Transportation Research Part C 58 (2015) 46–55

Contents lists available at ScienceDirect

Transportation Research Part C

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

Deliveries to residential units: A rising form of freight transportation in the U.S.

Xiaokun (Cara) Wang [a,*], Yiwei Zhou [b,1]

[a] Department of Civil and Environmental Engineering, 4032 JEC Building, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180-3590, USA
[b] Precision System, Inc., 1801 Rockville Pike, Suite 350, Rockville, MD 20852, USA

ARTICLE INFO

Article history:
Received 5 December 2014
Received in revised form 6 July 2015
Accepted 8 July 2015

Keywords:
Freight delivery
Online shopping
Residential units
NHTS

ABSTRACT

As a result of the rapid growth of online shopping, more goods and services are delivered directly to residential units. The door-to-door deliveries improve residents' accessibility to retail sector, and at the same time create truck delivery trips. However, partially due to the data limitation, most existing freight research focuses on freight trips generated by business establishments. Little is known about freight trips generated by residential units. As a growing number of urban areas are pushing for dense and mixed development, it is necessary to understand the pattern of truck freight trips directly generated by residential units. This paper uses the U.S. National Household Travel Survey (NHTS) data to investigate the freight trips generated by residential units. The 2009 NHTS provides accurate, comprehensive and timely information on trips, land use, household characteristics and social economic factors. It is the first time that the NHTS data is used to estimate freight trips. A binary choice model and a right-censored negative binomial model are used to identify the impacts of person-related, household-related, and regional-specific variables on home delivery frequency. A case study for the New York State Capital District is then presented. The estimated freight trips generated by residential units are also compared to the freight trips generated by business establishments. Results, although still preliminary and subject to uncertainty, indicate that freight trips generated by residential units have comparable magnitude as the freight trips generated by businesses. Such a study will supplement city logistics studies that traditionally focus on business behavior, helping reconstruct a complete picture of the freight activities in urban areas.

1. Introduction

Nowadays, people's lives are greatly facilitated with the advance of information and communication technology (ICT). The widespread use of internet has made online shopping possible. The efficient logistics system enables door-to-door delivery of online shopping goods. As a result, more and more people choose to shop online. Online shopping or e-commerce has been booming during the past decade. The total e-commerce sales in the U.S. in 2013 were estimated at $263.3 billion, an increase of 16.9% from 2012; it took up 5.8% of total sales and the percentage continues to increase (U.S. Census Bureau, 2014a).

The online shopping also brings great changes to the transportation system. Mokhtarian (2004) summarized that potential impacts of online shopping include changes in shopping mode share, volume of goods purchased, per capita consumption

* Corresponding author. Tel.: +1 518 276 2098.
E-mail addresses: wangx18@rpi.edu (X. (C.) Wang), zywadam@gmail.com (Y. Zhou).
[1] Tel.: +1 518 867 6669.

http://dx.doi.org/10.1016/j.trc.2015.07.004
0968-090X/

spending, and demographic changes. Golob and Regan (2001) also concluded that e-commerce had brought changes to both personal and freight transportation. From transportation planners' and policy makers' perspective, these changes imply impacts on economy, population, land use, freight transportation and passenger transportation, which need to be carefully evaluated when making decisions. Zhou and Wang (2014) investigated the impacts of online shopping on shopping trips. Results indicated that frequent online shoppers tend to make more shopping trips while more shopping trips tends to suppress the propensity toward online shopping. As one can expect, online shopping brings economic benefit to freight businesses, influences residents' shopping trips, and creates freight trips to residential areas. This paper focuses on the freight trips generated by residential units from online shopping. Much research have been done to estimate the freight trips using freight models. Generally, freight models were classified into seven groups: economic flow factor models, O–D factor models, truck models, four-step commodity models, economic activity models, logistic models, and vehicle touring models (Chow et al., 2010). Lawson et al. (2012) estimated freight generation based on three land use classification codes: the City of New York zoning resolution (NYCZR), the Land-Based Classification Standards (LBCS), and the Institute of Transportation Engineers (ITE) manual. It was found that models for NYCZR and LBCS land use classification codes provided better alternatives to ITE trip rates. Holguín-Veras et al. (2011) proposed to separate freight generation (FG) and freight trip generation (FTG) models. It was found that only 18% of the industry sectors in New York City revealed constant FTG rates per employee. The paper finally concluded that both economic-land use and spatial aggregations must be appropriate for a FG-FTG model to work well.

Due to the data limitation, most existing freight research focuses on freight trips generated by the multiple industrial sectors, little is known about freight trips generated by residential units. Ulmer et al. (2003) investigated the differences between trip generation rates calculated based on traffic counts and household surveys. Using data from Virginia, the authors found there was no significant difference between trip generation rates calculated with different data sources, although large and random variation exist among residential trip generation rates across neighborhoods. Holguín-Veras et al. (2012) estimated freight trips generated by individual business establishments where trip rates for 11 industrial sectors, categorized based on the standard industrial classification system, were estimated.

As more and more urban areas are pushing for dense and mixed development, it is necessary to understand the pattern of freight trips directly generated by residential units. However, research on this topic is very limited. The few existing studies tend to estimate the residential units-generated freight demand on rather aggregate level, typically based on freight generation rates for residential land use. For example, Fischer and Han (2001) summarized commercial vehicle trip generation for different land use types including the residential land use. They proposed simple linear regression formulas of daily commercial vehicle trip generation Rigorous modeling based on disaggregate data is still lacking in this field.

To fill this gap, this paper used the National Household Travel Survey (NHTS) 2009 dataset to investigate the freight trips directly generated by residential units. The NHTS 2009 dataset provides accurate, comprehensive and timely information on trips, land use, household characteristics and social economic factors. A set of statistical models is established to analyze this dataset to explain freight trips generated by residential units and to discover influential factors. The paper is organized in the following sections: "Method" section introduces the method to be used for investigation; "Data description" describes the NHTS dataset and presents the variable statistics; "Results" summarizes the estimation results and their interpretation; "Application" section applies the model to predict freight trips generated by residential units in the New York State Capital District; The "Comparison" part estimated results are then compared with freight trips generated by business establishments in the same study area; and the "Conclusion" section summarizes all findings and discusses future work.

2. Data description

The data used in this study is from the 2009 NHTS data (FHWA, 2012). NHTS collects detailed household travel data to assist transportation planning and research. Previous NHTS surveys were carried out in 1969, 1977, 1990, 1995 and 2001. The recently released 2009 NHTS dataset includes the latest information on: household trip purpose, mode, time, frequency, together with information on household income, size, education level, location, etc. The survey interviewed 150,147 households, including 308,901 individuals in the U.S. One new feature of NHTS 2009, compared to the previous versions, is the inclusion of online shopping related questions. The survey collected information about residents' web use pattern, online shopping frequency, and home delivery frequency. Table 1 summarizes the distribution of these variable values and the corresponding number of records in each category.

This paper uses the variable "delivery" as the dependent variable, which indicates the number of online purchases delivered to home in the month prior to the survey date. Out of the 308,901 respondents, 100,198 individuals provided valid numbers for their home delivery frequency, ranging between 0 and 200. Out of these 100,198 records, 88,322 received at least one home delivery; the other 11,876 records made online purchases but did not receive any home delivery because their goods used electronic delivery (such as movie streaming and music downloading), require store pickup, or were delivered to workplace. There were 208,634 respondents who "appropriately skipped" the question of home delivery frequency. As indicated by Table 1, out of these 208,634 records, 98,693 did not make any online purchase in the last month; 70,206 did not use the Internet at all; and 38,183 skipped the question due to age ineligibility. The remaining 1641 respondents refused to provide related information.

In short, of all residents 18 years or older in the NHTS sample, a total of 180,755 respondents received 0 home deliveries in the past month. The reasons for zero home deliveries, however, are different: 11,876 individuals made online purchases,