Transportation Research Part A 64 (2014) 135–146

Contents lists available at ScienceDirect

Transportation Research Part A

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

Integrating psychometric indicators in latent class choice models

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ARTICLE INFO

Article history:
Received 24 April 2013
Received in revised form 29 January 2014
Accepted 11 March 2014

Keywords:
Latent class
Discrete choice
Psychometrics
Behavior
Mode choice

ABSTRACT

Latent class models are a convenient and intuitive way to introduce taste heterogeneity in discrete choice models by relating attributes of the decision makers with unobserved behavioral classes, hence allowing for a more accurate market segmentation. Estimation and specification of latent class models can be improved with the use of psychometric indicators that measure the effect of unobserved attributes in the individual preferences. This paper proposes a method to introduce these additional indicators in the specification of integrated latent class and discrete choice models, through the definition of measurement equations that relate the indicators to attributes of the decision maker. The method is implemented for two mode-choice case studies and compared with alternative methods to introduce indicators. Results show that the proposed method generates significantly different estimates for the class and choice models and provide additional insight into the behavior of each class.

1. Introduction

Traditionally, travel demand models have considered quantitative variables, like travel time, cost and decision maker socioeconomics, as the principal variables that explain mode choice (Ben-Akiva and Lerman, 1985). However, there are more complex, unobserved factors that may have a relevant effect in the way choices in general are made. Some of these latent factors are the decision maker's lifestyle, personal attitudes or perceptions (McFadden, 1986), which can be integrated into choice models. We address that aspect in the present research.

The introduction of latent factors into discrete choice models has been treated under two main approaches: latent variable models (LVM) and latent class models (LCM). The latent variable approach deals with the explicit modeling of unobserved psychological characteristics of the decision maker, such as attitudes and perceptions. The latent class approach assumes that the population can be probabilistically segmented into discrete groups that have different preferences or perceptions and, therefore, have different choice behaviors.

Psychometric indicators are additional information that can be used to specify and estimate latent constructs. They usually reflect the preferences of decision makers on topics that are (closely or not so) related to the choice that is being analyzed/modeled. Examples of psychometric indicators range from the answers to questions about the level of agreement

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http://dx.doi.org/10.1016/j.tra.2014.03.010
0965-8564/

with a statement or the "grade" that is given to the quality of a service or object (Likert, 1932), to the set of adjectives that individuals use to characterize the topic in question (Glerum and Bierlaire, 2012).

Although the use of indicators should clearly help to estimate better latent class models, its use has been mostly developed and applied in the latent variable approach. However, the LCM approach has characteristics that make it, in some cases, preferable over other methods to capture heterogeneity (Greene and Hensher, 2003; Shen, 2009), like a more intuitive market segmentation that, if possible, should be improved with the integration of psychometric data.

This paper proposes a method to introduce psychometric indicators in the specification of discrete choice models with latent classes. The method uses ordinal logit models as measurement relationships between the observed answers and the "utility" a respondent of a particular class will perceive for providing each of these answers. The novel feature of this method consists of specifying the measurement relationships as class-specific structural relations between the aforementioned utility and the attributes of the decision maker/respondent. The structure of the proposed model is inspired by the Generalized Random Utility Model (Walker and Ben-Akiva, 2002). The method is applied on two datasets for transport mode choice but should be easily implemented in other choice contexts.

The paper is organized as follows. Section 2 reviews the use of latent class models in discrete choice models and the importance of psychometric indicators to characterize the classes. Section 3 presents the modeling approach adopted in this research and designed to provide a better specification of such models. Section 4 presents a first application of the methodology on a transportation mode choice case study conducted in the Nice area (France). Section 5 provides a second application of the methodology on a mode choice case study in the low-density areas of Switzerland. Section 6 concludes on the advantages of the proposed modeling approach.

2. Latent class models in discrete choice analysis

Widely used in social sciences for quantitative analysis (Lazarsfeld and Henry, 1968), latent class models were not proposed in the form of choice models with class-membership probabilities until the work of Kamakura and Russell (1989). Class-membership models explain the probability of an individual belonging to a consumer segment as a function of the consumer's characteristics; they are a powerful instrument because they allow to relate attributes of the decision maker with unobserved behavioral classes and, therefore, simplify the market segmentation process.

There is evidence in the literature suggesting that latent class models are a very convenient, flexible and intuitive way to introduce taste heterogeneity in discrete choice models. For example, Bhat (1997) applied the latent class approach to the transport mode choice problem finding that the endogenous segmentation into classes allows for better data fit and more intuitive results compared to other approaches used to capture heterogeneity. Greene and Hensher (2003), Shen (2009) and Hess et al. (2011) analyzed the LCM approach, comparing it with alternative methodologies like the Mixed Logit Model (McFadden and Train, 2000) concluding that, while both offer a good way to capture unobserved heterogeneity, experimental results suggest that the latent class approach allows for a better behavioral interpretation of the results. Keane and Wasi (2012) compared the latent class approach with several other models that account for taste heterogeneity, identifying it as the one allowing the most intuitive understanding of the patterns of heterogeneity.

Several application of integrated choice and latent class models can be found in the transport and land use-related literature. For example, the aforementioned works by Bhat (1997) and Shen (2009), applied the LCM approach to the choice of transport mode while Greene and Hensher (2003) did it for route choice. In the area of land use, Walker and Li (2007) identified different lifestyle classes among the population of a city, showing that the segments are key determinants in the choice of residential location. Zhang et al. (2009) used a latent class structure to model different intra-household choice mechanisms regarding car ownership. Wen and Lai (2010) used the latent class approach in the airline choice problem, identifying significantly different willingness to pay across consumer segments. Similar results were obtained by Wen et al. (2012) but in the context of the choice of mode to access stations of a high-speed train. Koutsopoulos and Farah (2012) used latent classes to identify and model different patterns (or regimes) of driving behavior for a microscopic traffic simulator.

2.1. Psychometric indicators

Psychometric indicators can be used improve the specification and estimation process of latent constructs (like classes) because they are a measurable manifestation of the effect of unobserved attributes in the preferences of individuals (Walker and Ben-Akiva, 2002). Moreover, the use of indicators in discrete choice models may help to identify latent classes that are not captured or described by the choice data alone (Ben-Akiva et al., 2002). Despite this, most methodological developments are focused on the use of indicators to estimate choice models using a LVM approach (Ben-Akiva et al., 2002), with few examples applied under the LCM approach.

Ben-Akiva and Boccara (1995) introduced the use of indicators to the estimation of models with a latent choice set by measuring the user's perceived availability of an alternative and modeling a linear relationship between this indicator, the modeled availability and the "desirability" (a proxy of the utility) of each alternative. They find that using this approach generates better predictive results than a standard logit model and that the use of indicators allows for more robust estimates.