Transportation Research Part D 52 (2017) 340–353

Contents lists available at ScienceDirect

Transportation Research Part D

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

A walk trip generation model for Portland, OR

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ARTICLE INFO

Article history:
Available online 24 March 2017

Keywords:
Walk
Trip generation
D variables
Street quality
Hurdle model

ABSTRACT

This study proposes a home-based walk trip generation model, based on the built environment around households, controlling for sociodemographic influences. Two-stage hurdle models are estimated based on a household travel survey in Portland, Oregon. The first stage predicts the probability of households making any home-based walk trips. The second stage predicts the number of home-based walk trips for the subset of households that make such trips. The study also tests built environment variables for three different buffer widths around household locations to see which scale best explains walking behavior. The results show that sociodemographic characteristics are strong predictors of walk trip generation. Specifically, household size, income, and number of workers in the household influence the probability of a household having any walk trips, while household size and number of children in the household affect the number of walk trips made by the subset of households making walk trips. Characteristics of the built environment are also significant. Activity density, transit stop density, employment accessibility, intersection density, and most interestingly, sidewalk quality are associated with the decision to walk as a mode of travel, while land-use entropy, transit stop density, employment accessibility, sidewalk quality, and traffic calming and signal are predictors of the number of walk trips made by households making walk trips. Sidewalk quality is represented by a single principal component that neatly captures the common variance in an array of sidewalk variables. To our knowledge, this is the first walk trip generation model to include a measure of sidewalk quality.

1. Introduction

Despite more than five decades of research into travel-demand modeling, it is a challenge to develop a model that reliably predicts walk trips (Kuzmyak et al., 2014; Liu et al., 2012; Singleton and Clifton, 2013). This study proposes a home-based walk trip generation model, which is based on attributes of built environment around households. Sociodemographic influences on walking are controlled as potential confounders.

In the past two decades, there have been two fields interested in walking (Saelens and Handy, 2008). The transportation planning field treats walking as a mode of transportation. In this field, studies make the connection between the built environment and travel behavior. The public health field represents walking as a form of leisure-time physical activity. Studies in this field focus on the connection between the built environment and walking for recreation or exercise.

Shifting travel from the automobile to walking is also a core strategy for reducing greenhouse gases (GHGs), regulated air pollutants, road infrastructure expenditures, traffic fatalities, and other social, economic, and environmental costs of auto-

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http://dx.doi.org/10.1016/j.trd.2017.03.017
1361-9209/

mobile use (Jacobsen, 2003; Krizek et al., 2009; Alliance for Biking and Walking, 2012). At the same time, walking is widely recommended for its health benefits (Pucher and Dijkstra, 2003; Frank et al., 2007).

When assessing the benefits, costs, and priorities of proposed pedestrian improvements for the government or developers, it is necessary to answer the question: what kinds of built environments encourage people to choose to travel on foot?

Conventional travel-demand modeling procedures generally predict total trip making (or in older models, trip making by vehicle) and mode choice based on variables such as a household's demographic characteristics, the time, and cost of traveling by competing modes, and the spatial characteristics of the built environment through which the trip occurs. In a four-step model, if total trips can be generated (including nonmotorized trips), then it should be possible to distribute trips in the trip distribution step, split trips between motorized and nonmotorized modes in the mode choice step, and then assign motorized and nonmotorized separately to their respective networks. However, even though there are several ways to handle non-motorized modeling within a four-step model, non-motorized modeling is often not carried past the trip generation step in such models owing to local data and resolution limitations.

An alternative approach, analogous to direct demand modeling of transit ridership (direct ridership modeling), is pursued in this paper (Cervero, 2006). Using household travel survey data for Portland in 2011 and built environment measurements, this study proposes a home-based walk trip generation model. This paper is organized as follows: the next section reviews the literature and highlights the gaps in previous studies of walk trip generation; Section 3 describes the conceptual framework, data and measures of the present study; Sections 4 and 5 present analysis methods and results; and the final section summarizes findings and discusses the contributions of this paper and the implications of these findings.

2. Literature review

Trip generation is "the process by which measures of urban activity are translated into numbers of trips" (U.S. Department of Transportation, 1977; p. 1–25). Trip generation analysis is used to forecast the number of trips for different purposes in terms of land use patterns and socioeconomics. For instance, a neighborhood in a suburban area might generate work commute trips mostly by automobile, whereas a shopping center close to a downtown light rail station might generate more shopping trips by public transit. Trip generation studies aim to quantify the relationship among the built environment, human activity and travel behavior.

2.1. Walking in current travel demand models

2.1.1. ITE trip generation studies

Planners, engineers, developers and government decision makers all rely on trip generation to predict traffic impacts of new development projects (Shoup, 2003). The *Trip Generation Manual* and *Trip Generation Handbook* of the Institute of Transportation Engineers (ITE) are standard sources for analysis of traffic impacts. ITE's *Trip Generation Manual* provides estimates of the number of vehicle trips generated by a specific land use based on trip surveys of suburban developments constructed after the 1960s. The trip rates given by ITE are mostly generated in single-use suburban development dominated by automobile travel. As the report describes: "Data were primarily collected at suburban localities with little or no transit service, nearby pedestrian amenities, or travel demand management (TDM) programs" (ITE 2012, vol. 1, p. 1), and "All data presented in this manual represent ***VEHICLE*** trip generation rather than person trip generation" (ITE 2012, vol. 1, p. 11). Further, ITE advises: "At specific sites, the user may want to modify the trip generation rates presented in this document to reflect the presence of public transportation service, ridesharing or other TDM measures, enhanced pedestrian trip-making opportunities, or other special characteristics of the site or surrounding area" (ITE 2012, vol. 1, p. 1). Walk trips, the focus of this paper, are not captured by the ITE manuals.

2.1.2. Four-step models

Travel demand models are primarily used to predict the number of vehicle and transit trips that will use the road and transit networks in the future based on projections of future land use patterns and future network capacities. The conventional four-step model has become the workhorse of long-range transportation planning. Its steps include trip generation, trip distribution, mode choice (or mode split) and route choice (trip assignment) (Beimborn et al., 1996; McNally, 2008; Zhou et al., 2009). However, the conventional four-step model has limitations when walk is considered as a transportation mode. In the conventional four-step model, an urban area is divided into a series of geographic subareas called travel analysis zones (TAZs). Although TAZs tend to be rather homogenous in terms of land uses (e.g., entirely residential or largely commercial) that would seem to suggest that most walk trips will be interzonal, the size of TAZs usually ranges from census block group to census tract or even several square miles in area. Walk trips tend to be much shorter than that. The average distances for walking is 0.7 mile in National Household Travel Survey (NHTS) 2009. The origin and destination of a walk trip might be contained within one TAZ in many cases, a surprisingly high percentage of walk trips are actually intrazonal (56%) from the Portland household travel dataset, which means that the conventional four-step model often excludes walking in the trip generation step. Furthermore, if walking is included in trip generation, trip rates often ignore local land use and street network characteristics since the four-step model reduces land use patterns to a single point (called the zone centroid)