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Analysis of mode choice for intercity travel: Application of a hybrid choice model to two distinct US corridors

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ABSTRACT

With growing concerns about greenhouse gas emissions and traffic congestion, there is an emphasis on encouraging shifts to public transport, for both short and long distance travel. Major differences exist across countries in how successful these efforts are, and the United States is often used as the key example of a country with a strong resistance to shifting away from private car use. Even within the United States however, there is strong heterogeneity across regions and across different types of travellers. This paper seeks to add empirical evidence to understand the drivers of mode choice for intercity travel, using stated choice data from two major US intercity corridors: the Northeast Corridor (NEC) and the Cascade Corridor. We develop a hybrid choice model that allows for deterministic and random variations across travellers in their preferences, some of which can be linked to underlying attitudinal constructs. Our results highlight extensive heterogeneity and provide interesting insights into the drivers of behaviour, and the relationship between attitudes and actual choices. As an example, we see that for some groups, notably West Coast respondents, a stronger anti-car attitude is counter-acted by a reduced utility for non-car modes when making choices, possibly due quality of public transport provision. Similarly, for other groups, such as older and female travellers, a reduced concern for privacy, which would benefit public transport, is counter-acted by a stronger pro-car attitude. These findings highlight the complex way in which attitudes can influence choices and provide insights for targeted policy interventions. Through scenario testing, we also show how future modal split might change depending on how these patterns of heterogeneity evolve over time, noting that the way this might happen is of course unknown at present.

1. Introduction

Understanding mode choice is of crucial interest for transport planning, and encouraging a shift from private car to public transport modes is an important component in efforts to reduce environmental impacts and ease congestion. While such efforts have been very successful especially for long distance travel in Europe, the United States (US) is often used as an example of a country where people will drive long distance rather than rely on either ground or air based public transport.[1] Even within the US, there is however extensive heterogeneity in modal preferences, both across population segments and across areas.

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[1] Notwithstanding that the latter raises environmental concerns too.

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The NCRRP (2016) study on which the present paper is based aimed to gain a deeper understanding of mode choice by US travellers. We looked at two major US intercity corridors: the Northeast Corridor (NEC) and the Cascade Corridor on the West Coast.

The NEC is the biggest intercity corridor in the country and is in desperate need for infrastructure investment, which will costs many billions of dollars. It is of great importance to US policy makers due to its high demand and extreme infrastructure vulnerability. Nearly 56 million riders a year, approximately 200,000 riders on any given weekday, use the Hudson River rail tunnels, which are a critical link in the NEC system connecting New Jersey with New York City. These tunnels, over a hundred years old, were severely damaged in Hurricane Sandy and are the only heavy rail infrastructure that links New York City to points south and west. The tunnels are at maximum capacity throughout most hours of the day (they can carry up to 24 trains per hour). As happened in July 2015 for multiple days, problems with the tunnels significantly delayed and stranded tens of thousands of riders due to the vulnerability of this overtaxed infrastructure.

The Cascade Corridor is the name this study used for the corridor that goes along the Amtrak passenger train route called the "Cascades" in the Pacific Northwest. The route is operated by Amtrak and travels from Vancouver, British Columbia south to Eugene, Oregon, with major stops in Seattle and Portland and several smaller stops in between. It is named after the Cascade mountain range that the route parallels. Like the NEC, there are also auto and air alternatives for this corridor. The route from Vancouver to Eugene is roughly 466 miles, nearly the same mileage as the NEC. This route was used in the study as a "foil" to the NEC—to represent something other than the NEC. The NEC is unique to the US, with significant train services as might be found in Europe (headways for trains between NYC and Washington, DC of just 15 min). The Cascade corridor, meanwhile, is more typical of US intercity rail, with just four daily round trips between Portland and Seattle, with two daily round trips between Seattle and Vancouver, and two daily round trips between Eugene and Portland. Even with this relatively low frequency, the Cascade is Amtrak's eighth-busiest route, with a total annual ridership of 792,481 or roughly 2000 riders per day.

There are also important differences between the two areas other than their rail service provision. While the NEC is quite urban and seen as "sophisticated", the Pacific Northwest is more rugged and seen as "individualistic" (although it has a thriving urban and "grunge" scene in its own right). While more individualistic, the Pacific Northwest is often more environmentally aware and "greener" than other parts of the US, including the NEC. This presents important scope for heterogeneity in mode choice, only part of which is likely to be able to be explained by the analyst (Ortúzar and Willumsen, 2011). In addition to the influence of socio-demographic and trip characteristics as well as random variations, we tested whether some of this underlying heterogeneity, whether deterministic or random, could be linked to longer term attitudes of the traveller, and if this is different between NEC and Pacific Northwest, which would provide a core opportunity for interventions aimed at changing behaviour. Throughout, we were also keen to test for underlying geographical differences in behaviour – i.e., all else being equal, including level of service, does the behaviour differ between East Coast and West Coast travellers.

We conduct our analysis using a hybrid choice model or integrated choice and latent variable (ICLV) structure (Ben-Akiva et al., 1999a; Ashok et al., 2009; Ben-Akiva et al., 2002; Bolduc et al., 2005). Hybrid choice models have been used for a large variety of applications across different disciplines. In the context of attitudes in transport work, they have been used for example in the study of key decisions such as vehicle type (Glerum et al., 2013), mode choice (Atasoy et al., 2013; Kamargianni et al., 2014), route choice (Prato et al., 2012) and departure time choice (Thorhauge et al., 2016). They have been used to study the role of a wide variety of attitudes, ranging from privacy and security concerns (Daly et al., 2012) to environmental considerations (Kim et al., 2012). While an increasing number of applications have relied on stated choice (SC) data, a wide variety of applications also exist on revealed preference (RP) data, as highlighted by Kim et al. (2014).

Alongside numerous empirical applications, further refinements of the model framework have taken place, looking at the specification of the measurement model (Daly et al., 2012), how and where to incorporate the latent variables into the choice model (Bahamonde-Birke et al., 2017) and testing for non-linearity and distributional assumptions (Kim et al., 2016). Substantial efforts have also gone into improved estimation techniques for the model and proper identification (Bhat & Dubey, 2014; Daziano, 2015; Raveau et al., 2012; Vij & Walker, 2014). For a fuller overview of the development and applications of hybrid choice models, see Abou-Zeid and Ben-Akiva (2014).

The hype surrounding hybrid choice models has not come without concerns about their use. As pointed out by Vij and Walker (2016), many applications have oversold the empirical benefits of the model, and it is important to allow sufficient flexibility for the choice model component to also allow for heterogeneity no not linked to the attitudinal constructs. This was a core consideration in our work, where we carefully attempted to study what part of the heterogeneity could in fact be linked to these attitudinal constructs rather than simply being misattributed heterogeneity that is driven by other factors.

In our work, we sampled respondents living in the larger metropolitan areas of Boston, New York, Philadelphia and Washington, DC (for NEC participants) or Portland, Seattle and Vancouver (for Cascade participants) and who made at least one intercity trip to other cities within their respective corridor. The sample for our study comprised roughly 5500 respondents from the NEC recruited through an online sample and a previous study of auto users in the NEC, with just over 500 respondents obtained from an online sample for the Cascade corridor. We specified a flexible model with a large amount of deterministic and random heterogeneity, and also tested the actual impact of the latent constructs in a scenario testing context (see also Daziano and Bolduc, 2013). The findings show major differences across areas, trip types and traveller characteristics, where at least part of these differences can be linked to underlying attitudes. Interestingly from a policy perspective, we see that attitudes can differ from actual choices, and that different attitudes can have counter-acting effects. For example, West Coast travellers are less pro-car, but still have an increased utility for car in the choice model, potentially reflecting lower quality of service. Similarly, while the reduced concern for privacy for older and female travellers increases the appeal of public transport, this is counter-acted by a stronger pro-car attitude.

While the empirical data relates to a specific US setting, the findings should be of broader interest in that they highlight how

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