ARTICLE IN PRESS

Transportation Research Part A xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Transportation Research Part A

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

Commercial vehicles time of day choice behavior in urban areas

Mubassira Khan [a,*], Randy Machemehl [b]

[a] HDR, 504 Lavaca Street, Suite 1175, Austin, TX 78701, United States

[b] University of Texas at Austin, Dept of Civil, Architectural and Environmental Engineering, 301 E. Dean Keeton St. Stop C1761, Austin, TX 78712-1172, United States

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Commercial vehicle travel behavior
Time of day choice
Mixed MDCP model

ABSTRACT

This study presents a mixed Multiple Discrete-Continuous Probit (MDCP) modeling framework to describe time of day choice behavior of commercial vehicles and the vehicle-miles-traveled (VMT) at the chosen time(s) of day. The mixed MDCP model recognizes the unobserved heterogeneity across commercial vehicles in response to customer-to-customer travel speeds, and service time/dwell time at customer stops due to customer preferences for predefined business hours. Possible common unobserved factors affecting different times of day are also captured estimating a general covariance error structure. The estimated models show that a host of factors affect commercial vehicle time of day choice behavior. These include commercial vehicle class, type, commodity type, total unloading weight, as well as location features of base and intermediate stops, frequency of stops to office locations and construction sites; and time of day attributes including travel speed and service time. The results indicate that travel needs, are for the most part, influenced by activity needs. The estimated model can be used to predict the likelihood of commercial vehicle time of day choice for performing daily activities and the VMT generated at the chosen time(s) of day.

1. Introduction

Choice of time of the day for freight shipments is inherently linked with the levels of service of roadways, consequently with road network congestion. Traffic congestion has become a critical issue in most urban and suburban areas, especially during the peak periods. Texas Transportation Institute's (TTI) 2012 Urban Mobility Report (Schrank et al., 2012) estimated that in year 2011 congestion caused a loss of 5.5 billion hours resulting in an extra 2.9 billion gallons of fuel used and contributed to a congestion cost of $121 billion in 498 metropolitan areas in the US. Transportation planners and policy makers have hence been constantly exploring travel demand management (TDM) strategies to mitigate traffic congestion. In the context of freight transportation planning-especially freight transport by road, an off-hour delivery (OHD) strategy –that allows carriers to deliver goods outside regular business hours – is one option aiming at spreading out peak travel that has received substantial attention and has been studied with considerable interest in the recent past (Holguín-Veras, 2008; Holguín-Veras et al., 2011). OHD strategy helps to minimize roadway congestion by moving freight deliveries to the off-hours or outside regular business hours. In a recent study based on implementation of the OHD strategy in the New York City metropolitan area, Holguín-Veras et al. (2011) highlighted the economic benefits of the OHD program in the range of $150–$200 million per year, associated with travel time savings, increased productivity of the freight industry,

* Corresponding author.
E-mail addresses: mubassira.khan@hdrinc.com (M. Khan), rbm@mail.utexas.edu (R. Machemehl).

http://dx.doi.org/10.1016/j.tra.2016.08.024
0965-8564/

Please cite this article in press as: Khan, M., Machemehl, R. Commercial vehicles time of day choice behavior in urban areas. Transport. Res. Part A (2016), http://dx.doi.org/10.1016/j.tra.2016.08.024

and sizable pollution reductions. After the OHD program from this research project was implemented in the New York Metropolitan area, an OHD program was adopted by the City of New York as part of its sustainability plan (City of New York, 2011). The Federal Highway Administration is planning to create its own program to promote OHD (Federal Highway Administration, 2012).

The activity-based approach of travel demand analysis methods attempts to incorporate the time dimension into the travel modeling process to better understand decisions concerning activities which affect travel demand (Axhausen and Garling, 1992; Pas and Harvey, 1997). From the transportation planning perspective activity-based travel demand modeling approaches offer a stronger behavioral framework for evaluating TDM strategies (Kitamura et al., 1996; Yamamoto and Kitamura, 1999; Pendyala and Bhat, 2004). Therefore it is not surprising that in the last two decades activity-based travel demand analysis has received greater attention to model passenger travel behavior over traditional trip-based approaches which analyze trip-related decisions without recognizing the time-use context in which activity participation and travel decisions are made (Bhat and Koppelman, 1999; Kitamura et al., 1996; Yamamoto and Kitamura, 1999).

It is very important to recognize the importance of the time dimension in the transportation planning process. As an example, one can consider the case of Off-hour delivery (OHD) strategy adopted by commercial vehicles. Note that implementation of OHD will enable shifting truck (i.e. carrier) delivery activities from regular hours to off-hours and thereby the travel associated with goods delivery, however, it requires the consensus of the receivers (customers) (Holguín-Veras et al., 2011). When carriers deliver goods to customers during the off-hours and the customers receiving goods allow delivery during off-hours then the travel associated with goods delivery activities by the carriers will shift to a different time of the day. Therefore, the carrier has additional time available for pursuing other activities, such as goods pick-up activities from a distribution center or a warehouse and maintenance activities-though there may also be additional costs for these other activities such as fuel costs or marketing cost. Shifting of the travel/trips associated with goods delivery influences carriers to engage in other activities at different times. Besides influencing other activity participation, OHD may influence the timing of activity engagement and the associated vehicles miles traveled for pursuing the activities. Shifting of goods delivery activity to the off-hours may shift the choice of different times of day by the carriers for engaging in other activities. Analyzing these temporal changes in activity engagement patterns is important for accurately assessing the impacts of a peak spreading strategy such as OHD on travel demand.

As illustrated by the above example, two key aspects associated with the temporal dimensions of commercial vehicle daily travel play very important roles to describe their travel behavior. The first one is the decision where a commercial vehicle driver decides when to travel and the second one is the decision about how much to travel during different times of the day to perform activities. In this paper, it is assumed that shippers and carriers jointly make the decision when to pick-up and drop off freight (the time of day) to the receivers/customers and consequently allocate VMTs based on receivers preferred time window to receive goods, which is unobserved to the analyst. In reality, carriers have a certain time window to deliver goods to receivers, which is not a specific time like 10 AM but it is likely to be a range (i.e. 7 AM–7 PM; 8 AM–1 PM; 10 PM–6 AM, etc.) and therefore carriers have some flexibility to choose a time window to perform their daily activities.

Commercial vehicles' choice of when to travel (time of day choice) can greatly affect congestion on the road network and the TDM policies (such as OHD) aimed at spreading out peak travel to mitigate congestion. The amount of travel represented by VMT is used as a traffic related input for the Environmental Protection Agency's (EPA) mobile source emission model MOVES (Motor Vehicle Emission Simulator). Clearly it is very important to accurately predict the times of the day chosen by commercial vehicles for performing daily activities and the vehicles usage (VMT) during different times of the day, to support critical TDM strategies and air quality planning decisions. An overview of the literature in this area is discussed in the next section.

2. Overview of the literature and the current study

This section presents an overview of the literature by examining three broad issues related to commercial vehicles time of day choice and vehicle usage: (1) review of the relevant literature, (2) the determinants of commercial vehicles' time of day choice and vehicle usage, (3) the model structure employed.

2.1. Review of the relevant literature

Time of day choice behavior of passenger traffic has been studied extensively in the literature to evaluate several peak spreading strategies to mitigate congestion during peak periods. Several dimensions are generally used to characterize the time of day choice behavior of a tour including the choice of tour departure time, tour end time and duration of all trips and activity stops on the tour (Zeid et al., 2006). The departure time choice of commuter tours has been studied extensively. Recognizing the impact of congestion on the choice of when to travel, Vickrey (1969) first proposed a determinate modeling framework assuming a single bottleneck situation consisting of one link where commuters make decisions on their time of travel based on the road (link) congestion and a demand supply equilibrium procedure that can determine commuters' departure time explicitly. Based on the ideas first proposed by Vickrey (1969), a number of earlier studies modeled departure time as a continuous quantity in deterministic modeling frameworks (e.g., Arnott et al., 1990; Hyman, 1997; van Vuren et al.,