E-shopping and urban goods flow modelling

Agostino Nuzzolo a, Antonio Comi b

* Dept. of Enterprise Engineering, Tor Vergata University of Rome, Italy, nuzzolo@ing.uniroma2.it
* Dept. of Enterprise Engineering, Tor Vergata University of Rome, Italy, comi@ing.uniroma2.it

Extended abstract

Objectives and motivation

Urban goods flows are mainly made of three components related to shopping and restocking:

- **shopping mobility**; it concerns the end-consumer shopping trips (passenger flows);
- **shop restocking mobility**; it refers to the goods trips performed in order to restock shops (truck flows for shop restocking) in which the goods required by end consumers is sold;
- **e-purchase delivering mobility**; it denotes the goods trips performed in order to delivery e-purchases to end consumers or to pick-up points (truck flows for e-purchase delivering).

End consumers usually buy at a shop and hence their shopping choices influences the restocking flows. Therefore, shopping demand represents the input of restocking, and subsequently, modifications occurring on shopping have indubitably effects on restocking. Besides, the penetration of Information and Communication Technologies into human life has influenced personal activities and also the related travel. In fact, among the several activities that can be performed without travelling, shopping is one of these. On-line shopping has been increased dramatically during the last decade. In Italy, the total e-shopping sales is yearly increasing of about 18% (Osservatori, 2013) and in the USA in the last year it has increased of about 16% (Census, 2015). As suggested by Mokhtarian (2004), the potential impacts of on-line shopping include changes in volume of goods purchased, changes in per capita consumption spending. Additionally, it creates goods delivering trips to residential areas, and influences end consumers’ trips. The expected benefits of e-shopping on passenger transportation demand is the reduction of related trips. At the other hand, this change can have goods distribution impacts. First of all, the supply chain structures have to modify in order to include this segment of demand. The purchased products have to be delivered to end consumers at home, and the result can be the increasing of veh-kms of commercial vehicles due to the parcelling of deliveries and the possible missing deliveries (e.g. about the 12% of deliveries have to be delivered a second time, Visser et al., 2014).

End-consumer choices in relation to type of retail outlet (e.g. small, medium or large) undoubtedly impact on goods distribution flows: the characteristics of shop restocking process are strictly related to the type of retail activities to be restocked in terms of delivery size, delivery frequency, goods vehicle type and so on. For example, delivery size, goods vehicle dimension, shopping car use and trip length tend to increase with the dimension of retail activities, while delivery and shopping frequencies tend to decrease, with considerable effect on the total distance travelled by goods and passenger vehicles.

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 type of shopping (in-store and on-line) and 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), shares of buying in-store or on-line, 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, shop restocking and e-purchase delivering characteristics may also do. 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 three goods transport components (i.e. shopping, restocking and e-purchase delivering), can affect one of these three components with impacts on the other, too. Therefore, a study of urban goods transport and the relative methodology to assess a city logistics scenario should consider these components jointly.

Method of analysis used

Studies on urban goods mobility traditionally focused only on shop restocking flows, i.e. vehicle flows from warehouse/distribution centres to trade or service locations (e.g. shops, food-and-drink outlets, service activities; Anand et al., 2012; Nuzzolo et al., 2013). Indeed, according to some surveys (Schoemaker et al., 2006; Lindholm, 2013), shopping-related activity is the second main scope of travelling within urban areas and purchasing activities account for about twice the veh-kms of deliveries and pick-up activities flows (i.e. shop restocking and e-purchasing delivering).

Then, recently, some researchers move to consider goods distribution and shopping mobility jointly (Oppenheim, 1994; Russo and Comi, 2010; Gonzalez-Feliu et al., 2010; Comi and Nuzzolo, 2014), but they usually neglect the flows due to e-purchasing, in terms both of trips not undertaken by end consumers to buy in a shop and of trips performed to deliver the e-purchases.

In this background, the authors propose an advancement of a general framework developed for simulating goods movements at urban scale (Nuzzolo and Comi, 2014). The proposed modelling framework allows to simulate the end-consumer mobility in order to obtain the goods quantities required in the study area and disaggregated for goods types, including the e-purchases. It consists of various steps:

- shopping model sub-system; which allows to simulate end-consumer shopping behaviour and estimate quantities bought in store by end consumers, and hence to identify restocking freight flows attracted by each traffic zone;
• restocking model sub-system; given the quantity attracted by each traffic zone, it allows to estimate the restocking quantity origin-destination (O-D) matrices by freight type and type of vehicle used;
• e-purchase delivering model sub-system; given the quantity bought on-line by end consumers living in each traffic zone, it allows to estimate the e-purchase delivering O-D matrices by freight type and type of vehicle used with respect to if the deliveries are performed at home or at pick-up point.

In the full paper, the above shopping model sub-system will be formalised and, moving from the general modelling architecture proposed by authors (Nuzzolo and Comi, 2014), the purchase choice mechanism will be detailed, showing the advancements required for including e-purchases. The shopping model sub-system was developed using some surveys carried out in Rome where about 800 households (2,347 household members) have been interviewed. The attention was paid on weekly purchases made by end consumers older than 14 years. The survey allowed to investigate purchasers’ behaviour, providing details on the purchases made in-store and on-line and offering the basis for assessing a new set of measures (new city logistics scenario) implemented in the inner area of Rome.

Results and conclusions
This paper presents advances in the modelling framework for estimating urban goods flows, under the assumption that goods attracted by an urban zone are strictly related to end-consumer choices. Some analyses based on a survey administered to end consumers in Rome are presented. The factors that mainly influence goods mobility in relation to purchase and trip generation are investigated. Such choices are influenced by both goods type and socio-economic household characteristics (e.g. age, number of component, employment status). The proposed models allow to test the heterogeneity among end consumers through advanced random utility models (e.g. mixed logit models), and to point out the effects of network attributes (e.g. active accessibility) on type of shopping.

The shopping model sub-system allows to point out the effects arising from implementation of action, for example, on the location of retail outlets, places of residence and on the use of private vehicles, and due to changes in the characteristics of the population (e.g. demographic and socio-economic changes).

The restocking sub-system includes models for the simulation of the freight distribution process from the freight centres to the retail zone, and can be used to determine the effects arising from implementation of actions on the location of logistic establishments (e.g. warehouses, distribution centres) and on measures that can modify the use of transport service type (i.e. incentives to switch towards third parties), the vehicle type, the shipment size and the delivery time (i.e. time windows).

The e-purchase delivering model sub-system allows to point out the effects arising from implementation of action on the location of courier establishments and places of residence, and on delivery tour (i.e. vehicle type and time windows). Changes in the characteristics of the population (e.g. demographic and socio-economic changes) and on-line supply can be also assessed.

By applying the above model sub-systems jointly, it is possible to forecast how changes in the characteristics of end consumers or due to the implementation of city logistics measures will influence the flows of restocking vehicles and shopping trips. Then, the effects in terms of sustainable development can be investigated.

Besides, the results of its application to the inner areas of Rome when socio-economic changes occur will be reported. The main results confirm the modelling goodness and at the same time demonstrate that these changes could cause significant effects, in particular increasing the use of e-shopping. The e-shopping could decrease the shopping trip production, but the pattern of home deliveries have to be investigated when new city logistics scenarios have to be assessed. The expectation is that internet shopping development could cause more deliveries and more goods vehicles in residential areas. Then, new actions have to be investigated in order to promote consolidation for making home deliveries more efficient or to use delivering system (e.g. packing stations) as implemented in some worldwide cities.

References
• Lindholm, M. (2013). Urban freight transport from a local authority perspective – a literature review. In European Transport \ Trasporti Europei 54, paper n° 3, Trieste, Italy.


Keywords: city logistics, shopping demand, urban freight transport, end-consumer behaviour, e-shopping.