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ORIGINAL ARTICLE

Value of time determination for the city of Alexandria based on a disaggregate binary mode choice model

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Abstract In the travel demand modeling field, mode choice is the most important decision that affects the resulted road congestion. The behavioral nature of the disaggregate models and the associated advantages of such models over aggregate models have led to their extensive use. This paper proposes a framework to determine the value of time (VoT) for the city of Alexandria through calibrating a disaggregate linear-in parameter utility-based binary logit mode choice model of the city. The mode attributes (travel time and travel cost) along with traveler attributes (car ownership and income) were selected as the utility attributes of the basic model formulation which included 5 models. Three additional alternative utility formulations based on the transformation of the mode attributes including relative travel cost (cost divided by income) and log (travel time) and the combination of the two transformations together were introduced. The parameter estimation procedure was based on the likelihood maximization technique and was performed in EXCEL. Out of 20 models estimated, only 2 models are considered successful in terms of the parameters estimates correct signs and the magnitude of their significance (t-statistics value). The determination of the VoT serves also in the model validation. The best two models estimated the value of time at LE 11.30/hr and LE 14.50/hr with a relative error of +3.7% and +33.0%, respectively, of the hourly salary of LE 10.9/hr. The proposed two models prove to be sensitive to trip time and income levels as factors affecting the choice mechanism. The sensitivity analysis was performed and proved the model with higher relative error is marginally more robust.

1. Introduction

Discrete choice models are used to predict a decision maker choice of one alternative from a set of alternatives through evaluating the attributes of each alternative using a decision rule [4,8].

In the transport demand models, the decision maker is the individual traveler, alternatives are transportation alternatives, the attributes are the attributes of traveling via those transportation alternatives. The decision rule is assumed to be a rational discrete choice model which is based on utility maximization [8].

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The two basic ways of modeling the group behavior of all decision makers are to directly model the aggregate share of the decision makers choosing each alternative as a function of the characteristics of the alternatives and the attributes of the group or to recognize the aggregate behavior by the enumeration of the individual choices modeled as a function of the characteristics of the alternatives and the attributes of each individual [8].

The aggregate demand transport models which are generally based on observed relations for groups of travelers are based on either observed relations for groups of travelers or an average relations at zonal level [13]. These types of models had continued to be largely used until the early 1980s; only then, the disaggregate demand models started to be seriously considered. The disaggregate demand models, on the other hand, are based on observed choices made by individual travelers.

The behavioral nature of the disaggregate models and the associated advantages of such models over aggregate models have led to the extensive use of disaggregate models.

Within the travel demand modeling field, mode choice is the most important decision that affects the resulted road congestion. Additionally, the mode choice is assumed to be trip-interchange model; that is, it is ordered as post-trip distribution model.

To represent the attractiveness of the alternatives, the concept of utility is used. Utility is the mathematical transformation which is usually constructed as linear combination of variables such as alternative attributes (travel time, travel costs, etc.) and the traveler attributes (car ownership, income, etc.). Elements such as perceived comfort and convenience which are not easy to measure or observe can be reflected in the mode-specific constants [13].

Both logit and probit mathematical models are based on the random utility principle, and can predict the probability of mode choice by comparing the alternatives mode utilities. The simplest and most popular practical discrete choice model is the logit model.

However, the discrete choice model cannot be calibrated simply by standard regression technique because their dependent variables, the choice probability, is an unobserved variable (between 0 and 1) and the observations are the individual choices. Maximum likelihood (ML) method is usually used in such cases [13]. Ben akiva and Lerman [4] argued that although the maximum likelihood estimation procedure can become computationally burdensome, it is conceptually quite straight forward.

The purpose of this research is to calibrate a logit mode choice model based on the person trip data of household travel survey for the city of Alexandria. However, with only a small sample of data collected for this purpose, no extensive modeling effort has been attempted, neither in terms of stratifying the model by the trip purpose nor in terms of complicating the model by using hierarchical model structure such as the nested logit model (NLM). A simple binary logit mode choice model is calibrated. The model validation is also addressed in terms of the determination of the value of time (VOT) implied by the model. The value of time can be interpreted as the marginal rate of time substitution with respect to cost or, in other words, its value [15].

2. Model formulation

2.1. Utility-based choice

A choice from a set of travel alternatives requires setting the decision rule that describes the process of evaluating the available information to reach a discrete choice. One class of decisions assumes that the attractiveness of a travel alternative is expressed by alternative's utility which is known as utility maximization principle [4]. The utility is defined by a vector of alternatives attributes that can be reduced to a single number, whose value is obtained as a linear combination of alternative's attributes.

The random utility approach is based on the assumption that inconsistency in observed choice behavior is due to the deficiency in the observation process. Although the individual is assumed to select the one alternative with the highest utility among the utilities of the available alternatives, such utilities are not known to the analyst with certainty and, therefore, they are treated as random variables. Thus, the probability of selecting alternative (*i*) is the probability that the utility of alternative (*i*) perceived by traveler (*n*), U_{in}, is greater than or equal to the utility of all other alternatives (within the choice set) accessible to that traveler.

The econometric formulation of the utility of a travel alternative is a sum of deterministic and random (observable and unobservable) components of total utility:

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

where,

V_{in}: deterministic utility component which is a function of attributes of alternatives (*i*) and individual (*n*).

ε_{in}: random utility component (error) of alternatives (*i*) and individual (*n*).

2.2. Variables influencing the choice of modes

The factors influencing the choice of mode may be listed under three groups [14]:

i. **Characteristics of the trip maker**
- car availability and/or ownership;
- possession of a driving license;
- household structure (young couple, couple with children, retired people, etc.);
- income;
- decisions made elsewhere (using car at work, take children to school, etc);
- residential density.

ii. **Characteristics of the trip**
- trip purpose;
- time of the day when the journey is undertaken.
- late trips are more difficult to accommodate by public transport.

iii. **Characteristics of the transportation mode**
Quantitative factors are as follows:
- relative travel time: in-vehicle, waiting and walking times by each mode;

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