Information and Communication Technology (ICT), the fragmentation of work activity, and travel behaviour: A structural equation analysis

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Abstract
There is widespread recognition that new Information and Communication Technologies (ICTs) affect human activity-travel patterns in a variety of ways. The use of ICT may replace travel through substituting physical activities by ICT-based activities, for instance, telecommuting. On the other hand, ICT may generate travel by stimulating a demand for new-location based activities. Based on information acquired through Internet, certain trip characteristics such as timing or mode can be modified, without affecting the amount of travel.

A growing number of empirical studies on the relationship between ICTs and travel has been produced (Hamer et al., 1991; Pendsyala et al., 1991; Balepue et al., 1998; Harvey and Taylor, 2000; Mokhtarian and Salamon, 2002; Hjorthol, 2002; Mokhtarian, 2003; Iscan and Naktiyok, 2005; Wang et al., 2007). From the theoretical and empirical evidence provided by these studies, it is apparent that the interaction between ICT use and human travel behaviour is highly complex. Mokhtarian (2003) argues that direct, short-term studies focusing on a single application (such as telecommuting) have often found substitution effects, but also that such studies are likely to miss the more subtle, indirect, and longer-term complementarity effects that are typically observed in more comprehensive analyses. Overall, substitution, complementarity, modification, and neutrality within and across communication modes are all happening simultaneously. Mokhtarian (1998) concluded that we cannot expect a significant reduction in travel related to the use of ICTs, and that ICTs will give individuals more flexibility in relation to their daily activity and travel.

Couclelis (2000, 2004) has argued that the association between activity, place and time has weakened through ICTs, thereby facilitating the decomposition of activities in terms of locations and time. Such separation of activities into discrete pieces is commonly termed fragmentation (Couclelis, 2000). She argues (page 346) that "fragmentation of activities is one of the reasons for the widely observed increases in travel demand in the industrialized world". However, no empirical research has yet investigated the interaction between ICT, activity fragmentation and travel.

The aim of this study is to gain more insight into the relationship between ICTs and travel behavior by identifying the casual relationships between ICTs, activity fragmentation and travel, controlling for confounding factors, such as socio-demographics. In this respect, the impact of ICTs on travel can come about in two ways. A first option is that ICTs may directly lead to an increase (through finding new locations and extending one's network) or a decrease (through substitution) in travel. Alternatively, ICTs may lead to fragmentation of activities, which in turn may affect travel decisions. A major contribution this paper will make to the literature is to find out to what extent ICTs impact on travel behaviour directly, or indirectly as the result of fragmentation.

Structural equation modeling was employed to deal with the complexity of these relationships. This method is attractive because it decomposes the relationships between variables into total, direct and indirect effects. Using data from a combined activity, travel, and communication diary collected in the
Netherlands in 2007, models were estimated to investigate the relationship between ICTs, fragmentation and work- and non-work related travel as defined above. The model focuses on the impacts of ICTs on fragmentation of the work activity, and its impacts on travel. To thoroughly test the effect of ICTs, a broad range of ICT indicators, including the experience with use of Internet, the possession of ICTs and its use for different purposes etc. was included in the model. Fragmentation of ICT was measured using various sophisticated indicators of spatial and temporal fragmentation, developed in earlier studies. Travel for work and non-work purposes was expresses in terms of number of trips as well as travel time.

The models that were estimated suggest that ownership and use of work related ICTs as well as Internet experience are positively associated with more fragmented work patterns and with making more work related trips. Also, higher fragmentation of work activities coincides with more work related travel. However, no evidence was found for indirect influence of ICTs on travel behaviour, in the sense that the increase in fragmentation as a result of ICTs in itself leads to more travel. Thus, ICT use and ownership and fragmentation can be regarded as independent impacts on work travel. In addition we find a substitution effect between work and non-work related travel.

Key words: Information Communication Technologies, Fragmentation, Travel and Structural Equation Model