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Restocking in touristic and cbd areas: Deterministic and stochastic behaviour in the decision-making process

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Abstract

The paper examines urban activity restocking process. The proposed models aim at examining how city logistics measures could modify the restocking process of retailers and ho.re.ca. managers located within the urban area. The process is considered in terms of distribution channel: pull or push movements to bring freight to the economic activities. The analysis has been based on surveys carried out in the inner area of Rome. The study points out that deterministic behaviour exists in relation to goods types and that the choices for acquisition (i.e. distribution channel and restocking area) are generally joint choices. For this scope, different behavioural models were tested according to different hypothesis on random residual distributions.

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Keywords: restocking movements; retailers' choices; ho.re.ca. restocking; mixed logit.

1. Introduction

Continuous growth of traffic congestion, especially inside urban areas during the last two or three decades, has resulted in significant problems, such as increased air pollution, noise nuisance and visual blight, as well as decreased traffic safety levels. Currently, in the field of urban freight transport, due to the need to deliver small parcels to

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customers, the above emerging problems and inefficiencies are mostly associated to flexibility issues, as suggested by DG MOVE (2012) leading to low load factors – empty returns, a large number of deliveries made to individual premises in a given time period, long dwell times at loading/unloading points and ultimately significant traffic problems in urban areas, lowering the effectiveness of city logistics, lowering the level of services provided and jeopardizing the environmental performance of the freight transport system. The freight sector (including product deliveries to shops as well as service activities) is often seen as a major contributor to congestion and traffic problems in urban areas, but little is understood about the individual supply chain characteristics that is the core of urban retail and shopping centres (Cherrett *et al.*, 2012).

In Europe, with its historic city centres and dense living areas, the nuisance of freight traffic has been dealt with a wide range of city logistics measures (Sugar, 2011; Russo and Comi, 2010a; Rizet *et al.*, 2012; Visser, 2013; Holguin-Veras and Aros-Vera, 2014) mainly devoted to introduce restrictions (e.g. time windows and access constraints) that, if they are not properly investigated, could increase both internal and external costs (McKinnon *et al.*, 2010). However, while most of the implementable measures could produce good results in terms of transport external cost reduction, some of them could increase the internal transport costs incurred by urban freight actors (e.g. receivers, shippers, carriers). Therefore, in an urban planning process (Munuzuri and Gonzalez-Feliu, 2013), the choice of the most appropriate set of solutions should be based on a quantitative analysis that points out all the different actors involved in urban goods movements. In this process, a key role is played by demand models as they can assess the effects of the scenarios to be implemented. The models and methods for scenario assessment must thus investigate the variables that have an important role in successful scenario implementation, pointing out the actors' behaviours.

Besides, urban areas are mainly freight attractors (Schoemaker *et al.*, 2006; Nuzzolo *et al.*, 2015) with commodity flows destined to satisfy the end-consumer needs at shops or at ho.re.ca. activities (hotel, restaurant and catering; mainly in urban historic centres). Even if the ho.re.ca. activities represent the final destination for the use/consumption of goods and subsequently it could be addressed to consider their restocking behaviour alike to end consumers' one, ho.re.ca. decisional process differs from end consumer's one due to three main elements: large quantity of freight daily moved (1), distribution channels used (2) and places of acquisition (3). Therefore, in the following, ho.re.ca. activities are considered as an intermediate point between production/warehousing and consumption.

Ho.re.ca. represents the majority of activities (especially in the touristic and CBD areas, where the related employees are about 6 times higher than shop employees; Sanchez-Diaz *et al.*, 2013; Nuzzolo *et al.*, 2015) in many worldwide city centres. The freight flows destined to these activities, in some urban areas, averagely represent about 31% of total daily quantities moved in urban areas (Schoemaker *et al.*, 2006; Nuzzolo *et al.*, 2015). Besides, a specific survey carried out in the city of New York (Sanchez-Diaz *et al.*, 2013) revealed that ho.re.ca. can determine a high number of movements per day, and although they have the lowest level of average sales, they have one of the highest employment levels. At the other hand, this segment of demand is very important because, for example, an establishment located in a high value location will prefer to have more frequent deliveries than using a larger area for storage of supplies. Additionally, establishments in this sector are usually small so they have to cope with space constraints to receive goods.

In the field of freight demand management, the analysis of the behaviours of the above decision makers (i.e. retailer and ho.re.ca. manager) becomes crucial to modify the impacts due to freight transport (Marcucci and Gatta, 2014). Several studies have pointed out that the external costs of freight transport in urban areas is greater than passenger one (Gonzalez-Feliu *et al.*, 2014; Taniguchi and Thompson, 2014). Urban authorities have traditionally considered freight only related to negative environmental impacts, often neglecting that it is an important element in the urban economy, both in terms of the income it generates and the urban development it supports (Lindholm, 2013). The inattention of public authorities to the trade-off between the increasing of internal cost (for the receivers, e.g. retailer and ho.re.ca) and the reduction of external cost for the collectivity determine "myopic" policy for the urban centre. For example, according to Stathopoulos et al. (2012), measures that often are promoted by local administrators as efficient such as time-windows and Urban Distribution Centre (UDC) can produce significant disparities among stakeholder sensitivities. Then, the subsequent low degree of acceptability among stakeholders can be solved through the analysis and selection of implementable measures, which consider all actors' needs and allow to pursue an optimal compromise among all involved interests. Therefore, a first objective of the paper is to review urban freight context pointing out the impacts produced, the decision makers involved and thus the city logistics measures implemented around the world for improving city sustainability and liveability.

In this background, an improved understanding of behaviours of retailers and ho.re.ca. managers would help planners to better decide the measures to implement, including the use of ex-ante assessment methodologies based on quantitative methods (Comi et al., 2014). To facilitate introduction of city logistics scenario, it is important to recognize the concerns of different actors, as well as retailers and ho.re.ca. managers. Then, starting from the results of surveys carried out with retailers and ho.re.ca. activities in Rome's Limited Traffic Zone (LTZ), the second objective of paper is to investigate their acquisition freight process trying to giving an answer to the following questions:

- Is restocking process deterministic or stochastic (non-deterministic)?
- Which attributes are significant in decisional restocking process?
- How could city logistics measures (impacting on the identified attributes) modify the restocking process in terms of distribution channel (i.e. *pull* or *push* movements) and acquisition area?

It represents a propaedeutic step to develop a modelling framework able to support the ex-ante assessment of future scenarios.

This paper is organized as follows. Next section outlines urban freight transport according to generated impacts, actors and measures to be implemented to improve the city sustainability. Subsequently, the decision makers' restocking is investigated on the basis of Rome surveys. The deterministic behaviours are analysed and then probabilistic/stochastic-behavioural models are proposed for simulating the joint choices of the acquisition process. Finally, paper closes with a discussion and summary.

2. Freight transport in urban and metropolitan areas

2.1. Urban freight impacts

Currently, the 50% of worldwide population lives in urban and metropolitan areas, and in Europe, this share reaches the 70%. In the 2050, the forecasts provide that these shares will reach the 69% at worldwide level, while in Europe it will be the 85% and the 91% in U.S.A. (UN, 2009). In this context, great importance assumes the urban transport and, in particular, the urban freight transport. In fact, an efficient freight transport system is required as it plays a significant role in the competitiveness of an urban area. The urban freight transport and logistics is mainly related to the last miles of supply chains, and the companies' strategies have to be confronted to the collective interests related to urban freight transportation and logistics. In fact, in the EU countries more than half of all goods (in terms of weight) in road transport are moved on distances below 50 km and more than three quarters on distances below 150 km, according to calculations based on Eurostat data (White Paper, 2011). As pointed out by White Paper (2011), these goods shipments will remain on trucks. Furthermore, road transport remains the most unsustainable transport mode. Several studies have revealed that it represents the 14% of vehicle-kilometres, the 19% of energy use, the 21% of CO_2 and more than 50% of Particulate Matter emissions (Schoemaker *et al.*, 2006; Rizet *et al.*, 2012; Holguin-Veras *et al.*, 2013). Then, city logistics measures are required to reduce its impacts in order to protect public health, safety, and welfare. Overall, they have to ensure liveability and the quality of life of people living and working in such an area. Besides, they have to minimize conflicts between incompatible land uses within the jurisdictions that adopt them and are intended to create adequate separation among uses, and allow the highest and best use of the land.

Then, the rapid growth of freight transportation within urban and metropolitan areas contributes to congestion, air pollution, noise (*environmental*) and to raise logistic costs, and hence the price of products (*economic*). In addition, a combination of different types of vehicles on the road increases the risk of accidents (*social*). Importantly, the objectives of sustainable development can be pursued, as previously said, by means of measures that are sometimes conflicting, and generate impacts that are influenced by the acceptance of stakeholders and external factors (Anderson *et al.*, 2005; Stathopoulos *et al.*, 2012; Daunfeldt *et al.*, 2013).

2.2. Goods movements and decision makers

Freight transport in urban and metropolitan areas concerns both pick-up and delivery in retail, parcel and courier services, waste transport, transport of equipment for the construction industry and a broad range of other types of transport. At the urban scale, two different types of goods movements can be identified: end-consumer and logistic movements. End-consumer movements refer to movements made by end consumers (customers) travelling from their residence/consumption zones to other zones where they make their purchases. The logistic movements are those connected with restocking process and allow shops and warehouses to be restocked (Russo and Comi, 2010b).

For the former type of movement, the customer can be assumed to be the decision-maker. In particular, some surveys carried out in many urban and metropolitan areas have shown that the main share is due to private end-consumer trips for purchases, thus the private end consumer (e.g. family) can be assumed as decision maker. For the logistics movements, the identification of decision makers is complex because the freight movement is a trip chain and in each ring of the chain it is possible to have various decision makers as shown in the literature (Taniguchi *et al.*, 2000; Friedrich *et al.*, 2014).

Focusing on restocking choice process, the decision makers (actors) involved in urban freight transport can be classified in four main classes (Taniguchi *et al.*, 2001; Russo and Comi, 2010a):

- *Goods receiver*: in this class the economic activity managers, as well as retailers and ho.re.ca. ones, are considered; their choices are mainly related to restocking movements (e.g. frequency and size of delivery); their main interest is to bring goods at their activities at lower price and to have a high attractive/livable city;
- *End-consumer*: in this class inhabitants (residents or businessmen/employees) and the visitor/shopping public are considered; their choices are related to end-consumer movements primarily through the journeys they undertake for purchasing; their main interest is minimizing hindrance caused by goods transport and having a variety of the latest products in the shops at a low price or a high quality relative to the price;
- *Transport and logistics operators*: in this class the shippers (wholesalers), the transport companies, the receiver/shop owners that operate restocking on own account are considered; all these types of actors are responsible for restocking the service purchasing; their main interest is minimising hindrance caused by goods transport;
- *Public administration*: in this class local government and national governments are considered; their aim might be to organize an attractive city for inhabitants and visitors, with minimum hindrance, though effective and efficient transport operation.

2.3. Logistics measures to improve city sustainability

To make urban mobility more sustainable, measures to reduce the economic, social and environmental impacts of freight transport have to be implemented. Thus, the analysis and classification of implementable measures have to take into account the possibility to use methods and models for the ex-ante assessment. Some of the main studies proposing an analysis of city logistics measures are: COST 321 (1998), Munuzuri *et al.* (2005), City Ports (2005), BESTUFS (2007), van Duin and Quak (2007) and Russo and Comi (2010a), NCFRP (2012).

The in-depth analysis of above measure classifications shows that some of them are quite aggregate. BESTFUS (2007) that can be seen as a follow-up and continuation of the COST 321 project (1998) evidences the importance of Urban Distribution Center and the use of delivery points for on-line purchases (pick-up points). Therefore, it provides a specific class for UDC and pick-up points, and includes all other measures in a large class that does not allow to identify who has to abide by them and to identify easy their planning horizons. Similar lack is in classification adopted within European research project City Port (2005). Munuzuri *et al.* (2005) classify in function of stakeholders pointing attention on local administrators because they are responsible for establishing regulations regarding traffic and transport in the city. Van Duin and Quak (2007) propose to classify in function of objectives but they consider only three classes that do not allow to point out the different planning horizons and to stress the different actors involved in their implementation. Russo and Comi (2010a) proposed four main classes that explicitly support the identification of planning horizons and also which sustainable goals may be pursed. Finally, NCFRP (2012) mainly focuses on land-use based on the concept that the local authority can have responsibility for land use and zoning. Besides, measures for improving off-street delivery are also pointed out.

3. The movements of retailer and ho.re.ca. activities

In the following, the restocking process of transport and logistics operators are point out from the receivers' standpoint. Models point out two segments of freight movements related to retailers and ho.re.ca. activities that are not always investigated in-depth in the literature. The ho.re.ca. activities represent the final destination of goods consumption and it suggests to assimilate them to end consumers. However, for the above reason (see Section 1), the ho.re.ca. restocking decisional process is closer to retailer than end consumer. Therefore, starting from this statement, they are considered similar to retailers and the choices of the distribution channel and the acquisition place can be simulated through similar patterns and random utility models. Aim of the following proposed models is to investigate which attributes are significant in decisional restocking process and sub-sequentially how city logistics measures (impacting on the identified attributes) could modify the restocking process of restocking activities located within the urban and metropolitan area in terms of distribution channel (i.e. pull or push movements).

3.1. The considered pattern

Recalling the general modelling system proposed by the authors (Russo and Comi, 2010b), within the first level, it provides to calculate the goods quantity flows due to consumption and shop restocking. This modelling framework simulates urban goods movements combining urban passenger travel and commodity flows (because it is assumed that commodity flows are generated to support a given need), and pointing out the interactions among consumers and other decision makers involved (e.g., producers, carriers, retailers). In particular, authors deepened the pull movements of the end consumer and retailer through a sequence of behavioural models. With this respect, in the following some advancements that allow to include models developed to simulate the choices of ho.re.ca. activities are proposed. Then, receivers' restocking is modelled in terms of pull and push movements, focusing on retailer and ho.re.ca. (i.e. hotel, restaurant and catering) manager decision process. The investigation pointed out that some movements are freight-based, while others are strictly related to level-of-service attributes (e.g. travel time, restocking frequency).

Let $Q_{s,tot,d}$ the total quantity of freight type s attracted from zone d, to sell in the shop and ho.re.ca. activities. This freight quantity can come from inside (W) or outside (Z) the study area. The freight flow is from producers to retailer and ho.re.ca. activities (and thus to end consumers). For this aim, different distribution channels are used. According to previous works, let c be the distribution channel identified with a generic path from production/international trade to residence/consumption zone, and let Y be the set of inside or outside zones ($Y = W$ or Z) with respect to the urban study area (Fig. 1).

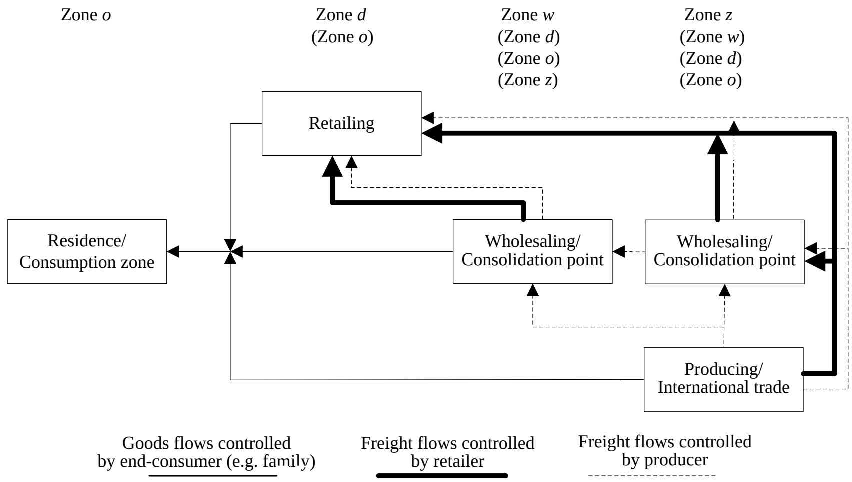

Fig. 1. Graph of distribution channels (Russo and Comi, 2010b).

With respect to the above identified retailer and ho.re.ca. manager macro-behaviour (i.e. pull or push) and as proposed by Russo and Comi (2010b), the distribution channels can be analysed by means of an aggregation into two classes depending on who the decision maker is:

- Hyper-channel r (c_r); it includes all distribution channels in which the decision-maker chooses how, where and when to go (or to send their transport employees) to bring the goods for restocking d (*pull* hyper-channel);
- Hyper-channel l (c_l); it includes the other distribution channels in which the decision maker cannot be considered the receiver and in which many different decision makers can be considered; in this case receiver suffers the choice of other subjects involved who choose how and from where the freight must be delivered and can give some addressings regarding the delivery time (*push* hyper-channel).

Referring to freight quantity flows for restocking, let $Q_{s,tot,d}\,(cY)$ be the quantity of freight type s moved between the macro-area Y (inside or outside the study area) and zone d using the distribution channel c. This quantity can be calculated as follows:

$$Q_{s,tot,d}(cY) = Q_{s,tot,d} \cdot p[cY/ds] \tag{1}$$

where $p[cY/ds]$ is the probability that the freight flows to a shop in zone d uses the hyper-channel c and comes from macro-zone Y for restocking freight type s; it can be obtained by an *hyper-channel* and *restocking area choice model*. Then, the probability, $p[cY/ds]$, of choosing the hyper-channel c and the restocking area Y can be expressed as:

$$p[cY/ds] = p[c/ds] \cdot p[Y/cds] \tag{2}$$

where

- $p[c/ds]$ is the probability of choosing hyper-channel c for restocking activities located in zone d of freight type s;
- $p[Y/cds]$ is the probability of choosing the restocking area Y having chosen the hyper-channel c for restocking activities located in zone d of freight type s.

As shown by surveys carried out in Italian (Russo and Comi, 2013) and Spanish cities (Nuzzolo *et al.*, 2015), the supply chain is changing and the choice of hyper-channel and macro-zone for restocking is also dependent from freight types and it cannot be always considered two-step choice. Then, the previous model becomes a joint model that gives the probabilities to choose the hyper-channel and macro-zone for restocking (cY), $p[cY/ds]$. This probability can be estimated using model belongs to discrete choice theory and developed within random utility theory. Therefore, each decision maker is considered a rational decision maker who maximizes utility relative to her/his choices. Basing on this theory assumptions (Domencich and McFadden, 1975; Ben-Akiva and Lerman, 1985), $p[cY/ds]$ can be calculated as follows:

$$p\left[cY / ds\right] = p\left[U_{cY} > U_{cY'}\right] \qquad \forall cY, cY' \tag{3}$$

where U_{cY} is the perceived utility that restocking is performed using the hyper-channel c and the restocking area Y.

The involved decision maker is who manages the restocking process, and according to previous hyper-channel definition, retailers, ho.re.ca. managers (in the hyper-channel c_r), or freight senders (in the hyper-channel c_l) can be assumed as decision makers. The below analysis is based on Rome surveys and was carried out in order to identify whether deterministic or non-deterministic behaviours exist in relation to freight type s and acquisition macro-area Y. For non-deterministic behaviours different model forms are tested for cY choice: multinomial logit and mixed logit (to test the heterogeneity in the choices).

3.2. The dataset

The study area coincides with Freight Limited Traffic Zone, where access and parking were subject to regulations in two time windows (Ibeas *et al.*, 2015). It has an extension of 6 km^2, about 50,000 inhabitants and 130,000 employees, of which 24,000 are related to trade. The study area was interested of about 14,500 tons/day, 34,000 deliveries/day and 16,000 trucks/day. According to the different above defined hyper-channels, the 51% is push-type, while the 19% is pull-type. For the remaining 30%, the surveys did not provide useful data for characterizing the hyper-channel used because no data were available for identifying who directly manages the commodity movements. In the following analysis, the quantities destined to retailers represent the 36% of daily moved freight quantity, while 33% is destined to ho.re.ca. activities. The remaining 31% is destined to final business end consumers (Russo and Comi, 2013) that is physically an end consumer.

The study area is a mixed land-use area (cbd, residential, commercial, touristic) and the most famous zone in the city, with the high presence of service and ho.re.ca. activities. The literature, as earlier discussed, presents limited analyses on both their behaviours, then in the following the retailer and the ho.re.ca. restocking process is investigated.

3.3. The model estimation

This section presents the estimation results of the daily acquisition process in terms of hyper-channel and macro-area for the retailers and ho.re.ca activities. The results for retailers, showed for the first time below, and for ho.re.ca, shortly presented in Russo and Comi (2013), indicate that according to freight types, deterministic or stochastic (non-deterministic) behaviour can be identified. Therefore, in the following subsections, before the retailers' standpoint is investigated, subsequently the stochastic behaviour of ho.re.ca. decision making is explored showing the performance improvement in behaviour simulation moving from the simplest multinomial logit towards mixed logit.

3.3.1. The deterministic behaviour of retailer

From survey data, it emerged that in the inner area of Rome, about 1,600 tons are daily destined to retail activities. The 78% of whole use the hyper-channel c_l (push-type behaviour) and about the 67% comes from acquisition zone located within the municipality borders (Table 1). According to the main assumptions introduced above, W is the set of acquisition zones internal to the study area from where the freight arrive at shops (zone d), while Z is the set of acquisition zones outside. Besides, according to the land use government policies specific for each metropolitan area, some distributors or wholesalers could be addressed to locate their facilities outside borders of the inner urban areas, always within municipality border. Therefore, the Z set was disaggregated in two sub-sets: Z_{inside}, that contains all zone within the border of municipality, and the complementary $Z_{outside}$. From data reported in Table 1, it emerges that when the retailer decides the restocking process (i.e. hyper-channel c_r), s/he does not prefer to go and bring freight far from his/her shop (no retailer chooses $Z_{outside}$). Generally, s/he prefers nearby warehouses. Furthermore, if the restocking is made within the study area (i.e. W), 89% use hyper-channel c_r, while increasing the distance of restocking place (Z_{inside} or $Z_{outside}$), the percentage of hyper-channel c_l raises.

Table 1. Hyper-channel and restocking area distributions (retail outlet movements).

Restocking area	c_r (pull-type)	c_l (push type)	Total	c_r (pull-type)	c_l (push type)	Total
W	89%	11%	100%	27%	1%	7%
Z_{inside} (inside municipality)	23%	77%	100%	73%	66%	67%
$Z_{outside}$ (outside municipality)	0%	100%	100%	0%	33%	26%
Total	22%	78%	100%	100%	100%	100%

Table 2 shows the statistical summary of the retail outlet daily movements. A majority of goods are push, but a consistent quantity refers to freight for which the type of hyper-channel cannot be univocally defined (i.e. fresh food and hardware). Then, based on Rome data, some retail outlet acquisition strategies (hyper-channel and macro-area) can be identified as deterministic (Table 2):

- No-fresh foodstuffs, electronics, stationery, clothing, household and hygiene represent the 53% of total restocking quantity flows, generally are restocked by push hyper-channels (c_l), and 79% of restocking quantity flows come from zones located within the municipality (restocking area W and Z_{inside});
- Flowers and home accessories represent the 17% of total restocking quantity flows, are restocked by pull hyper-channel (c_r) and come mainly from restocking area W and Z_{inside};
- The remaining products (i.e. fresh foodstuffs and hardware) did not make up significant percentages of all other freight types (30%) and are totally distributed in relation to hyper-channels and macro-zone as reported in Table 3; no freight comes from restocking area W. Besides, increasing the distance of restocking place (i.e. warehouses located in Z_{inside} or Z_{ouside}), the percentage of hyper-channel c_l raises (i.e. from 74% to 100%).

Table 2. Revealed hyper-channel distributions for freight types (retail outlet movements)

Freight types	Total [kg/day]	c_r (pull)	c_l (push)	Total	Type of hyper-channel
No-Fresh Foodstuffs	93,243	0%	100%	100%	generally push hyper-channel
Fresh Foodstuffs	421,574	4%	96%	100%	not defined
Home accessories	176,831	98%	2%	100%	generally pull hyper-channel
Electronics	39,313	0%	100%	100%	generally push hyper-channel
Hardware	55,899	72%	28%	100%	not defined
Stationery	205,532	0%	100%	100%	generally push hyper-channel
Clothing	245,234	8%	92%	100%	generally push hyper-channel
Household and personal hygiene	31,408	0%	100%	100%	generally push hyper-channel
Other	230,116	0%	100%	100%	generally push hyper-channel
Flowers	92,940	100%	0%	100%	generally pull hyper-channel
Total	1,592,090	22%	78%	100%	

Table 3. Hyper-channel and restocking area distributions: not pre-definable behaviour (retail outlet movements).

Restocking area	c_r (pull-type)	c_l (push-type)	Total	c_r (pull-type)	c_l (push-type)	Total
Z_{inside} (inside municipality)	26%	74%	100%	100%	40%	47%
$Z_{outside}$ (outside municipality)	0%	100%	100%	0%	60%	53%
Total	12%	88%	100%	100%	100%	100%

3.3.2. The stochastic behaviour of retailer

This section presents the estimations results of the models for daily acquisition process in terms of hyper-channel and macro-area for those freight quantities whose restocking behaviour cannot be pre-definable (i.e. fresh products and hardware, Table 2). As emerged from Table 3, only three alternatives can be identified (because no data are available for restocking trips from internal restocking area W and for the alternative hyper-channel c_r from outside municipality, $Z_{outside}$): two hyper-channels (c_r and c_l) and two macro-areas (Z_{inside} and $Z_{outside}$).

Different sets of attributes were tested in relation to freight type, level-of-service attributes (e.g. travel time from origin and destination of trip), socio-economic variables (e.g. number of employees related to retail activities and to specific freight types).

Two sets of models were calibrated: multinomial and mixed logit. Table 4 reports the obtained results for Multinomial logit. The presented models are the result of several specifications and calibrations based on different combinations of possible attributes. The model which performed the best statistical significances is given. All parameters have the expected signs and most of them are statistically significant as demonstrated by the *t-st* values. Parameter analysis shows the important role of travel time; in fact, increasing the travel time, the length of restocking trip increases and *push* hyper-channel (c_l) can be preferred. It confirms that city logistics measures that increase travel time (i.e. governance measures) should push to use *push* hyper-channel and to use third party transport that is more optimized than on own account. Referring to dimension of shops (i.e. average number of employees), it confirms that increasing the dimension of shops, the share of pull movements decreases.

The presented model hence allows to investigate if the freight sold in the shop is brought inside or outside the study area. City logistics measures impacting on generalised transportation costs can influence the choice of restocking area. Among them there are both *material infrastructure* (e.g. sub-network for freight vehicles; Urban Distribution Centre and nearby delivery area) and *governance measures* (e.g. traffic limits and road-pricing). In general, it depends on producers or distributors who might or might not prefer to stay close to the selling area; for the case of the pull hyper-channel, the results have shown that retailers prefer to restock from neighbouring warehouses, for example because they can make more than one trip per day. Indeed, many city-centre shops have little space to store unsold products. This could increase the number of freight trips and could have negative effects in terms of city sustainability.

Table 4. Multinomial logit model for retail acquisition ($\rho^2 = 0.46$)

Attribute	Alternative*	Reference unit	Parameter	t-st value
Travel time	1	minutes	-1.516	-3.095
Travel time	2	minutes	-1.623	-3.315
Average number of retail employees in zone d	1		-0.787	-2.601
Restocking frequency	3	Monthly frequency	-3.679	-0.835

* $1 = (c_r\ Z_{inside})$, $2=(c_l\ Z_{inside})$, $3=(c_l\ Z_{outside})$

Similar results were obtained by mixed logit with normal distribution of all parameters. Table 5 gives the calibration results. According to the above choice set and to Hensher and Greene (2003), different sets of attributes were tested and the random parameters were selected assuming that all parameters included in logit models are random. The examination of their estimated standard deviations was carried out by a zero-based *t-test* for individual parameters and a likelihood-ratio test for establishing the overall contribution of the additional information. The best statistically model provides specification similar to previous multinomial logit with significance of all standard deviations. Comparing the results of two model specifications, the improvement of good-of-fit (ρ^2) can be noted and the heterogeneity of travel time in alternative *2* (i.e. push hyper-channel from zones outside the study area but within the city municipality), and the high negative weight of average number of retail employees in the choice of alternative *1* (i.e. pull hyper-channel from zones outside the study area but within the city municipality). It synthetises that within the study area (and in general within the main city centres) there could be a lot of shops with a significant heterogeneity in number of employees belonging to franchise stores, chain stores and large-scale retail outlets that tend to be restocked by push hyper-channels. Therefore, this aspect has to be considered when city logistics measures are assessed and hence implemented because the different supply-chains used are defined by distributors and usually are not city-specific. These first prototypical mixed logit calibrations are promising and are the basis for further developments of this research.

Table 5. Mixed logit model for retail acquisition ($\rho^2 = 0.56$)

Attribute	Alternative*	Reference unit	Parameter	Standard deviation
Travel time	1	minutes	-1.832 (-2.05)	0.142 (3.55)
Travel time	2	minutes	-2.552 (-2.07)	0.955 (2.66)
Average number of retail employees in zone d	1		-5.496 (-1.97)	0.258 (2.40)
Restocking frequency	3	Monthly frequency	-2.305 (-1.33)	0.041 (1.90)

** 1 = (c_r Z_{inside}), 2=(c_l Z_{inside}), 3=(c_l $Z_{outside}$); (-) = t-st values*

3.3.3. The stochastic behaviour of ho.re.ca.

This section presents the advancement in model estimation for daily acquisition process of ho.re.ca. activities in terms of hyper-channel and macro-area. Following similar analysis procedure performed for retailer, the movements of goods belonging to beverage, cloths, non-fresh foodstuffs, home accessories and laundry classes were found with not pre-definable behaviours. They represent about the 60% of commodity related to this segment mobility and are characterised by hyper-channel and restocking areas as synthesised in Table 6 (for more details refer to Russo and Comi, 2013).

Therefore, as showed in Table 6, five alternatives were identified according to the used hyper-channels (c_r and c_l) and restocking macro-areas (W and Z). In fact, the available data (Table 6) did not allow to consider the alternative c_lW (i.e. pull hyper-channel and from zones within the study area).

Different sets of attributes were tested in relation to freight type, level-of-service attributes (e.g. travel time from origin and destination of trip), socio-economic variables (e.g. number of employees related to ho.re.ca.).

To improve the first results presented in Russo and Comi (2013), a mixed logit model with normal distribution of parameters was estimated and the results are reported in Table 7, showing that a heterogeneity exists and has to point out when ho.re.ca. manager behavior is investigated. The rho-square with respect to the literature models (Russo and Comi, 2013) increases, although a reduced number of attributes is used, consisting mainly in the exclusion of freight specific dummy variables, whose effects are now properly described by parameter heterogeneity.

Besides, the parameter analysis shows that the absolute value of parameter relative to travel time decreasing for c_r and c_l, and for inside or outside macro-zones, as provided by the propensity of transport on own account to bring freight in nearby warehouses.

As regards the relative influence of travel time in the choice, as expected, the absolute value of the travel time parameter relative to area W is higher than area Z. The results demonstrate that increasing the travel time and the introduction of more restrictive time windows could lead to an increasing of long acquisition trips. Increasing the restocking quantity per trip, the probability of choosing hyper-channel c_l increases; at the other hand, this probability decreases by increasing the restocking frequency. Although they are generally described as a homogenous retail segment, ho.re.ca. activities present very different logistics and organizational constraints according to the specific service offered. In particular, according to the parameter relative to average zonal number of employees, the share of activities that uses pull-type movements (the so called cash & carry) increases if average number of employees raises. The result is opposite with respect to retailer, confirming that these types of activities tend to be restocked on own account mainly if variety is particularly relevant (mostly in larger activities). These first prototypical mixed logit calibrations are promising and will address the further developments of this research.

Table 6. Hyper-channel and restocking area distributions: not pre-definable behavior (ho.re.ca. movements)

Restocking area	c_r (pull-type)	c_l (push-type)	Total	c_r (pull-type)	c_l (push-type)	Total
W	100%	0%	100%	20%	0%	7%
Z_{inside} (inside municipality)	32%	68%	100%	60%	68%	65%
$Z_{outside}$ (outside municipality)	25%	75%	100%	20%	32%	28%
Total	35%	65%	100%	100%	100%	100%

Table 7. Mixed logit model for ho.re.ca. acquisition (ρ^2 = 0.48)

Attribute	Alternative*	Reference unit	Parameter	Standard deviation
Travel time	1	minutes	-2.267 (-3.18)	0.170 (2.05)
Travel time	2, 4	minutes	-0.600 (-2.58)	0.001 (1.98)
Travel time	3	minutes	-1.074 (-2.88)	0.469 (2.35)
Average number of ho.re.ca employees in zone d	1		0.805 (3.44)	0.066 (2.01)
Delivered quantity	5	kg	-0.134 (-2.24)	0.032 (2.05)
Restocking frequency	5	monthly frequency	-1.033 (2.41)	0.030 (2.00)

** 1 = (c_r W), 2=(c_r Z_{inside}), 3=(c_r $Z_{outside}$), 4=(c_l Z_{inside}), 5=(c_l $Z_{outside}$); (-) = t-st values*

4. Conclusions

The paper presented some calibration advancements for simulating the joint choice of hyper-channel and restocking area. The models are structured in order to point out their relationships, considering that the choice process can be considered as a joint choice process, where each choice dimension can be influenced by each other. Based on these analyses, deterministic behaviours were found and then multinomial and mixed logit models were calibrated for non-deterministic (stochastic) behaviours.

Although retailer and ho.re.ca. transport decision process is generally described as an homogenous segment, their analysis showed that heterogeneity exists and it must properly treated. In particular, some movements are freight-based (i.e. deterministic behaviour), while others are strictly related to level-of-service attributes (e.g. travel time, restocking frequency) and present a significant heterogeneity in how there are perceived by decision makers.

In addition, different behaviours emerged for retailer and ho.re.ca. managers. First of all, delivered quantity is a relevant attribute for ho.re.ca. because the establishments in this sector are usually small so they have to cope with space constraints to receive goods, while average dimension of activity (measured in terms of average number of employees) tends to reduce the probability of retailer to be restocked on own account and to increase the probability of ho.re.ca. manager because the larger establishments have to find a trade-off between variety, price of products and storage space.

These first results also demonstrated that increasing the travel time and the introduction of more restrictive time windows (governance measures) could lead to an increase in hyper-channel c_l and hence freight transport that is longer efficient. Frequent shipments tend to leave from nearby warehouse, generally located in the suburbs.

Subsequentially, the mixed logit were used in order to capture the zonal variability of choice across the study area in Rome. During the model development, several potential attributes were tested using a stepwise procedure and the best performing ones were level-of-service (i.e. travel time), socio-economic (i.e. average number of zonal retail employees) and shipment (i.e. frequency) attributes. The calibration results showed that heterogeneity is significant and could cause relevant effects in scenario simulation if not properly treated. Further developments mainly are addressed to extend these results, to investigate if a further heterogeneity exists within freight-based homogeneous decision makers, and to test more advanced specification, including land use attributes.

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