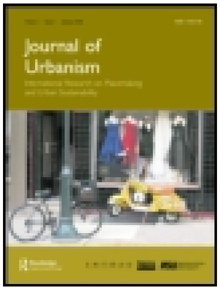

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Urban freight transport policies in Rome: lessons learned and the road ahead

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Urban freight transport policies in Rome: lessons learned and the road ahead

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Given that few studies have investigated the effects of implementing city logistics measures, this paper focuses on actions implemented in the inner area of Rome in the last 10 years in order to improve both livability and freight distribution, providing insights into the effectiveness of such measures. The analysis covers the famous inner area of the city where the main tourist monuments are located and includes several pedestrianized shopping streets. Evaluation is based on data collected in 1999 and 2008 consisting of traffic counts and interviews with retailers and truck drivers. The implemented measures provided effective in abating through-traffic, in reducing the share of transport on own-account and in increasing the use of less polluting vehicles. Further, the increase in the number of stops per tour, in the average quantity delivered and hence in the average loading factor was revealed. Although all these changes improved the freight transport within the city, some critical issues remain and further measures have to be implemented.

Keywords: urban freight transport; city logistics policy assessment; urban freight surveys; urban freight regulation; Rome

Introduction

In urban areas the need to improve freight traffic conditions and assign parking areas for loading and unloading operations is emerging. However, a balance has to be sought between an effective and efficient urban logistics system and a sustainable level of externalities, especially congestion and pollutant emissions. Sustainable city logistics solutions have to be implemented in order to reduce the effects of freight transport without penalizing city life. After all, freight transport enables products to reach the end consumer and thus plays a key role in the maintenance of functions related to trade and city life.

An efficient urban logistics system allows freight to move at decreasing prices, while the effectiveness of the system is expressed by the supplier's capacity to ensure that freight deliveries meet the demand of customers in terms of quantity, place and time. Several factors make the system difficult to manage: the various actors involved, the constraints dictated by the urban structure and high dispersion of retail activities, and the existence of distribution processes in which the recipient manages the last mile.

In order to ensure an efficient urban freight distribution system able to meet the demand of the various stakeholders involved, to minimize negative externalities and hence to improve urban sustainability, several measures can be implemented (Bestufs 2007; Russo and Comi 2011a). In implementing such measures, local administrators aim to reduce the number of commercial vehicles on the roads, to reduce the distance covered by heavy goods vehicles (HGVs) from warehouses and distribution centers, to increase the

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share of third party (3P) transport and to increase the use of light and environmentally friendly vehicles (*environmental* sustainability); to optimize loading and unloading operations in order to reduce traffic congestion (*economic/financial* sustainability); to and reduce interference with other urban mobility components such as pedestrians (*social* sustainability).

Since urban freight systems are complex and cities differ in size and other characteristics, site-specific data could be required for the development of the design and implementation phases. Indeed, cities differ from one another in many aspects of transport and traffic conditions (demand, supply, infrastructure, traffic control and management, etc.), and other factors including geographical, environmental, demographic and socio-economic conditions, cultural heritage, and institutional and legal frameworks. In most cases it will also be necessary to liaise with users and stakeholders and ensure their support. Therefore, it is a challenging task to make sure that success in one city can be replicated in another (Jeffery 2011).

As revealed by recent studies (Ibeas et al. 2012), there is a broad diversity of city logistics measures, and each city decides the measures to implement without considering the major repercussions possibly affecting actors operating in nearby areas. Although the nature of urban freight transport is specific to each city, from a logistic operator's point of view it is important to implement a uniformity of measures at the local and larger scale (regional, national and perhaps European).

Therefore, all these indications should be followed and should be the basis for an implementation process consisting of several steps which may do the following (Nuzzolo and Comi 2014a):

- Reveal the current critical issues through specific surveys (e.g. traffic counts, interviewees with retailers, truck drivers etc.);
- Define models to simulate the current scenario and assess the future;
- Share objectives and find an optimal compromise among the different actors involved;
- Assess *ex-ante* the new scenario by estimating impacts and system performance, and compare them with a set of given target values;
- Monitor the freight system after scenario implementation (*ex-post*) in order to evaluate the effectiveness of implemented solutions.

In this context, a key role is played by *ex-ante* and *ex-post* assessment methods that allow the obtainable effects to be evaluated prior to implementation and their results to be verified afterwards. While several *ex-ante* methods have been proposed (Comi et al. 2012; de Jong et al. 2012), *ex-post* assessments have been largely neglected due to lack of data availability. That said, since several city logistics measures have been implemented worldwide, some lessons could be learned by analyzing the results obtained. Thus we set out to analyze the results obtained by implementing city logistics measures in Rome. We compare the surveys carried out in the last 10 years in order to gain insights into the freight transport strategies being developed in the city and the process by which this is achieved. This could be of importance to policy-makers in other towns and cities that are in the process of developing and building up their own freight strategies.

The paper is structured as follows. The second section recalls the main *ex-ante* and *ex-post* methods to support the design and implementation of city logistics scenarios. The analysis shows that *ex-post* evaluations mainly concern test cases and that few cities have implemented an extensive urban freight planning process. The third section describes the evolution of the city logistics policies in Rome over the last 10 years; while the fourth section reports the results of two surveys carried out in 1999 and 2008 that allow us to evaluate the effectiveness of such policies. Finally, some conclusions are drawn based on the Rome experience in the fifth section.

Policy assessment methodology

The need to find solutions to support the definition of new city logistics scenarios has led mainly to the development of methods for *ex-ante* assessment, while few studies have proposed methods to monitor and assess *ex-post* effects due to measure implementation.

As regards *ex-ante* assessment, Visser, Binsbergen, and Nemoto (1999) presented a general overview of public policy and planning in the field of urban freight transport. Taniguchi and van der Heijden (2000) presented the methodology for evaluating city logistics initiatives using dynamic traffic simulation. Yamada, Taniguchi, and Itoh (2001) developed a cooperative vehicle-routing and scheduling model with optimal location of logistics terminals. Crainic, Ricciardi, and Storchi (2004) proposed an organizational and technological framework based on a two-tier approach. Nuzzolo, Crisalli, and Comi (2008) developed the technical and economic feasibility analyses of freight distribution by railways. Filippi et al. (2010) presented an overall assessment framework and provided a detailed description of the methodology for estimating pollutant emissions from road vehicles. Russo and Comi (2011b) developed a general modeling system to simulate urban goods movements, focusing jointly on end-consumer and retailer choices. Nuzzolo, Crisalli, and Comi (2012) and Nuzzolo and Comi (2013) provided a new modeling framework able to capture the effects of city logistics measures on actors' behaviors.

A comprehensive collection of *ex-post* assessment results of research projects can be found in Browne, Allen, and Attlassy (2007) and Allen et al. (2008), while Browne, Allen, and Leonardi (2011) present an *ex-post* assessment of an urban consolidation centre implemented in London in 2009. The evaluation indicated an increase in distance travelled per parcel, even if the system were able to eliminate CO_2 eq. emissions per parcel delivered in the city as a result of the electric vans used for final distribution. Munuzuri et al. (2012), focusing on Spanish cities, presented a picture of the current scenario and the typical regulation schemes, analyzing the reasons for system failure and the possible efforts, which were relatively cheap and easy to implement, to be made towards improvement.

This brief analysis shows that several methods and models have been proposed for supporting *ex-ante* assessment, while few studies refer to *ex-post* assessment. This was mainly due to lack of data required for different purposes: to provide an understanding of freight operations, to obtain data to be used in urban freight models for forecasting and to monitor the effects of policy measures. Therefore data are essential in helping public and private sector decision-makers ensure that urban freight transport is efficient and sustainable.

As noted by Ogden (1992), it is not possible to make definitive comments about data requirements when studying urban freight transport. These will vary depending on the issues concerned, the planning and policy framework in which the issue arises, established practice in data collection, and the availability of previously collected data.

Since urban freight systems are complex and cities differ in size and other characteristics, site-specific data are required for the development of models that could support the sustainable management of urban logistics.

A survey of European countries carried out within the BESTUFS research project (Ambrosini and Routhier 2004; Bestufs 2008) has found much less availability of freight data at the urban level than at a national level, and lower than data available for passengers. Data at the national scale are often collected on a continuous basis, while data at the urban scale are collected within one-off projects which are not repeated over time. This circumstance can be viewed as reflecting the somewhat limited interest of policy-makers in this mobility segment. An issue here is that freight data are often held by private organizations and are not made available to the public. In this context, Rome is an exception because local administrators have focused on freight transport and several surveys have been carried out in the last 10 years.

City logistics policies in Rome

In order to make urban mobility more sustainable, measures to reduce the economic, social and environmental impacts of freight transport have been implemented in Rome over the last 10 years. In the following sections their evolution will be analyzed.

Our analysis refers to the inner area of Rome (Figure 1), i.e. the historic and best-known zone in the city, with the main monuments, such as the Colosseum, and many pedestrianized shopping streets. It occupies an area of some 6 km^2, has about 50,000 inhabitants and 130,000 employees, of which 24,000 are employed in the retail trade.

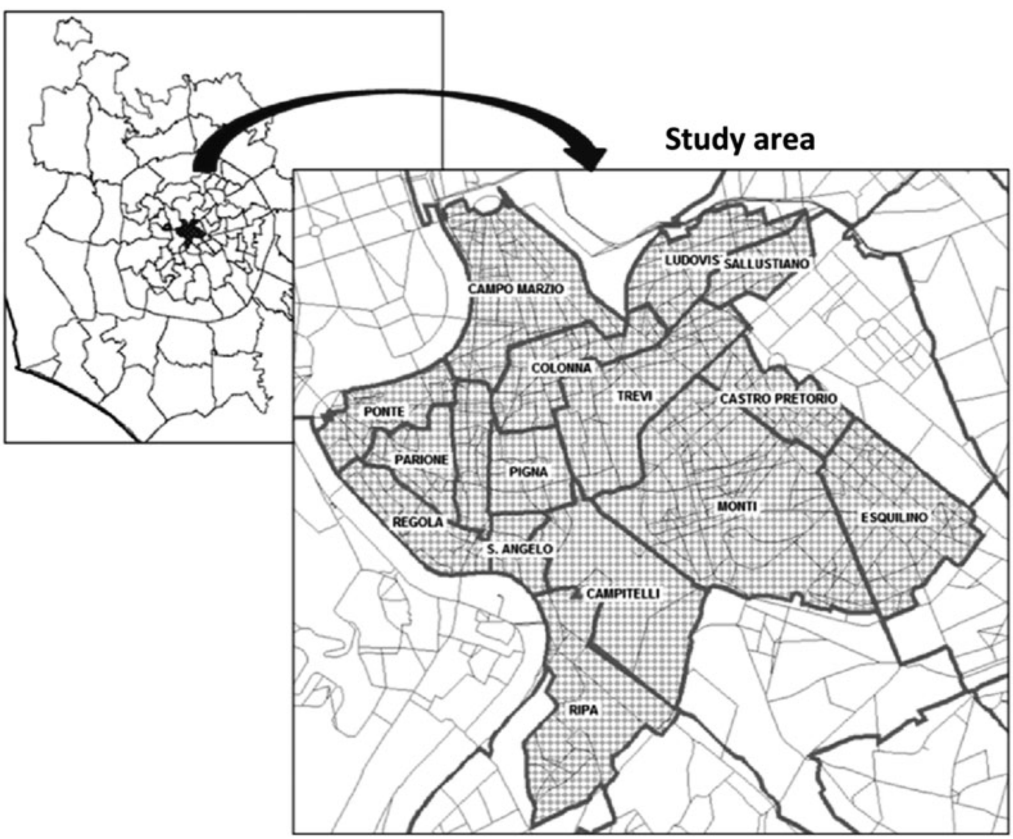

Figure 1. City of Rome: municipality and inner area.

Table 1. Freight regulation development in the inner city of Rome.

Measures/ policies	Before 2001		2001–11		After 2011	
	Less than 3.5 t	More than 3.5 t	Less than 3.5 t	More than 3.5 t	Less than 3.5 t	More than 3.5 t
Time windows	Access: • 9.30 am–11 am • 2.30 pm–4 pm	Access: Specific path and time permits	Access: • 8 pm–10 am • 2 pm–4 pm	Access: • 8 pm–7 am and subject to specific path and time permits	Access (Euro 2 and 3): • 8 pm–7 am • 10 am–4 pm Access (Euro 4, 5 and 6): • 8 pm–5.30 pm	Access: • 8 pm–7 am and subject to specific path and time permits
	Exemptions for valuables, pharmaceuticals, newspapers and vehicles carrying out maintenance work		Exemptions for third-party vehicles, valuables, pharmaceuticals, newspapers and vehicles carrying out maintenance work Electronic Access Control		Exemptions for electric, LPG, CNG, hybrid vehicles less than 6.5 t complying with the gauge of LGVs (less than 3.5 t) Maximum loading and unloading time: 30 min Electronic Access Control	
Emission constraints	None	None	No access for Euro 0 and 1 freight vehicles		No access for Euro 0, 1, 2 (from 2012) and 3 (from 2013) freight vehicles	
Road pricing	None	None	€570/year Discounts for low-emission vehicles (–20% CNG, LPG hybrid, −50% electric)		depends on vehicle emission standards	

Pre-2001 traffic regulation

Before 2001 the inner area was a Freight Limited Traffic Zone (LTZ), where access and parking were subject to regulations in two time windows (Table 1). However, due to the large number of exemptions and low enforcement, this regulation had little effect in terms of reducing freight traffic in the inner area and improving environmental sustainability.

In 1999 the municipality carried out some surveys (traffic counts, retailer and truck driver interviews; see the fourth section for more details) aiming to identify the problems of freight transport and support the decisions on action to be implemented. The surveys highlighted the presence of through-freight traffic, representing 24% of all freight trips, the high share of own-account transport (54%) and commercial vehicles exceeding 1.5 tons (t) (74%). It also emerged that freight vehicles were delayed by congestion and had problems loading and unloading, especially due to insufficient parking space. The problem was pointed out by 34% of retailers, and only 5% of interviewed truck drivers stated they used spaces reserved for loading and unloading.

Regulations between 2001 and 2011

In 2001, based on the 1999 survey results, new regulations for freight traffic with restrictions on access and parking in the inner area were put in place. In addition, for a large portion of the inner area an electronic system of access control was implemented for both passenger and freight vehicles.

According to the new regulations (Table 1), access and parking of freight vehicles is subject to time windows. HGVs (of more than 3.5 t of gross laden weight) are granted access and parking in the 8 pm–7 am window. Other vehicles (less than 3.5 t) are granted access and parking in the 8 pm–10 am and 2 pm–4 pm windows. Exemptions from time windows with around-the-clock access and parking are granted to 3P vehicles, vehicles transporting perishable food, valuables, pharmaceuticals, newspapers, and vehicles carrying out maintenance work. In addition, there is an around-the-clock ban on Euro 0 vehicles.

In the portion of the inner area subject to electronic access there is a charge for the permit which grants access on a yearly basis and is in the range of €570. There are discounts for compressed natural gas (CNG), liquefied petroleum gas (LPG) and hybrid vehicles which pay in the range of €430, and for electric vehicles which pay about €300. Temporary permits on a daily basis can be purchased for a charge of about €35 plus a one-off amount in the range of €20 paid for the first permit only.

In 2008, the city municipality carried out new surveys (see the fourth section for more details) in order to monitor the effects of this new regulation and to find out whether other measures should be implemented to improve area sustainability.

The 2001 regulations were designed essentially for the following:

- To create incentives for 3P also in an attempt to discourage long parking of own-account vehicles, given the shortage of on-street space in the area.
- To reduce the share of the most polluting vehicles.
- To reduce the share of HGVs.

The time window regulation together with the charging scheme has allowed the share of own-account vehicles to be reduced to 21%. The new regulations have also encouraged the use of light goods vehicles (LGVs): in 1999 they represented 44% of all vehicles entering the area, while in 2008 they accounted for 65%. Good environmental results have been obtained: in 2008, 83% of freight vehicles were at least Euro 3 or 4 (the low level of enforcement in the LTZ not subject to electric access control resulted in more than 6% being Euro 0).

The 2008 surveys also pointed out the existence of several problems even if good results had been obtained. The share of retailers who considered problems related to space for loading and unloading very important had increased (69%): 22% used space for loading and unloading operations often or always, which may be due to access restrictions for passenger vehicles and automatic enforcement in the LTZ area. The traffic counts indicated that the number of freight vehicles attracted by the area increased by about 24% from 1999 to 2008. On the other hand, the frequency of restocking increased and there were more retailers receiving goods one or more times a day. The decrease in own-account trips, which typically consisted of only one journey per day, led to an increase in restocking frequency.

The pollution level in the inner area was still too high and environmental standards were often exceeded. Therefore, following these results the city administration planned to modify its freight regulations and appraise further solutions.

Post-2011 regulation

As stated above, according to the evaluations in 2008 good yet not excellent results were obtained. New measures were thus planned from 2012 to achieve higher levels of sustainability (Table 1). New access limits for commercial vehicles (both vehicles for freight distribution and services) were introduced:

- No access for vehicles non-compliant with Euro 2 standards and from 2013 no access for those non-compliant with Euro 3.
- Environmentally friendly vehicles (i.e. CNG, LPG, hybrid and electric) have a reduced charge for accessing the study area.

These new regulations provide some supporting measures able to increase its success: incentives to buy new environmentally friendly vehicles, enforcement of the proper use of loading and unloading zones.

Ex-ante assessment is in progress, but preliminary results suggest that charges will need to be adjusted in order to obtain revenues that can support the new integrative measures (e.g. control of loading and unloading zones). *Ex-ante* environmental assessment shows that good results can be obtained in terms of pollutant reductions: particulate matter could be cut by 6% by 2012, while a 33% reduction could be achieved by 2013.

The city administration is also verifying the possibility of banning access for all vehicles (both private and commercial) to the core of this inner area. The implementation of transit points or Nearby Delivery Areas (NDA), as set up in French cities (Patier 2006), has been assessed. The goods should be unloaded from incoming vehicles at the border of the restricted area and from that point should be distributed by electric vehicles. Transport operators could choose to rent an electric vehicle and continue distribution by themselves or to confer their load to NDA operators for last-mile distribution. The transit point could be equipped with areas for: loading and unloading operations, short-term warehousing (a maximum of one week) and recharging of electric vehicles. An Intelligent Transportation System (ITS) will be implemented in order to monitor the delivery system and give some on-line information (e.g. shop opening and closing times, availability of stop zones, reservations service). The main idea is that these actions could improve the environmental sustainability of the area, optimize goods movements and reduce interaction between pedestrians (mainly tourists) and vehicles.

The surveys

As occurred in other European countries in the 1990s, the municipality authority of Rome found it had no data on urban freight traffic. Therefore, surveys were carried out in 1999; the initial goal was to build a comprehensive database in order to help decision-makers in the field of city logistics in the inner area. Very similar surveys were carried out in 2008. The latter were part of a study of new policies for urban freight transport in the city commissioned by the municipality and carried out by academic researchers, with a twofold aim. One was to update the survey carried out in 1999 and monitor the effects of freight traffic regulations implemented from 2001, the other was to develop a modeling framework able to support *ex-ante* assessment of future scenarios. The developed modeling system is a multistage model that considers a discrete-choice approach for each decisional level and captures actors' choices that can be influenced by city logistics measures (Nuzzolo and Comi 2014b).

The same methodology was used for the 1999 and 2008 surveys. In this way, comparison between the two stages was possible (STA 1999; Filippi et al. 2008). The survey consisted of the following:

- Traffic counts of commercial and private vehicles carried out in 28 sections.
- Telephone interviews with retailers in order to obtain information about the retail trade in the study area for each freight type (about 600 in 2008 and 250 in 1999); the retailers to be interviewed were randomly extracted from the list of the Rome Chamber of Commerce.
- Interviews with truck drivers to investigate their freight distribution trips (about 500 in 2008 and 800 in 1999 per driver); the drivers to be interviewed were randomly stopped at border sections (1999) or randomly selected from the list of permits issued by the local administration (2008).

Based on the results of the above surveys, we analyze below the evolution of urban freight transport characteristics over the last two decades.

Traffic counts

About 190,000 private cars and 25,000 commercial vehicles were counted in 1999 from 7 am to 6 pm, while in 2008 in the same time interval the two vehicle classes were respectively 217,000 and 25,000. The traffic counts indicate that in the area the number of freight vehicles has remained fairly constant, while the daily share of freight vehicles has decreased from 12% of 1999 to 9% in 2008. Given that in 2008 through-freight traffic can be assumed to be zero due to area pricing implementation, the freight traffic attracted by the zone has grown by about 24%.

Figure 2 shows the distribution of freight vehicles entering the study area. More than 50% of vehicles enter the study area from 7 am to 12 pm: 58% in 1999 and 54% in 2008.

The fleet composition changed as the new regulations forced the use of LGVs (Table 2). Even if other factors may have contributed to this effect, such as increasing franchising shares and increasing shop sizes, in the investigated area these changes were

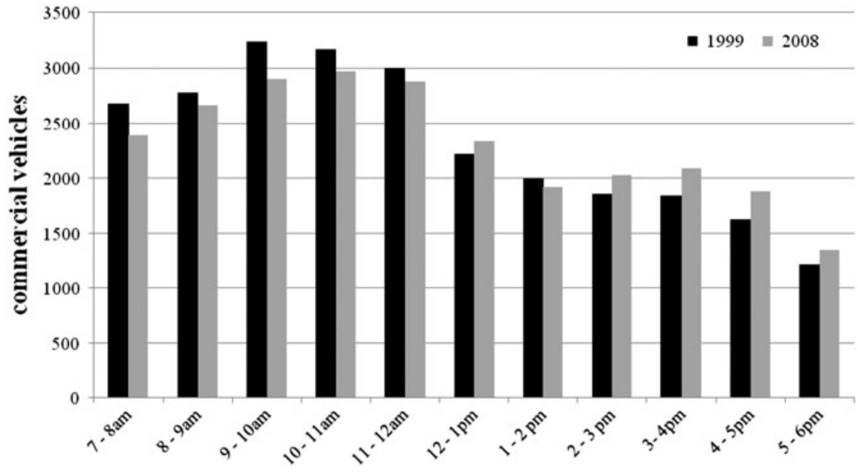

Figure 2. Distribution of commercial vehicles entering the study area.

Table 2. Traffic counts: distribution by vehicle type.

Vehicle type	2008	1999
Gross laden weight less than 1.5 t	57%	26%
Gross laden weight between 1.5 and 3.5 t	33%	50%
Gross laden weight between 3.5 and 8.5 t	10%	22%
Other vehicles		2%
Total	100%	100%

very limited, as also confirmed by the analysis of commercial supply carried out by the Municipality (Filippi et al. 2008; Stathopoulos, Valeria, and Marcucci 2013). Besides, for example, in the rest of the city vehicle size has remained quite similar during the last 10 years (ACI 2012).

Retailer interviews

In 1999 and 2008, samples of 2150 and 1500 retailers, respectively, were randomly extracted from the register of the CCIAA (Chamber of Commerce). The response rates were 12% in 1999 and 38% in 2008. This growing rate demonstrates the increasing interest of retailers in this problem. The questionnaire used in 2008 included all the information (i.e. sections able to characterize and identify the business, transport, deliveries to customers, problems and suggestions) collected in the previous survey in order to make evaluation of the main differences between 1999 and 2008 feasible.

In 1999, 65% of the investigated sample consisted of shops and food-and-drink outlets, while in 2008 they represented 85%.

In 2008, about 68% of interviewees had a sales area of less than 100 m^2, while in 1999 such retailers represented 82%. In 2008, 22% of retailers had no storage at all, 71% had little storage space (less than 100 m^2), 6% had storage space of between 100 and 200 m^2, and the remaining 1% had storage larger than 200 m^2. Importantly, 10% did not have any storage space close to the shop. In 1999, in keeping with smaller sales areas, 11% of

Table 3. Average number of employees.

Activity type	2008	1999
Retailers and food-and-drink outlets	2.98	2.40
Arts and crafts	2.37	2.70

retailers had more than 100 m^2 of storage space and 9% had storage space far from the shop. The number of employees per business increased in line with the expanding retail area. Indeed, we revealed an average increase in the number of those employed in retail and food-and-drink outlets and a decrease in those employed as artisans (Table 3).

In 1999, 54% of businesses used their own transport; in 2008 it was only 21%. The share of retailers reporting a restocking frequency of one or more trips per day increased from 38% in 1999 to 55% in 2008. In 2008, the use of cars, vans and SUVs rose from 61% to 71% (Table 4).

The peak months for goods movements in 1999 were October and November, uniformly distributed from Monday to Friday; in 2008 peak movements were in March, April and May, and distributed among weekdays as follows: Monday (23%), from Tuesday to Thursday (15%), and Friday (26%).

As regards time of day, it emerged that goods movements have been brought forward by about 1 hour. In 2008, 54% of goods were delivered between 7 am and 12 pm; in 1999, 56% between 8 am and 1 pm.

With regard to restocking, it emerged that, in 1999, 38% of interviewees experienced a restocking frequency of one or more, while in 2008 this share reached 55%. Tables 5

Table 4. Vehicle type shares.

Vehicle type	2008	1999
Cars and SUVs	71%	61%
Vehicles with a gross laden weight below 1.5 t	22%	30%
Vehicles with a gross laden weight between 1.5 and 3.5 t	7%	9%

Table 5. Characterization of restocked freight quantity in 2008.

	Occasionally	Never	Always	Often	Not available	Total
Less than 100 kg	4%	3%	55%	31%	7%	100%
100–1000 kg	20%	54%	2%	17%	7%	100%
More than 1000 kg	5%	86%	1%	1%	7%	100%

Table 6. Characterization of restocked freight quantity in 1999.

	Occasionally	Never	Always	Often	Not available	Total
Less than 100 kg	10%	10%	56%	24%	–	100%
100–1000 kg	17%	60%	7%	16%	–	100%
More than 1000 kg	6%	89%	1%	4%	–	100%

and 6 report the distributions of quantities per delivery, showing quite similar results for the two surveys.

In the two surveys, all the interviewees were willing to bring forward their receipt of deliveries. In 2008, 63% stated they received freight even 1 h before, while in 1999 this share was 55%. Finally, the main problems perceived by the retailers refer to loading and unloading areas: in 1999, 34% of interviewees considered this problem important; by 2008 this share had grown to 69%.

Truck driver interviews

In 1999 and 2008, respectively, 779 and 502 truck drivers were interviewed. The questionnaire consisted of several sections able to capture the characteristics of the interviewee and transport firm as well as the transport characteristics (e.g. own account or 3P, vehicle, delivery journey).

The composition of freight flows (tons), estimated on the basis of counts and data from the truck-driver survey, is given in Table 7. The study area is a trading area that is mainly affected by attraction freight flows. The analysis highlights freight movements in the study area amounting to about 15,000 t/day: 36% consisted of food (about 16% were for restaurants and bars, 14% for food retailers) and the remaining 64% consisted of other end-consumer products (e.g. household and health products).

According to the truck-driver survey, the most common vehicle type used in the 2008 was the LGV (i.e. with a maximum gross laden weight of less than 1.5 t) with an average of 3.2 deliveries per trip. The composition of trucks entering the study area has changed. The comparison between 2008 and 1999 of revealed freight vehicles accessing the study area showed an increase in LGVs from 44% to 65% and a decrease in other types of freight vehicles (Table 8). The increase in the number of LGVs and the stability of

Table 7. Revealed freight flow distribution in 2008.

	Produced (t/day)	Attracted (t/day)
Building materials	–	467.7
Clothing	38.2	1075.0
Foodstuffs	34.4	5234.2
Home accessories	88.3	2863.8
Household and personal hygiene	0.1	207.4
Stationery	31.0	2475.9
Other goods	3.2	2175.2
Total	195.2	14 499.2

Table 8. Characteristics of the commercial vehicle fleet.

	2008			1999		
Fuel	Less than 1.5 t	More than 1.5 t	Total	Less than 1.5 t	More than 1.5 t	Total
Gasoline	8%	1%	8%	10%	3%	13%
Diesel	56%	34%	90%	33%	53%	86%
LPG	1%	0%	1%	1%		1%
CNG	0%	1%	1%			0%
Total	65%	35%	100%	44%	56%	100%

Table 9. Characteristics of delivery destinations.

Destination type	2008	1999
Warehouse	6%	3%
Factories	2%	1%
Shop	33%	17%
Others (e.g. food-and-drink outlets)	61%	79%

Table 10. Time spent delivering and average number of deliveries.

	2008		1999	
Freight type	Time spent delivering (min)	Average number of deliveries per day	Time spent delivering (min)	Average number of deliveries per day
Books and musical products	22	2.2	27	1.9
Building materials	32	1.8	37	1.2
Clothing	24	2.0	38	1.5
Flowers	24	1.8	28	1.1
Foodstuffs	28	2.6	22	2.1
Home accessories	40	1.8	45	1.2
Household or electrical appliances	23	2.2	33	1.3
Hygiene products	21	1.8	23	1.6
Laundry	16	2.5	21	2.1
Pharmaceuticals	13	2.1	23	1.9
Stationery	25	2.0	23	1.5
Other goods	21	2.6	29	1.6
Average	24	2.1	29	1.6

businesses explained the increase in freight traffic in absolute terms. In 2008, 39% of truck drivers stated they were the owners of vehicles, against 61% in the 1999 survey.

As regards trip frequency, in 2008, 31% of the interviewees had a frequency of one journey per day, and 37% more than one per day, which represents only a slight change over 1999 (41% and 38% respectively). Table 9 gives the distribution of journeys in relation to destination types. Shops and food-and-drink outlets were the main destinations.

The average number of deliveries per journey and the time spent on unloading operations are reported in Table 10. In 1999, the highest value was found among food retailers, with more than two deliveries daily and 22 min required to complete each delivery. However, the average time required to complete delivery operations decreased overall in 2008 (from 29 to 24 min), although operations related to foodstuffs required more time (plus 6 min).

The number of stops per journey increased for all types of freight (Table 10), probably due to the decrease in the share of own-account retail transport. Own-account retail transport generally involves a ring trip (one origin and one destination), while 3P trips have more than one stop.

Conclusions

The measures implemented in 2001 (mainly access restrictions and a charging scheme) have led to some major changes in freight transport patterns within the inner area of

Rome. Such regulations have proved effective in abating through-traffic, which has negative impacts (congestion) on the inner area, and in reducing the share of traffic by retailers doing their own restocking, which subtracts parking space from other vehicles and is less productive than 3P transport due to the lower load factor.

Comparison of the results from the 1999 and 2008 surveys shows a change in the freight vehicle fleet composition, with an increased share of less polluting vehicles. The share of smaller vehicles (with a gross laden weight below 1.5 t) also increased, while the quantity delivered also rose substantially. This can be seen as the operators' response to the problem of the lack of parking space combined with development in just-in-time (JIT) logistics. The number of deliveries per tour also increased, while the delivery time decreased as justified by the increase in 3P share. Indeed, although the study area experienced an increase in the presence of franchise stores, market chains and large-scale retail trade that mainly use 3P services, we revealed that this alone does not explain the reduction in own-account transport. Besides, the average loading factor in 2008 improved, exceeding 50%. In terms of daily pollutant emissions, the implemented measures allowed them to be reduced by more than 6%.

The 2008 survey shows that urban freight transport still raises some critical issues in the inner area of Rome. Among these are the time-wise distributions of freight loading and unloading operations, which are still concentrated in the morning hours, and, according to the operators' stated opinions, insufficient parking spaces for freight vehicles (that said, the use of dedicated parking spaces has increased.) Other critical aspects are the increase in the absolute number of freight vehicles accessing the inner area and increased restocking frequency, with a higher number of retailers receiving goods once or more times a day.

These critical aspects suggest that further measures to improve the efficiency of the goods distribution process are needed, such as those allowing the number of freight vehicles to be reduced, especially the most polluting ones, and the optimization of available spaces for loading and unloading, such as the automatic control of dedicated spaces. Measures leading to an increase in the load factor and a reduction in kilometers traveled, such as urban distribution centers, transit points and nearby delivery areas, also need to be considered and investigated by the municipality in order to achieve more sustainable freight transportation.

These types of study may be a useful pre-guide for city planners or administrations needing to ascertain whether a successful approach in one city is likely to prove successful in another, and whether the necessary conditions and organization required for such an approach are already in place.

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References

ACI. 2012. Autoritratto 2011, Rome, in Italian: Automobile Club d'Italia.

Allen, J., M. Browne, T. Cherrett, and F. McLeod 2008. "Review of UK Urban Freight Studies." Report Produced as Part of the Green Logistics Project: Work Module 9 (Urban Freight Transport), London, UK. http://www.greenlogistics.org.

Ambrosini, C., and J. L. Routhier. 2004. "Objectives, Methods and Results of Surveys Carried out in the Field of Urban Freight Transport: An International Comparison." *Transport Reviews* 24 (1): 57–77. Taylor & Francis.

BESTUFS. 2007. *BESTUFS - Good Practice Guide on Urban Freight*. BESTUFS Consortium: http://www.bestufs.net.

BESTUFS. 2008. *D3.2 BESTUFS Best Practice in Data Collection, Modeling Approaches, and Application Fields for Urban Commercial Transport Models*. BESTUFS II Project (Best Urban Freight Solutions), Sixth Framework Programme, http://www.bestufs.net.

Browne, M., J. Allen, and M. Attlassy. 2007. "Comparing Freight Transport Strategies and Measures in London and Paris." *International Journal of Logistics* 10 (3): 205–219. Taylor & Francis.

Browne, M., J. Allen, and J. Leonardi. 2011. "Evaluating the Use of an Urban Consolidation Centre and Electric Vehicles in Central London." *International Association of Traffic and Safety Sciences Research* 35: 1–6. Elsevier Ltd.

Comi, A., P. Delle Site, F. Filippi, and A. Nuzzolo. 2012. "Urban Freight Transport Demand Modelling: A State of the Art." *European Transport/Trasporti Europei* (51): paper 7, ISTIEE, Trieste, Italy.

Crainic, T. G., N. Ricciardi, and G. Storchi. 2004. "Advanced Freight Transportation Systems for Congested Urban Areas." *Transportation Research Part C* 12 (2): 119–137. Elsevier.

Filippi, F., A. Campagna, A. Comi, P. Delle Site, M. V. Salucci. 2008. "Survey on Freight Traffic, Comparison with 1999 Survey and European Regulation Best Practice." Report for the Sector Study on Freight Mobility in Rome. (In Italian).

Filippi, F., A. Nuzzolo, A. Comi, and P. Delle Site. 2010. "Ex-Ante Assessment of Urban Freight Transport Policies." In *Procedia - Social and Behavioral Sciences*, 6332–6342. Elsevier Ltd. DOI: 10.1016/j.sbspro.2010.04.042.

Ibeas, A., J. L. Moura, A. Nuzzolo, and A. Comi. 2012. "Urban Freight Transport Demand: Transferability of Survey Results Analysis and Models." In *Procedia - Social and Behavioral Sciences*, 1068–1079. Elsevier Ltd, DOI: 10.1016/j.sbspro.2012.09.822.

Jeffery, D. 2011. *Guidelines for Assessing the Transferability of an Innovative Urban Transport Concept*. NICHES+, Coordination Action funded by the European Commission under the Seventh Framework Programme for R&D, Sustainable Surface Transport.

de Jong, G., I. Vierth, L. Tavasszy, and M. Ben-Akiva. 2012. "Recent Developments in National and International Freight Transport Models within Europe." *Transportation* 40 (2): 347–371. Springer.

Muñuzuri, J., P. Cortés, J. Guadix, and L. Onieva. 2012. "City Logistics in Spain: Why It Might Never Work." *Cities* 29 (2): 133–141. Elsevier Ltd.

Nuzzolo, A., and A. Comi. 2013. "Tactical and Operational City Logistics: Freight Vehicle Flow Modeling." In *Freight Transport Modelling*, edited by Moshe Ben Akiva, Hilde Meersman, and Eddy Van de Voorde, chapter 21, 433–451. United Kingdom: Emerald Group Publishing Limited.

Nuzzolo, A., and A. Comi. 2014a. "Direct Effects of City Logistics Measures and Urban Freight Demand Models." In *Sustainable Urban Logistics: Concepts, Methods and Information Systems*, edited by J. Gonzalez-Feliu, F. Semet and J. L. Routhier, 211 –226. Springer-Verlag Berlin Heidelberg. DOI: 10.1007/978-3-642-31788-0_11.

Nuzzolo, A., and A. Comi. 2014b. Urban Freight Demand Forecasting: A Mixed Quantity/Delivery/Vehicle-Based Model. In *Transportation Research Part E*, Elsevier, DOI: 10.1016/j.tre.2013.12.014.

Nuzzolo, A., U. Crisalli, and A. Comi. 2008. "Metropolitan Freight Distribution by Railways." In *Innovations in City Logistics*, edited by E. Taniguchi and R. G. Thompson, 351–368. Hauppauge NY, USA: Nova Science Publishers.

Nuzzolo, A., U. Crisalli, and A. Comi. 2012. "A System of Models for the Simulation of Urban Freight Restocking Tours." In *Procedia Social and Behavioral Sciences*, 664–676. Elsevier Ltd, DOI: 10.1016/j.sbspro.2012.03.138.

Ogden, K. W. 1992. *Urban Goods Movement*. Hants, England: Ashgate.

Patier, D. 2006. "New Concepts and Organizations for the Last Mile: French Experiments and Their Impacts." In *Recent Advances in City Logistics - Proceedings of 4th International Conference on City Logistics*, edited by R. G. Thompson and E. Taniguchi, 361–371. UK: Elsevier Ltd.

Russo, F., and A. Comi. 2011a. "Measures for Sustainable Freight Transportation at Urban Scale: Expected Goals and Tested Results in Europe." *Journal of Urban Planning and Development* 137 (2): 142–153. American Society of Civil Engineers (ASCE), DOI: 10.1061/(ASCE)UP.1943-5444.0000052.

Russo, F., and A. Comi. 2011b. "A Model System for the Ex-Ante Assessment of City Logistics Measures." In *Research in Transportation Economics* 31 (1): 81–87. Elsevier Ltd, DOI: 10.1016/j.retrec.2010.11.011.

STA. 1999. *Study on Freight Mobility in the Rome Historic Centre*. (in Italian).

Stathopoulos, A., E. Valeria, and E. Marcucci. 2012. "Stakeholder Reactions to Urban Freight Policy Innovation." *Journal of Transport Geography* 22: 34–45.

Taniguchi, E., and R. E. C. M. van der Heijden. 2000. "An Evaluation Methodology for City Logistics." *Transportation Reviews* 20 (1): 65–90.

Visser, J., A. J. van Binsbergen, and T. Nemoto. 1999. "Urban Freight Transport Policy and Planning." In *City Logistics I*, edited by E. Taniguchi and R. G. Thompson, 39–69. Kyoto: Institute of System Science Research.

Yamada, T., E. Taniguchi, and Y. Itoh. 2001. "Co-Operative Vehicle Routing Model with Optimal Location of Logistics Terminals." In *City Logistics II*, edited by E. Taniguchi and R. G. Thompson, 139–153. Kyoto: Institute of Systems Science Research.