Applied Geography 60 (2015) 230–239

Contents lists available at ScienceDirect

Applied Geography

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

Empirical examination of neighborhood context of individual travel behaviors

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ARTICLE INFO

Article history:
Available online 27 November 2014

Keywords:
Trip behavior
Trip survey
Multilevel
Neighborhood
Context

ABSTRACT

In recent years, recognition of the importance of neighborhood context has produced a growing body of geographic research. When making their activity–travel decisions, individuals are restricted in different ways. In particular, individual choice behavior is often influenced by a neighborhood environment and a built environment. This study using the 2010 household trip survey demonstrated the effectiveness of incorporating multilevel mechanisms in various contexts of activity–travel behavior by comparing with traditional models. The analysis shows that one individual's activity participation patterns with respect to mode choice, trip count, trip distance, and trip time, under a variety of spatio-temporal constraints, tend to be affected by shared characteristics of neighborhoods. The results also imply that neighborhood travel behaviors are significantly influenced by neighborhood characteristics requiring policy makers to consider not only individual characteristics but surrounding environment.

Introduction

In recent years, recognition of the importance of neighborhood context has produced a growing body of research (Antipova Wang, & Wilmot, 2011; Badland et al., 2009; Frank et al., 2010; Van Dyck et al., 2010). It is well known that individual choice behavior is often influenced by neighborhood environment, and in some cases choices are made jointly by a built environment. Individuals are restricted in different ways when making their activity–travel decisions. More and more studies have been showing interest in studying neighborhood environment in various contexts of activity–travel behavior and confirmed the effectiveness of incorporating multi-level mechanisms by comparing with traditional models (Mercado & Paez, 2009; Schwanen, Dieleman, & Dijst, 2004). Although the importance of neighborhood influence is widely recognized in transportation planning, most of the research efforts to date have accommodated individual–neighborhood interaction effects by using average characteristics as explanatory variables in individual-level models.

Many previous studies have confirmed the relationship between land use and household vehicular travel. The empirical analysis of previous research also supports the hypothesis that changing land use can be a potential way to decrease the household vehicular travel distance and use of automobiles. With gasoline hustling past $4 per gallon, a poll conducted earlier in 2008 by California State University, Sacramento, found that 12% of respondents had changed jobs or moved to denser communities in the past year to shorten their commute to work (The Wall Street Journal, 2008). This study tries to answer [1] whether the travel pattern varies across neighborhoods (e.g. census tracts), [2] whether their travel behaviors are different from each other, and [3] what are the contributing variables to the neighborhood variations. The paper aims to apply multilevel method to investigate the effects of variables on the trip mode, trip count and trip distance of daily trips.

This article is organized as follows: the following section explores issues relevant to the multilevel analysis and travel behaviors shown in previous research; the methodology section provides a brief explanation of a multilevel model; and the application of the proposed model is demonstrated with empirical analyses of trip survey data in Hamilton County, Ohio. Concluding remarks are given in the final section.

Previous studies

An activity-based travel model incorporating household decision mechanisms has gradually been studied by transportation researchers. Previous studies provide a useful toolkit for exploring

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http://dx.doi.org/10.1016/j.apgeog.2014.10.017
0143-6228/

comprehensively multilevel trip behaviors and interaction between individual and neighborhood demonstrating the advantages of analyzing multilevel modeling of trip behaviors. Arentze and Timmermans (2009) described the household behavior based on the concept of need in the context of multi-day, and multi-person activity participation. The need of household or its member is the source of motivations to perform various activities and the change of need consequently generates the utility. The authors introduce the concept of potential to illustrate how and how much an activity could satisfy certain need of a household and/or its member(s). Bricka, Sen, Paleti, and Bhat, (2012) have examined the propensities and magnitude of trip making as reported through the survey data and as recorded using GPS units for both work and non-work purposes suggesting that any study considering GPS-collection only should strongly consider the details used to develop the algorithms to assign trip purpose. GPS should be considered as the data collection method when dealing with the younger, more technology savvy individuals as well as those that have high travel propensities or characteristics associated with trip chaining, in order to ensure that all trip details are recorded. However, for the elderly and more leisurely travelers, the traditional survey method is recommended. Trip distance, time, count (frequency) and mode choice are commonly used to define the travel behaviors. For units of measurement, vehicle miles traveled (VMT), vehicle hours traveled (VHT) and vehicle kilometers traveled (VKT) are used as outcomes for the land use-travel models. While both travel distance and time are continuous value, mode choice is usually categorized with dummy variables (Cervero & Kockelman, 1997).

Ewing and Cervero (2010) conducted a meta-analysis of the multitude of built environment-travel literature existing at the end of 2009 in order to draw generalizable conclusions about the relationship between travel and the built environment. Over 150 built-environment/travel studies were summarized in their paper. A similar meta-analysis composed of 17 different studies about the impact of urban form on travel behavior was conducted by Leck (2006). Many papers provide various methods to model the relationship between land use and household travel, encompassing the simultaneous observation and analysis of more than one outcome variable (Kockelman, 1997; Næss, 2009; Schimek, 1996; Tracy, Su, Sadek, & Wang, 2011). Many previous studies masked individual behaviors and concerned about the aggregated data at the household level or even some larger geographic unit such as the census tract, traffic analysis zone (TAZ), or the metropolitan. However, results derived from those studies conducted at aggregated level could not be used to predict individual travel behavior since it is inappropriate to make causal and associative inferences about individuals based on results obtained from aggregate data. Shay and Khattak (2012) modeled the relationship between land use and travel behavior at the personal level. As with travel behaviors, aspects of land use have been quantified in many ways. The commonly used variables in the built environment are three Ds: Density, Diversity and Design. Many studies found density to be negatively associated with car ownership, car use and travel distances. For example, based on the travel data in Belgium, Van Acker and Witlox (2011) found that densely built neighborhoods are associated with lower car use and shorter commuting distances. A similar result has been found by Tracy et al. (2011) in Buffalo, New York suggesting that high density development appears to encourage non-motorized travel. Another important aspect of land use is diversity, which measures the number of different land uses in a given area and the degree to which they are represent in land area. Higher diversities are believed to result in lower car ownership levels, lower car use, shorter travel distances and shorter travel times. For instance, Tracy et al. (2011) found that mixed land use development appears to be a valid way to encourage non-vehicle travel. Based on the travel data of Seattle and the San Francisco Bay Area, land use mixing was found to be significantly related to less car use and more walking and transit usage (Cervero & Wu, 1997; Frank, Stone Jr, & Bachman, 2000). For the land use mixture measurement, entropy measures of diversity, wherein low values indicate single-use environments and higher values more varied land uses, are widely used in travel studies (Cervero, 2002; Cervero & Kockelman, 1997; Ewing & Cervero, 2010; Kockelman, 1997).

Accessibility, a frequently used concept referring to the ability to reach activities or locations by means of a combination of travel modes (Geurs & van Wee, 2004), is an important land use characteristic. Kitamura, Mokhtarian and Laidet (1997) found that better accessibility by public transport result in more trips by public transport. A popular functional form for quantifying accessibility was provided by Kockelman (1997), which was built with the attractiveness of destination and the travel time from origins to destinations. In fact, accessibility is highly correlated with other land use characteristics, especially density. Higher density usually indicates a higher likelihood of having destinations within reach, hence high accessibility. Kockelman (1997) even found that the impact of density was negligible after accessibility was controlled. However, even though some authors have noticed the autocorrelation between accessibility and density, they did not really discuss about this problem in their studies. Therefore, a suggestion for future research would be to consider the autocorrelation between accessibility and built density, and then assign different weight to their effects on travel behavior when build the land use-travel model.

Recently, there is a growing interest in the issue of residential self-selection (e.g., Næss, 2009; Xinyu, Mokhtarian, & Handy, 2009), which refers to a tendency of people to choose places of residence based on their travel abilities, needs and preferences. About the existence of residential self-selection issue, numerous studies indicated that socio-demographics have played an important role in shaping travel behavior (Cervero & Kockelman, 1997; Næss, 2009; Shay & Khattak, 2012; Van Acker & Witlox, 2011). Tracy et al. (2011) found that including median household income, household vehicles, household students, household workers, and household size helped address the residential self-selection problem to some extent. On the other hand, Næss (2009) pointed out that inclusion of those household variables may result in an underestimation of the effects of the built environment. Therefore, it would be better to examine the effects of land use on travel behavior with and without controlling for the socio-demographics for person and household. Nevertheless, the inclusion of socio-demographics may depend on the geographic scale of the study unit. If a study is conducted at the metropolitan level like Cervero and Murakami's study (2010), it is meaningless to take individual socio-demographics into account.

Despite the importance of neighborhood context discussed, most previous empirical studies devoted to individual travel behaviors have not considered interaction between individual and neighborhood. The impact of using different level of spatial unit (i.e., individual vs. neighborhood) on empirical findings concerning travel patterns remains unexplored.

Study area

The study area is Hamilton County in Ohio, located in the southwest corner of the state of Ohio, as shown in Fig. 1. The census of 2010 reported that the population of this county is 802,374, making it the third most populous county in Ohio. This study explores the trip behavior from two hierarchical levels: individual and neighborhood (census tract). The tract boundary used in this paper was released in 2010, which has overall 222 census tracts.