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

Modeling urban freight generation: A study of commercial establishments' freight needs

Iván Sánchez-Díaz Ph.D.

Department of Technology Management and Economics, Chalmers University of Technology, Vera Sandbergs Allé 8, Göteborg 41296, Sweden

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Freight trip generation
Freight generation
Freight attraction
Urban freight
Freight demand modeling
Receivers' behavior

ABSTRACT

Increasing urbanization, and the environmental and liveability impacts associated with urban activity, have directed attention to the need for sustainable cities. Achieving sustainable urban development requires including freight systems in strategic urban development plans. In this context, joint efforts involving academia and public- and private sector to collect the right data and develop suitable models, can contribute toward a better understanding of establishments' freight needs, the quantification of freight's traffic impacts and the development of appropriate methods to support decision making and strategic plans. This paper studies urban commercial establishments' freight needs and impacts on traffic using data collected from establishments in the City of Gothenburg (Sweden). The data cover different zones of the city and include commercial sectors found typically in urban cores (e.g., retailers, food services, health care, public sector offices and education). The paper introduces a set of statistical models—developed based on regression analyses and discrete choice models—to estimate the number of freight trips produced and attracted per week, and the attraction of weight and volumes of freight. In addition to shed light on the factors determining establishments' freight- and freight trips generation, the models are designed with the purpose of assisting planning and policy design efforts, thus the explanatory variables are selected based on suitability and availability. The results show that retailers of perishable goods have the highest freight trip generation per establishment, followed by public sector offices and education establishments, retailers of non-perishable goods and restaurants. The results also reveal a heterogeneity between sectors, and a differential business size effect across commercial sectors.

1. Introduction

During the last decades, the world has seen a rapid growth of an urban population with an increasing access to global supplies. While in 1950 only one-third of the global population lived in urban environments, this proportion reached half of the population in 2014, and is expected to grow to two-thirds by 2050. In absolute terms, this means that urban environments hosted 746 million dwellers in 1950, 3.9 billion in 2014 and are expected to host 6.4 billion in 2050 (United Nations, 2014). This growth raises several concerns as cities already generate more than 80% of the global gross domestic product (GDP), consume two-thirds of the world's energy, and produce more than 70% of global greenhouse gas emissions (The World Bank, 2014). Not surprisingly, this situation has intensified global efforts to align policy, planning and investment choices in a way that favors efficient, inclusive, safe, resilient and sustainable cities.

E-mail address: ivan.sanchez@chalmers.se

http://dx.doi.org/10.1016/j.tra.2016.06.035
0965-8564/© 2016 Elsevier Ltd. All rights reserved.

Urban planners, researchers and policy makers have identified some elements—such as increasing walkable spaces, mixing land-uses, increasing urban density, promoting the use of public transportation, and fostering cleaner vehicle technologies—that can be instrumental in this quest (Smart Growth Network and ICMA, 2002). The passenger transportation system has progressively been adapted to cope with this new reality by increasing access to public transportation, decreasing parking space for cars, implementing congestion charges, integrating transportation and land-use plans, among other initiatives. However, in the case of freight, public interventions have been limited to a few measures that have often not being effective or even generated counterproductive effects (e.g., access restrictions based on time of the day, load factor, vehicle size; congestion charging; urban consolidation centers) (Holguín-Veras et al., submitted for publication). In this context, there is a pressing need for the freight transportation research community to find ways to smooth the access of goods to citizens without hampering the city's livability.

One of the reasons explaining the unsatisfactory results from initiatives aimed at improving freight movements' efficiency is the lack of knowledge about the urban freight system and the behavior of freight agents, as well as the deficient quantification of the problem. Hence, the efforts to collect quality data and develop urban freight models are bound to improve the knowledge of the system, to facilitate the formulation of suitable initiatives and to enhance the public sector's decision making process. A step in this direction is to study urban establishments' freight needs and the traffic generation that these needs entail, which can be done through the collection of Freight Generation (FG) and Freight Trip Generation (FTG) data, and the development of quantitative models.

FG can be defined as the physical expression of the flows from economic exchanges (i.e., goods exchanged for money between two economic agents) which can be quantified in terms of weight, value, or volume; while FTG denotes the amount of freight vehicles (i.e., traffic) that are required to transport the FG (Holguín-Veras et al., 2011; Holguín-Veras et al., 2012). In sub-urban areas, FG is mainly a consequence of large scale operations (e.g., manufacturing, wholesale, warehousing and logistic operations) that results into high FG per establishment. In central urban environments, the focus of this paper, FG is mainly a consequence of commercial activities that serve final consumers (e.g., food services, retailers, schools, hospitals, offices), resulting into numerous establishments with relatively small—compared to sub-urban areas—FG per establishment. However, when added together these establishments require a substantial amount of freight that needs to be transported in an efficient way to reach the final destination with minimum impacts to the city.

It is important to study both FTG and FG because FTG quantification is crucial to assess the traffic impacts of different activities and evaluate potential savings of novel initiatives, and FG quantification is key to design and evaluate the feasibility of those initiatives. For instance, FTG models can be used to assess potential traffic impacts savings from a consolidation center; but a FG analysis is necessary to identify whether an establishment's freight needs can be fulfilled through a consolidation center, the type and amount of vehicles that would be necessary, and the space needs for the consolidation facility.

This paper is organized in four sections in addition to this introduction. Section 2 provides a background on the concepts of FG and FTG and provides a discussion of the relevant literature. Section 3 describes the methodology followed for this study. Section 4 presents the results, and Section 5 discusses the conclusions from this research.

2. Background

In line with the generic terminology used for demand models, the term generation encompasses both production and attraction (Ortúzar and Willumsen, 2011). Urban establishments have a Freight Attraction (FA) that depends on the intensity of their economic activity; and a Freight Trip Attraction (FTA) that depends on (i) their FA, (ii) the variety of supplies required for their type of activity, and (iii) their ordering policy (Holguín-Veras et al., 2011; Holguín-Veras and Sánchez-Díaz, 2016). The role of the shipper and the carrier is typically to select a shipment size and a vehicle type that meet the receivers' requests while maximizing their own benefits. Central urban establishments' Freight Trip Production (FTP) tends to be smaller than in suburban establishments because most goods are consumed in place or brought home by the final consumers through personal transportation modes.

Although during the last two decades the interest on freight demand modeling has significantly increased, the body of literature studying FG and FTG is still small. The main reasons are the lack of establishment-based data and the complexity of modeling the heterogeneous behavior of firms. Some authors have attempted to counter this difficulty through the use of traffic counts and disaggregating data from regional models (Institute of Transportation Engineers ITE, 2008; Ramakrishna and Balbach, 1994). However, these secondary sources of information are complementary but cannot replace the data from shippers and receivers because the latter provide the connection between FG/FTG and the underlying economic activity, which offer key insights for planning and public policy development. Table 1 summarizes the different sources of data for FTG and local traffic analysis and their advantages and disadvantages.

The FTG literature includes a number of reports that compile models from different sources or estimate their own statistical models (Holguín-Veras et al., 2012; Institute of Transportation Engineers ITE, 2008; Beagan et al., 2007; Federal Highway Administration, 1999; Cambridge Systematics Inc., 1996). The Quick Response Freight Manual II (Cambridge Systematics Inc., 1996), for instance, uses the data collected from a freight origin-destination study in Phoenix (Arizona) to estimate FTG rates for different truck types based on employment. The Institute of Transportation Engineers (ITE) Trip Generation Manual, one of the most popular manuals for passenger trip generation, is a compilation of trip generation studies submitted by public agencies, consulting firms, and universities, for which FTG is estimated as a proportion of passenger