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City Logistics Planning: Demand Modelling Requirements for Direct Effect Forecasting

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Abstract

The paper analyses some aspects of city logistics planning in order to define the main requirements of demand modelling to be applied in *ex-ante* assessment of scenario effects. The phases of the planning process, in terms of identifying objectives and strategies and assessing effects ex-ante, are briefly analysed in the first part of the paper. The second part focuses on direct effects and the relative forecasting procedure, discussing the models of freight demand to be used. Since one of the identified requirements is an integrated shopping-restocking approach, in the third part of the paper, a state-of-the-art of such approach is reported. Some considerations and conclusions are given in the final part of the paper.

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1. Introduction

This paper analyses some aspects of city logistics planning in order to define the main requirements of demand modelling (Taniguchi, Thompson, Yamada & van Duin, 2001; de Jong, Vierth, Tavasszy & Ben-Akiva, 2012; Comi, Delle Site, Filippi & Nuzzolo, 2012) to be applied in *ex-ante* assessment of planning scenario effects. The basic question concerns what effects have to be forecasted. The answer will depend on the objectives and strategies of city logistics planners and in particular on the effect indicators that they use to quantify the expected results of

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the plan. Of course, the effects of the planning measures have to be forecasted using the same metrics as these indicators.

Further, the plan's forecasted effects are also used in evaluation procedures that use methods such as cost–benefit analysis, multi-criteria analysis, cost-efficiency or cost-effectiveness analysis. Therefore, the effects to be forecasted are those required by such methods, which usually distinguish between internal and external, direct and second-order (indirect), and short, medium and long term effects.

The phases of the planning process concerning the identification of objectives and strategies, with related planning result indicators, and ex-ante planning assessment are briefly analysed in the first part of the paper. The second part focuses on direct effects, that are used for example in cost–benefit analysis, and the direct effect forecasting procedure is considered, discussing the models of freight demand to be used.

Urban freight flows are mainly made of two components related to *shopping* and *restocking*. The characteristics of the restocking process are strictly related to the type of retail businesses to be restocked in terms of delivery size, delivery frequency, freight vehicle type and so on. For example, delivery size and freight vehicle dimension tend to increase with the size of retail businesses, while the delivery frequency tends to decrease, with a major influence on the total distance travelled by freight vehicles. Therefore, end-consumer choices between small, medium and large retailers affect restocking characteristics and the total freight vehicle distance travelled.

Furthermore, end-consumer shopping destination choices depend on the siting of commercial supply with respect to the consumer's residence and on end-consumer behaviour, which in turn depends on characteristics such as age, income, family size, lifestyle, and so on. Further, the end consumer's choice of retail type may also depend on the accessibilities of commercial areas; thus if accessibility changes (for example, due to management of shopping travel demand), the type of shop and/or transport mode may also change. Then, if there is a change in the characteristics of end consumers, the geographical distribution of residential property and shops, and/or accessibility to the commercial area, freight restocking characteristics may do so as well. Similarly, some city logistics measures can reduce the restocking accessibility of an area and induce re-allocation of retail activities.

Therefore, a city logistics scenario can influence one of the two components with impacts on the other as well, and urban freight transport planning, and the relative method to assess city logistics scenarios, should consider both these components jointly. Thus, in the third part of the paper a state-of-the-art description of such a modelling approach is reported, with a simulation framework using integrated shopping mobility and restocking demand models. Some considerations and conclusions are given in the final part of the paper.

2. City Logistics Planning

In order to reduce the negative effects of urban freight transport on city sustainability and to improve the efficiency of the urban supply chain, several measures can be used as part of the planning procedure. City logistics planning includes several activities, amongst which are the following:

- identification of objectives and strategies by city logistics planners,
- determination of planning result indicators,
- definition of the planning scenarios, and
- ex-ante assessment of the plan's effects, including simulation of planning scenarios.

2.1. City logistics planning objectives

Following the (city logistics) planning management approach, in order to obtain planning scenarios to be implemented that are the best compromise between the various objectives of city planners and city logistics stakeholders (Taniguchi, Thompson & Yamada, 2012), the process should also include interaction with the main city logistics actors, namely urban supply chain (USC) operator (i.e. goods wholesalers and distributors, carriers, small, medium and large retailers) and end consumers.

In the framework of sustainable mobility development (EC, 2011) and seeking to take into account the objectives and the strategies of USC operators and other stakeholders, the objectives of city logistics planners can include the following:

- Economy (improvement in the economic output of the study area)
  - reduction in network transportation costs,
  - reduction in transportation and logistics costs of the supply chain (e.g. distributors, wholesalers, carriers, retailers, end-consumers),
  - reduction in selling prices of goods for end consumers,
- Safety
  - reduction in road accidents linked to freight mobility,
- Environment and land use
  - reduction in environmental impact of freight mobility,
  - sustainable land-use development,
- Equity (society)
  - improvement in the shopping component of urban quality of life,
  - development of transport, logistic and retail employment,
  - improvement in legality of freight sectors: vehicles, drivers and goods.

2.2. City logistics planning strategies and measures

Both restocking and shopping flows produce negative impacts on city sustainability and liveability, and several city logistics measures (Muñuzuri, Larraneta, Onieva & Cortes, 2005; Russo & Comi, 2011) can be implemented with a view to reducing the negative effects of these two freight transport components. They can be classified in relation to planning level as strategic, tactical and operational.

Referring to freight restocking, local administrators seek to:

- reduce the number of commercial vehicles,
- increase the use of light, environment-friendly vehicles,
- optimize loading and unloading operations in order to reduce traffic congestion, and
- reduce interferences with other urban mobility components (e.g. cars and vulnerable users).

In relation to shopping mobility, the main interest of local administrators is to:

- reduce the use of private vehicles,
- increase the use of transit, cycling and walking, and
- reduce the shopping travel distance, increasing the use of nearby commercial areas.

The relationships among strategies, measures and planning levels are summarized in Table 1.

2.3. Formulation and ex-ante assessment of alternative planning scenario

Since the characteristics of urban areas can substantially differ, while all measures could produce good results in terms of external transport costs, some of them could, for example, increase the costs incurred by some freight system actors. Therefore, in order to implement the most effective city logistics measures, the choice of a set of measures should be based on a design scenario implementation process, which consists of several steps able to:

- reveal the current critical issues through specific surveys (e.g. traffic counts, interviews with retailers, truck drivers etc.) and listening to stakeholders,
- share objectives and strategies as an optimal compromise among the different actors involved,

- define the results indicators,
- find suitable measures and set up a new city logistics scenario,
- define models to simulate the current scenario and assess the future one, and
- assess *ex-ante* the new scenario by estimating impacts and system performance, and compare them with the set of their given pre-fixed values (targets).

The assessment method has to be able to highlight different types of specific effects for the study area, reported in the next section.

Table 1: Synopsis of city logistics measures.

Type of flows	Planning Levels	Strategies	Measures
Restocking	Operational	Interference reduction	Time windows
Restocking	Operational	Interference reduction/Loading-unloading optimization	Loading/Unloading zones
Restocking	Operational	Use of better performing vehicles	Access constraints
Restocking	Operational	Reduction in vehicle number	Area pricing
Restocking	Operational	Interference reduction	Route constraints
Restocking	Tactical	Use of better performing vehicles	Financial incentives
Restocking	Tactical	Reduction in vehicle number	Access control
Restocking	Tactical	Reduction in vehicle number	Nearby delivery area
Restocking	Strategic	Use of better performing vehicles	UDC/Transit point
Restocking	Strategic	Use of better performing vehicles	Railways
Restocking	Strategic	Reduction in vehicle number/ Loading-unloading optimization	Design standard/urban infrastructure
Restocking	Strategic	Reduction in vehicle number/Use of better performing vehicles	Cooperation
Restocking/ Shopping	Strategic	Reduction in vehicle number/ Interference reduction	Urban land-use governance
Shopping	Operational	Increasing the use of transit, cycling and walking/ Reduction in shopping travel distance, increasing the use of nearby commercial areas	Increase in LTZs and pedestrian areas
Shopping	Strategic	Increasing the use of transit, cycling and walking	Improving public transport services
Shopping	Strategic	Increasing the use of transit, cycling and walking	Transit-oriented development

2.4. New city logistics scenario effects

Freight urban mobility may be summarised as the result of several choices undertaken by different city logistics actors (Fig. 1):

- end consumers (e.g. residents, visitors) choose where and at what type of retail outlet to make purchases (i.e. local market, shopping centre) and transport mode,
- retailers (including large-scale outlets), in the medium-short term, choose the type of transport to use (e.g. own account, third party) and shipment size; in the long term, their choices concern shop and store location,
- wholesalers and distributors choose what type of transport to use for restocking their customers (e.g. own account, third party), departure time and type of vehicle to use for restocking and the delivery tour, and
- carriers' choices are mainly related to departure time, type of vehicle to use for restocking, as well as the delivery tour to follow.

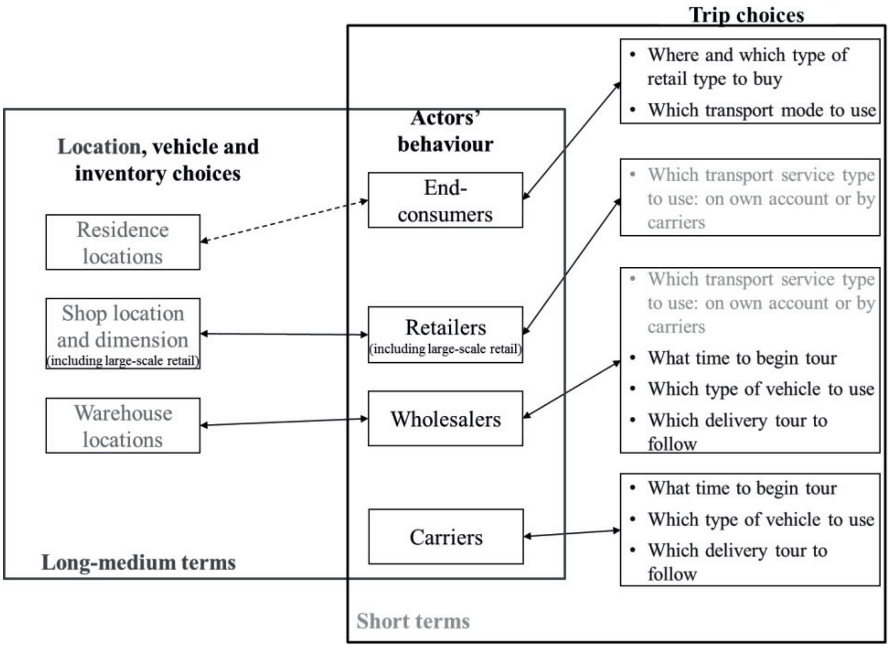

Fig. 1. Urban freight transport: actors and choices

In relation to the reaction times, the effects due to the implementation of a new city logistics scenario could be classified as:

- *short-term effects*, that appear in a few days or weeks, and
- *medium/long-term effects*, that appear after several months or years.

Further, within each of these two classes, the effects may be:

- *direct effects* that is variations in transportation system costs, and
- *indirect* or *second-order effects*, mainly cost variations induced by transport cost modifications, related to the economic and social sphere or to business location.

Finally, in relation to the set of actors involved, each of the previous effects can be classified as:

- *internal,* if it involves the USC operators (i.e. retailers, wholesalers, distributors, carriers) and end consumers;
- *external*, on members of the public not directly involved in using the system; e.g. pollutant emissions, noise, road accidents.

In the following part of the paper, we focus *on internal/external direct effects,* which include those considered in traditional cost–benefit analysis (EU, 2008).

2.5. Direct effect target and outcome indicators

For proper assessment of the planning process, the Logical Framework Approach (LFA; NORAD, 1999) which exploits suitable result indicators may be used. Table 2 presents an example of target and outcome indicators related to direct effects.

Table 2: Example of outcome indicators

Sustainable sphere	Target indicators	Strategic objectives	Outcome indicators
Economy	Network total travel time	Reduction in interference with other mobility components	Network average speed
	Total delivering travel and stop time	Reduction in loading-unloading time	Average loading-unloading time
		Reduction in freight vehicle travel distance	Freight veh-km
Environment	CO_2 emissions	Reduction in freight vehicle travel distance	Freight veh-km + shopping car-km
		Increase in share of better performing vehicles	Less pollutant freight veh-km
		Increase in share of 3P	3P veh-km
Safety	Deaths in road accidents involving freight vehicles	Reduction in freight vehicle travel distance	Freight veh.-km + shopping car – km
		Reduction in interference with other mobility components	Multi–user road length

3. Direct Effects Simulation Models

In the process described above, a key-role is played by simulation models used in order to assess *ex-ante* the target and outcome indicators in relation to direct effects of the scenario to be implemented. The forecasting scenario variables are the following:

- network travel time and average speed,
- average loading – unloading time,
- total freight vehicle – km and shopping car-km,
- vehicle – km of less pollutant freight vehicle,
- vehicle – km of 3P vehicle, and
- length of multi-user roads.

These variables can be forecast using the procedure reported in Fig. 2, that requires as input the shopping car and the freight vehicle O-D matrices. These matrices are assigned to the road network, obtaining link flows, which in turn are used as inputs of other models that allow determination of pollution emissions, energy consumption, road accidents and so on. The shopping car O-D matrices and the restocking freight vehicle O-D matrices are obtained using the freight demand models reported in the followings sections.

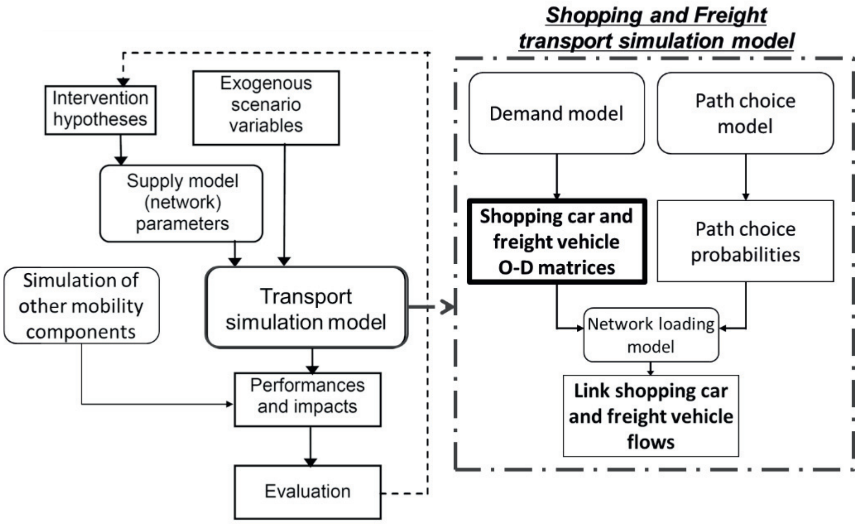

Fig. 2. Models for road network transportation and environmental costs (Nuzzolo & Comi, 2013a)

3.1. Freight demand modelling

As reported in the introduction, urban freight flows are mainly made of two components related to *shopping* and *restocking*. Thus a city logistics scenario has to be implemented that reduces the impacts of these two freight transport components. Further, as the two components are strictly connected, measures that concern one can have impacts on the other, too. Therefore, assessment of a city logistics scenario has to use simulation models that consider both these components jointly.

Few studies have analysed shopping mobility as a component of freight mobility and have considered that traffic management actions impacting on purchasing behaviours of end consumers (e.g. type and site of retail outlet, transport mode to use) can also affect restocking mobility (Bronzini, 2008; Wygonik, Bassok, Goodchild, McCormack & Carlson, 2012; Kawamura & Sriraj, 2012).

Likewise, there have been few joint modelling frameworks (Oppenheim, 1994; Russo & Comi, 2010; Gonzalez-Feliu, Ambrosini, Pluvinet, Toilier & Routhier, 2012) proposed which explicitly consider restocking flows as being generated to satisfy end-consumer demand. Comi & Nuzzolo (2013) present a modelling system which allows for some factors of end-consumer behaviour, such as the choice of retail outlet (shop) type, and links shopping with restocking mobility. It consists of four model sub-systems to estimate the shopping mobility O-D matrices, the restocking quantity O-D matrices, the delivery O-D matrices and the restocking vehicle O-D matrices, as reported in the following sub-sections.

3.2. An integrated modelling framework

The integrated modelling framework consists of four model sub-systems (Fig. 3):

- shopping mobility sub-system; this simulates the end consumer's behaviour *vis-à-vis* shopping, and estimates the modal O-D matrices and freight flows attracted by each traffic zone per outlet type; this step allows us to pinpoint the effects of measures on the choices of type and location of shops and transport mode,
- quantity model sub-system; this allows us to estimate the quantity origin-destination (O-D) matrices with freight types and restocked outlet type,

- delivery model sub-system, which converts quantities into delivery O-D flows per outlet type; the delivery flows are also split in terms of transport services used (e.g. retailer on own account, wholesaler on own account and carrier); this step specifically studies restocking journeys in terms of transport service and shipment size, and
- vehicle model sub-system; this allows us to obtain the restocking vehicle O-D flows satisfying the given delivery O-D matrices, and investigate the tours undertaken to restock the study area, comprising departure time, number of stops, vehicles used and sequence of delivery locations.

Below, only the formulation of the model sub-systems is reported.

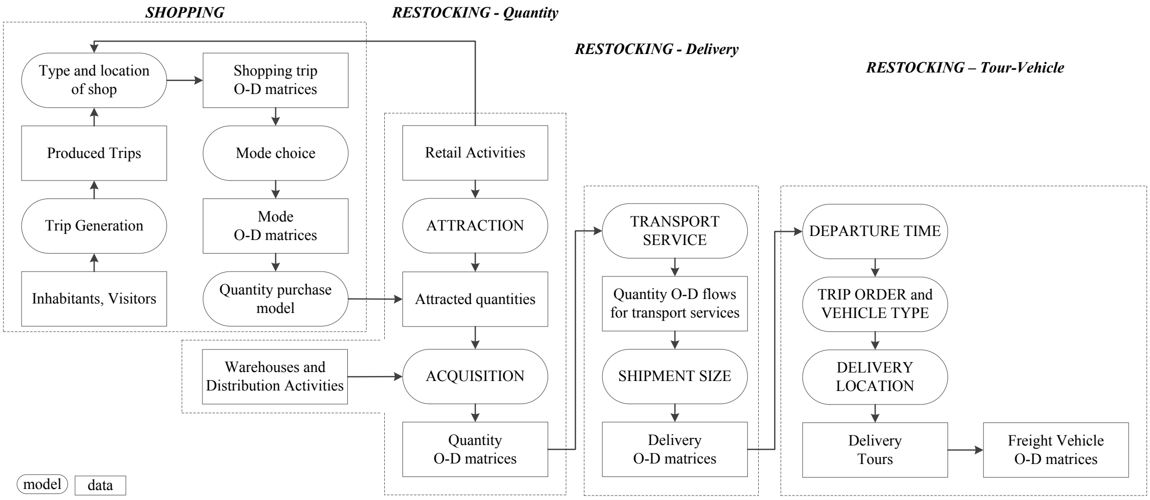

Fig. 3. Integrated framework modelling

3.3. Shopping flow modelling

Following that proposed by Russo & Comi (2010) and developed in Comi & Nuzzolo (2013) and assuming that the end consumer leaves from zone *o*, the choice dimensions involved are: the number of trips (*x*) for shopping, the type of shop (*k*; e.g. small, medium, large) and destination (*d*), the transport mode (or sequence of modes; *m*). The global demand function can be decomposed into the product of partial share sub-models, each relating to one or more choice dimension. The sequence used is the following:

$$D^i_{od}\left[skm\right] = D^i_{o.}\left[s\right] \cdot p^i\left[dk/so\right] \cdot p^i\left[m/dkso\right] \quad (1)$$

where

- $D^i_{od}[skm]$ is the weekly average number of trips with origin in zone *o* undertaken by end consumers of category *i* for purchasing freight of type *s* in retail outlet *k* located in zone *d* by using transport mode *m*,
- $D^i_{o.}[s]$ is the weekly average number of relevant trips undertaken by end consumers of category *i* for freight of type *s* with origin in zone *o,* obtained by a *trip generation model*,
- $p^i[dk/so]$ is the probability that users, from *o*, travel to destination zone *d* for shop type *k* (small shop, supermarket, hypermarket), obtained by a *destination and shop type choice* model, and
- $p^i[m/dkso]$ is the probability that users, travelling between *o* and *d* for shopping in shop type *k*, use transport mode *m*, obtained by a *modal choice or split* model.

It should be noted that when the end consumer arrives in a zone, she/he can purchases something of a given quantity. Then, the quantities required by each zone to satisfy end-consumer needs can be obtained by introducing a *quantity purchase model* (Russo & Comi, 2012). This model gives us the probability that the end consumer, arriving in zone *d*, purchases something of a certain dimension (*dim*). In this way, the trip O-D matrices are converted into quantity. The quantity of freight type *s* sold by retail outlets *k* in zone *d*, $Q_{.d}[sk]$, can be calculated as:

$$Q_{.d}\left[sk\right] = \sum_i Q^i_{.d}\left[sk\right] = \sum_i \sum_{o,m,dim} D^i_{od}\left[skm\right] \cdot p^i\left[dim / mks\right] \cdot dim \quad (2)$$

where

- $Q^i_{.d}[sk]$ is the goods quantity bought/sold in retail outlet *k* in zone *d* given by the demand of end consumers belonging to category *i* living/working in a zone *within* the study area;
- *dim* is the dimension of purchases, expressed in kg;
- $p^i[dim/mks]$ is the probability that a trip concludes with a purchase of dimension *dim* conditional upon undertaking a trip to retail outlet *k* for a purchase of goods type *s* using transport mode *m*.

3.4. Restocking flow modelling

Referring to the general modelling framework proposed by Nuzzolo & Comi (2013b), the following sections describe a model sub-system that allow us to estimate quantity, delivery and freight vehicle O-D flows with characteristics of restocking tours. Although they can refer to different freight types *s*, for simplicity of notation, the class index *s* will be understood.

3.4.1. Restocking quantity O-D flow sub-model

Let $Q_{od}[k]$ be the average quantity of restocking flows moved from zone *o* (e.g. warehouse location zone) to the outlets of type *k* of zone *d*; it can be estimated as follows:

$$Q_{od}\left[k\right] = Q_{.d}\left[k\right] \cdot p\left[o / dk\right] \quad (3)$$

where

- $Q_{.d}[k]$ is the average freight quantity attracted by (i.e. to be delivered in) zone *d* and retail outlet *k*, obtained by the *shopping mobility sub-system* (see eq. *2*);
- $p[o/dk]$ is the probability that freight attracted by zone *d* and retail outlet *k* comes from zone *o*; it represents the acquisition share obtained by an *acquisition model*.

3.4.2. Delivery O-D flows

This step receives inputs from the previous model sub-system and provides as output the number of deliveries needed to transport the estimated freight quantity. Freight can be transported and hence each establishment can be restocked by different transport services according to which transport service is used (e.g. retailer or wholesaler on own account, carrier).

The average delivery O-D flow carried out by transport service type *r* on pair *od*, $ND_{od}\left[rk\right]$, can be determined as follows:

$$ND_{od}\left[rk\right] = Q_{od}\left[k\right] \cdot p\left[r / okd\right] / q\left[rk\right] \quad (4)$$

where

- $p\left[r/okd\right]$ is the probability that a retail outlet k is restocked by transport service type r obtained by a *transport service type model*;
- $q\left[rk\right]$ is the average freight quantity delivered to retail outlet k with transport service type r (*shipment size*).

3.4.3. Vehicle O-D flows

Having obtained the O-D flows in terms of deliveries, the next step is to convert them into tours and hence into O-D freight vehicles. The vehicle level aims to do precisely that. The translation is not direct because freight vehicles undertake complex routing patterns involving trip chains (tours). In fact, each restocker jointly chooses the number and the location of deliveries for each tour and hence defines his/her tours, trying to reduce the related costs (e.g. using routing algorithm). The freight vehicle O-D matrices, satisfying the given delivery O-D matrix, can then be estimated by using an aggregate multi-step delivery tour model that considers the average behaviour of all restockers starting from the same warehouse zone. Therefore, the freight vehicle O-D matrices are obtained from the delivery O-D matrices using a two-step procedure: definition of delivery tours from delivery O-D matrices, definition of freight vehicle O-D matrices from delivery tours.

The total number of *tours* $T_o[rk]$ departing from zone o to restock retail outlet k with transport service type r can be determined as follows:

$$T_o\left[rk\right] = \sum_{d'} ND_{od'}\left[rk\right] \Big/ \bar{n}_o\left[rk\right] \quad (5)$$

where $\bar{n}_o\left[rk\right]$ is the average number of deliveries performed by tours departing from zone o to restock retail outlet type k.

Let $p[n/orkt]$ be the probability that a tour departing at time t from origin zone o has n stops/deliveries for restocking shop type k obtained by a *trip chain order model*. Therefore, $\bar{n}_o\left[rk\right]$ can be estimated as:

$$\bar{n}_o\left[rk\right] = \sum_{n,t} n \cdot p\left[n/orkt\right] \cdot p\left[t/rko\right] \quad (6)$$

- $p[t/rko]$ is the probability that the delivery tours depart at a certain time t from an origin o (i.e. warehouse zone) for restocking shop type k obtained by a discrete choice *delivery tour departure time model*;
- $p[n/orkt]$ is the probability that deliveries are performed by tours departing from a given zone o at a certain time t with n stops for restocking shop type k obtained by a discrete choice *trip chain order model*.

Let $p[v/nrko]$ be the probability of using a vehicle type v obtained by a *vehicle type model*. The number of tours with n stops/deliveries departing from origin zone o and operated by vehicle type v, $T_o[vnkr]$, is obtained as:

$$T_o\left[vnkr\right] = T_o\left[rk\right] \cdot p\left[nv/rko\right] = T_o\left[rk\right] \cdot p\left[n/rko\right] \cdot p\left[v/nrko\right] \quad (7)$$

Let $p\left[d_j^{h+1} / d_i^h\, vnrko\right]$ be the probability of delivering in zone d_j the delivery ($h+1$), conditional upon having previously delivered in zone d_i delivery h, within a tour with n stops/deliveries departing from a given zone o and using a vehicle type v for restocking shop type k, obtained by a *delivery location choice model*.

Finally, the number of vehicles $VC_{d_i d_j}$ (*freight vehicle O-D matrices*) on pair (d_i d_j) can be estimated as follows:

$$VC_{d_i d_j}\left[vnrko\right] = \sum_h VC_{d_i^{h+1} d_j^h}\left[vnrko\right] = T_o\left[vnkr\right] \cdot \sum_h p\left[d_j^{h+1} / d_i^h vnrko\right] \quad (8)$$

3.5. Study cases

The above modelling system was calibrated using some interviews to end consumers, to truck-drivers and retailers and was used to assess some city logistics scenarios. From end-consumer survey carried out in the city of

Rome and consisting of interviewing more than 300 households, it emerged that the choice of retail outlet mainly depends on freight types. Different multinomial logit models for the choice of retail outlet (shop) types were then estimated (Comi & Nuzzolo, 2013) according to the four main identified freight types: foodstuffs, hygiene and household products, clothing and shoes, other products. Different findings were revealed according to freight type. For foodstuffs, the model estimation results confirm that many people travel to shop together or to buy many items and that large retail outlets are preferred if time for shopping is available. Besides, the probability of purchasing in small retail outlets increases if the purchase is made on Saturday and the customer is a woman. As regards hygiene and household products, the estimation results show the inclination of customers to choose medium retail outlet for rapid shopping for already-chosen products, such as washing-up liquid or soap powder. The results also confirm that younger customers travel to larger retail outlets (e.g. to find special discounts and because they have more free time). The results obtained for clothing show that customers prefer to go to large retail outlets on Sunday and in the early afternoon because they have more time to spend on shopping (including leisure). Finally, the findings related to trips for other types of goods show the inclination of many people to travel to large retail outlets for shopping together or for recreation.

The truck-driver and retailer surveys were designed to capture the characteristics of the interviewee, retailers and food-and-drink outlets, and transport firms as well as the characteristics of transport (e.g. own account or third party, vehicle type, delivery location sequence). Surveys were carried out in the inner area of Rome in 2008 where more than 500 truck drivers and more than 600 retailers were interviewed. The delivery tour modelling was mainly pointed out (Nuzzolo, Crisalli & Comi, 2012; Nuzzolo & Comi, 2013a). The models were developed to capture behaviour that can be influenced by tactical and operational measures.

For example, the implementation of freight traffic management measures such as time windows, area pricing, route constraints or vehicle type constraints could modify delivery zone accessibility as well as shipment size with subsequent effects on the definition of delivery tours. Hence the attributes refer to level-of-service (e.g. accessibility of warehouse and retail zone), characteristics of delivery (e.g. type of freight and delivered quantity), and tours (e.g. distance covered during current tour). Therefore, the choice behaviour of number of stops and vehicle type was modelled, testing both multinomial and nested logit model forms. The influence of accessibility on tour definition was then investigated. The estimation results showed that the number of deliveries per tour decreases if the accessibility of the warehouse zone increases. This confirms that restockers prefer to do round trips if the warehouse is located in a zone with high accessibility as it allows them to reduce the operational complexity of tour management. The probability of using light goods vehicles (less than 1.5 tons) increases for foodstuffs, while it decreases if the average delivered quantity increases. Therefore, as expected, the probability of using medium goods vehicles (less than 3.5 tons) increases according to the distance of the zone to be served.

In relation to the assessment of city logistics measures, the modelling system was used within a general methodology for forecasting the effects of some measures designed to reduce pollutant emissions (Filippi, Nuzzolo, Comi & Delle Site, 2010) in the inner area of Rome. The result was that an urban distribution centre can be more effective in reducing environmental externalities than measures based on vehicle fleet renewal. As regards land-use governance measure scenarios, the model was implemented in the city of Padua (Nuzzolo, Comi & Papa, 2013). The strategy for locating freight activity seems to favour the clustering of freight distribution centres and of large retail outlets in the first urban ring. This distribution could have a win-win positive effect both on the reduction of freight distribution vehicle-km and shopping trips – km made by car.

4. Conclusions

In analysing the city logistics planning process and examining the objectives and strategies pursued by stakeholders and city planners, several planning result indicators were identified. Further, the effects to be assessed as evaluation inputs, such as cost benefit analysis, were classified. For proper assessment of such indicators and effects, especially internal and external direct effects, the requirements of freight demand simulation models were highlighted and an integrated shopping mobility and restocking demand modelling framework was presented.

Even if further modelling improvements are required to best forecast the choice behaviour of city logistics actors as effects of planning measures, the characteristics of the available demand models would appear quite sufficient to forecast the main effects of tactical/operational city logistics actions.

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