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Public transport: One mode or several?

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ABSTRACT

This paper develops a methodology for testing and implementing differences in preferences for a set of public transport modes, relating to observed and unobserved attributes, in state-of-practice large-scale travel demand models. Results of a case study for commuters in the Stockholm public transport system suggest that there are preference differences among public transport modes. We found that the value of time for train is lower than for bus and metro, and that it is higher for auxiliary modes than for the main mode. Surprisingly, we found no evidence for differences proportional to the in-vehicle time between bus and metro, suggesting that characteristics of in-vehicle time in these two modes are valued equally by the travellers. Nevertheless, unobserved preference for metro is higher than the preference for bus. Regarding the existence of a rail factor, we find evidence to support the hypothesis that rail-based modes have in fact a smaller time parameter (train) or higher alternative specific constant (metro), indicating that rail modes are preferable to bus, ceteris paribus.

1. Introduction

There is a political preference for rail-based Public Transport (PT) modes over bus services. Decision makers in many European countries seem to prefer rail over bus services, claiming that travellers prefer services operating on tracks, referring to this as a “rail factor”. Moreover, property developers often claim that metro investments increase the land values over and above what a bus system with equal capacity and travel times would. If travellers’ preferences differ between PT modes, the treatment of them as the same mode in transport models translates into biased parameter estimates and model predictions. Such bias would then propagate to all types of policy analyses including Cost Benefit Analysis (CBA).

A higher preference for rail-based PT modes is to some extent supported by studies in psychology, transport modelling and economics. For instance, Eliasson (2016) found that accessibility by metro increases the property prices of apartments in Stockholm more than accessibility by bus. In the transport modelling field, Ben-Akiva and Morikawa (2002) explore differences in the preference for rail and bus services in two case studies. They estimate choice models on combined revealed preference (RP) and stated preference (SP) data. The utility function for PT includes dummy variables for each PT mode. The alternative specific constants indicate that metro is most preferred, followed by bus and commuter train. However, level-of-service (LoS) parameters do not differ significantly across PT modes. Scherer and Dziekan (2012) includes a meta-analysis of German and Swiss studies focusing on user perceptions and mental representation of train, tram, and bus. They conclude that there is a rail factor, loaded with emotional and social attributions.

In this study, we develop a method for testing whether travellers’ preferences for PT differ between modes in a state-of-practice

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large-scale transport model. We show how to implement such differences in the transport model. We find that in the Stockholm public transport system, travellers' preferences vary across PT modes and travel time components. We also find that the value of time is higher for auxiliary modes than for the main mode, consistent with earlier literature (see the meta-study by Wardman, 2004).

We expand the analysis by Ben-Akiva and Morikawa, by introducing a more flexible model specification tailored to capture differences in observed and unobserved preferences between PT modes. The models are specified to capture the systematic difference in unobserved preferences among PT modes (alternative-specific constants), the correlation of the random errors across the PT modes, and the systematic differences in preference for LoS variables and travel time components. We introduce the definition of main mode, in cases where more than one PT mode is used within the same trip. To our knowledge, no previous study on large-scale models has in this way systematically explored how the preference differs across PT modes in all these dimensions, although large-scale transport model prediction is the cornerstone of transport appraisal.

We stress that the aim of this paper is primarily to develop an approach for testing and implementing systematic differences in preferences among PT modes. Such differences are likely to vary across transport systems, since customer preferences derive from perceptions and beliefs which are influenced by local conditions and cultures (Scherer, 2010). Hence, empirical evidence might differ across transport networks and over time.

The rest of the paper is structured as follows: Section 2 presents the modelling framework and hypotheses tested. Section 3 provides an overview of the data. Section 4 discusses the application of the framework. Section 5 presents some properties of the models obtained and Section 6 concludes.

2. Method

We begin by defining a state-of-practice mode choice model, specified as a Multinomial Logit model (MNL). We include a sub-set of PT modes as well as a number of other modes. The utility of alternative j is defined as

$$U_j = \sum_{i \in I_j} \beta_{ij} x_{ij} + ASC_j + \varepsilon_j, \tag{1}$$

where I_j is the set of explanatory variables for alternative j, β_{ij} are the parameters for variable i and alternative j, x_{ij} are explanatory variables, ASC_j is the alternative-specific constant, and ε_j is the random variation of the unobserved variables, assumed independent across alternatives. Preference differences across PT modes j can be represented in this model by PT mode-specific constants – ASC_j, systematic differences in preference for observable LoS variables – β_{ij} – and in the random error ε_j. Different alternative-specific constants and level-of-service parameters can be implemented in the model even if all PT modes are modelled as one alternative with one utility function in the choice model. However, when modelling all PT modes as one single alternative, with the same utility function, the random error is assumed to be the same for all PT modes. In contrast, modelling the PT modes as different alternatives in an MNL model implies that the errors ε_j are independent. If the error terms of the PT alternatives are correlated, but independent from the error terms of the other modes, this can be modelled in a Nested Logit (NL) model, including the PT mode alternatives within the same nest.

In Section 2.4 we describe how we systematically test for preference differences captured by the alternative-specific constants, the LoS-parameters and the random errors. This is done by estimating a series of increasingly flexible models. In Section 2.3 we present the statistical tests that we apply. Section 2.2 describes why the Value of Travel Time might differ across modes, and as some travellers use several PT modes within one trip, we define the main PT mode of each trip in Section 2.1.

2.1. Main mode definition

To model the choice between different PT modes, a main mode needs to be defined. Unless one defines a main mode, then, as in Ben-Akiva and Morikawa, 2002, the model estimation needs to be constrained to use "pure" observations only – observations where only one PT mode is used – neglecting all PT intermodal observations. Hence, to be able to use all available information to investigate nuances in the preference for different PT alternatives, we need to define the main PT mode of all PT trips, when generating alternatives in the mode choice model. The present sub-section lays out this definition. Note however that in the national travel survey that we use to estimate the model, all PT travellers are asked to state the main PT mode they use, and the chosen main PT mode does not have to be defined in the present study. The respondents are instructed to state the mode that they used for the longest travel distance as the main PT mode.

When generating the PT alternatives, we define the main mode of a PT trip as the mode used for the longest distance among the different PT modes (in consistency with the definition in the travel survey). We applied this definition for two reasons. First, a definition based on distance, as opposed to travel time, will not change with traffic conditions. Second, it is consistent with how the main mode was defined in the national travel survey data used to estimate the model, allowing us to cross-check whether the user-reported main mode and the main mode imputed from network attributes are the same. Observations where the main modes differ are discarded for this study.

Still, the concept of main mode is an artificial construct. We acknowledge that other main mode definitions are possible, for instance a hierarchical definition, and that the definition of the main mode might influence the results. As the main mode definition is