phone calls, and SMS. The general findings can be summarized as follows. First, the use of ICT was found to increase trip making propensity and induce more time spent on travel. The present study also revealed that ICT had a substitution effects on the time use for in-home and out-of-home physical maintenance activities. Furthermore, this study provides another justification for the holistic and comprehensive approach to studying the interrelationships between ICT and daily activity and travel behavior. The model shows that the strongest cause of ICT usage is from out-of-home recreational activity participation. Second, the model results revealed substitution relationships between virtual in-home activities and out-of-home activities. To conclude, the empirical results support many of our hypotheses regarding the possible relationships between socio-demographic, ICT use and daily in-home and out-of-home physical and virtual activity and travel.

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