Transportation Research Part A 66 (2014) 39–51

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Evolution of latent modal captivity and mode choice patterns for commuting trips: A longitudinal analysis using repeated cross-sectional datasets

Khandker Nurul Habib *, Adam Weiss

Department of Civil Engineering, University of Toronto, Canada

ARTICLE INFO

Article history:
Received 23 August 2012
Received in revised form 30 January 2014
Accepted 22 April 2014

Keywords:
Commuting mode choice
Latent captivity
Parameterized logit captivity model
Pooled model
Longitudinal analysis
Mode choice preference structure

ABSTRACT

This paper presents an investigation of the temporal evolution of commuting mode choice preference structures. It contributes to two specific modelling issues: latent modal captivity and working with multiple repeated crossectional datasets. In this paper latent modal captivity refers to captive reliance on a specific mode rather than all feasible modes. Three household travel survey datasets collected in the Greater Toronto and Hamilton Area (GTHA) over a ten-year time period are used for empirical modelling. Datasets collected in different years are pooled and separate year-specific scale parameters and coefficients of key variables are estimated for different years. The empirical model clearly explains that there have been significant changes in latent modal captivity and the mode choice preference structures for commuting in the GTHA. Changes have occurred in the unexplained component of latent captivities, in transportation cost perceptions, and in the scales of commuting mode choice preferences. The empirical model also demonstrates that pooling multiple repeated cross-sectional datasets is an efficient way of capturing behavioural changes over time. Application of the proposed mode choice model for practical policy analysis and forecasting will ensure accurate forecasting and an enhanced understanding of policy impacts.

1. Introduction

Commuting trips are the major and most repeated trips of urban residents. Patterns of commuting trips in any urban area define its transportation system performance cycles: peak versus off-peak period traffic congestions. As such, major transportation policies and planning decisions always target commuting trips to manage travel demand, land use and emissions (Zaman and Habib, 2011). Mode choice for commuting is a primary factor in defining any urban area's traffic congestion levels. Thus, research on commuting mode choice behaviour always has planning and policy implications. Modelling mode choice behaviour for commuting trips has fascinated many researchers from the early age of behavioural analysis of travel demand (Wilson et al., 1984). The availability of alternative modes as well as captivity to certain types of modes is recognized to be extremely critical in defining mode choice behaviour (Tardiff, 1976; Stopher, 1980).

Captivity to a specific mode refers to not considering alternatives, either because there are no other feasible options or there is no desire to consider alternatives. Modal availability refers to the feasibility of alternative modes and it defines

* Corresponding author. Tel.: +1 416 946 8027; fax: +1 416 978 6813.
E-mail addresses: Khandker.nurulhabib@utoronto.ca (K.N. Habib), adam.weiss@utoronto.ca (A. Weiss).

http://dx.doi.org/10.1016/j.tra.2014.04.013
0965-8564/

explicit captivity. Alternative modes that are not feasible are not available and hence cannot be considered. However, a lack of desire to consider alternatives to the chosen available mode refers to an implicit captivity in mode choice. If modal availability is deterministically introduced (whether a specific mode should be in the choice set or not) in a mode choice model, then the leftover modal captivity is definitely latent in the choice process. Hence, the implicit captivity can also be referred to as the latent captivity. However, the issue of implicit or latent captivity in mode choice is often ignored or misrepresented in mode choice modelling (Jacques et al., 2012). Also, the concept of modal captivity is often debated as the various definitions of captivity can be possible (Polzin et al., 2000). For example, latent captivity is often referred to as captivity by choice and modal unavailability is referred as captivity by force (Jacques et al., 2012). While captivity by force is easy to identify (factors such as having no driving license or having no transit service nearby), latent captivity is difficult to predict in choice models. Such captivity may be the result of mostly positive or negative experiences or alternatively, satisfaction or dissatisfaction with specific modes (Ergun, 1999). The attributes of specific modes (e.g., higher mobility with private car, less mental engagement while travelling with transit, and physical exercise for non-motorized modes) can create different levels of attractiveness and thereby latent captivity.

Latent captivities to different commuting modes have a wide variety of policy implications. For example, latent captivity to the driving private car option may cause major hindrances to successful implementation of many sustainable transportation policies. However, latent captivity to transit modes or non-motorized modes would be quite positive from a sustainable transportation point of view. Understanding the factors that can influence the latent captivity to different modes will be beneficial to transportation planners and policy makers in devising sustainable plans and policies. Specialized surveys are often used to identify various levels of attractiveness to different available alternative modes (Paez and Whalen, 2011; Abou-Zeid and Ben-Akiva, 2011; Creemers et al., 2012). Specialized surveys can provide rich datasets for modelling latent captivity. In the absence of any such specialized survey, explicit modelling of choice set formation by using regular travel survey data can allow the capture of latent captivity in commuting mode choice (Swait and Ben-Akiva, 1986). The concept of such choice models is not new, but its application in travel demand modelling is very rare, perhaps because of model estimation difficulties. Only a very limited number of applications of such modelling exercises are available in the literature.

There are two main modeling issues treated in the paper: modal captivity and working with pooled samples. Latent modal captivity recognizes that some individuals may not have considered what an analyst defines as a choice-set, but, instead blindly uses a single mode. This first difficulty is addressed in the paper using the modeling framework proposed by Swait and Ben-Akiva (1986, 1987), which can be seen as a generalization of Gaudry and Dagenais (1979). The second modeling issue that is treated in this paper is working with a pooled database built as the combination of different years. This problem is addressed by considering different scales for each sample along with different coefficients of some key variables that have shown changing influences over the year, equivalent to what is done for the combination of RP and SP data. The main objectives of the paper are evaluating the factors that influence the evolution of latent captivity and preference structures for commuting mode choices over time in the Greater Toronto and Hamilton Area (GTHA). The lessons learned from this investigation will help to develop better commuting mode choice prediction models by using repeated cross-sectional datasets.

For empirical investigations, we used three repeated cross-sectional datasets of a large-scale household travel survey collected in the Greater Toronto and Hamilton Area (GTHA). These datasets were collected in a five-year cycle from 5% of the population of the GTHA. Using these datasets, we developed a captivity choice model for commuting mode choices. In addition to the three separate models, we pooled the datasets to estimate a pooled model. The pooled model provides an estimate of latent modal captivity to the seven sets of modes used in the study area. The pooled model also reveals the evolution of latent modal captivity, systematic utility function, mode choice model scale parameters and changing patterns of key policy indicators (e.g., value of travel time savings (VOTS)). The paper presents the behavioural interpretations of the pooled model parameter and policy implications of the findings.

The remainder of the paper is organized as follows. The next section presents a brief literature review on modelling efforts used to capture modal captivity. The literature review section is followed by other sections that explain the data sets, econometric model formulations and empirical models. The paper concludes by identifying key findings and offering recommendations for future studies.

2. Literature review

Captivity in mode choice modelling can be captured through choice models with integrated choice set formation. Manski (1977) proposed the general framework for a choice model considering the endogenous choice set formation process. Initially, this approach defines a universal choice set that consists of any and all available options to any individual within the sample. This approach then considers a given set of alternatives as a feasible set. The concept of a feasible alternative set implicitly introduces a form of captivity within the choice model formulation, namely, forced captivity. A feasible alternative set explicitly considers forced captivity by including alternatives that are feasible and excluding those that are unfeasible. For a fixed number of feasible alternatives, there can be a number of possible combinations of feasible alternatives forming choice sets for the final choice. Manski's framework allows for the explicit capture of forced captivity in the choice model formulation, but the concept of latent captivity is not fully appreciated. The concept of latent captivity may be captured indirectly through the formation of feasible choice from the available alternatives, but it requires detailed personalized