Simulating the effects of shopping attitudes on urban goods distribution

Nuzzolo A, Comi A, Papa E

Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 111 (2014) 370 – 379

Procedia
Social and Behavioral Sciences

EWGT2013 – 16th Meeting of the EURO Working Group on Transportation

Simulating the effects of shopping attitudes on urban goods distribution

Agostino Nuzzolo[a], Antonio Comi[a,*], Enrica Papa[a]

[a]Department of Enterprise Engineering, "Tor Vergata" University of Rome, viale del Politecnico 1, 00133, Rome, Italy

Abstract

Studies of urban freight mobility traditionally focused only on restocking flows and usually neglected the linkage with shopping activities even if end consumer's choices in relation to the type of retail undoubtedly impact on freight distribution flows. The paper focuses on the distribution of urban freight facilities, the choices of type of retail and the travel mode used and some models for simulating the choice of retail outlet and the transport mode are presented. The models, jointly with urban freight demand models were used to assess the effects of some land-use scenarios and to define optimal spatial distribution of urban freight facilities able to improve city sustainability and to meet the interests of end consumers, freight operators and society. The results of an application of this method to a test site are also reported and discussed.

Selection and/or peer-review under responsibility of Scientific Committee

Keywords: urban freight transport; city logistics; land use policy; shopping demand.

1. Introduction

This research germinates from the view that freight mobility concerns two segments of mobility: freight distribution and shopping. These two segments should be jointly analysed as components of the same system (Russo and Comi, 2010; Gonzalez-Feliu et al., 2010; Browne et al., 2012; Nuzzolo and Comi, 2013a). The separation of freight distribution mobility and shopping mobility has an impact in city logistics and traffic planning processes. Local administrators are looking at city logistics measures in order to reduce the negative impacts of urban freight transport, using mainly tactical and operational city logistics measures (Muñuzuri et al., 2005; Russo and Comi, 2011), and the two segments of mobility are independently managed through restocking freight demand management and shopping travel demand management. Little attention has been paid to strategic actions such as urban land-use governance. Further, in the definition of urban goods activities location, the role of urban freight movement has often not taken into account and only aspects related to passenger mobility are traditionally pointed out. By the same token, goods

* Corresponding author. Tel.: +39 06 7259 7059; fax: +39 06 7259 7053.
E-mail address: comi@ing.uniroma2.it

1877-0428 © 2013 The Authors. Published by Elsevier Ltd.
Selection and/or peer-review under responsibility of Scientific Committee
doi:10.1016/j.sbspro.2014.01.070

movement and freight distribution are widely underrepresented in regional science and geographical research (Hesse and Rodrigue, 2004; Allen et.al, 2012).

However, more recent studies stress the importance of the role of freight activities location for urban freight movement as land-use factors have important influences on freight activity in urban areas (McKinnon 2009; Cidell, 2010; Brunetta and Morandi, 2010; Allen et al. 2012, Miodonski and Kawamura, 2012). In the literature, it is widely accepted that land-use and transportation policies known as smart growth, travel minimising, transit oriented development can encourage non-motorized travel and lead to less demand for travel by cars, following the principles of sustainable development. The same principles can be assumed for freight flows: urban density and distribution of facilities can have profound impacts on both the volume and efficiency of freight movements (Bronzini, 2008).

This study starts from the hypothesis that the location of freight distribution centres and retail outlets has to be considered by city logistics planners in order to minimise total transportation costs in terms of both freight restocking and shopping mobility (Nuzzolo and Comi, 2013a). Starting from such considerations, and within a transport - land use integrated approach for freight mobility, in this paper we examine the effects of end-consumer behaviour (e.g. choice of retail type and transport mode) and location of retail outlets (e.g. small, medium and large retail outlets) and restocking centres (e.g. warehouses and distribution centres) upon urban freight mobility. The paper starts from analysing the objectives and strategies of city planners, supply-chain actors, retailers and end consumers in the freight sector (section 2). We then present a method to compare different scenarios of urban freight activity location to improve city sustainability (section 3). Finally, the results of the simulation for a test site of three land-use scenarios are analysed with a view to define optimal spatial distribution of urban goods facilities (e.g. retail outlets, warehouses) which may improve city sustainability, seeking to meet the interests of end consumers, freight operators and society as a whole (section 4). Some conclusions and further developments are given in section 5.

2. Sustainable location of urban freight activities

2.1. Location of urban goods activities

Freight facility location in urban areas involves several stakeholders that have different goals and act with complementary strategies. The decision makers involved in the process include supply-chain actors, shopping actors and city planners. From the analysis of stakeholders' behaviour and from the literature (Russo and Comi, 2011, Browne et al., 2012), some general laws can be defined: freight distribution and shopping costs depend on the locations in the urban area of warehouses and distribution centres and of retail outlets, in particular medium-size shops such as supermarkets and large retail outlets.

Internal and external freight restocking costs strictly depend on the locations of logistics centres (such as warehouses and distribution centres), retailers and end consumers. Given that warehouses and distribution centres are located mainly in the suburbs (Ibeas et al., 2012), increasing the share of retail outlets located in the city centre would lead to an increase in restocking costs (Wygonik et al., 2012). Moving retail outlets out of residential or central zones would reduce transportation costs for restocking but could increase end-consumer costs of purchasing (shopping mobility) and of course can reduce the attractiveness of the city centre.

Research carried out in France has shown that transport costs for shopping mobility are higher than their freight restocking counterpart (Schoemaker et al., 2006; Gonzalez-Feliu et al., 2010). Thus, for land-use and city logistics planners, it is important to investigate the influence of the location of retail outlets on end-consumer choices, such as where to shop and how to get there, and vice versa. Parking supply is also one of the attributes that influence the choice of a shopping destination together with the travel distance from home to shopping destination, the assortment/choice range, the price of goods and the quality of products (van der Waerden et al., 1998). According to this, in recent decades end consumers have appeared to prefer clusters of shops or commercial centres to combine shopping with other leisure activities. That said, new channels such as those provided by e-commerce (Taniguchi et al. 2003; Durand and Gonzalez-

Feliu, 2012) are becoming increasingly popular, with many positive effects on the transport system as detailed by Mokhtarian (2004).

In synthesis, the location of shops, warehouses and distribution centres has impacts on freight distribution mobility and shopping mobility, according to their distance from urban centres. Location outside residential or central zones of warehouses and distribution centres increases restocking costs by increasing the distances between retailers and distribution activity. The location of large retail businesses outside residential or central zones reduces restocking costs by reducing the distances between retailers and distribution activities and increasing the average transported quantity and vehicle size. As regards the impact of shopping mobility, the location of large retail businesses outside residential or central zones reduces the number of shopping trips (trip frequency), but increases shopping trip lengths and car use, whilst reducing the attractiveness of city centres.

2.2. Land-use governance strategies for locating freight activities

Starting from the above considerations, integrated transport - land use planning strategies can be developed in metropolitan areas in order to minimise transport costs both for freight distribution and for shopping. Most urban areas, that are characterized by a concentric structure, can be categorised into three types of urban space according to the distance from the centre: the central area (CA), where the density of end consumers and small retailers is usually higher, the first ring (FR), with medium end-consumer density and the presence of warehouses, and the second ring (SR), where end-consumer density is low and large shopping malls and freight distribution facilities are located. According to this common categorisation, some strategies for locating freight activities can be applied and then verified through appropriate assessment methodology consisting of relocation of medium and large retail outlets from CA into SR, in order to bring distribution centers close to shopping malls and hence to reduce freight distribution travel distances, and to increase the average transported quantity and vehicle size. On the other hand, this strategy increases shopping travel distances. The clustering of warehousing and distribution centres in FR could reduce freight distribution travel distances and keep shopping travel times constant. The clustering of warehousing, distribution centres and medium and big size retail outlets in FR could reduce both freight distribution travel distances and shopping travel distances.

In order to achieve sustainable development goals, medium and large retail activities should be placed in high accessible areas, near multimodal transport nodes, in barycentric position with respect to the metropolitan areas residential distribution and in already dense and mixed used areas. As regards Urban Distribution Centre, despite its positive results, in some cases, urban distribution centre instead of reducing congestion, can generate more freight vehicle movements depending of local conditions (Huschebeck and Allen, 2005; Browne et al., 2011 and 2012).

Land-use tools to put into practice these strategies are urban master plan and urban retail master plans that through zoning define the localization and the planning of the projects linked to shops, retail trade and their environment.

2.3. City planning assessment methodology

The assessment method proposed in this study concerns the city planner’s point of view and is based on an analytical tool for objective-oriented planning and the assessment of different scenarios, which follows the logical framework approach (LFA) (NORAD, 1999). According to different general goals, several target indicators, the strategic objectives, and outcome indicators can be defined (Nuzzolo and Comi, 2013a). According to the city planner’s point of view, the assessment methodology is able to evaluate ameliorative scenarios in terms of transportation costs. As many outcome indicators are a function of vehicle-km, in this fist research phase, the different scenarios are compared using aggregate transport indicators: total distance travelled (vehicle km), number of shopping trips (trip km), number of freight vehicle km and pollutant emissions from freight and passenger vehicles (C02, NOx, PM10, PM2.5, VOC).

The future steps of this research assessment will also take into account indicators of congestion, which remains one of the most ambiguous components of external costs to be quantified.

3. Urban freight modelling framework

In order to evaluate the city logistics scenarios through the estimation of the indicators identified above, a system of models that simulates the two demand segments (i.e. restocking and shopping flows) has to be used. Traditionally, these two demand segments have been independently managed. Studies of urban freight mobility (Taniguchi et al., 2001; Nuzzolo et al., 2013) generally focused only on restocking flows, i.e. vehicle flows from warehouse/distribution centres to trade or service locations (e.g. shops, food-and-drink outlets, service activities). They usually neglected the linkage with shopping activities, even if end-consumer choices in relation to type of retail outlet (e.g. small, medium or large) undoubtedly impact on freight distribution flows. Indeed, the characteristics of the restocking process are strictly related to the type of outlets to be restocked in terms of delivery size, delivery frequency, freight vehicle type and so on.

The modelling framework used, derived from the current literature where few authors propose joint modelling frameworks (Russo and Comi, 2010; Gonzalez-Feliu et al., 2012), is based on that proposed by Nuzzolo and Comi (2013b; 2013c), and consists of two main components:

- shopping model sub-system; it allows us to simulate end-consumer behaviour for shopping and to estimate freight flows attracted by each traffic zone (i.e. freight quantity bought by end consumers in order to satisfy their needs);
- restocking model sub-system; given the quantity attracted by each traffic zone, it allows us to estimate the quantity origin-destination (O-D) matrices characterized by freight types and type of vehicle used.

The shopping model sub-system allows us to point out the effects arising from implementation of long-term actions on the location of retail outlets and places of residence, and due to changes in the characteristics of the population (e.g. age distribution).

The restocking sub-system (Nuzzolo et al., 2012) 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 long-term effects arising from implementation of actions on the location of logistic establishments (warehouses, distribution centres).

By applying jointly the above modelling sub-systems, it is possible to forecast how land-use changes in the locations of retail and logistics businesses and shopping attitudes will influence the flows of restocking vehicle and shopping trips and hence the effects in terms of sustainable development.

3.1. Shopping model sub-system

Following that proposed by Russo and Comi (2010; 2012) and assuming that the decision-maker (i.e. family) is in 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 sub-models, each of which relates to one or more choice dimensions. 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 the end consumer (i.e. family) belonging to category *i* (e.g. families with one or more components) for purchasing freight of type *s* (e.g. foodstuffs) in the type of retail outlet *k* (e.g. small, medium and large retail outlets) 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 (i.e. family) belonging to category *i* for purchasing goods of type *s* with origin in zone *o,* obtained by a *trip generation model*;
- $p^i[dk/so]$ is the probability that users, undertaking a trip from *o*, travel to destination zone *d* for purchasing at shop type *k*, obtained by a *shop type and location* model;
- $p^i[m/dkso]$ 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.

Finally, the quantities required by each zone to satisfy end consumer needs can be obtained by introducing a *quantity purchase model*. This model gives us the probability that the end consumer, arriving in a given zone, purchases something of a certain size. Therefore, the total quantity of freight type *s* attracted by retail outlet *k* in zone *d*, $QT_d[sk]$, can be calculated as:

$$QT_d\left[sk\right] = \sum_i Q^i_d\left[sk\right] + QE^i_d\left[sk\right] = \sum_i \sum_{o,m,dim} D^i_{od}\left[skm\right] \cdot p^i\left[dim/mks\right] \cdot dim + QE^i_d\left[sk\right] \qquad (2)$$

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;
- $QE^i_d\,[sk]$ is the goods quantity bought/sold in retail outlet *k* in *d* given by the demand of end consumers belonging to category *i* living/working in a zone *external* to the study area;
- *dim* is the dimension of purchases, e.g. 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 from zone *o* to retail outlet *k* in zone *d* for a purchase of goods type *s* using the transport mode *m*.

In the following, we consider the study area as a closed system and then assume that the goods quantity is bought by end consumers living/working in a zone external to the study area can be neglected ($QE^i_d\,[sk] = 0$).

3.2. Restocking model sub-model

Once the quantity of goods bought/sold in retail outlet *k* in zone d, $QT_d[sk]$, has been estimated by the above model sub-system, the restocking quantity flows characterised for vehicle type *v*, QV_{od}, departing from zone *o* can be obtained as follows:

$$QV_{od}\left[skv\right] = QT_d\left[sk\right] \cdot p\left[o/dks\right] \cdot p\left[v/dk\right] \qquad (3)$$

where:

- $QV_{od}[skv]$ is the freight quantity of type *s* bought/sold in retail outlet *k* in zone *d* transported on pair *od* by vehicle type *v*;
- $p[o/dks]$ is the probability that the freight attracted by outlet type *k* located in zone *d* comes from warehouse zone *o*, obtained by an *acquisition model*;
- $p[v/dk]$ is the probability that the freight attracted by outlet type *k* located in zone *d* and coming from zone *o* is transported by vehicle type *v*, obtained by a *vehicle choice model*.

Finally, assuming that each vehicle only delivers to retail outlets located in the same traffic zone, the number of vehicles of type v required for restocking the retail outlets of the study area can be estimated as follows:

$$VC_{od}\left[v\right] = \sum_{sk} QV_{od}\left[skv\right] / Q\left[skvd\right] \qquad (4)$$

where:

- $VC_{od}[v]$ is the total average number of freight vehicles of type *v* moving on pair *od*;
- *Q[skvd]* is the total average freight quantity of type *s* delivered to retail outlets *k* in zone *d* by vehicle type *v*

Below we neglect the contribution due to freight vehicles used for home deliveries (e.g. e-commerce). In fact, the quantity attracted for satisfying end consumers' needs can also arrive directly to their consumption zone (e.g. home) using different type of purchasing (e.g. e-commerce). Therefore, in order to characterise this freight flows, a further model could be included in the *eq. (3)* in order to disaggregate the O-D flows for vis-à-vis shopping and e-commerce. Furthermore, we concentrate on predominant shopping modes and leave these new patterns out of consideration. These problems will be addressed in future research.

4. Application to a medium size urban area

In this section, the proposed method was applied to study the effects of strategies for urban freight activity location upon transport costs in the medium-size urban area of Padua in northern Italy. We chose this test-site area because it is an example of medium-size Italian urban area which is characterized by an already well balanced distribution of freight activity location. Furthermore its well-defined commercial offer make possible to suppose it as a closed system so it's worth the assumptions made in the *eq (2)*.

Padua municipality is also very active since many years to the problems of urban freight transport as shown by the successful Cityporto logistics scheme. It consists of an urban freight consolidation and distribution (UDC) operating since 2004 and located in the freight village "Interporto Padova". The study area comprises the Padua Municipality and 13 small neighbouring municipalities. The total population in 2011 was about 370,000, mainly concentrated in the centre of Padua where residential density is over 18 inh./ha. In the study area, the total number of shops is 6,761 with 23,144 retail employees that are mainly located in the historical city centre and in the small town of Abano Terme, a tourist attraction in the south of the study area. There are 4,750 warehouses in 2001 with 17,016 warehouse employees, mainly located in west of the city centre, near the boundary with Noventa Padovana, where a large warehouse centre is located (Padua City Porto). The study area was split into 25 traffic zones.

The system of models described in the previous paragraph was applied to three scenarios where a different distribution of retail and freight employees is supposed. For more details on models refer to Nuzzolo and Comi (2013b, c) and Comi and Nuzzolo (2013). The definition of different scenarios can be considered of the long-term results of some different land-use governance measures that local administrators could promote in order to improve the sustainability of the city. Each scenario was defined hypothesizing to shift both retail and warehouses employees among the three identified urban spaces (i.e. centre, the first and the second ring). The scenario definition was in terms of percentages of retail and freight employees with respect to the total number and with respect to scenario S0 (status-quo), as described in Table 1. In scenario S1, a shifting of retail employees from the city centre and the first ring to the second ring with the location of new large outlets was supposed. In scenario S2, a shifting of warehouse employees from the city centre and the second ring to the first ring was hypothesized. Finally, the scenario S3 was defined moving the retail and warehouse employees from centre and the second ring to the first ring. According to the general strategies as described in previous paragraphs the medium and large retail outlets, and the warehouses are located in the different scenarios in high accessible areas, along major roads and junctions.

In the existing scenario (S0), the distribution of freight flows, expressed in tons/day is represented in Figure 1 (on the left). The highest flows (more than 200 vehicles/day) are recorded between the city centre and the two main distribution points in Padua suburban area and between the municipality of Abano Terme and the City Porto distribution centre.

As regards shopping trips, in Figure 1 (on the right) the more frequent *od* (origin-destination) relations are represented, showing a clear concentric structure of the shopping flows, mainly directed towards the city's historical centre.

Table 1. Scenario definition - % of retail and freight operators employees, with respect to the total number

	S0		S1		S2		S3	
	RE	**FOE**	**RE**	**FOE**	**RE**	**FOE**	**RE**	**FOE**
△% Central area CA	37%	18%	29%	18%	37%	14%	29%	14%
△% First ring FR	20%	35%	16%	35%	20%	48%	36%	48%
△% Second ring SR	43%	48%	55%	48%	43%	38%	35%	38%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

S1: increase in retail activity (shopping malls) density in the second ring; S2: increase in warehousing and distribution centre density in the first ring; S3: increase in warehousing and distribution centre density in the first ring (S2) and an increase in medium-size retail businesses in the first ring; RE: retail employees; FOE: freight operators employees.

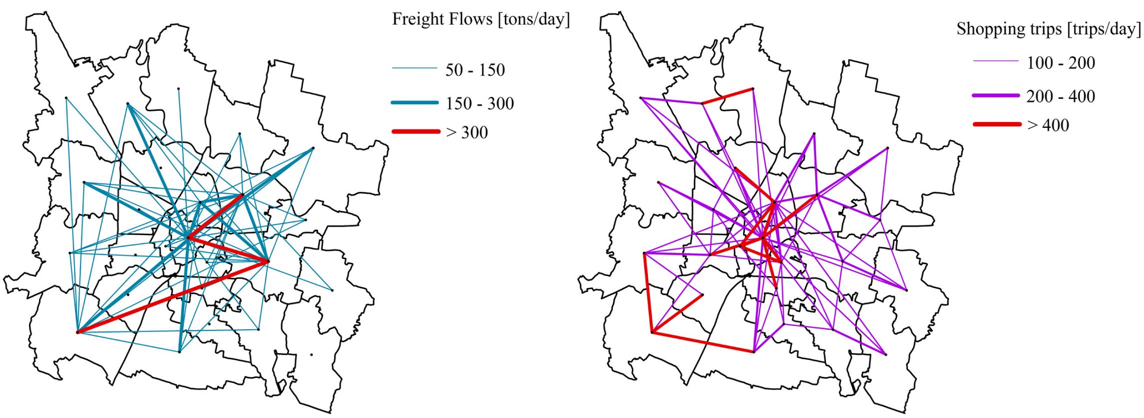

Fig. 1. Freight flows (vehicle/day) and shopping trips (trips/day) in scenario S0

In Table 2, the aggregate indicators for the three simulated scenarios are summarized, and, in particular, the effects of the different location of freight activities on the transport system are measured by the vehicle-km of commercial vehicle (for three different vehicle types), the vehicle-km of car shopping trips, the number of shopping trips by car and the total equivalent vehicle-km. Besides, following Filippi et al. (2010), the methodology of COPERT (COmputer Programme to calculate Emissions from Road Transport; Eggleston et al., 2000) was adapted for the urban and metropolitan contexts and then the external effects in terms pollutant emissions were estimated and are reported in Table 3.

We can observe that scenario S1, where large retail outlets increases in the second ring is the least favourable: while the vehicle - km of commercial vehicles for freight distribution decrease of 3.9%, and the purchase car movements increase of 2.9%, the total equivalent vehicle-km increase of 2.8%. In scenario S2, where there is an increase of warehousing activities and distribution centres density in the first ring, there is a more relevant decrease of freight distribution vehicle-km in the urban area of 5.0%, while the variation of car shopping trips remain constant. Scenario S3, that corresponds to the clustering strategy of freight distribution and retail activities in the first urban ring, would be more favourable with a decline of 7.4% in freight distribution vehicle-km and 12.8% of shopping trips – km by car: these variation correspond to a variation of total equivalent vehicle-km of 12.7%. In this last scenario, we observe also a consistent reduction of heavy good vehicle - km of 5.7%.

Table 2. Scenario comparison: number of vehicles and vehicle-km changes w.r.t. scenario S0.

			S1	S2	S3
freight distribution	LGV	veh-km	-4.8%	-5.3%	-7.6%
		veh	-5.8%	-2.0%	4.7%
	MGV	veh-km	-0.1%	-4,0%	-6.7%
		veh	0.0%	0.0%	0.0%
	HGV	veh-km	5.4%	-2.5%	-5.7%
		veh	-1.6%	-1.7%	-1.9%
	Total freight distribution	veh-km	-3.9%	-5.0%	-7.4%
		veh	-5.1%	0.0%	-1.6%
shopping	passenger vehicles	veh-km	2.9%	0.0%	-12.8%
		veh	0.0%	0,0%	0.2%
Total	**Δ% equivalent veh-km**		**2.8%**	**-0.1%**	**-12.7%**

LGV: Light Goods Vehicles, MGV: Medium Goods Vehicles; HGV: Heavy Goods Vehicle

Table 3. Scenario comparison: external costs and pollutant emissions changes w.r.t. scenario S0.

			S1	S2	S3
CO2 emission	freight distribution	LGV and MGV	-4.8%	-5.7%	-8.0%
		HGV	0.9%	-4.5%	-7.3%
	shopping	passenger vehicles	-0.1%	0.0%	-13.6%
	total		**0.0%**	**-0.1%**	**-13.5%**
PM10 emission	freight distribution	LGV and MGV	-4.8%	-5.7%	-8.0%
		HGV	0.9%	-3.7%	-6.5%
	shopping	passenger vehicles	-0.1%	0.0%	-12.1%
	total		**0.0%**	**-0.3%**	**-11.9%**
PM2.5 emission	freight distribution	LGV and MGV	-4.8%	-6.0%	-8.3%
		HGV	0.9%	-4.0%	-6.8%
	shopping	passenger vehicles	0.2%	0.0%	-12.6%
	total		**0.0%**	**0.0%**	**-12.3%**
NOx emission	freight distribution	LGV and MGV	-4.8%	-5.5%	-7.8%
		HGV	0.9%	-4.5%	-7.3%
	shopping	passenger vehicles	1.4%	0.0%	-13.2%
	total		**1.3%**	**-0.2%**	**-13.0%**
VOC emission	freight distribution	LGV and MGV	-3.7%	-3.9%	-5.6%
		HGV	0.9%	-3.7%	-6.5%
	shopping	passenger vehicles	-0.3%	0.0%	-13.3%
	total		**0.4%**	-0.0%	-13.2%
Total external costs due to pollutant emissions*			**0.0%**	**-0.2%**	**-13.1%**

LGV: Light Goods Vehicles; MGV: Medium Goods Vehicles; HGV: Heavy Goods Vehicle; * for homogenization coefficients refer to MIT (2006)

5. Conclusions

The paper proposed an overview of the effects of end-consumer behaviour and location of retail outlets and restocking centres upon urban freight mobility and presented a scenario analysis using an empirical simulation approach. In the application of the proposed system of models, three scenarios, each related to the distribution of retail outlets and freight distribution centres, were presented and simulated.

In order to test the model, and to define an approach adaptable to different cities, we applied this methodology to a test-site area, characterized by an already well balanced distribution of freight activities location. The main results are confirming the model structure and at the same time demonstrate that in areas where freight activities distribution is balanced, the ameliorative margin of land-use planning strategies are not significant for all supposed scenarios. These results depend on the already well planned location of retail activities in Padua municipality and the presence of the City Port distribution centre in the first ring. Now that the model is tested, a second step of the research will start, with the application of the proposed methodology to an urban area that do not present the same balanced distribution of freight activities, also with the aim of comparing different contexts application results.

The research demonstrates that land-use planning and in particular spatial distribution of urban goods facilities (shops, warehouses etc.) can minimise, with more or less influences, transport costs and their environmental impacts both for freight distribution and for shopping. Furthermore, the proposed assessment methodology is able to evaluate land-use scenarios, in terms of transportation costs, that can be used to measure economic, social and environmental target strategic objectives.

The strategy for locating freight activity, according to the results of the application, seems to favour the clustering of freight distribution centres and of medium-size retail businesses 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. This implies a reduction of total freight distribution travel time, on total shopping travel time and on pollutant emission. In other words, the strategy of clustering of warehousing, distribution centres and medium/large retail outlets in the first ring can have impacts in terms of reduction of both freight distribution travel distances and shopping travel distances. In fact, with respect to the other land-use scenario, this solution implies a reduction in freight distribution vehicle – km, a small increment in number of car shopping trips that is offset by a consistent reduction in the car shopping trips vehicle - km. Furthermore, the study offers a focus on the impacts of land-use planning policies and in particular of the location choices of retail activities and freight distribution centres on end-consumer behaviour and freight distribution flows. The proposed analysis methodology jointly analyses the freight distribution and shopping mobility segments impacts. The variation of vehicle – km of the two segments components and the variation of equivalent vehicle - km demonstrate that the shopping mobility transport costs are higher than their freight restocking counterpart and that it is fundamental to investigate the two components at the same time. The integrated approach has the advantage of stressing the interrelations between the two elements and to jointly measure their impacts.

Some interesting extensions of this study include but not limited to the following: (1) to apply the system of model to a not balanced urban area; (2) to estimate more disaggregate indicators in order the geolocalize the impacts into different urban areas; (3) to define for each study area specific planning strategies according to their logistic profile; (4) to include the e-commerce.

6. References

Allen, J., Browne, M., & Cherrett, T. (2012). Investigating relationships between road freight transport, facility location, logistics management and urban form. *Journal of Transport Geography 24*, Elsevier Ltd, 45–57.

Bronzini M. (2008). *Relationships between land use and freight and commercial truck traffic in metropolitan areas*. Special Report 298. Transportation Research Board.

Browne, M., Allen, J., & Leonardi, J. (2011). Evaluating the use of an urban consolidation centre and electric vehicles in central London. *International Association of Traffic and Safety Sciences 35*, Elsevier, 1 – 6.

Browne, M., Allen, J., Nemoto, T., Patier, D., & Visser, J. (2012) Reducing social and environmental impacts of urban freight transport: A review of some major cities. *Procedia - Social and Behavioral Sciences 39*, Elsevier Ltd, 19 – 33.

Browne, M., Sweet, M., Woodburn, A., & Allen, J. (2005). Urban freight consolidation centres final report. Transport Studies Group, University of Westminster for the Department for Transport.

Brunetta, G., & Morandi C. (eds) (2010). *Polarità commerciali e trasformazioni territoriali. Un approccio interregionale*, Alinea Editrice.

Cidell, J. (2010). Concentration and decentralization: The new geography of freight distribution in US metropolitan areas. *Journal of Transport Geography Vol 18 (3),* Elsevier Ltd., 363–371.

Comi, A., & Nuzzolo, A. (2013). Simulating urban freight flows with combined shopping and restocking demand models. *Proceeding of the 8th International Conference on City Lo*gistics, E. Taniguchi and R. G. Thompson (eds.), Kyoto, Japan.

Durand B., & Gonzalez-Feliu (2012). Urban logistics and e-grocery: Have proximity delivery services a positive impact on shopping trips? *Procedia - Social and Behavioral Sciences 39*, 510 – 520.

Eggleston, S., Gorißen, N., Hassel, D., Hickman, A. J., Joumard, R., Rijkeboer, R., White, L., & Zierock, K. H. (2000). *COPERT III: Computer Programme to Calculate Emissions from Road Transport*. European Environment Agency.

Filippi, F., Nuzzolo, A., Comi, A., & Delle Site, P. (2010). Ex-ante assessment of urban freight transport policies. *Procedia – Social and Behavioral Sciences 2 (3)*, E. Taniguchi and R. G. Thompson (eds.), DOI: 10.1016/j.sbspro.2010.04.042, Elsevier Ltd, 6332 - 6342.

Gonzalez-Feliu, J., Toilier, F., & Routhier, J. L. (2010). End-consumer goods movement generation in French medium urban areas. *Procedia -Social and Behavioral Sciences 2(3),* E. Taniguchi and R. G. Thompson (eds.), Elsevier Ltd, 6189-6204.

Hesse, M., & Rodrigue, J.P. (2004). The transport geography of logistics and freight distribution. *Journal of Transport Geography 12 (3)*, 171-184.

Huschebeck, M., & Allen, J. (2005). *Policy and Research Recommendations I. Urban Consolidation Centres, Last Mile Solutions*. Best Urban Freight Solutions II, Deliverable D. 1.1, Brussels.

Ibeas, A., Moura, J. L., Nuzzolo, A., & Comi, A. (2012). Urban freight transport demand: transferability of survey results analysis and models. *In: Procedia - Social and Behavioural Science 54*, Vincent Aguiléra, Neila Bhouri, Nadir Farhi, Fabien Leurent and Régine Seidowsky (eds.), DOI: 10.1016/j.sbspro.2012.09.822, Elsevier Ltd, 2012, 1068-1079.

McKinnon A. (2009). The present and future land requirements of logistical activities., *Land Use Policy Vol. 26*, S293–S301.

Miodonski, D., & Kawamura, K. (2012) Effects of Built Environment on Freight Consumption. *Procedia - Social and Behavioral Sciences 39*, 74–88.

MIT (2006). *Linee guida per la misura dei costi esterni.* Ministero delle Infrastrutture e dei Trasporti, Italia, Roma.

Mokhtarian, P.L. (2004). A conceptual analysis of the transportation impacts of b2c e-commerce. *Transportation, 31 (3)*, 257–284.

Muñuzuri, J, Larraneta, J., Onieva, L., & Cortés, P. (2005). Solutions applicable by local administrations for urban logistics improvement. *Cities 22 (1),* Elsevier Ltd.

NORAD (1999). *Logical Framework Approach: handbook for objectives-oriented planning*, Norad.

Nuzzolo, A., & Comi, A. (2013a). City logistics planning: demand modelling requirements for direct effect forecasting. *Proceedings of the 8th International Conference on City Logistics*, E. Taniguchi and R. G. Thompson (eds.), Kyoto, Japan.

Nuzzolo, A., & Comi, A. (2013b). Tactical and operational city logistics: freight vehicle flow modelling. *Freight Transport Modelling*, Ben-Akiva, M., Meersman, H., & Van de Voorde, E. (eds.), Emerald Group Publishing Limited, Bingley, U.K., chapter 21, 433 – 451.

Nuzzolo, A., & Comi, A. (2013c). Urban freight demand forecasting: a mixed quantity/delivery/vehicle-base model. *Transportation Research Part E*, Elsevier Ltd, forthcoming.

Nuzzolo, A., Coppola, P., & Comi, A. (2013). Freight transport modeling: review and future challenges. *International Journal of Transport Economics vol. XL (2)*, Fabrizio Serra Editore, Rome, 151 – 181.

Nuzzolo, A., Crisalli, U., & Comi, A. (2012). A System of Models for the Simulation of Urban Freight Restocking Tours. *Procedia - Social and Behavioral Sciences 39*, E. Taniguchi and R. G. Thompson (eds.), DOI: 10.1016/j.sbspro.2012.03.116, Elsevier Ltd, 664-676.

Russo, F., & Comi, A. (2010). A modelling system to simulate goods movements at an urban scale. *Transportation 37 (6)*, DOI: 10.1007/s11116-010-9276-y, Springer Science+Business Media, LLC, 987-1009.

Russo, F., & Comi, A. (2011). Measures for sustainable freight transportation at urban scale: expected goals and tested results in Europe. *Journal of Urban Planning and Development 137 (2)*, DOI: 10.1061/(ASCE)UP.1943-5444.0000052, American Society of Civil Engineers (ASCE), 142-152.

Russo, F., & Comi, A. (2012). The Simulation of Shopping Trips at Urban Scale: Attraction Macro-Model. *Procedia - Social and Behavioral Sciences 39*, E. Taniguchi and R. G. Thompson (eds.), DOI: 10.1016/j.sbspro.2012.03.116, Elsevier Ltd, 387- 399.

Schoemaker, J., Allen, J., Huschebek, M., & Monigl, J. (2006). *Quantification of Urban Freight Transport Effects I*. BESTUFS Consortium, www.bestufs.net.

Taniguchi E., & Kakimoto T. (2003). Effects of e-commerce on urban distribution and the environment. *Journal of Eastern Asia Society for Transportation Studies 2003 (55)*, 2355 – 2366.

Taniguchi, E., Thompson, R. G., Yamada, T., & van Duin, R. (2001). *City Logistics – Network Modelling and Intelligent Transport Systems*. Pergamon.

van der Waerden, P., Borgers, A., & Timmermans, H. (1998). The impact of the parking situation in shopping centres on store choice behaviour. *GeoJournal, 45(4)*, 309-315.

Wygonik, E., Bassok, A., Goodchild, A, McCormack, E., & Carlson, D. (2012). Sustainable urban goods movement: emerging research agendas. *In Proceedings of Workshop Innovation in Urban Freight*, Seattle, WA, USA.