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Development of destination choice models for pedestrian travel

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ABSTRACT

Most research on walking behavior has focused on mode choice or walk trip frequency. In contrast, this study is one of the first to analyze and model the destination choice behaviors of pedestrians within an entire region. Using about 4500 walk trips from a 2011 household travel survey in the Portland, Oregon, region, we estimated multinomial logit pedestrian destination choice models for six trip purposes. Independent variables included terms for impedance (walk trip distance), size (employment by type, households), supportive pedestrian environments (parks, a pedestrian index of the environment variable called PIE), barriers to walking (terrain, industrial-type employment), and traveler characteristics. Unique to this study was the use of small-scale destination zone alternatives. Distance was a significant deterrent to pedestrian destination choice, and people in carless or childless households were less sensitive to distance for some purposes. Employment (especially retail) was a strong attractor: doubling the number of jobs nearly doubled the odds of choosing a destination for home-based shopping walk trips. More attractive pedestrian environments were also positively associated with pedestrian destination choice after controlling for other factors. These results shed light on determinants of pedestrian destination choice behaviors, and sensitivities in the models highlight potential policy-levers to increase walking activity. In addition, the destination choice models can be applied in practice within existing regional travel demand models or as pedestrian planning tools to evaluate land use and transportation policy and investment scenarios.

1. Introduction

There have long been calls for research to improve our understanding of walking behaviors and to create better analytical tools to aid in planning for non-motorized modes. Such tools have the potential to inform infrastructure investments, quantify mode shifts, improve safety analyses, and create outputs relevant to emerging issues of public health, economic development, and sustainability. Despite recent increased interest in planning for walking, current forecasting tools—namely regional travel demand models—incompletely represent pedestrian behaviors (Singleton and Clifton, 2013). However, two recent advances have opened the door to significant innovations in pedestrian modeling: (1) the availability of spatially disaggregate travel behavior data (documenting walking trips more accurately); and (2) detailed data about the quality of the

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pedestrian environment (including pedestrian barriers and supports and fine-grained land use characteristics). Both advances allow pedestrian travel behaviors to be modeled at an appropriate scale.

Taking advantage of these data, recent research by the authors shows how four-step travel models can be improved to account for walking behaviors (Clifton et al., 2013, 2016). Our previous work identified factors associated with trip generation for pedestrian trips. This paper takes our work to the next stage—destination choice—and describes the development of pedestrian destination choice models, including behavioral influences, conceptual frameworks, model estimation results, policy implications, and planning applications.

Little research exists on the destination choice behaviors of pedestrians. Our paper contributes to this topic by including commonly-identified influences on destination choice from the broader literature along with spatial variables that account for the quality of the pedestrian environment. Measures developed here include elements of the environment that support walking and those that detract from walking. That is, this study focuses on destination choices for pedestrian travel, testing the influences on walking behavior at a scale appropriate for pedestrians, and includes relevant variables for pedestrian travel. It identifies measures, especially of the built environment, to which pedestrian behavior may be sensitive, highlighting potential policy-levers to increase levels of walking and physical activity. These behavioral sensitivities to distance, destination attractions, and the pedestrian environment can be useful for informing land use, urban design, and transportation policies, including policies related to carless households. Combined with previous work, our effort adds to the development a pedestrian planning tool that can be used to better estimate total walking activity in a given study area by combining data on trip origins and destinations.

The paper first provides background and context on the framework for four-step models to better represent walking activity. It then presents key concepts included in destination choice modeling along with methods and data. Model estimation results follow. The paper concludes with a discussion of the behavioral interpretations and policy-relevance of our findings, potential planning applications of the pedestrian destination choice models, study limitations, and opportunities for future work.

2. Background

A framework to better represent walking activity in travel demand models, introduced previously by the authors (Clifton et al., 2013, 2016), is illustrated in Fig. 1. The framework consists of four main steps, outlined below. Foremost, it increases the ability of regional travel models to represent walking within a trip-based structure without adding significant complexity or data requirements. It also has the potential to be modified to function as a standalone tool for pedestrian planning at a variety of scales, and the destination choice step in particular may be amenable for inclusion in activity based models.

1. Change the spatial unit of analysis for trip generation (all modes) from transportation analysis zones (TAZs) to pedestrian analysis zones (PAZs). Here, PAZs are uniform grid cells; in this application they have 264 ft (80 m) sides.
2. Apply a walk mode split model to estimate the number of walk trips produced in each PAZ. This binary logit model includes spatially disaggregate built environment and socioeconomic variables that measure relationships between walking and the physical environment.
3. Aggregate trips by vehicular modes (auto, transit, and bicycle) to the zonal structure of the regional model (TAZs) and then proceed with the remaining stages for these modes in the regional model.
4. In parallel procedure, apply a destination choice model to distribute the number of walk trips produced in each PAZ (step 2) to destinations.

Steps 1–3 have been described previously (Clifton et al., 2013, 2016). This paper focuses on the fourth step and describes the development of the pedestrian destination choice model.

3. Literature review

Trip distribution is the second step of traditional four-step travel demand models (Ortúzar and Willumsen, 2011). Historically, trip distribution methods include growth factor methods and gravity model methods. More recently, practice is moving towards using destination choice models to distribute trips from origins to probable destinations. Destination choice models can have a similar model structure to the multinomial logit (MNL) models often used for mode choice. (The traditional gravity model for trip distribution has been shown to be mathematically equivalent to an MNL model with two attributes: size and impedance (Anas, 1983).) Existing literature offers guidance for estimating destination choice models, especially with respect to choice set generation (Pagliara and Timmermans, 2009) and variable specification (Ben-Akiva and Lerman, 1985; Bernardin et al., 2009; Borgers and Timmermans, 1988; Pozsgay and Bhat, 2001). While choice sets could be constructed using deterministic rules or data on the perceived availability of alternatives (Ortúzar and Willumsen, 2011; Pagliara and Timmermans, 2009), most destination choice sets contain a sample of alternatives (Ben-Akiva and Lerman, 1985; Lemp and Kockelman, 2012). Destination choice model specifications typically include, at a minimum, terms for impedance (e.g., distance, generalized cost) and size (e.g., employment) (Ben-Akiva and Lerman, 1985; Bhat et al., 1998).