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Modeling route choice criteria from home to major streets: A discrete choice approach

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ABSTRACT

A discrete choice model that consists of three sub-models was developed to investigates the route choice criteria of drivers who travel from their homes in the morning to the access point along the major streets that bound the Traffic Analysis Zones (TAZs). The first sub-model is a Nested Logit Model (NLM) that estimates the probability of a driver has or has no multiple routes, and if the driver has multiple routes, the route selection criteria are based on the access point's intersection control type or other factors. The second sub-model is a Mixed Logit (MXL) model. It estimates the probabilities of the type of intersection control preferred by a driver. The third sub-model is a NLM that estimates the probabilities of a driver selecting his/her route for its shortest travel time or to avoid pedestrian, and if the aim is to take the fastest route, the decision criteria is based on the shortest distance or minimum stops and turns. Data gathered in a questionnaire survey were used to estimate the sub-models. The attributes of the utility functions of the sub-models are the driver's demographic and trip characteristics. The model provides a means for transportation planners to distribute the total number of home-based trips generated within a TAZ to the access points along the major streets that bound the TAZ.

1. Backgound and motivation

This paper describes the development of a discrete choice model to predict the route choice criteria of drivers when they travel from homes to the access points of major streets, i.e., intersections along the main streets that bound the Traffic Analysis Zones (TAZs). This research is motivated by the network representation in a Microscopic Traffic Simulation (MTS) model as well as the need to convert an Origin-Destination (O-D) matrix from a Metropolitan Transportation Planning (MTP) model into the counterpart in a MTS.

In the past ten years, advances in MTS has enable several relatively new and commercial software to have the capability to simulate large urban networks faster than real-time. Along with this trend, several vendors have been marketing both MTP software and MTS software as compatible packages. Examples of such bundles are VISUM-VISSIM (McFadden, 1973) and TransCAD-TransModeler (Anderson and Hernandez, 2017). However, users of such tools must aware that MTP models

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are macroscopic while MTS models are microscopic. They represent objects in the network in different levels of details. McFadden (1977) and Mannering et al. (2016) have also developed tools that facilitate the so-called "multiresolution simulation". These tools are to convert a macroscopic MTP model into a mesoscopic traffic simulation model, and a mesoscopic traffic simulation model into a MTS model, respectively. The scope of this paper is about converting the O-D matrix of a MTP model directly into a MTS model.

MTP tools, being macroscopic in nature, model an urban area as multiple interconnected TAZs. Typically, each TAZ has one traffic generator (or centroid) that loads vehicles into the network and receives vehicles from the network. Users of MTS simulation usually demand a more detail network representation in order to simulate the traffic more realistically and to be able to identify local traffic problems. For example, a TAZ may be as small as 1 km $\times$ 1 km to 5 km $\times$ 5 km in area, depending on the population density, O-D trips and other factors. A TAZ in a MTP model is typically bounded by several arterials (or highways), has only one centroid and one connector that loads and receives vehicles between the centroid and one of the arterials. A MTS model usually codes this TAZ into several zones. Each zone its respective traffic generator that loads vehicles into and receives vehicles from an arterial. In this way, traffic load from this TAZ is split into several smaller zones, access and egress points along the major streets. This prevents an over-estimation of traffic demand and congestion at a single loading point, as often observed in MTP models.

The VISUM-VISSIM and TransCAD-TransModeler packages mentioned above, convert a TAZ in a MTP model into one traffic zone in the corresponding MTS model. To the best of the authors' knowledge, tool or algorithm has not been developed to facilitate the coding of a TAZ into multiple MTS zones, and to split the trips generated from and attracted to this TAZ into these zones. Users of MTS models always have to hard code and traffic zones, connectors and manually "guestimate" the traffic volume from/to each zone.

This paper assumes that, given the network topology of a TAZ, the major access points of traffic from the TAZ to the surrounding arterials can easily be identified. The objective of this research was to develop a disaggregated discrete choice model (DCM) to analyze drivers' route choice preferences when they select the routes from their homes to the access points of a city's transportation network. To make the model transferable, we have designed the choice set to be the route choice criteria (instead of specific routes in a TAZ). The model's attributes are based on socioeconomic characteristics and morning trip habits of the drivers. The data used to develop the DCM was obtained from a stated preference survey described in this paper.

The outline of this paper is as follows. After explaining the background and motivation, the next section of this paper reviews the application of DCMs in route choice. The subsequent section covers the model's framework and the fundamental concepts of DCM. This is followed by the description of the data used, and the model development process. The developed model was than applied to a TAZ in a case study, before making the conclusion.

2. Literature review

This section reviews the application of DCM and its variants in route choice analysis. DCMs have traditionally been used to mimic real life decisions, and in the transportation domain travel demand estimation, especially in mode choice. McFadden and Train (2000) calibrated a Multinomial Logit (MNL) model to represent a commuter's route choice as a function of land use and transportation infrastructure. Nava et al. (2012) used cross-NLM and traditional NLM to describe the joint choice of residential location, travel mode, and departure time as functions of housing cost, travel time, travel cost and socio-demographic characteristics of the traveler. McFadden et al. (1981) analyzed a traveler's modes choice among bus, metro, walking, cycling, taxi and driving automobile by constructing a NLM as functions of value of time, trip distance, among other factors. Brands et al. (2014) presented a NLM to predict a traveler's mode choice. The choice set included single modes (including driving car) and multiple combinations of public transportation modes. The generalized cost functions included travel time, trip distance, waiting and transfer time and mode specific constants.

DCMs have also been applied in public transportation. Greene (2012) tested a MNL model, a NLM and a Mixed Logit (MXL) model to predict the seat belt use of school bus riders in Alabama. Three alternatives were considered in the choice set: wearing, not wearing, and improperly wearing seat belts. A student's choice probabilities of these alternatives are modeled as functions of the student's demographic characteristics, trip attributes, seat location and level of bus driver's involvement. The NLM and MXL model were recommended. Mai et al. (2015) used a NLM model to estimate the traveler's choice of transit access (boarding) stop as functions of available transit modes (among bus, train and ferry), the available routes within each modes and the departure times.

In the context of this research, some of the most recent applications of DCM have focused on the route choice behavior under the influence of traffic information and network topology. Nassir et al. (2015) developed a MNL model to estimate a traveler's route choice behavior under the provision of traveler information. The attributes included the traveler's socio-demographic characteristics, content of traffic information and departure time. Dalumpines and Scott (2017) proposed a route choice model in which the choice of path is modeled as a sequence of link choices. This nested recursive logit model used link travel time; turn penalties, as the attributes of the links.

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