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ASSESSING THE IMPACT OF FUEL COST ON TRAFFIC DEMAND IN FLANDERS USING ACTIVITY-BASED MODELS

Bruno Kochan, Tom Bellemans, Davy Janssens & Geert Wets

Transportation Research Institute (IMOB), Hasselt University, Diepenbeek, Belgium

ABSTRACT

The basic principle underlying activity-based travel demand models consists of the fact that travel is derived from the activities individuals need to perform. Important in the theoretical reasoning behind activity-based models are the constraints that dictate whether or not activities can be performed in particular time-space settings. In addition to constraints, empirical evidence also indicates that individuals' activity-travel sequences are susceptible to changes in transport network characteristics, as they directly influence the individual perception with respect to different travel modes. By strategically managing the controllable properties of the transportation system, traffic demand can be influenced. However, the search for good traffic demand management measures is complicated by the abundance of available measures and their interactions. Activity-based models are conveniently suitable for incorporating these transport system characteristics in the decision process model yielding activity-travel schedules. Due to the consideration of transport system characteristics, activity-based models provide a tool to assess the impact of contemplated measures using simulation. In order to illustrate the potential of this approach towards traffic demand modeling, a simulation based analysis of the impact of fuel price on the traffic demand in Flanders is performed. To this end, an activity-based model in the FEATHERS (Forecasting Evolutionary Activity-Travel of Households and their Environmental RepercussionS) framework is applied on a fraction of the Flemish population.

INTRODUCTION

According to United Nations (2001) the demand for transport services is expected to grow considerably as incomes rise, the trend toward urbanization continues and as the process of globalization moves forward with expected increases in world trade and personal travel. In order to meet this rising demand and because governments cannot afford to allow transport constraints to have a negative impact on the future competitiveness of their products, different kind of transport demand measures (TDM) are being considered. One of the ways to better streamline traffic demand is by alteration of the transport system. By strategically modifying the controllable properties of the transportation system, traffic demand can be influenced. The big challenge however consists of implementing sustainable measures that yield the desired result on traffic demand. The search for good traffic demand management measures is complicated by the abundance of available measures and their interactions. Therefore, activity-based models provide a tool to assess the impact of contemplated measures using simulation.

This paper is part of a broader research that aims at developing an activity-based model for Flanders in the FEATHERS (Forecasting Evolutionary Activity-Travel of Households and their Environmental RepercussionS) framework. The FEATHERS framework provides a structured approach to agent-based modeling of activities and travel for individuals within a household context. In order to illustrate the potential of this approach towards traffic demand modeling and of the FEATHERS framework, a simulation based analysis of the impact of fuel price on the traffic demand in Flanders is performed on a fraction of the population.

ACTIVITY-BASED MODELS

Since 1950, due to the rapid increase in car ownership and car use in the US and in Western Europe, several models of transport mode, route choice and destination were used by transportation planners. These models were necessary to predict travel demand in the long run and to support investment decisions in new road infrastructure which originated from this increased level of car use. In those days, travel was assumed to be the result of four subsequent decisions which were modeled separately. Within transportation literature these models are also referred to as four-step models. More recently, especially in the eighties and early nineties, several researchers claimed that very limited insight was offered into the relationship between travel and non-travel aspects in the widely used four-step models. Indeed, travel has an isolated existence in these models and the question why people undertake trips is completely neglected. This is where activity-based transportation models came into play. The major idea behind activity-based models is that travel demand is derived from the activities that individuals and households need or wish to perform. The main difference however between traditional (i.e.

four-step) transportation forecasting methodologies and activity-based transportation models is that the latter attempt to predict interdependencies between several facets of activity profiles (Davidson *et al.*, 2007). These facets are often identified as *which* activities are conducted *where*, *when* and for how *long*, with *whom*, and with which *transport* modes. Hence, activity-based models are designed to keep linkages between the travel decisions of members of a single household as research has shown that interactions among family members, whether coordinating the use of household vehicles, sharing household responsibilities or performing joint activities, often affects and in many cases largely determines people's travel. Four-step models that ignore such linkages misstate people's responses to travel demand policies (Vovsha and Bradley, 2006).

FEATHERS FRAMEWORK

The FEATHERS framework (Janssens *et al.*, 2007) was developed in order to facilitate the development of activity-based models for transportation demand. This framework suggests a four stage development trajectory for a smooth transition from the four-step models towards static activity-based models in the short term and dynamic activity-based models in the longer term. The scheduling model that is currently implemented in the FEATHERS framework is based on the scheduling model that is present in the Albatross system (Arentze and Timmermans, 2004), which is a representative exponent of the activity-based approach. Currently, the framework is fully operational at the level of Flanders. The real-life representation of Flanders is embedded in an agent-based simulation model which consists of over six million agents, each agent representing one member of the Flemish population. The scheduling is static and based on decision trees (Breiman *et al.*, 1984), which are trained based on data collected by means of paper-and-pencil diaries and PARROTS, a custom-made activity-based survey tool (Kochan *et al.*, 2005). A sequence of 27 decision trees, derived by means of the CHAID algorithm (Kass, 1980), is used in the scheduling process and decisions are based on a number of attributes of the individual (e.g., age, gender), of the household (e.g., number of cars) and of the geographical zone (e.g., population density, number of shops). For each agent with its specific attributes, it is for example decided if an activity is performed. Subsequently, amongst others, the location, transport mode and duration of the activity are determined, taking into account the attributes of the individual.

TRAVEL DEMAND MEASURES

As stated before, one of the major promises of the activity-based modeling approach is an increased sensitivity for postulated measures that are generally important in transport planning and policy making. In contrast to four-step models, activity-based models should be sensitive to transportation-system related factors. Such changes may be related, for example, to public transportation facilities (e.g. increased public transport speed and/or service frequency) or pricing measures including parking pricing, congestion pricing and fuel pricing (Victoria Transportation Policy Institute, 2008).

An important asset of activity-based models in this context is their integrated approach towards activities and travel. Due to this approach, it can be taken into account that certain trips, which are linked to activities that are not so flexible (such as e.g. work activities) are less likely to be altered under changing traffic system conditions than others (such as e.g. leisure activities). In addition, activity-based models are not only able to predict an increase or reduction in the demand for travel, but they also predict shifts between modes of transportation and the reallocation of activities due to imposed measures.

Providing a structured approach to agent-based modeling of activities and travel for individuals, the FEATHERS framework is able to account for traffic demand measures.

IMPACT OF FUEL COST ON TRAFFIC DEMAND

Price changes can have a variety of impacts on travel, affecting the number of trips people take, their destination, route, mode, travel time, type of vehicle (including size, fuel efficiency and fuel type), parking location and duration, and the type of transport services they choose. In order to predict the impact of price changes, the scheduling model has to be structured to account for those changes.

The scheduling model that is currently implemented in the FEATHERS framework is based on the Albatross scheduling model in which price and cost parameters are incorporated in the decision trees that are concerned with activity selection, timing, trip-chaining, location and mode choices. The extended decision trees or Parametric Action Decision Trees (PADT) combine conventional decision trees and parametric action assignment rules yielding a model that is sensitive for travel-costs scenarios (Arentze and Timmermans, 2005).

To test the sensitivity of the FEATHERS scheduling model, a fuel cost scenario was considered. At the time of writing, the decision trees, embedded in the current FEATHERS

scheduling model, had been estimated by means of a small fraction of the Flemish population. Therefore, the findings presented in this paper should be considered preliminary, since the data collection process and analysis for this research is still ongoing. Hence, the purpose of this paper is to test the sensitivity of the model to a limited number of trip facets.

This section of the paper reports the results of a scenario-based simulation study to explore mobility effects in case of an increase of variable fuel cost for all times of day and for a fraction of the Flemish population. As shown in table 1, for an increase of the fuel cost, FEATHERS predicts a decrease of the average number of car trips (as a driver), an increase in the number of car trips (as a passenger) and a decrease in slow mode trips (i.e. cycling, walking).

Car driver	-
Car passenger	+
Slow	-

Table 1: Impact of Fuel cost on average number of trips per mode per day

The output of FEATHERS also reveals changes in travel distances. As table 2 indicates, distances traveled by car, both as driver and passenger, and by slow mode (i.e. bike, pedestrian) all increase.

Car driver	+
Car passenger	+
Slow	+

Table 2: Impact of Fuel cost on total travel distance

Surprisingly, the results of the scenario show an increase in car travel distance. However, as table 1 indicates, the number of car trips decreases. Both effects, a decrease in the number of car driver trips and an increase in car driver travel distance, could be indicative for a shift in particular activities in the executed activity program as people instinctively try to adapt to the increase in fuel cost. Given a planned activity program for a specific day, individuals and households have to make a number of interrelated choices concerning the destination, transport mode, timing and duration. For a particular day, the scheduling of activities can be accomplished in a variety of ways and as travel demand is derived from the activities that individuals and households need or wish to perform, activities can be organized into different kind of trips and home-based tours. Additional research should reveal if shifts arise in activities

that are conducted by making a series of separate single-purpose trips, all starting and ending at home and trips combined and organized into multi-purpose home-based tours.

CONCLUSIONS

This paper considered the results of a specific scenario, that is a fuel cost increase, conducted to test the sensitivity of the FEATHERS scheduling model. Preliminary results show that a fuel cost increase leads to changes in travel demands and travel distances. Therefore, applying the model to a fuel cost scenario appears to be a promising method. However, further research is needed to investigate and validate the relationships between changes in trip and activity facets. New data is currently being collected to expand the results and validate the computed measures.

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