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Simulating Urban Freight Flows with Combined Shopping and Restocking Demand Models

Antonio Comi[a]*, Agostino Nuzzolo[a]

[a]*Department of Enterprise Engineering, University of Rome Tor Vergata, via del Politecnico 1, Rome 00133, Italy*

Abstract

This paper presents the development of a modelling system to simulate urban freight flows and preliminary results of a survey carried out to investigate end-consumer behaviour. The set of models involves the simulation of end-consumer choices in relation to type of retail outlet (e.g. small, medium or large) since such choices undoubtedly impact on freight distribution flows. Indeed, the characteristics of the restocking process are strictly related to the type of retail activities to be restocked in terms of delivery size, delivery frequency, freight vehicle type and so on. The paper details each model for shopping mobility origin-destination matrix estimation and investigates the main variables affecting behaviour in relation to trip generation and type of retail outlet.

Keywords: Urban freight transport; city logistics; demand model; shopping trip; shop type choice

1. Introduction

Urban freight flows are mainly comprised of two components related to *shopping* and *restocking*. Indeed, surveys carried out in some European cities (Schoemaker, Allen, Huschebek & Monigl, 2006; Gonzalez-Feliu, Ambrosini, Pluvinet, Toilier & Routhier, 2012) reveal that, considering only urban freight mobility, about 69% of urban distances (veh-km) covered each day by motorized vehicles consist of shopping trips, 24% of restocking

* Corresponding author. Tel.: +39 06 7259 7059; fax: +39 06 7259 7053.
E-mail address: comi@ing.uniroma2.it

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trips and the remaining 7% result from urban management (e.g. building sites, waste collection, network maintenance).

End-consumer choices in relation to type of retail outlet (e.g. small, medium or large) undoubtedly impact on freight distribution flows: the characteristics of the restocking process are strictly related to the type of retail activities to be restocked in terms of delivery size, delivery frequency, freight vehicle type and so on. For example, delivery size and freight vehicle dimensions tend to increase with the dimension of retail activities, while delivery frequency tends to decrease, with considerable effect on the total distance travelled by freight vehicles. Therefore, end-consumer choices among small, medium and large retail businesses affect restocking characteristics and the total freight vehicle distance travelled.

Furthermore, end-consumer shopping location choices depend on the location of commercial supply with respect to residence and on end-consumer behaviour, which in turn depends on some characteristics such as age, income, family dimension and lifestyle. Further, end-consumer choices of retail type can also depend on the accessibility of shopping areas; thus if accessibility changes (for example, as a consequence of shopping demand travel management), type of shop and/or transport mode can also change. Then, if the characteristics of end consumers, residential and commercial land-use distribution, and/or accessibility to the commercial area change, the freight restocking characteristics may also too. Similarly, some city logistics measures can reduce the restocking accessibility of an area and induce re-allocation of retail businesses.

In this context, a city logistics scenario (i.e. set of measures), implemented to improve urban sustainability and reduce the impacts of these two freight transport components (i.e. shopping and restocking), can affect one of the two components with impacts on the other, too. Therefore, a study of urban freight transport and the relative methodology to assess a city logistics scenario should consider both components jointly.

Although several models have been proposed in the field of shopping mobility and restocking mobility (de Jong, Vierth, Tavasszy & Ben-Akiva, 2012; Comi, Delle Site, Filippi & Nuzzolo, 2012), traditionally these two demand segments have been independently handled. Shopping mobility has been studied as a component of passenger demand through the relationships between travel behaviour, the built environment (e.g. land use allocated for different business activities, density) and socio-economic characteristics (Nuzzolo & Coppola, 2005; Ewing & Cervero, 2010). Few studies have analysed it as a component of freight mobility and considered that actions impacting on purchasing behaviour of end consumers (e.g. location of retail outlet, transport mode to use for shopping) can also affect restocking mobility (Bronzini, 2008; Miodonski, & Kawamura, 2012; Wygonik, Bassok, Goodchild, McCormack & Carlson, 2012).

With regards to restocking, various freight demand models have been proposed, many of which are multi-stage models (Taniguchi, Thompson, Yamada & van Duin, 2001; Comi, Delle Site, Filippi & Nuzzolo, 2012; Anand, Quak, van Duin & Tavasszy, 2012) that can be classified in relation to the reference units used: quantity, delivery, tour and vehicle. Quantity allows us to point out the mechanism underlying the generation of freight transport demand: freight transport is generated by the requirement of end consumers to satisfy their needs for goods and services (Gonzalez-Feliu, Toilier & Routheir, 2010; Russo & Comi, 2012). Quantity-based models are more specific for assessing strategic action on transportation flows, such as those impacting on the location of warehouses and retail activity. Delivery is the unit used by transport and logistics operators, allowing us to investigate in greater depth the logistic process of restocking (Muñuzuri, Cortés, Onieva & Guadix, 2012). Using delivery-based models, assessment may be made of the impacts on the transport service type used for restocking (e.g. on own account or by third party), and on shipment size. Tours can be used to investigate delivery in relation to departure time, vehicle type, number and sequence of stops. Finally, vehicle flows, interacting within the assignment model, allow us to obtain link flows and to estimate and evaluate the transport performance and impacts of a given city logistics scenario.

Although restocking flows are generated to satisfy end-consumer demand and restocking models consequently have to take account of end-consumer choices, few have proposed joint modelling frameworks (Oppenheim, 1993; Russo & Comi, 2010; Gonzalez-Feliu, Ambrosini, Pluvinet, Toilier & Routhier, 2012), showing that further work needs to be done in this field.

Given the desirability of a joint modelling framework, this paper presents a modelling system which takes into account some factors of end-consumer behaviour, such as the choice of retail outlet type, and links shopping and