An aggregate approach for urban delivery tour simulation

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Abstract

Today, most cities have to deal with the large number of trucks and vans delivering goods in the inner area and local administrators are looking at city logistics measures in order to reduce the negative effects of freight transport [1]. It is therefore important to have methods and models able to assess new city logistics measure scenarios [2, 3, 4]. In a general methodology for simulating and assessing freight transport system, a key-role is played by demand models in order to point out two sets of flows taking place in the study area. The first one is the flow of commodities (e.g. from producers or wholesalers to retailers or end-consumers), while the second one is the flow of commercial vehicles on the road network. The current literature has mainly investigated the former, and methods and models for the estimation of the level and the spatial distribution of goods exchanges, in terms of commodity and/or delivery Origin-Destination matrices, have been proposed [5, 6]. Commodity-based models accurately simulate the mechanism underlying the generation of freight transport demand, while those using delivery units are more specific for studying the logistic process of restocking.

But in order to analyze the network performances and to evaluate the freight transport impacts, the vehicle O-D matrices have to be used and then delivery O-D flows have to be translate into vehicle O-D flows. The translation is not direct, particularly in urban areas where freight vehicles undertake complex routing patterns involving trip chains. Given, for each zone *i* of the study area, the values D_{ij} of the total number of deliveries from the zone *i* to zone *j*, we have to obtain the delivery tours leaving from the zone *i*, including the sequence of successive delivery zones. In this way the vehicle O-D matrices can be easily obtained.

Few studies have investigated this modeling stage, and the proposed solutions [6, 7] consist of two different approaches: disaggregate (e.g. micro-simulation or agent-based) and aggregate ones.

The disaggregate models generally use micro-simulation and optimization models [2] for each decision-maker (e.g. carrier), that has different location of warehouses and shops to restock, different vehicles and time constraints to respect. A number of different principles have been used to accomplish this leading to models based on: logistic considerations [8, 9, 10] behavioral models [11, 12], activity models [13], or profit maximization behavior [14, 15]. However, in spite of their significant potentials, the implementation of these types of models has a fundamental limitation which is related to the number of required information (that can be only available through specific large surveys) and to the expansion to the universe.

The aggregate models consider the average behavior of all restockers (or categories of restockers) leaving from the same warehouse zone. They give the probabilities that a delivery tour has a given number of stops and a given sequence of served zones. Within this class, two approaches have been proposed: incremental growth and multi-steps. The former studies [16, 17, 18] propose to obtain the number of stops per tour by an incremental growth for which, at each stop, the option to come back to the base (warehouse) is considered. If the tour continues, the probability of the next destination zone is derived. This approach implies relevant approximations because the actual choice process is not reproduced, as generally the choices of the number of stops and delivery zone sequence are pre-trip choices. The multi-step approach [19] defines the tours through the joint definition of the trip chain order (that is the number of stops in a tour) and vehicle type, and the choice of the relative delivery location sequence.

The paper focuses on the multi-step approach and presents some improvements of works developed by the authors in previous studies [19]. In particular, the model, implemented to convert delivery O-D matrices into vehicle O-D ones, has been specified, calibrated and validated for the city of Rome, as a component of a wide model developed in order to support the ex-ante assessment of city logistics measures [20]. The study has been supported by some surveys consisting of about 600 interviews to truck drivers. In the paper, different model sequences, specifications and calibrations within the Random Utility Theory are tested and the results are also compared with the revealed flows.

The proposed model allows us to assess how the choices of the two considered dimensions (the number of stops per tour and the stop delivery sequence) could be modified by the implementation of city logistics solutions. For example, measures that reduce the transported load, such as vehicle weight constraints, or that modify the origin or destination zone accessibility, such as area pricing or new transit points, can be assessed in terms of new number of tours and relative sequence of stops.

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