Transportation Research Part C 77 (2017) 516–528

Contents lists available at ScienceDirect

Transportation Research Part C

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

Transport habits of travelers using new energy type modes: A random parameters hazard-based approach of travel distance

Panagiotis Ch. Anastasopoulos [a,*], Grigorios Fountas [b], Md Tawfiq Sarwar [c], Matthew G. Karlaftis [d,†], Adel W. Sadek [e]

[a] Department of Civil, Structural and Environmental Engineering, Engineering Statistics and Econometrics Application Research Laboratory, Institute for Sustainable Transportation and Logistics, University at Buffalo, The State University of New York, 241 Ketter Hall, Buffalo, NY 14260, United States
[b] Department of Civil, Structural, and Environmental Engineering, Engineering Statistics and Econometrics Application Research Laboratory, University at Buffalo, The State University of New York, 204 Ketter Hall, Buffalo, NY 14260, United States
[c] National Research Council, Federal Highway Administration, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, T-210 McLean, VA 22101, United States
[d] National Technical University of Athens, Zografou Campus: 9 Heroon Polytechniou, Athens 15780, Greece
[e] Department of Civil, Structural and Environmental Engineering, Institute for Sustainable Transportation and Logistics, University at Buffalo, The State University of New York, 212 Ketter Hall, Buffalo, NY 14260, United States

ARTICLE INFO

Article history:
Received 14 February 2015
Received in revised form 23 January 2017
Accepted 24 January 2017

Keywords:
Travel distance
Low CO_2 emissions
New energy type mode transport habits
Hazard-based duration modeling
Survival analysis

ABSTRACT

With environmental concerns on the rise, identifying the factors that affect travel demand for energy efficient and environmentally friendly means of transportation becomes critical. It is, thus, beneficial to identify the characteristics of new energy type – low CO_2 emissions – transport habits. Travel time is one such characteristic that has been extensively studied within the context of activity-based travel demand modeling. However, when travelers choose a new energy type with low CO_2 emissions transport mode, it is likely that travel time may be playing a secondary role in their mode choice criteria as opposed to travel distance, especially in highly congested urban areas. Within this context, the origin-destination distance of a trip has the potential to reveal interesting traveler preferences and trip patterns. This paper presents an exploratory empirical analysis of origin-destination distance for such new energy type mode transport habits, in the Metropolitan area of Athens, Greece. Using hazard-based econometric modeling and random parameters to account for the longitudinal nature of trip distance and unobserved heterogeneity, respectively, trip distance is found to be affected by a number of influential factors, such as traveler socio-economic and demographic characteristics, trip purpose, trip time, trip frequency, and time of day for the trip.

Published by Elsevier Ltd.

1. Introduction

Transport habits typically involve frequent trips towards the same destination for the same activities using the same transport modes. The travel characteristics of the users of the new energy type – low CO_2 emissions – modes are of great

* Corresponding author.
E-mail addresses: panastas@buffalo.edu (P.Ch. Anastasopoulos), gfountas@buffalo.edu (G. Fountas), mdtawfiq@buffalo.edu (M.T. Sarwar), asadek@buffalo.edu (A.W. Sadek).
† Deceased author; Matthew G. Karlaftis passed away on June 4, 2014.

http://dx.doi.org/10.1016/j.trc.2017.01.017
0968-090X/Published by Elsevier Ltd.

interest, particularly when their mitigative effects on global warming are considered. One such characteristic that has been studied extensively within the context of activity-based travel demand modeling, is travel time (for example, see Ben-Akiva et al., 1996; Niemeier and Morita, 1996; Hamed and Easa, 1998; Kwan, 2000; Ettema and Timmermans, 2006; Ferdous et al., 2011; Fosgerau and Fukuda, 2012; Carrion and Levinson, 2013; Tirachini, 2013; Kamga and Yazici, 2014; Alexander et al., 2015; Liao, 2016). These studies have looked at a number of influential factors, such as trip and transport mode, financial information and demographics, socio-economic characteristics, and their effect on travel time (from origin to destination). Various methodological approaches have been utilized – such as, agent-based modeling, dynamic modeling, neural networks, genetic algorithm-based methods (Beltran et al., 2009; Nayeem et al., 2014; Kepaptsoglou et al., 2015; Wu et al., 2015), and advanced statistical and econometric methods (Mannering et al., 1994; Jha et al., 1998; van Lint et al., 2005; Arentze et al., 2010; Fei et al., 2011; Khosravi et al., 2011; Li and Rose, 2011; Haworth et al., 2014; Kim and Mahmassani, 2014; Hojati et al., 2016; Woodard et al., 2017) – with hazard-based duration econometric modeling (Mannering and Hamed, 1990; Bhat and Steed, 2002; Zhong et al., 2008; Anastasopoulos et al., 2012a; Hasan et al., 2013; Haque and Washington, 2015; Huang and Levinson, 2015; Yu et al., 2017) being very popular, due to the longitudinal nature of travel time.

Besides travel time, there is a cluster of research that has accounted for spatial effects, or used the origin-destination distance as an alternative to travel time (Wellman, 1996; Algers et al., 2001; Axhausen, 2002; Handy et al., 2002; Cabanne, 2003; Kockelman, 2007; Gkiotsalitis and Stathopoulos, 2016; Jian et al., 2016). In fact, the origin-destination distance of a trip has the potential to reveal interesting traveler preferences and trip patterns, as trip distance under the selection of low CO_2 emissions transport modes is likely to play a more significant role than the duration of the trip, especially in city center trips where travel time may not be the sole criterion for traveler's mode choice. For example, in highly congested areas (such as central business districts of large metropolitan areas), travel distance may be more influential in the selection of transport mode, especially for short and medium distance trips where travel time may not significantly vary. This is because travel distance may be associated with other – seemingly negligible – mode choice specific unobserved characteristics (such as riding quality, noise level, in-vehicle crowdedness and environmental impact), which, in turn, are likely to favor the use of new energy type transport modes.[1]

The goal of this paper is to empirically explore the spatial dimension of such new energy type public transport usage in the Metropolitan area of Athens, Greece, where, over the last couple of decades, new technologies in transit (including electric and natural gas powered modes) have been employed to reduce environmental pollution and improve mobility and safety.[2] To that end, the relationship of the origin-destination distance is investigated, for trips that use a new energy type with low CO_2 emissions transport mode, and various influential factors (such as, traveler socio-economic and demographic characteristics, trip purpose, trip time, energy type of transport mode, trip frequency, and time of day for the trip), using hazard-based econometric modeling approaches. The proposed approach accounts for mode choice specific unobserved heterogeneity, through the use of random parameters.

2. Methodological approach

It has been empirically and mathematically shown that hazard models applied to temporal and spatial settings are conceptually equivalent (Waldorf, 2003; Anastasopoulos et al., 2012b). To this end, the length of the distance from origin to destination can be statistically modeled as longitudinal data using hazard-based duration modeling methods. Under such an approach, additional insights can be provided into important survival effects, such as the manner in which the probability that a trip will end changes over the distance the trip has already lasted (Hensher and Mannering, 1994; Wang et al., 2005; Washington et al., 2011; Sharman et al., 2012).

For travel distance, hazard-based models consider the conditional probability of a trip distance ending at some distance δ, given that it has not ended until distance δ, with the hazard function written as:

$$h(\delta) = \frac{f(\delta)}{1 - F(\delta)} = \frac{f(\delta)}{S(\delta)} \tag{1}$$

where, $F(\delta)$ and $f(\delta)$ are the cumulative distribution function and the density function of trip distances, respectively, and $S(\delta)$ is the survival function (the probability that a trip distance is greater than or equal to distance δ). In this case the hazard function gives the rate at which trip distances are ending at distance δ, given that they have lasted up to distance δ. If this hazard function is upward sloping over the distance of the trip ($dh(\delta)/d\delta > 0$), then the probability that a trip will end soon increases the longer the trip distance is. If the hazard function is downward sloping over the distance of the trip ($dh(\delta)/d\delta < 0$), then the probability that a trip will end soon decreases the longer the trip distance is. And, if the hazard function is constant over the distance of the trip ($dh(\delta)/d\delta = 0$), then the probability that a trip will end soon is independent of the length of the trip distance.

[1] It should be noted that Athenian public transit modes running on energy efficient types are clearly distinct from the conventional means, with the use of distinguished external visual features (color and design consistency for natural-gas and electric buses).

[2] Note that during the data collection period, the new energy type transport modes were perceived by the majority of public transportation users as a new "green" alternative to the conventional means, with comparative advantages relating to the quality of riding conditions (Tyrinopoulos and Antoniou, 2008). Specifically, those means were associated with low noise operation, smoother riding conditions, and better in-vehicle conditions.