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Hybrid choice models: Principles and recent progress incorporating social influence and nonlinear utility functions

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Abstract

Hybrid choice models have been developed as an extension of discrete choice models, particularly multinomial logit models, in an attempt to include attitudinal variables. The quintessence of hybrid choice models is that a model of attitude formation is estimated and the estimated attitudes are added to the commonly used set of attributes in discrete choice models: attributes of the choice alternatives and socio-demographic variables. The most commonly applied model is based on linear specifications, both for the attitude model and the utility function. In this review paper, we discuss the principles underlying the hybrid choice model, summarize the specifications used in previous applications of the model and then continue discussing recent progress that added social influence to the model specification and replaced the linear specification of the utility function with a nonlinear function.

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Keywords: Hybrid choice model, social influence, nonlinear functions.

1. Introduction

Discrete choice analysis has become a standard approach for the analysis of activity-travel choice behaviours, such as travel mode, residential and activity locations, car ownership, and so forth[1,2]. Numerous authors have proposed alternative discrete choice models to represent a behaviourally more realistic choice process. However, it is not easy to completely understand and represent a decision-maker's choice behaviour because a considerable number of difficult to measure factors, such as decision-makers' latent attitudes, tastes, perceptions, beliefs, values, etc. may influence the choice process. These unobservable factors and the causal relationships among them are

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difficult to identify. The hybrid choice model (HCM) represents an attempt to identify such unobservable factors and include them into a discrete choice analysis.

In the present paper, we discuss the principles underlying the HCM. The paper serves two aims. First, we give an overview of the HCM framework, which should be helpful for readers new to the field in understanding the original HCM formulation. Second, we review several variations of the HCM, including the authors' elaborations of its sub-frameworks. These efforts allow different representations of choice behaviour. In particular, first, we focus on the model incorporating social influences. Social influence can be defined as the influence of choices of social network members. Second, we show how the model can accommodate a nonlinear utility function specification. Assuming nonlinear relationships is theoretically more appealing because it represents a more general approach to model specification.

This paper is organized as follows. The following section presents an overview of the original framework, underlying the HCM, and commonly used formulations and estimation methods. In the third section, recent progress in accommodating social influence and nonlinear utility function are explained. The last section presents a discussion and conclusion.

2. Overview of the hybrid choice model

HCM can be viewed as an expanded discrete choice modeling framework, which integrates different types of models into a single structure that is estimated simultaneously[3]. Basically, HCMs incorporate a latent variable model into a discrete choice model in order to improve the explanatory power of the choice model by considering the effects of decision makers' latent attitudes. The HCM framework is illustrated in Fig. 1. The ellipses represent unobservable variables, while the rectangles represent observable variables. Each of these sub-models comprises a structural component and a measurement component. Since the latent attitudes (i.e. latent variables) cannot be directly observed from revealed choices, they should be identified through a set of attitudinal indicators. The latent variable model permits identifying latent constructs as a function of the indicators, and capture the causal relationships between exogenous explanatory variables and the latent variables. By simultaneously integrating discrete choice and latent variable models, the latent variables can be treated as explanatory variables in the utility functions of choice alternatives. According to the models included, this structure has also been referred to as the integrated choice and latent variable (ICLV) model[4].

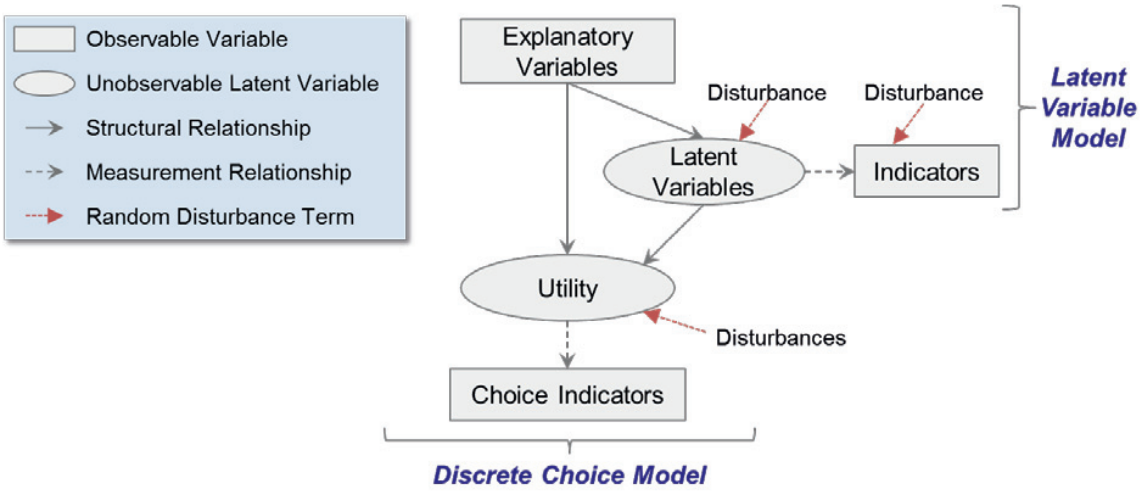

Fig. 1. Framework for hybrid choice model: an integrated discrete choice and latent variable model (adapted from Ben-Akiva et al.[5]).