The Presentation of an Activity-Based Approach for Surveying and Modelling Travel Behaviour

Davy Janssens[1], Geert Wets[1], Harry Timmermans[2]

[1]Universiteit Hasselt, Transportation Research Institute, Agoralaan – gebouw D,
B-3590 Diepenbeek, Belgium
Tel: +32(0)11 26 -- -- {89 60; 86 49}
E-mail: {davy.janssens; geert.wets}@uhasselt.be
[2] Eindhoven University of Technology, Urban Planning Group, PO Box 513,
5600 MB Eindhoven, The Netherlands
Tel: +31 40 247 3315
E-mail: h.j.p.timmermans@bwk.tue.nl

Abstract

This paper announces a potential contribution to the field of activity-based modelling by the presentation of an innovative and extensive research program. The research program is innovative because it includes the development of an activity-based transportation model including short-term rescheduling decisions and (long-term) learning components. The program is extensive due to the fully integrated approach that is followed, including an advanced form of data collection, in which an extensive survey will be carried out; a model calibration and application phase.

1. Introduction

Travel demand models that embody a realistic representation and understanding of the decision-making process of individuals can be used to better guide and substantiate the decisions of transportation planners. The first type of models that has been widely adopted on a worldwide scale is the four-step modelling approach (Ruiter and Ben-Akiva, 1978). The models that were adopted at that point in time mainly focused on policies of infrastructure expansion. However, models that have the potential to be responsive to the analysis of a wider range of transport policy measures are commonly recognized as activity-based models. The activity-based approach to travel demand analysis views travel as a demand derived from the need to pursue activities distributed in space. Travel is merely seen as a means to pursue goals in life but not as a goal in itself. Therefore, modelling efforts should merely concentrate on modelling activities or on a collection of activities that form an entire agenda which triggers travel participation. Activity-based travel analysis has seen considerable progress in the past couple of decades and has led to the development of several comprehensive activity-travel models.

To date, partial and fully operational activity-based microsimulation systems include the Micro-analytic Integrated Demographic Accounting System (MIDAS), the Activity-Mobility Simulator (AMOS), Prism Constrained Activity-Travel Simulator (PCATS), SIMAP, ALBATROSS, Florida's Activity Mobility Simulator (FAMOS) and other systems developed and applied to varying degrees in Portland, Oregon, San Francisco, and New York.

The aim of this paper is to announce an important potential contribution to this line of research by the presentation of a comprehensive and extensive research program that has been funded by the IWT, which is an Institute for the Encouragement of Innovation through Science and Technology in Flandres.

2. Problem Formulation

Despite the fact that activity-based models were able to replace four-step models in most scientific publications, and due to their complexity, activity-based transportation models were not adopted at the same pace by practitioners. Until recently, most Metropolitan Planning Organizations (MPOs) in the United States were still using conventional regional models based on the basic four-step modelling paradigm. For modellers, the advantages of activity-based transportation models in terms of capturing behavioural realism of individuals and their ability to come closer to an understanding and modelling of individual behaviour are clear and strong. For practitioners however, this core concept often proved to be less appreciated or misunderstood in the past since transportation planning decisions are generally based on aggregate forecasts of demand for and performance of transport facilities.

Another factor which is likely to contribute towards a reduced use of activity-based transportation models is the fact that data that is required in an activity-based transportation model are probably more difficult to collect (i.e. require more resources) than in traditional four-step models. Typically data for an activity-based model is collected by means of activity diaries, but this implies an increased amount of diligence to fill out and provide this (more detailed) information. A problem which is also highly present in data collection is the difficulty to collect detailed and long range data. It was already evidenced in previous studies that the number of activities that were reported during the second day of a two-day lasting data collection effort, were significantly lower than they were the first day (Zwerts and Nuyts, 2003).

A third problem in activity-based approaches is related with their model formulation. While activity-based transportation models have the potential to lead to more realistic and accurate predictions, many of these models still heavily focus on the static correlation between observed travel behaviour and explanatory variables. The static property may not directly hamper predictive results as such, but it restricts a more thorough degree of application, for instance in case something unexpected occurs. An example may be the rescheduling of activities (which means some activities may be executed in another sequence than originally scheduled, some may be completely omitted or others may be inserted) due to several external factors. Ideally, a comprehensive model should be able to anticipate in these circumstances and adapt its behaviour. Another aspect of dynamics, which is only very occasionally investigated, is the effect of adaptation and “long-term” learning.

3. Presentation of the Research Program

In order to come to a solution for the problems that were identified above, a research program has been initiated that has four main workpackages, which are further divided in different subtasks.

3.1 Workpackage 1: Data Collection

The data collection workpackage consists of two subtasks, i.e. first, a specification of the survey design and second, the implementation of both a mobile survey through a Personal

Digital Assistant (PDA) with GPS technology and an integrated computer-assisted information system that ensures enhanced data quality.
With respect to the first subtask, a feasibility study has already been carried out at the current stage of the project. The study describes how the data collection should be effectuated, using innovative devices. Several methodological issues (e.g. phrasing of the questions, sample size, sample origin, sample clustering) have been discussed. To current date, a number of these decisions have already been implemented or will be implemented in the near future. The main decisions involve the sample size of the study, which should include 2401 households. Approximately one half of the sample will receive a PDA-module; the other part of the sample will be questioned by means of a traditional paper-and-pencil method. This choice enables us to carry out comparative studies with respect to the behaviour of both target groups in terms of response rates, experience, etc.. The households will be selected using a stratified cluster technique, which ensures a geographical and spatial distribution in the sample which is representative for the study area of Flanders. The survey will ask the members of the selected household to fill out a diary and to report rescheduling decisions (the reasons for rescheduling are reported as well) during a one-week period. In comparison with other activity-based studies, the survey period is particularly long, especially in combination with the high number of households that will participate in the survey. Finally, detailed cost estimates have already been made and a description of logistics and needed CATI-support are currently being investigated and will be reported in the study as well. These and other design specifications will be used as core information in the second task of this workpackage.
The second task involves the design and implementation of the data collection module. In the past, desktop computer-assisted data collection tools were used for filling out travel surveys. However, existing systems such as CHASE and REACT! are not able to trace the actual activity-travel execution due to their mobility constraints and were already criticized because of this limitation in a study by Zhou and Golledge (Zhou and Golledge, 2004). In order to solve this problem, one might think of a Personal Digital Assistant (PDA) with GPS technology for enhancing the data collection tool’s mobility. The evaluation of such a tool has only been rarely evaluated in the context of transportation research but the topic is gaining increased attention in recent years. For a more detailed overview of the different functionalities of our system, we refer to (Kochan *et al.*, 2005).

3.2 Workpackage 2: Specification of a Dynamic Activity-Based Travel Demand Model

The aim of the second workpackage is to explore how an activity-based transportation model can be developed that is able to incorporate (short-term adaptation and learning) dynamics. To this end, the second workpackage has been divided into four different subtasks.
The aim of the first subtask is to incorporate “learning” in the model calibration. Given the fact that travelers’ information is limited, imperfect and often biased, their day-to-day decisions rely on the experience of previous choices. By repeatedly making decisions, an individual acquires knowledge (learns) about his environment and thereby forms expectations about the attributes of the environment. Because an individual does not know which choice is best, it is in his interest to explore different choices in the beginning and become involved in more goal-directed behaviour at a later stage. Two different theoretical foundations can be given for this specification. The first argument is related towards the reinforcement learning literature (Kaelbling *et al.*, 1996), which states that it makes more sense to weight more recent outcomes more heavily as more recent experience may provide more reliable information. The second argument is related to the theory of memory retention (Anderson, 1983), which states that memory is perceived as a decay parameter. In the first argument, the definition of time relates to previous experiences, while in the second argument time depends on clock

time. Some of the work relating to learning has been conducted by Ben-Akiva et *al.* (1991), Axhausen et *al.* (1995), Nakayama et *al.* (2001), Polak and Oladeinde (2000).

All these proposed methods attempt to predict a change in the implementation of activity-travel patterns *in response to some external source*. As mentioned previously, the occurrence of critical incidents and key events may be an example of such an external source. Several key events may be investigated in this manner, but an obviously important event is a change in residential, work or educational location ("moving"). However, also other events such as a change in household composition, car availability or household income may also contribute to a new environment that needs to be "learned" by the respondent. There is ample opportunity to further elaborate the conceptualisation of adaptation and learning in a transportation context. Moreover, most of the models focus on an isolated decision dimension and do not account for the impact on the complete activity-travel pattern. Furthermore, operational models are still seriously lacking.

One of the most advanced conceptual models to date has been developed by Arentze and Timmermans (2003), who developed a model of learning and adaptation in activity choice, where memory and search play an important role. Individuals explore choice opportunities through search and keep a memory of cumulative reward or punishment based on the implementation experience. As part of this workpackage, we will therefore develop models of learning in transportation settings, using Arentze and Timmermans' conceptual model (2003) as a starting point.

The second subtask within this workpackage deals with short-term adaptation based on within-day rescheduling. One of the major problems in individuals' scheduling is that people frequently want to do more than they are able to do given the limited amount of time that is available. To solve conflicts in a short-term, individuals may consider several strategies such as re-sequencing activities, compressing activity durations or changing priority. In some of the work by Gärling et *al.* (1999), it is indeed stressed that anticipated time pressure is an important factor controlling the frequency of activity scheduling and that it is an additional factor constraining the feasibility of schedules. Doherty and Axhausen (1999) suggested another conceptual model of scheduling behaviour. In this work scheduling is assumed as a multi-stage process, which distinguishes between routine scheduling decisions and short-term, impulsive decisions. Again, probably one of the most advanced works has been proposed by Joh, Arentze and Timmermans (2003). The work proposed is quite comprehensive since it allows modelling the dynamics of activity scheduling and rescheduling decisions as a function of unexpected events during the execution of activity programs. Although these studies are theoretically appealing and key concepts are supported by numerical simulations, this line of work has not yet resulted in a fully operational model of activity rescheduling behaviour. To this end, we will start with collecting information about the activity-travel schedule and about rescheduling decisions using the data collection tool that was described in Workpackage 1 as an alternative way for measuring short-term adaptation. As mentioned before, the system was specifically built to capture short-term rescheduling decisions and reasons for rescheduling.

The third task of the second workpackage deals with the creation of synthetic datasets. The research idea which has been conceived in this task is to simulate a synthetic local travel survey sample dataset, using the available local information in conjunction with national travel (often trip-based) survey data. Local socio-demographic data for the different city regions are available from the National Institute of Statistics (NIS). National travel survey data are available from Zwerts and Nuyts (2003), which are updated on a regular basis and from Hubert and Toint (2002). As an additional data source, we will use the study "Time Use of the Flemish People"- financed by the Flemish Community (Policy Oriented Research Program 97/3/109). For this study, 1533 Flemish people between the age of 16 and 75 kept a diary during one week.

It will be examined whether synthetic data that is built from joining together a different number of data sources (time use survey, national travel survey data, local information) can enhance the data that is used in the (dynamic) activity-based model.
Important research questions will still need to be addressed to join together the different sources of data. Obviously, if this process is of value, it will significantly reduce the costs for local travel data collection. To validate the procedure of creating synthetic local data, the travel surveys that were collected in the city regions of Ghent, Antwerp, Hasselt-Genk can be used as benchmark datasets.
As a fourth subtask, the knowledge of the first three tasks in workpackage 2 is finalized by the development of a prototype system. This means that the learning concept, the short-term rescheduling adaptation model and the development of the state-of-the-art method for producing synthetic datasets are incorporated as independent modules in the system. This will result in a fully operational model that is used to read in data, both from the integrated PDA system (national scale) and from the synthetic dataset module (local scale). The tool is used to help practitioners to facilitate the change from trip-based to activity-based models.

3.3 Workpackage 3: Transition from Conventional 4-step Models to Activity-Based Transportation Models

Once the dynamic model has been developed in Workpackage 2, a profound evaluation and transition process will be implemented to facilitate the changeover from the conventional and currently used four-step model in Flanders. The same transition exercise has been slowly initiated in the United States in a number of cases, where practitioners acknowledged that activity-based models can be especially attractive for practical planners in view of their direct linkage to the actual planning issues (Vovsha *et al.*, 2003).
The first subtask provides a detailed theoretical comparative analysis. The study will for instance detail upon the time-of-day choice dimension that benefits most from the activity-based approach.
Secondly, it has been recognized that it would be beneficial to develop a trip-based model and an activity-based model in parallel for the same region (based on the same surveys and other data sources) in order to compare them in various applications (Vovsha *et al.*, 2003). This will facilitate the transition for practitioners from trip-based models to activity-based models. Therefore, subtask 2 consists of a comparative research carried out on the same set of data with different traditional four-step models and the developed dynamic activity-based model.

3.4 Workpackage 4: Valorisation

Finally, this high-end research program has a strong multi-disciplinary character and offers plenty of opportunities to address additional spin-off activities and research questions. The multi-disciplinarity of this proposal is reflected in a valorisation workpackage which main task is to let several actors of the target sector become involved in the execution of the project. The target sector consists of representatives that are selected from the “mobility” and the “environmental” sector. In addition to this, both a user committee and a valorisation committee have been created that are responsible for the dissemination of the scientific and technical results that come out from the different tasks of the research project and for the valorisation of this knowledge towards a broader range of application domains.

4. Conclusion

This paper has presented an extensive research program and announces an important potential contribution to the current state-of-the-art of activity-based transportation models. The project has been reviewed by several external referees. All of them acknowledged the innovative scientific contributions of the proposal. Especially the dynamic character of the activity-based travel demand model and the fully integrated approach from data collection, model calibration and transition process were highly appreciated. In terms of broader contributions for society, the reviewers appreciated the valorisation workpackage and opportunities for additional follow-up activities. It was also acknowledged that the potential domain of application may go beyond the representatives of the target sector which are in the user committee. To this end, wider application domains such as spatial planning, location-based services or tourism may benefit from the improved analytical and predictive capabilities of the model that will be developed.

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