Transportation Research Part A 68 (2014) 56–74

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Activity fragmentation, ICT and travel: An exploratory Path Analysis of spatiotemporal interrelationships

Eran Ben-Elia [a,*], Bayarma Alexander [b], Christa Hubers [c], Dick Ettema [d]

[a] Department of Geography and Human Environment, Tel-Aviv University, Israel
[b] Southern California Association of Governments, Los Angeles, CA, United States
[c] Faculty of Architecture and the Built Environment, Delft University of Technology, The Netherlands
[d] Department of Human Geography and Planning, Utrecht University, The Netherlands

ARTICLE INFO

Article history:
Available online 5 May 2014

Keywords:
Activities
ICT
Travel behaviour
Fragmentation
Paid work
Path Analysis

ABSTRACT

This paper focuses on the interrelationships between ICT, activity fragmentation and travel behaviour. The concept of fragmentation relates to how activities are spatiotemporally reorganized, by subdividing activities into smaller components that are then performed at different times and/or locations, in connection with ICT use. The association between ICT, activity fragmentation and travel relationships remains uncharted. Based on a two-day Dutch communication-activity-travel diary different associations between ICT use, paid work spatiotemporal fragmentation indicators and frequency of travel are specified and tested with Path Analysis Modelling accounting for sociodemographic and land use factors. The results demonstrate that the interrelationships between fragmentation, ICT and travel are quite complex. ICT and fragmentation apparently have a reciprocal relationship with mobile ICT use influencing the degree of spatial fragmentation whereas the usages of sedentary ICT are influenced by the degree of temporal fragmentation. Person-ICT attributes and ICT use mediate the participation in non-work activities, and can replace work and non-work travel. Fragmentation reduces work trips but at the same time restricts non-work personal travel possibilities and can reallocate time for leisure activity and travel.

1. Introduction

In many developed countries, we live now in a post-industrial era associated with rapid technological and societal changes. One of the key manifests of these changes is the gradual proliferation and penetration of pervasive information and communication technologies (ICT) into many domains of everyday life, in particular, but not exclusively, to activities involving and relating to paid work. Depending on the availability of telecommunication infrastructure and using various nomadic devices like laptop computers, tablets and mobile smartphones, people are now communicating with each other synchronously and asynchronously accessing and exchanging information practically from anywhere and even anytime while stationary and on the move.

Over the past 30 years, especially since the rise of the Internet, there has been much theoretical debate and empirical research on the association between ICT use and travel behaviour. Generally this debate has centred on if and how

* Corresponding author. Tel.: +972 3 6409098.
E-mail addresses: eranbe@post.tau.ac.il (E. Ben-Elia), Aleksandr@scag.ca.gov (B. Alexander), C.G.T.M.Hubers@tudelft.nl (C. Hubers), d.f.ettema@uu.nl (D. Ettema).

http://dx.doi.org/10.1016/j.tra.2014.03.016
0965-8564/

telecommunications influence travel (Handy and Mokhtarian, 1996; Mokhtarian and Salomon, 1997). In the late 1980s and early 1990s, Salomon (1985, 1986) and Mokhtarian (1990) asserted four plausible ways by which ICT may influence activity and travel choice. The first is substitution of a real activity by a virtual one e.g. e-working or e-shopping (where e-*x* stands for conducting activity *x* through electronic means, also familiar as tele-*x*), resulting in reduced need to travel. The second way is generation, stimulation or complementarity, whereby the use of ICT and participation in virtual activities brings about the need for more travel than previously. The third is modification of travel that would have occurred anyway and the fourth is neutrality or no influence. Mokhtarian and Tal (2013), suggest it is better to examine the impacts of ICT in terms of the mechanism by which they operate namely: replacement of traditional activities, displacement i.e. taking time/money from other activities, overlaying (multitasking), resource reallocation i.e. giving time/money to other activities and enablement/facilitation/modification of activities.

Plenty of hope was pinned by policy makers and practitioners on the replacement of travel by ICT as envisioned by Albertson (1977). Indeed some of the empirical literature reported substitution effects particularly in relation to paid work (Hamer et al., 1991; Pendyala et al., 1991; Yeraguntla and Bhat, 2005; Mokhtarian et al., 2005). Devotion of time and money to in-home rather than out-of-home leisure activities (Balepur et al., 1998; Vilhelmson and Thulin, 2006; Graaff and Rietveld, 2007) has also reduced the need for certain types of leisure travel. Letting the fingers do the walking prevents unnecessary in-store shopping and shopping trips (Line et al., 2011). However, much of the empirical ICT-travel literature suggests that generation and modification offset substitution as despite an exponential growth in ICT use over the last decade (e.g. the number of owned mobile phone handsets) no concrete evidence is apparent to a major decline in distance travelled or reduction in traffic congestion (Mokhtarian, 2009, 2003; Handy et al., 2005). Fifteen years ago, Mokhtarian (1998) concluded that related to the use of ICT a significant reduction in travel is not to be expected, as ICT will give individuals more flexibility in relation to their daily activity and travel decisions. History seems to have endorsed this prophecy. These conclusions have not changed, though as the years have passed the explanations have become much more rich and complex referred to recently by Mokhtarian and Tal (2013) as a tapestry of relationships.

Mokhtarian (2009) elucidates why ICT does not always reduce travel or can eventually increase travel. First, ICT use is not always possible, feasible or desirable. Following Hägerstrand's (1970) triple constraints definitions, coupling constraints imply that for some activities (e.g. patients and doctors during surgery) people have to be in specific locations at specific times. Human need for physical objects such as food, shelter and clothing cannot be replaced virtually and require transportation. Capability constraints suggest that a technological replacement is not always available for replacing physical presence e.g. support and maintenance for ICT (hubs and servers) that require human presence. Authority constraints imply that ICT is not always allowed or tolerated (e.g. mobile phones in hospitals, or theatres). Being there or co-presence suggests face-to-face meetings and encounters are still preferred to a virtual substitute particularly in business situations but also for social ones (Tillema et al., 2010; Aguilera, 2008; Mokhtarian, 2004). Second, sometimes travel can carry benefits of its own such as commuting providing a transition window between home and work (Ory et al., 2004) while ICT can also change the travel experience itself making time spent more enjoyable or productive through multitasking (Jain and Lyons, 2008; Lyons and Urry, 2005; Ettema and Verschuren, 2007). Third, not all ICT usage has a relation to travel e.g. email substituting phone calls or post (Mokhtarian and Meenakshisundaram, 1999). Fourth, ICT improves transportation efficiency and reduces real and perceived travel costs. Availability of travel information and satellite navigation improve mobility adaptation and allow better comparison between mode and route alternatives both pre-trip and midway (Avineri and Prashker, 2006; Bogers et al. 2006; Ben-Elia et al., 2008; Ben-Elia and Ettema, 2011). However, information is often sought to predisposed modes of travel (Farag and Lyons, 2012) thus substantial replacement of car trips by public transport is not expected. Fifth, ICT could directly induce more travel by increasing opportunities and accessibility of engaging in activities, especially socialising (Robinson and Martin, 2010; Mokhtarian et al., 2006; Harvey and Taylor, 2000) or shopping (Cao, 2012; Rotem-Mindali et al., 2010) and by displacing time and money devoted to other activities both for individuals and firms (Mokhtarian, 1991; Milgrom et al., 1991). Sixth, though still uncharted, ICT may encourage more decentralised land use patterns which may increase travel distances (Ory and Mokhtarian, 2006; Mokhtarian et al., 2004).

The proliferation of nomadic ICT end devices like laptops, tablets, mobile phones and smartphones and the widespread availability of high speed mobile and wireless Internet connections, allow individuals who possess these end devices and have a viable wifi or mobile connection to participate in certain activities virtually from almost anywhere and anytime. In this context, the concept of Fragmentation is hypothesized to play a central role. Fragmentation was proposed by Couclelis (2003) to assess how activities are reorganized in time and space in connection with ICT use. Fragmentation can be understood as the decomposition of activity categories, that were traditionally tied to a fixed location and time slot (such as a 9–5 working day at the office) into components that can be more freely allocated across various times and places. The activity fragmentation concept suggests that pervasive ICT have loosened the associations between activity, place, and time. As a result of this decoupling of activity and place, people's opportunities to undertake activities have increased significantly. Instead of the place dictating the activities that can be performed there, a person is increasingly free to decide for herself where and when to engage in activities.

Urban and transportation planners should show greater interest in the impacts of this growing space-time flexibility. Since traditionally, land-use and transport planning are built on a place-based view of society, the shift to a person-based view exemplified by the fragmentation of activities could have unknown societal consequences (Couclelis, 1998). From a transportation planner's angle, an important question is whether these changes in ICT-facilitated activity practices, have any impact on the amount of travel and its spatial and temporal organization, as this would imply a possible change in