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ACTIVITY-BASED MODELING OF TRAVEL DEMAND AND BEHAVIOUR

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Abstract:
In all developed and developing countries of the world, the government transportation's policies aimed at controlling aggregate phenomena such as congestion, emissions and land use patterns. These are achieved through the provision of employer-based commute programs, single occupant vehicle regulation, road pricing, multimodal facilities and transit oriented land development. But these policies affect the aggregate phenomen indirectly through the behaviour of individuals. Furthermore, individuals adjust their behaviour in complex ways, motivated by a desire to achieve their activity objectives. This paper examines the activity based modeling of travel demand and behaviour, the concepts underlying the methods and modeling approaches. Finally, it identified three classes of model systems, which are econometric model systems, hybrid simulation systems and the theory of planned behaviour model, and also look at some examples in each class, considering how they work, and their particular strengths and weaknesses, and above all, looking at the big picture.

Keywords: activity-based, modeling, travel demand, models, systems, econometric, hybrid simulation, planned behaviour

1. Introduction

Activity based travel model is a richer framework in which travel behaviour is analyse as a daily or multi-day patterns of behaviour, related to, and derived from the differences in lifestyle and activity participations among the population. In order words people makes trips because they wants to participate in activities. And also people make modal choices in order to suit the activities in which they want to participate. So,

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in order words activities is primary and travel secondary. Concerns about congestion, emissions and land use patterns lead governments to consider policies aimed at controlling them. These policies include, for example, employer-based commute programmes, single occupant vehicle regulation, road pricing, multimodal facilities and transit oriented land development. But these policies affect the congestion, emissions and land use patterns indirectly through the behavior of individuals. Moreover, individuals adjust their behavior in complex ways, aggravated by a desire to achieve their activity objectives. This can be illustrated in Figure 1. This figure represents the daily activity and travel pattern of one person who drove alone to work at 8:00 a.m., returned home at 5:00 p.m., and stopped to shop on the way home. In response to an employer sponsored programme which gave strong financial incentives to commute by transit, this person made the switch to transit. This required them to begin their commute earlier, at 7:30 a.m., in order to arrive at work on time. Because their preferred shopping destination wasn't on the transit path, they decided to come straight home after work, then drive alone to do their shopping after arriving at home in the evening.

This response was rooted in demand for activity, and involved a complex adjustment in their entire day's pattern. In this case, a conventional trip based forecasting model would probably fail to predict the compensating peak period auto trip induced by the transit incentive program. Forecasting models will only be able to accurately capture this kind of response if they represent how people schedule their daily activities.

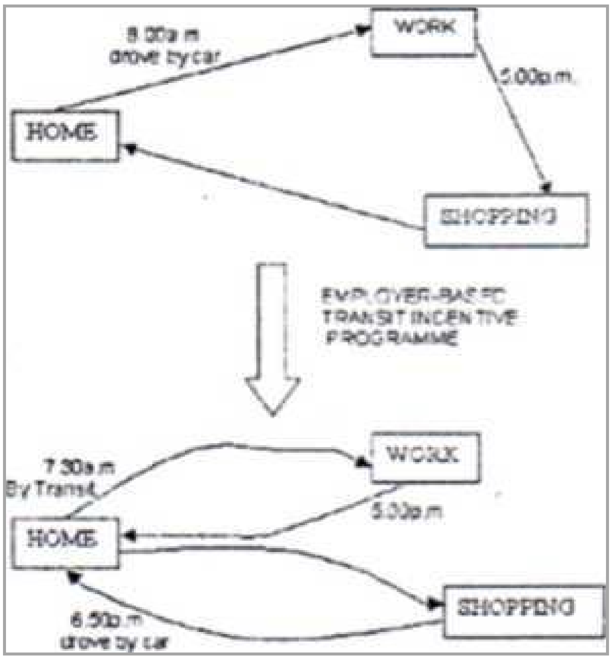

Figure 1: Activity based policy responses involve complex behavioral adjustments forced by a desire to achieve activity objectives

2. The Theory behind Activity' Based Travel Demand Forecasting

The theory underlying activity based travel demand forecasting starts with the framework in which activity and travel decisions are made. Figure 2 shows how activity and travel scheduling decisions are made in the context of a broader framework, surrounded by and connected in important ways to other decisions (Ben-Akiva and Lerman[1] 1985; Ben-Akiva, Bowman and Gopinath[2] 1996). Urban development decisions of governments, real estate developers and other firms influence the opportunities available to households and individuals. Government bodies may provide public transportation services, and tax and regulate the behavior of individuals and firms. Real estate developers provide the locational opportunities for firm and individual location decisions. Firms determine the locations of job opportunities through their location and production decisions.

Household and individual choices include:

- mobility and lifestyle decisions,
- activity and travel scheduling, and
- implementation and rescheduling, fall into distinct time frames of decision making.

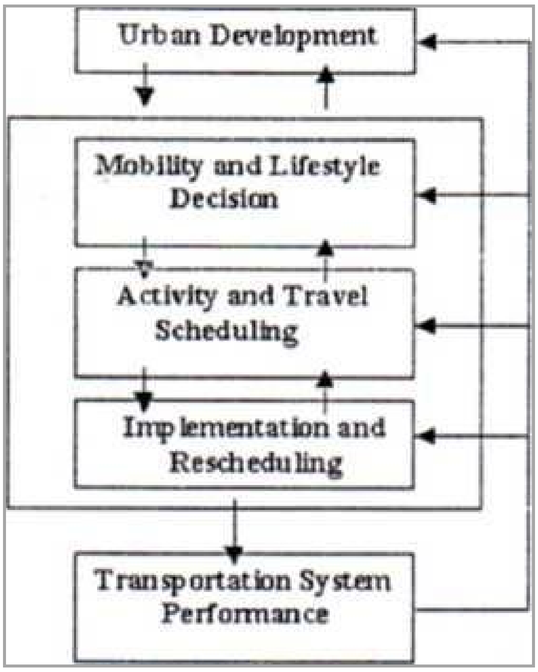

Figure 2: Activity and Travel Decision Framework

Source: Ben-Akiva and Lerman 1985[1]

Mobility and lifestyle decisions occur at irregular and infrequent intervals, in a time frame of years. These include major decisions of household composition and roles, workforce participation, workplace, residential location and long term activity commitments. They also include a set of long term transport decisions such as auto ownership, work travel mode, transit and parking arrangements, commute program participation, and, potentially, the acquisition of equipment for automated traveler information systems.

Activity and travel scheduling is a planning function which occurs at more frequent and regular intervals. It involves the selection of a particular set of activities and their priorities, the assignment of the activities to particular members of the household, the sequencing of the activities, and the selection of activity locations, times and methods of required travel. It is convenient to make the simplifying assumption that the activity and travel scheduling decision addresses a particular time span, such as a week or a day. The models we examine later do this, using a 24 hour day as the decision time span.

Within the day, unplanned implementation and rescheduling decisions occur. These include en- route decisions of route choice, travel speed, acceleration, lane changing, merging, following distance, and parking location. Scheduling decisions are made to fill previously unscheduled time with unplanned activities, and rescheduling occurs in response to unexpected events.

Urban development directly influences the decisions of individuals and households, and together the urban development and individual decisions affect the performance of the transportation system. This is manifested in several ways, including travel volumes, speeds, congestion and environmental impact. These manifestations of transportation system performance simultaneously affect the urban development and individual decisions.

3. The Characteristics of Activity and Travel Demand

"Travel demand is derived from activity demand" is one of the most fundamental, well known and widely accepted principles. That is why based on this principle decision framework includes travel decisions as components of a broader activity scheduling decision, and it requires us to model the demand for activities. According to Chapin' (1974), theorized that activity demand is motivated by basic human desires, such as the desires for survival, social encounters and ego gratification. It is also moderated by various factors, including, for example, commitments, capabilities and health. The conclusions are that:

- households influence activity decisions,

- the effects differ by household type, size, member relationships, ages and genders, and
- children, in particular, impose significant demands and constraints on others in the household.

Hagerstrand' (1970) focused attention on constraints which limit activity options available to individuals. These include coupling constraints, authority constraints and capability constraints. Coupling constraints require the presence of another person or some other resource in order to participate in the activity opportunity. Examples include participation in joint household activities or in an activity which requires an automobile for access. Authority constraints are institutionally imposed restrictions, such as office or store hours, and regulations such as noise restrictions. Capability constraints are imposed by nature or technology limits. One very important example is the nearly universal human limitation which requires us to return home daily to a home base for rest and personal maintenance. Another example Hagerstrand called the time-space prism; we live in a timespace continuum and can only function in different locations at different points in time by experiencing the time and cost of movement between the locations.

However, not all activity requires our physical movement. Furthermore, the advance of telecommunications technology makes it possible to participate in more and more kinds of activities without physically moving, by increasing the quantity and quality of one- and two-way information exchange which can occur electronically. This leads to choices for individuals between travel and non-travel activity alternatives for work, shopping, conferring and recreation. The modeling implications of this are very important:

- models need to represent the time and space constraints people face and
- models also need to represent the choices people make between travel and non-travel alternatives.

4. Modeling Approaches

4.1. Econometric Models

Econometric models use decision protocols. As shown in Figure 3 below, econometric models represent the choice set generation, or search, stage very simply, either assuming the decision maker considers all feasible alternatives, or using a simple search rule (heuristic) which results in a large choice set. Most of the model is devoted to the complex representation of a utility-based multi-dimensional choice.

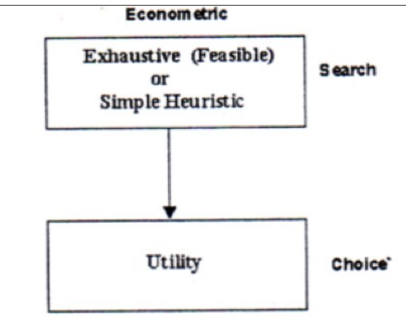

Figure 3. Econometric model represent the search simply, and focus attention on the choice.

Econometric model systems are systems of equations representing probabilities of decision outcomes. They are based on the theory of probability and statistics, generate probabilities for all alternative outcomes, and are usually based on a utility maximization assumption. The trip-based model and tour-based model are examples of econometric model. Basically, these model systems rely heavily on (a) multinomial logic and (b) nested logit probability models. The integrated trip-based system an example of econometric model system and was developed during the mid-1970's for the MTC in San Francisco (Ruiter and Ben-Akiva 1978). The demand model portion of the MTC system has three major components, as shown in Figure 4 (a).

The mobility and lifestyle component represents long term decisions related to auto ownership and home-based work trips. Short term activity and travel decisions deal with other home based trips and non-home based trips. Each model component is conditioned by choices at the higher level, and the activity and travel models influence the mobility and lifestyle models via measures of expected utility. Figure 4 (b) shows details of the mobility and lifestyle component of the model system. At this level, we can see that the system is in the class of household models because it explicitly models work travel decisions for two workers in the household. Arrows in the figure show how the models are integrated, with solid arrows indicating conditionality and dashed arrows indicating expected utility. For example, the number of autos chosen in the auto ownership model is conditioned by the choice of workplace. That is, the model assumes the workplace is known when it models the auto ownership decision. The auto ownership decision itself conditions the mode choice model. The model also accounts for how auto ownership is influenced by the ease of travel for shopping and work by including variables of expected utility generated by the shopping destination and mode choice and work mode choice models.

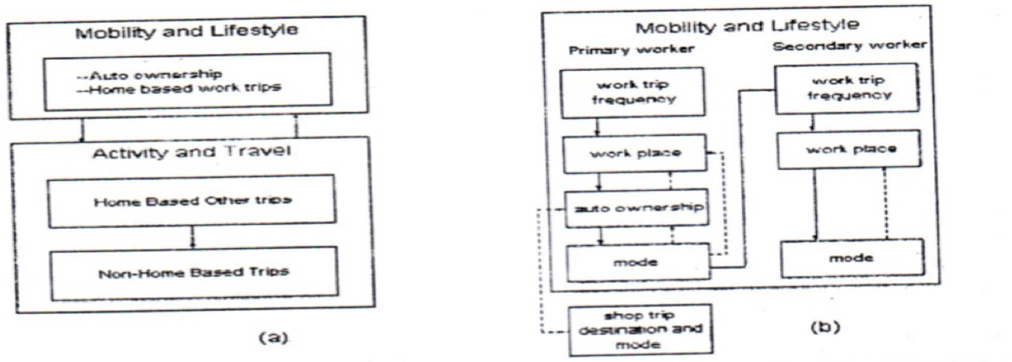

Figure 4(a) Three major components of the MTC model system, and (b) details of the mobility and lifestyle component, showing integration of the models via conditionality(solid arrows) and expected utility (dashed arrows). (Source: Ruiter and Ben-Akiva[5] 1978)

4.2 Hybrid Simulation Model

Hybrid simulations are systems of sequential rules predicting decision process outcomes. The hybrid simulations are all implemented as realization models, simulating the choice of a single outcome for each individual in the representative population. Such a model focus most of their attention on the choice set generation stage, employing a complex search heuristic which yields a very small choice set. A very simple utility or satisfaction based model is used to represent the choice from this set. Often the protocol involves iteration between search and choice. The daily schedule model of the Ben-Akiva and Bowman model, STARCHILD and AMOS, are examples of hybrid simulation models.

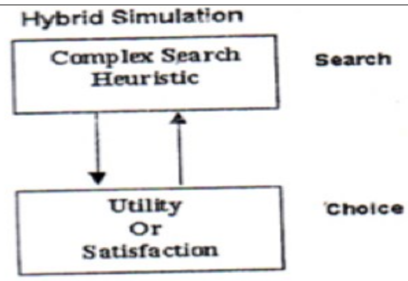

Figure 5. Hybrid simulations focus on the search, representing the choice simply.

The STARCHILD's (Recker, McNally and Root' 1986) is an example of Hybrid simulations, which models the activity and travel scheduling decision as a classification and choice process Figure 6 below shows STARCHILD that begins with a detailed activity program which must be supplied from outside the model. The activity program identifies many details of the schedule, including activity purpose, participation, duration and location, as well as constraints on sequence, timing and coupling of activities. It then models the scheduling decision as a four step process which yields the timing and sequence of the activities in the program. Choice set generation occurs in the first two steps,

Feasible alternatives are exhaustively enumerated with careful attention to constraints. They are then classified, using a statistical similarity measure, and one alternative is chosen to represent each of approximately 3-10 classes. The remaining two steps comprise the choice process. A decision rule is used to eliminate some alternatives. A multinomial logit model then represents a utility maximizing choice among the remaining non-inferior alternatives. The developers of STARCHILD conceived the activity schedule as a plan, which is followed by implementation and rescheduling, but did not develop the latter model.

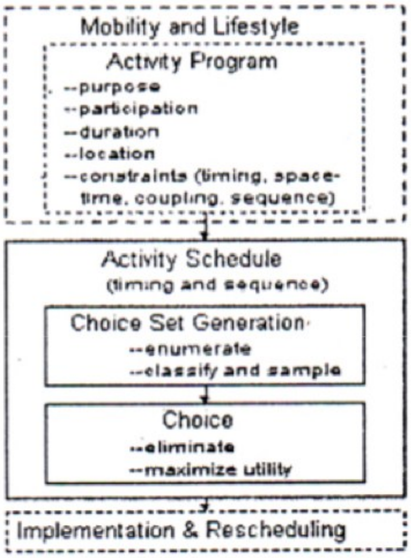

Figure 6. STARCHILD takes an externally supplied activity program and simulates the scheduling decision. Choice set generation involves enumerating, classifying and sampling the schedule alternatives. This is followed by a simple utility maximization choice.

4.3. The Theory of Planned Behaviour Model

The theoretical basis of approach design to obtain information on public perceptions of transport problems and how their perceptions changed as a result of various interventions was the Theory of Planned Behaviour (TRB). The theory of planned behaviour state that all behaviour is determined by the intention to carry it out, according to Ajzen and Fishbein' (1985). Intention is determined by three factors, called attitudes, subjective norms and perceived behavioural control. The Theory seeks to explain the links between beliefs, attitudes, intention and behaviour, when the behaviour is not under the full control of the individual, but subject to external influences, such as when making a transport decision.

This Theory set out three types of beliefs: Behavioural Belief: - This is the beliefs that his behaviour will leads to the outcome and evaluations, Normative Beliefs: - This beliefs that his friends or family or society that is important to him approve or disapprove a given behaviour. Control Beliefs: - These are the Beliefs that certain obstacles and facilitators will hinder or help a person to use to use a mode.

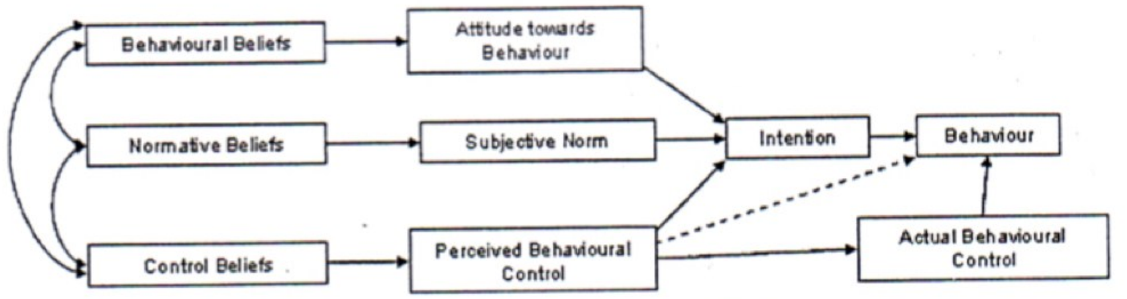

Figure 7. The Theory of Planned Behaviour

As shown in the Figure 7 above, Behavioural Beliefs translated into attitudes to the behaviour. For example, what someone believes to be the case when travelling by car, will determine their attitude to car travel. Normative Beliefs translate into what is called the Subjective Norm. An example here is that if somebody believes that their friends think cycling is dangerous, they will restrained from thinking otherwise. Finally, Control Beliefs translate into Perceived behavioural control. For example, if somebody is to transport a large suitcase, they might perceive that it would be impossible to get on the bus. Perceived behavioural control can be seen to be an estimation of the actual control, that is it may be true that it is not practical to take a large suitcase on the bus and is therefore a good indication of whether a person intends to try out a behaviour.

Actual behavioral control refers to the extent to which a person has the skills, resources, and other prerequisites needed to perform a given behavior. Successful performance of the behavior depends not only on a favorable intention but also on a sufficient level of behavioral control. To the extent that perceived behavioural control is accurate, it can serve as a proxy of actual control and can be used for the prediction of behavior.

Although there are some theoretical weaknesses of each of the systems. The primary weakness of the trip-based MTC system is that they sometimes fail to integrate the trips or tours in a complete daily activity schedule. The hybrid simulations such as the STARCHILD, where sometime sample of alternatives may inadequately represent choice set. But these weaknesses can be overcome by combining the econometric model systems and the hybrid simulation systems with theory of planned behaviour.

5. Conclusions

It is important to note the clear influence of the activity-based approach to travel demand analysis and behaviour. The theory underlying activity based travel demand forecasting starts with the framework in which activity and travel decisions are made. Furthermore, activity and travel scheduling decisions are made in the context of a broader framework, surrounded by and connected in important ways to other decisions. Three classes of model systems are identified, which are econometric model systems, hybrid simulation systems and theory of planned behaviour model which can be used to predict modal choices and travel demand. Econometric model systems are systems of equations representing probabilities of decision outcomes and the trip-based and tour-based model can be used to model travel demand. Hybrid simulations are systems of sequential rules predicting decision process outcomes. Therefore, to bring about an effective transportation facility, Activity-based approach and the Theory of planned behaviour can be adopted alongside with the traditional approach during transportation planning in modeling travel demand and behaviour.

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