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Urban freight demand forecasting: A mixed quantity/delivery/vehicle-based model

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ABSTRACT

The research germinates from the statement that the cities have to solve the impacts due to freight transport in order to improve their sustainability implementing sets of city logistics measures. But city logistics measures involve several actors and choice dimensions. It is therefore important to have methods and models able to assess the effectiveness of the measures to be implemented. The current models were mainly developed to simulate some aspects of urban freight transport, and are not able to forecast many impacts of implementing traffic and transportation measures at an urban scale.

This paper presents a modelling approach that tries to point out the relations existing among city logistics measures, actors and choice dimensions. It comprises three model sub-systems to estimate the quantity O–D matrices by transport service type (e.g. retailer on own account or wholesaler on own account or by carrier), the delivery O–D matrices by delivery time period, and the vehicle O–D matrices according to delivery tour departure time and vehicle type.

This modelling system is a multi-stage model and considers a discrete choice approach for each decisional level. It was first tested using some data collected in the inner area of Rome, including traffic counts and interviews with retailers and truck-drivers. The model estimations were also compared with the experimental ones, and quite satisfactory results were obtained.

1. Introduction

Local administrators are looking at city logistics measures in order to reduce the negative effects of freight transport within their cities (Russo and Comi, 2011; Lindholm and Behrends, 2012). Freight transport is the result of choices made by several stakeholders, and in particular by transport and logistics operators (retailers, wholesalers and carriers). Feasible solutions thus also have to be an optimal compromise between the various interests concerned (Dablanc, 2007; Stathopoulos et al., 2011; Holguín-Veras and Wang, 2011).

It is therefore important to have methods and models able to consider the behaviour of actors involved in the urban freight transport process (Friesz et al., 2011; Holguín-Veras, 2011; Muñuzuri et al., 2012). In this context, a key role is played by freight demand models that have to satisfy the requirements described in Section 2.

Analysis of the state-of-the-art (Section 2) shows that many of the proposed models do not use a general and mixed framework approach that considers actors and their choice dimensions. It is thus difficult to forecast the effects of implementing city logistics measures.

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In order to find a feasible solution that allows these identified limits to be overcome, we present a system of models (Section 3) that was calibrated by using some surveys carried out in the inner area of Rome. The surveys were based on interviews with retailers and food-and-drink outlets, and truck drivers, and included commercial traffic counts. The models are specified within the quantity/delivery/vehicle mixed modelling approach and are integrated in a unified modelling framework. Although, as described in Section 4, the results of this first calibration phase are satisfactory, further developments, including the analysis of transferability, are in progress as described in Section 5.

2. Freight demand model requirements

2.1. The system to be modelled

The first step of the simulation procedure is to identify the components of urban freight transport, seeking to link choice behaviour and city logistics measures. In urban and metropolitan areas, freight transport is mainly related to the distribution of final products from producers, wholesalers and distribution centres to the businesses in the area (e.g. shops, food-and-drink outlets, offices, consulting firms). For examples, in Rome it represents more than 80% of total quantity and delivery daily movements. In particular, urban distribution can be represented through the functional scheme of freight distribution as pictured in Fig. 1. Even if the proposed model can be applied to whole urban freight distribution system, this paper will deal with the bold part of Fig. 1, that is the case in which the freight passes through a retailer or a food-and-drink outlet before arriving at the end-consumer. As confirmed by several surveys (Ambrosini and Routhier, 2004), this flow represents the main component of freight moved to the centre of urban areas (e.g. in Rome, it represents the 70% of daily delivery flows), where most of the freight transport impacts are concentrated (Ibeas et al., 2012; NCFRP, 2012), and most of the city logistics measures are implemented. Besides, in these areas the measures are quite different from the rest of the city, where they mainly refer to road safety.

As regards the restocking of retailers and food-and-drink outlets, urban freight transport is characterised by different actors which act to move freight. In particular, actors can be grouped according to three classes:

- *wholesalers*, that are sometimes responsible for planning and managing the physical distribution of products; below, we assume that this class also includes producers, distributors and logistics operators which consolidate/deconsolidate freight during the transportation chain up to consumers; this class of actors can decide the transport service type, time, vehicle and possible intermediate facilities (e.g. urban distribution centres), as well as delivery tour;
- *carriers*, which include the actors responsible for transport that decide how to provide transport; we also include transport operators and express companies (couriers);
- *retailers* and food-and-drink outlets, that sell goods to end consumers and can decide how much and how to restock, from where, what time, which vehicle, which delivery tour has to be used.

Referring to the choice dimensions influenced by more common and effective city logistics measures, we can identify two sets of choices: one related to demand and one related to supply/logistics (Table 1). The former class includes choices relative to: how much to be restocked daily, where to get freight to sell in the shop. The latter class includes choices relative to: which type of transport service to be used (e.g. directly on one's own or using third parties), what time to make the delivery journey, which type of vehicle to be used, which delivery tour (e.g. sequence of pick-ups/deliveries). As summarised in Table 1, each of the previous choices can be modified by more common and effective implementing city logistics measures. These measures can be classified in two levels: strategic and tactical/operational. At *strategic level* (Muñuzuri et al., 2005; van Duin and Quak, 2007; Russo and Comi, 2011), the city logistics measures are mainly addressed to influence land use (e.g. government of urban transformations) and end consumers' behaviours. At the other hand, the *tactical/operational* measures predominantly impact on delivery vehicle journeys. A modelling system able to assess these city logistics measures should thus consider all these choice dimensions.

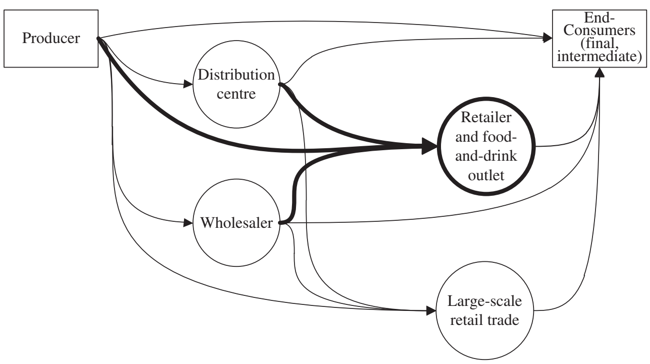

Fig. 1. Structure of urban freight distribution.