A classification of city logistics measures and connected impacts

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Abstract

Around the world, interest in urban and metropolitan goods movements is increasing since they account for a substantial share of traffic in urban/metropolitan areas. In this context, many city administrators have implemented measures to mitigate the negative effects of freight transport. Starting from an analysis of existing studies relative to freight policies implemented at urban scale, this paper proposes a general classification of measures adopted at an urban scale and an empirical analysis of obtainable results. © 2010 Elsevier Ltd. Open access under CC BY-NC-ND license.

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1. Introduction

The rapid increase in freight vehicles in urban and metropolitan areas contributes to congestion, air pollution, noise and increased logistics costs, and hence the price of products. In addition, a combination of different types of vehicles on the road increases the risk of crashes. An efficient freight distribution system is required as it plays a significant role in the competitiveness of an urban area, and it is in itself an important element in the urban economy, both in terms of the income it generates and the employment levels it supports.

Today, there is a worldwide focus on setting up a Sustainable Development Strategy to identify and define measures to achieve a continuous long-term improvement in quality of life by creating sustainable communities, able to manage and use resources efficiently, tap the ecological and social innovation potential of the economy and in the end ensure prosperity, environmental protection and social cohesion. Referring to the definition of sustainable development given during the World Commission on Environment and Development (1987), to meet the needs of the present without compromising the ability of future generations to meet their needs. It is necessary to propose new development models in the sphere of the United Nations Climate Change Conference of Bali (ONU, 2007), which culminated in the adoption of the Bali Road Map, consisting of a number of forward-looking decisions that

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represent the various tracks that are essential to achieve a secure climate future. In this context, development must be characterized by the definition of economic, environmental and social sustainability.

Although many indicators can be found with different goals and targets in the literature, in a compact way, we consider that economic and social sustainability can be treated in terms of efficiency and safety, and environmental sustainability in terms of air pollution. Importantly, the objectives of sustainable development can be obtained by measures that are sometimes conflicting, and generate impacts that are influenced by the acceptance of stakeholders and external factors.

Starting from an analysis of existing studies on freight policies implemented on an urban scale, we propose a general classification of city logistics measures and a brief empirical analysis of the results obtained. In the following sections, we first identify the functional relationships between producers and end-consumers; hence a detailed analysis of city logistics measures is given. The analysis is made in terms of actors involved and application fields. In particular, the proposed classification of measures seeks to identify homogeneous bands of interventions that are quite varied; secondly, some indications on the type of implementation are reported, seeking to unify measures that give similar results, after which conclusions are drawn. Analysis of implementable measures begins from the investigation of the relations and the interests of urban transport stakeholders/actors. During goods movements from origin to destination there may be different decision-makers who choose how the freight has to move. Implementation of city logistics measures must consider such different interests.

2. Urban Goods Movements and Its Actors

The urban transport system is a complex system in which freight is moved on the same transport system as that on which passengers travel. The global problem of urban freight transport simulation has been extensively treated elsewhere, with attempts to identify homogeneous freight movements in urban and metropolitan areas and relative decision-makers (actors); the complete problem of city logistics from the end-consumer to the producer has been rarely tackled. In this paper we refer to the assumptions of Russo and Comi (2006) who propose an integrated modelling system that allows the linkage between final consumer choices and restocking choices made within the urban or metropolitan area.

2.1. Urban goods movements

In the analysis of urban freight transport two main freight movements can be identified:

- **end-consumer**: these movements are made by end-consumers (customers) travelling from their residence/consumption zone to others where they make their purchases; for these types of movements it may be hypothesized that the decision-maker is the end-consumer;
- **logistics**: these movements allow freight to arrive at markets or directly at end-consumers; for these movements several decision-makers can be considered.

End-consumer movements concern movements in which freight is moved by the customer (private or business end-consumer) who purchases and consumes the goods (e.g. in this class of movement there is freight movement effected by a generic purchaser who buys goods in a shop and then transports them to a place where she/he will consume them). The unit of freight moved by end-consumers is called a **parcel**.

Logistics movements are those in which the freight reaches the facilities where it is delivered to markets for producing other products (goods) or services (e.g. freight movement from the warehouse to the retail outlet); these movements allow shops and warehouses to be restocked. The unit of logistic movements is called **size**.

As regards the various ways of moving freight from producers to end-consumers, several functional relations and trade schemes may be identified. Freight may reach end-consumers (Figure 1):

- without any contact points (**directly**), e.g. the customer buys on the web and the producer sends the products directly from the production site (white square) to their consumption site (black square);
- with one contact point that is usually called the **retailer**; in this case the producer uses the network of retailers (black circle) in order to reach the consumption zone;
with one or more contact points to consolidate or deconsolidate the load (white circle); these types of points derive from the need to reduce logistics and transportation costs.

As with the identification of these possible functional relationships among the producers and the consumers, some commercial schemes may be recognized. In fact, the commercial schemes may make the black circle (retailer) coincide with:

- the black square (consumption site); e.g. mail order selling,
- the white square (production site); e.g. sale at factory/firm, or
- the white circle (consolidation/deconsolidation sites): e.g. cash and carry.

![Urban scale: Functional relations and commercial schemes (Russo and Comi, 2006)](image)

2.2. Urban goods actors

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. The purpose of the measures to be implemented is to reduce the negative effects given by the interactions between goods vehicles and other infrastructure users. Several actors are directly or indirectly involved in urban goods transport (Ruesch and Glucker, 2001):

- the shipper (wholesaler), whose main interest is delivery and picking-up of goods at the lowest cost while meeting customer needs;
- the transport company, whose main interest is a low-cost but high-quality transport operation, satisfying the interests of the shipper and receiver (shop);
- the receiver/shop owner, whose main interest concerns products delivered at a short lead-time;
- the end-consumer; in this class we can consider:
  - inhabitants (residents or businessmen/employees), whose main interest is to minimise the disutility caused by goods transport;
  - the visitor/shopping public, whose main concern is to minimise the disutility caused by goods transport and variety of the latest products in the shops;
- public administration; in this class we can consider:
  - local government, whose prime concern is an attractive city for inhabitants and visitors: minimum disutility, though with effective and efficient transport operation;
  - national government, whose main interest is to minimize external effects from transport and maximize net economic benefits.
Interactions between freight actors at urban scale were studied by Wisetjindawat et al. (2007) who proposed a model for urban freight movement incorporating the behaviour of freight actors and their interactions in supply chains. Application to the Tokyo metropolitan area is also described. Analysis of stakeholder behaviour related to some measures has been proposed by Taniguchi and Tamagawa (2005), who developed a method for evaluating city logistics measures considering the behaviour of several urban freight transport stakeholders. In all, five stakeholders were considered: administrators, residents, shippers, freight carriers and urban expressway operators.

Analysis and selection of implementable measures has to consider such interests and find an optimal compromise between the interests of all the actors involved. This is a critical factor in the success of each city logistics measure, as confirmed in the UK. Indeed, UK Freight Quality Partnerships (FQPs) can be considered a key factor for studying and implementing successful city logistics initiatives (DfT, 2003). A FQP group might aim to identify problems and schemes and examine sustainable best practices, and help implement them. As Binsbergen and Visser (2001) have underlined, the objective of these methods is to create a, “supporting environment” for defining and implementing city logistics measures.

3. Proposed Classification of Measures

An initial list of measures related to urban freight transport was given by COST 321 (1998). About 60 measures were identified and classified into eight different classes. COST 321 provided quantitative results on the impacts of measures and estimated effects in projects and case studies. Following the COST 321 results, in 2000, the European Commission established a thematic network called, Best Urban Freight Solutions (BESTUFS) with a four-year duration. Interest in this project lead to the follow-up initiative, BESTUFS II. The two projects sponsored by the European Commission BESTUFS I and BESTUFS II provided handbooks and a best practice guide (BESTUFS, 2007) where regulation measures are addressed. These documents include case studies from European cities which provide details of measures implemented and their effects. BESTUFS (2007) proposes guidance to actors involved in the movement of freight in urban areas, when they are considering measures which may be implemented to improve the flows of products in urban areas and reduce the environmental impact of the operation. Three main classes of measures have been identified: goods vehicle access and loading approaches in urban areas (e.g. efficient usage of infrastructure; guidance on measures for goods vehicle access and loading in urban areas, technology in urban freight), principal issues involved in last mile solutions (e.g. home shopping via e-commerce) and principal issues associated with urban consolidation centres (urban distribution centres).

Investigation of tools and policies for urban goods distribution in some European cities was also conducted under another European project called City Ports that was concluded in 2005. This project produced a general method to address city logistics within a comprehensive framework where policies are defined after local analysis, ranking of critical issues, design and evaluation of specific solutions, and through the involvement of the various stakeholders. The proposed classification is based on the combination of two criteria: what is regulated (e.g. infrastructure, logistics platforms, operative times, vehicles and transport efficiency); how to regulate, by ordering the measures according to a more or less a “interventionist” style (e.g. by restrictive measures, by pricing measures; by permissive measures; by exchange of information between Public Administrations and those who actually are providing the transport services and by the setting up or management of certain services/infrastructures; by incentive measures).

Some examples of their application in the cities are also reported (City Ports, 2005). Starting from these proposals and in order to identify homogeneous characteristics that allow us to identify who must take decisions (public authorities, private companies or public-private partnerships) or who has to abide by them (end-consumers, receivers or shippers), we propose the following classification that also considers, implicitly these criteria and the possibility of a correlation with the links identified and depicted in Figure 1 could be:

- measures related to material infrastructure; such types of measures can be:
  - linear, if they refer to links of the urban/metropolitan transport network (e.g. use of an urban transportation sub-network only for freight vehicles);
  - surface (and/or nodal), if they refer to areas that can be reserved for freight operations (e.g. areas for loading and unloading operations, logistic nodes to optimise freight distribution in metropolitan/urban areas like Urban Distribution Centres);
• measures related to *immaterial infrastructure* (telematics) or Intelligent Transportation Systems; this class includes systems for traffic information, freight capacity exchange systems, route optimisation services, vehicle maintenance management systems, other information services through internet access, and centralized route planning;
• measures related to *equipment*; this class includes measures:
  ○ on loading units, if they refer to the introduction of new standards for loading units to optimize handling and transport by new low-emission vehicles;
  ○ on transport units, if they refer to characteristics of transport units (e.g. reduction in truck emissions and use of electric vehicles, methane vehicles, metropolitan railways and trams);
• measures related to *governance* of the traffic network; in this class we can find traffic regulations (e.g. access times, heavy vehicle networks, road-pricing, maximum parking times, maximum occupied surface and specific permission).

Implementation of one or a set of measures can be considered a *rational* decision-making process and it can have different temporal scales: strategic, tactical and operative (Russo and Rindone, 2007). Strategic horizons involve decisions associated with long-term capital investment programs for the realization of new infrastructure (material infrastructure measures) and/or the change of vehicles and technologies (e.g. equipment measures: environment-friendly vehicles; immaterial infrastructure measures: control systems). Short/medium term tactical implementation is concerned with decisions on projects requiring limited resources, usually assuming minor changes (or none) in infrastructure (e.g. governance measures: loading and unloading zones and road-pricing). Short-term operative programs can include the implementation of some measures regarding particular aspects of mode operations (e.g. governance measures: time windows and specific permits).

Further details on some these measures are presented below. Some test cases are also reported.

### 3.1. Material infrastructure measures

The main objective of this type of measure is to increase sustainability within the urban area by implementing actions to optimise freight transport. Material infrastructure measures can be classified as linear or surface.

Linear measures refer to urban transportation network links, hence definition of an *urban transportation sub-network only for freight vehicles*. Indeed, some city planners, who plan the flows of heavy vehicles within a metropolitan area on a larger scale usually distinguish small street network links from medium and large-size main routes. These measures mainly refer to transport companies, and to links between white and black circles (Figure 1). In this sphere, some cities have investigated the use of truck routes in order to minimise travel times and trip lengths for all trucks on the city’s road network and for all residents affected by freight traffic (economic and environmental impacts). As a result, the city printed and distributed a map for drivers with recommendations on routes. Final evaluation, in many cases, showed positive acceptance.

Example of surface measures are *loading and unloading zones*, which have provided good solutions for many dense urban areas. Such action affects transport companies, receivers and end-consumers (residents and visitors). Indeed, without such zones goods vehicles usually park on a 2nd parking row, with huge negative effects upon road capacity (economic and environmental impacts) at times. Many cities meanwhile provide dedicated zones for handling freight. For example, in Rome, the authorities are developing a new inner city plan and are considering the introduction of about 700 new areas for handling operations, all equipped by ICT to manage and control their usage. In the city of Stuttgart within the MOSCA project we find an example of electronic management of loading/unloading zones.

Rationalization of freight flows by installing a logistics platform, usually called an Urban Distribution Centre (UDC), has attracted great interest. The Urban Distribution Centre is a place for transhipment from long-distance to short-distance (urban) traffic where consignments can be sorted and bundled (white circle in Figure 1). This type of measure meets the interests of shippers and transport companies (potential users). The concept of logistics terminals (multi-company distribution centres) has been proposed in Japan to alleviate traffic congestion and reduce environmental, energy and labour costs (Taniguchi et al., 1999). Indeed, improvements in freight transport within urban areas are possible only by optimizing road freight transport, since more than 50% of freight travels under 50
km. Hence it is important to consider areas to consolidate/deconsolidate loads in order to improve the transported payload (economic impacts). Such centres could help re-balance the modal split and reduce environmental impacts.

To identify the potential development of Urban Distribution Centres (UDCs), in the United Kingdom the Department of Transport commissioned the Transport Studies Group of the University of Westminster to analyze the advantages and disadvantages, the impacts on transport operations and on other supply chain activities given by Urban Distribution Centres (Browne et al., 2005). Paglione (2008) presents a detailed analysis of the different types of UDCs, currently installed in Europe, clustering them according to specific key words and summarising the main advantages and disadvantages of their implementation.

The first example of a UDC implemented in Europe is the City Logistik Zentrum (CLZ) project in Munich where the local authority has planned to install a terminal, accessible by rail, from which to distribute goods to shops in the centre of Munich. The companies that use the CLZ as a central store facility (at a much reduced price compared to normal rent levels for business space in the city centre) will have to receive at least 40% of their traffic by rail and the final distribution of goods to Munich’s central retail areas will have to be by truck in consolidated shipments.

In Italy, implementation of a UDC in the city of Padua has had great success. It was the result of an agreement signed in 2004 between the Municipality, the Province, the Chamber of Commerce, the APS Holding Spa, and the Padova Interporto SpA. The operative scheme is totally voluntary even though the City Council that promotes its use has introduced some operating incentives such that vehicles operating from the UDC are allowed 24-hour access to the city, can use bus-only lanes and have reserved loading areas. The UDC serves clients linked to all kinds of supply chains, except for food (in particular those segments that need a controlled temperature), and prices them according to the use of service. Finally, the scheme was also able to achieve environmentally positive results. In particular, from 2005 to 2007 deliveries rose from 44,472 in 2005 to about 64,000 deliveries in 2007 (43%). Cityporto was able to save 11,000 km/month in terms of running operations and 270 round trips/month. Moreover, the total reduction in terms of external costs was 174,000 €/year, 132,500 €/year of which were linked to the reduction of emissions, 22,600 €/year to noise reduction, 12,400 €/year to the reduced accident rate and finally 6,500 €/year to the reduction in energy consumption (Stefan, 2008).

3.2. Immaterial infrastructure measures

Measures related to information and communication technology (ICT) may both improve the effectiveness (in terms of high service levels) and efficiency (in terms of cost reduction) of logistics flows, and reduce negative externalities as well as improve enforcement efficiency and broadening the scope of enforcement. These systems could be developed within some telematics architecture, e.g. KAREN (Keystone Architecture Required for European Networks) or ARTIST (Italian Telematics Architecture for Transportation System). With regard to urban freight transport, the ITS (Intelligent Transportation System) components could include Advanced Traveller Information Systems (ATIS), Advanced Traffic Management Systems (ATMS) and Advanced Vehicle Control Systems (AVCS), and mainly Commercial Vehicle Operation (CVO). They are generally considered to be components of an in-vehicle navigation system which uses advanced information and communication technology to manage traffic, advise drivers and control vehicle flow. With the use of telematics tools (usually termed ITS tools), it is possible to connect different modes of transport together, so as to take advantage of sustainable-friendly means of transport, as well as optimize distribution systems due to transport bundling and better loading capacity. Thus telematic tolls permit a reduction in external costs as well as private costs (e.g. lower overall logistics costs). In brief, the main objectives of telematics applications are to:

- promote the exchange of information among actors,
- support vehicle routing and scheduling according to the degree of congestion on the transport network,
- allocate loading/unloading bays efficiently, and
- increase the load factors of vehicles.

Telematic applications for electronic access control or traffic monitoring and traffic control are applied in several cities such as Maribor, Brno, Salzburg and Rome. These measures concern transport companies and shippers as well as public administrators. The policy considers the movements between white and black squares (Figure 1) and seek to reduce economic (e.g. in terms of traffic congestion) and environmental (e.g. air pollution) impacts. Another
example is provided by SURFF (Sustainable Urban and Regional Freight Flows) project. SURFF (2003) was a research project that examined network operations of freight centres and city logistics (urban distribution), and aimed to develop and evaluate a number of telematic solutions which were applied to freight centre users and urban distribution communities. A detailed analysis of the introduction of such tools for city logistics is reported in Taniguchi et al. (2001).

3.3. Equipment measures

This type of measure refers to the development of sustainable-friendly devices in terms of propulsion and handling (at pick-up and delivery sites). Such measures chiefly concern producers that, driven by the implementation of sustainability measures in urban and metropolitan areas, build new low-emission vehicles equipped with devices to facilitate handling and increase safety and security. This type of policy can be implemented, and may improve the sustainability of each city, independently of governance measures. For example, running-boards improve pick-up and delivery, electric engines are more environmentally sustainable and, finally, the introduction of parking sensors can improve social sustainability. These measures affect shippers and transport companies since they could modify their transport organization and fleet. As regards the movements reported in Figure 1, the measures are related to all links between the white squares and black circles.

An example of this type of measure is given by the Cargo Sprinter System, which uses small vehicles for city deliveries and a special transhipment technology to solve the problems of overhead line-horizontal movement and, finally, logistic boxes, standardised boxes, with different sizes used by rail and road vehicles (Dorner, 2001). Other examples are the Abroll Container Transport System (ACTS) in Switzerland, or Metrocargo in Italy, which have introduced new transhipment technology. Moreover, the Cargo Domino project in Zurich (operational since 2002) deploys special railway wagons to facilitate the horizontal transhipment of standard swap bodies between rail and road vehicles.

With regard to vehicles, we find many vehicle restrictions around the world according to their physical characteristics: weight, space occupancy and emissions. These measures seek to change the types of vehicles driving in inner cities, hence the vehicles used by transport companies. The objective of such measures is to reduce traffic congestion (weight and space) and air pollution (emissions). Their impacts are mainly on shippers and transport companies because they must be equipped with appropriate vehicles, and on end-consumers (residents and visitors in the urban area). Some cities such as Munich or Rome base their limits on vehicle weight (limit of 8.5 tons); others such as Milan and Brescia consider vehicle length (whether they are longer than 7 m or 6 m), while Piacenza considers width (the limit is 2.20 m). Vehicle restrictions are the most common regulations in Europe and tended in the past to be more restrictive in urban areas, which has enhanced the use (and number) of small delivery vehicles.

Recent measures tend to stabilize regulations at a higher weight level, producing less environmental impact due to fewer trips and corresponding lower emissions. Access regulations based on vehicle size and weight differ greatly within Europe but also from city to city within the same country. An increasing number of cities offer limited access to central urban areas for only zero-emission vehicles, electric vehicles or low-emission hybrid vehicles. Regulations related to transport vehicles are crucial for vehicle manufacturers and for fleet owners. They have to provide the right vehicle for a dedicated transport application in a dedicated region. The widest possible harmonization of regulations is therefore highly recommended. In other words, measures on vehicle weight, size and emissions standards regulations aim to reduce environmental impact and the risk of crashes involving goods vehicles.

Measures on vehicle weight usually concern the permissible maximum laden mass: vehicle length, vehicle width, vehicle area (length times width), number of axles. Although this form is widely used, it might lead to more trips performed by smaller vehicles and hence higher fuel consumption and polluting emissions.

Measures based on the environmental performance of vehicles aim to create incentives to use less polluting vehicles or even to renew the vehicle fleet. These measures can be based on propulsion, on emission class or on vehicle age. The propulsion mode may be petrol, diesel, electric, compressed natural gas (CNG), liquefied petroleum gas (LPG), hybrid (that is electric and fossil fuel propulsion, e.g. diesel-electric). Electric and CNG propulsions have the additional virtue that there is no generation of heavy vehicle traffic (tanker lorries) to supply filling stations. The emission classes can be derived from the Euro class based on existing Euro standards. The Euro standards set limits for exhaust emissions of the PM of diesel vehicles. For example in Rome, access and circulation
in the central area is prohibited for pre-Euro 1 and Euro 1 light vehicles and pre-Euro I and Euro I heavy goods vehicles.

Another example based on the environmental performance of vehicles is given by the use of railway vehicles for freight transport in metropolitan areas. Although the use of rail has been rather limited, it has been used in particular areas and time periods, e.g. transportation of some types of goods by tram, set up in some cities during the energy crisis, to satisfy some logistics needs of private firms or for restocking retailers who sell products within a congested metropolitan area in which a railway network already exists. In recent years, railways have been increasingly used for freight distribution within urban areas both to reduce accessibility of metropolitan areas to road transport due to congestion effects, and to implement environmental measures, despite the initial difficulties of rail transport being competitive with road transport. Examples are provided in the city of Dresden, Zurich and Amsterdam where cargotrams have been implemented. A test case was also developed in Italy within a European Initiative INTERREG IIIB (Mobilmed Project), in which an application to a real case (Sorrento Peninsula) was also developed (Nuzzolo et al., 2008). This freight railway service uses the residual capacity with respect to passenger services, and the above paper analyses its technical and economic feasibility. On-site application allowed us to prove the technical feasibility of this new freight railway system, and to assess the benefits of this new freight railway service with respect to road transport from a public authority point of view, which is keen to reduce externalities and enhance environmental quality.

3.4. Governance measures

The main city logistics measures that can be included within this class refer to: time window access, sub-network for freight vehicles, road-pricing, incentives to optimise transport efficiency (economic impacts, e.g. increasing load factor), and specialised permits (e.g. for use of loading zones).

Many cities have regulations on delivery time windows within city centres, especially for pedestrian zones. While such measures are easier to implement, they require a sound surveillance system to prevent any possible violation. These measures can influence the interest of recipients (retailers) who might at times modify shop opening times, and shippers and transport companies that must organize their activity in compliance with this regulation. The policy impacts are the connections between white and black circles are depicted in Figure 1.

An example is given by Rome where freight vehicle access and parking is subject to time windows in the inner area termed “LTZ freight” (Limited Traffic Zone). Heavy vehicles (more than 3.5 tonnes) are granted access and parking in the 8:00 pm to 7:00 am window. Light vehicles (less than 3.5 tonnes) are granted access and parking in the 8:00 pm to 10:00 am and 2:00 pm to 4:00 pm windows. Another possibility is given by night-time delivery in order to reduce traffic congestion during the day. However, this measure shows some limits (for example, night-time noise levels may increase); it has to be coordinated with land-use policies and, in particular, with the need to extend the time window within which commercial activities can perform their operations. An interesting example of night-time delivery is the city of Barcelona where under the CIVITAS project, the supermarkets MIRACLES receive deliveries during the night (between 10:00 pm and midnight) with the use of appropriate vehicles in order to reduce noise emissions. Night-time delivery was a trial measure implemented in the city of Dublin as well which then gave rise to a follow-up programme.

Great interest in time windows is shown by French cities, which can be divided into two classes: while some cities consider it a very good strategy to decrease the number of trucks in the city during the day, others argue that truck and delivery noise impacts are too high and night-time deliveries should be banned. Delivery time windows very much depend on the opening times of shops while local habits and cultural differences lead to an acceptance or disapproval of night-time deliveries. Regulations based on time windows is addressed in Quak and de Koster (2006) who review the state of practice in Dutch cities and provide an assessment of possible changes to current policy. Time windows seek to avoid interference with car traffic during peak hours, and to avoid interference with pedestrian traffic. In the former case prohibitions apply in early morning hours; in the latter they apply to hours when shops are open. A hybrid form of time windows with charging may also be applied: in certain hours freight transport is free of charge, in the remaining hours there is a permit to load and unload but only if a charge is paid. Generally, time windows pose a constraint on delivery and collection, producing a loss of efficiency. This explains why operators are not in favour of this measure.
Bus lanes are commonly found in cities. Permission to use them is often granted to other vehicle categories such as taxis, diplomatic cars and cars used by the disabled. Permission can be extended to certain categories of freight vehicles to create incentives, thereby developing a sub-network for freight vehicles (see also material infrastructure measures). Vehicles would benefit from higher speed especially if permission applied during peak hours. Transport companies would benefit from the reduction in travel time and hence increase the efficiency of their activities. This type of measure mainly concerns movements between the white and black circles identified in Figure 1.

Other governance policies concern the requirement of a minimum load factor. Here the aim is to create incentives to increase load factors, which is beneficial in terms of efficiency (economic impacts). This type of measure applies to transport companies and seeks to optimise transport between the white and black circles in Figure 1. Implementation of load factor differentiation faces a number of challenges as shown by the experience of Copenhagen and Göteborg (Markworth et al., 2005; TELLUS, 2005). It is possible to define criteria for the load factors by taking account the average, over a certain period, of indicators such as weight, volume, number of parcels or pallets, or the number of customers visited. There are, however, three problems:

- the first is how to set the threshold value for this measure; one solution is to estimate an average in the pre-scheme phase and to set the threshold slightly above the observed average; the Göteborg experience has shown that in view of load factor variability across vehicles there will be vehicles which will not be able to reach the threshold and would therefore lose the incentives; ideally the threshold should be differentiated on an individual basis;
- the second problem is due to the variability over time of the load factor within the same vehicle; the Göteborg experience has shown that in most cases it has been possible to improve the load factor only temporarily, which means it might not be sufficient to maintain the incentives;
- the third problem is to define the size of the area over which the load factor is calculated, whether this should be the area where incentives apply or a wider area covered by the delivery/collection routes of the vehicles.

The scheme requires a reporting mechanism since the city authority can calculate the load factor measure only on the basis of the data communicated by vehicles. The Göteborg experience has demonstrated that technology based on GPS, digital pen and mobile phones can be effectively used for the reporting task. As this equipment is an additional cost for the operators the scheme should be implemented on a voluntary basis to avoid opposition.

Interestingly, some city administrators have recently tried to create incentives to switch from own account to third account. The presumption here is that third account is more efficient. The problem of empty running in one leg of the delivery trip (return leg) and of the collection trip (outward leg) occurs in own account operations and is indicative of poor efficiency. Another reason is the occupation of parking spaces by own account vehicles which is seen negatively when, during idling periods, the vehicles are parked for many hours in areas with a shortage of parking spaces. An example is given by Rome, where incentives have been given by extending the time windows for third parties. In 1999, the share of third parties was about 46% and, with incentives, it became about 79% in 2007 (Comi et al., 2008).

Another type of governance measure is road-pricing. Different forms of access charging have been implemented in many cities. This measure is chiefly aimed at regulating passenger traffic. Underlying the scheme is one of the following alternative principles:

- all those willing to pay have access; payments are possibly subject to exemptions and discounts for certain categories, or
- only certain user categories are granted access and have to pay a charge for it.

This measure affects shippers, transport companies, receivers and end-consumers since its implementation could influence the cost of transport and hence the cost of products. It could also modify the revenue of some of the actors (e.g. transport companies), influencing goods movements between white and black circles in Figure 1. The congestion charging schemes in London and Stockholm are applied to both passenger and freight vehicles. All those who are willing to pay the charge are granted access to the central area. In London there are discounts for residents and exemptions for certain vehicle propulsion categories (electric, CNG, LPG and hybrid). For more details the
The reader can refer to Comi et al. (2008). In particular, the cited paper explores two case studies in Italy (Rome and Milan) and details concerning the range of opportunities are given by charging differentiation among vehicles.

Some cities issue specific permits, such as those for using loading and unloading zones. The aim is similar to that discussed in the case of material infrastructure measures with the difference that the areas are subject to specific permits. This is exemplified by the city of Barcelona where, given the lack of off-street loading capacity close to commercial premises, a system for multi-purpose lanes has been implemented. In particular, the system converts the equivalent of 44 on-street parking spaces into unloading spaces during prescribed (between peak) hours. During peak hours, the lane is used as a priority bus lane, while at night-time it is used for parking private vehicles. In the event of scarcity of delivery bays as well as their inappropriate use (e.g. occupied by private vehicles) regulations must be enforced so that they are used only by commercial vehicles and, in particular, commercial vehicles that meet certain requirements. For example, Göteborg has followed the strategy to permit the use of loading bays only to vehicles whose load factor was no less than 65%.

4. Conclusion

This paper reviewed city logistics measures that can be taken to regulate freight transport and logistics within urban and metropolitan areas. We have proposed a classification and have reported examples of implementation from many cities around the world. The framework can be a useful tool for city authorities when designing measures, which ideally should be done in co-operation with freight operators, and needing to verify whether their expected results match the results obtained in the other cities. Deciding on implementation measures requires a full assessment of social costs and who has to abide by them. The proposed classification allows us to identify who must take decisions or who has to abide by them, taking into account the possibility of a correlation with the functional relations among the producers and the end-consumers. Each measure has been interpreted in terms of actors/decision-makers involved, theoretical goals and obtainable results. Temporal reference scale (strategic, tactical, operational) was also recalled with some examples of cities where such measures have been implemented.

The dominant pattern currently found in cities is one where prohibitions are the rule. In order to carry out the obtainable measures according to their main promotor that is whether they are based on a public initiative, a private one or a joint initiative. While some of the measures outlined above are those promoted and implemented by public authorities, other categories are either promoted directly by private agents (especially with regard to management measures) or are the result of an incentive from public authorities to private agents. It emerges that many measures are related to economic and environmental sustainability, while only a few can be attributed to social sustainability (e.g. road safety). Sometimes the measures, which were classified in the paper in a specific class, are applied together with others. An example is given by the implementation of an Urban Distribution Centre (material infrastructure measures) which is generally supported by providing for the implementation of other governance measures. In Padua, the implementation of a UDC has created an incentive to switch from own account to third parties. Another example is given by the implementation of measures related to vehicles. Though classified herein as equipment measures, they are implemented as governance measures.

Infrastructure measures have a major short-term impact on urban freight transport. They also need time and to reach a certain break-even point (e.g., in terms of freight volume handled) to obtain good results. Finally, while some measures are easier to implement and at least show a higher degree of acceptability among stakeholders, they could require a sound surveillance system to enforce compliance. For this purpose a consultation forum or public-private partnership should be pursued.

References


Urban freight transport measures: environmental evidences from the cities

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Abstract: The paper, within the field of city logistics sustainability, recalls the overview of measures to be implemented, in a “what if” framework, with strong references to the ex-post assessment carried out in order to support the definition of city logistics scenarios that should have to be evaluated ex-ante by simulation models. The analysis is done in relation to the goals of environmental sustainability to be pursued and the main characteristics of the analyzed cities (e.g. population, density).

Keywords: city sustainability, urban freight transport, city logistics, environmental impacts.

1. Introduction

Today, there is growing interest in the concepts of sustainable development and then on sustainable transport. Sustainable city logistics solutions have to be implemented in order to reduce the effects of freight transport without penalizing the life of the city. For example, as it happens in passenger mobility we can brave the problems related to externalities related to transport addressing to transit. It allows us to do not reduce accessibility and penalize the life of the city. At the same way, city logistics
has to investigate the possible solutions that allow us to reduce externalities, to increase sustainability without damaging the city life.

Around the world, different types of city logistics measures have been proposed and implemented, but sometimes they have not given the expected results [1, 2]. Thus, as it happens in the analysis of passenger mobility, in which we have different classes of measures that can be implemented in relation to city structure and level of demand, the same should be desired for freight mobility.

The current development must be characterized by the definition of economic, environmental and social sustainability [3]. In fact, referring to the main accepted definition of sustainable development it meets the needs of the present without compromising the ability of future generations to meet their own needs [4] and, thus, of sustainable transport a sustainable transport system is one that is accessible, safe, environmentally-friendly and affordable [5] - it is necessary to propose new development models. Then, the rapid freight transportation increasing in 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 by means of measures that are sometimes conflicting, and generate impacts that are influenced by the acceptance of stakeholders and external factors.

In this context, the paper, within the field of environmental sustainability, recalls the overview of measures to be implemented, in a “what if” framework, with strong references to the ex-post assessment carried out in order to support the definition of city logistics scenarios that should have to be evaluated ex-ante by simulation models (Figure 1). The study presents the empirical relations among outcomes (e.g. reduction of greenhouse gas – CO₂ - or air pollutant emissions – CO, NOₓ, SOₓ, PM) and city logistics measures. The trends of expected results related to environmental sustainability in function of city characteristics will be deepened. From this type of analysis, it will be possible to identify the maximum expected reduction of externalities obtainable from a given city logistics measure in relation to a specific city.

**Figure 1.** City logistics ex-post and ex-ante assessment.
2. Urban Freight Transport and City Logistics measures

As confirmed by several empirical studies the total urban freight vehicles account for 6 – 18% of total urban travel [6, 7, 8] and for 14% of vehicle-kilometers, 19% of energy use and 21% of CO₂ emissions [9]. Some studies have also evidenced the importance of light vehicle against the heavy in the production of negative impacts within urban areas [10]. Others have studied the impacts due to the implementation of measures in order to shift logistics operations to night-time hours [11] or to the implementation of an urban distribution center verifying that it can be more effective in reducing environmental externalities than policies based on vehicle fleet renewal [12] or to the implementation of governance measures, such as access restrictions and charging scheme, that can cause some important changes in freight transport patterns [13].

It has to be also noted that in some cases it was difficult to quantify the impacts due to the implementation of recalled measures, at least for two reasons. For one hand, as several authors agree, the implemented measures are not yet fully validated for lack of interest by local authorities. For the other hand, there is a shortage of data. In a few cases comprehensive surveys have been carried out.

In order 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 has to do taking into account the possibility to use methods and models for the _ex-ante_ assessment. As proposed by Russo and Comi [14], a general modeling framework should allow us to simulate the choices of each decision-maker involved in the urban freight transport and logistics and to investigate how the policies and the following measures can influence her/his choices. In particular, the urban freight demand modeling is part of a general transportation modeling framework commonly used to assess and design the urban transportation system [15]. The used transportation models are also characterized in relation to their based assumptions, whether they represent user behavior or whether they are only statistical relations. Thus, there are descriptive models (empirical relations between freight demand and variables of the economic and transportation system), and behavioral models, in which there are explicit hypotheses on the decision-makers involved in the choices. It may be noted that for some analytical functions both the models can have the identical form. A recent overview of how models allow us to obtain behavioral solutions from descriptive data is given by Russo and Vitetta [16].

Respect to the city logistics measures, a classification that allows us to point out the involved decision-makers, outcomes and goals, planning horizons should be desirable. Then, we refer to that proposed by the authors in previous studies [17, 18]. Their classification should allow, in an easy way, to aggregate and analyze the city logistics measures respect to who takes the decision (public authorities, private company, public-private partnership) or which links of logistics system are interested (producer-wholesaler, wholesaler-retailer, producer-retailer), and which class of goals or outcomes can be pursued by their implementation.

The used classification of measures consists of four classes:

- _material infrastructures_, consisting of building new infrastructures in order to optimize the freight transport (e.g. urban distribution center, sub-network only for freight vehicles);
  - impacted decision makers: local government, logistics and transport operators;
goals: to increase sustainability within the urban area by building new features (linear and surface) in order to optimize freight transport;
planning horizons: strategic (or tactical);

- **non-material infrastructures**, consisting, generally, of solution related to research, learning and training, while we also consider the telematics in terms of Intelligent Transportation System (ITS);
  - impacted decision makers: local government, logistics and transport operators;
  - goals: to improve effectiveness (in terms of high service levels) and efficiency (in terms of cost reduction) of logistics flows, and reduce negative externalities, also improving enforcement efficiency and broadening the scope of enforcement;
  - planning horizons: tactical and operative (sometimes strategic e.g. traffic monitoring);
- **equipment**, consisting of the introduction of new standards for loading and transportation units;
  - impacted decision makers: logistics and transport operators;
  - goals: to optimize handling and transport by new low-emission vehicles (loading units); to reduce environmental impacts of transport units (e.g. reduction in truck emissions and use of electric vehicles, methane vehicles, metropolitan railways, trams);
  - planning horizons: strategic or tactical or operative
- **governance**, consisting of the actions related to traffic regulations and limits;
  - impacted decision makers: logistics and transport operators;
  - goals: to reduce the interference with other components of urban mobility, to reduce the number of driving vehicles;
  - planning horizons: strategic or tactical or operative

This used framework mainly refers to specific measures and not to cross measures, such as measures related to promotion, cooperation and enforcement which need different types of models to assess. For more details on implementation steps and/or difficulties encountered, the reader can refer to large literature on this topic [19, 20, 21 and references quoted therein].

3. Results and Discussion

Starting from the *ex-post* analysis of implemented city logistics scenarios in Europe in the last 6 years, some environmental indicators will be proposed in order to support the definition of freight planning within the urban transport planning. Moreover, sustainable transportation is difficult to measure directly so various performance indicators could be used to evaluate them. For example, pollutants can be directly measured or not, and then we can have direct (e.g. NOₓ) or indirect (e.g. CO₂) measures.

In order to find possible relationships among city characteristics, city logistics measures and environmental outcomes (i.e. reduction of CO₂ that, in general, can be assumed to be a proxy of air pollutant emissions; CO, NOₓ, SO₂ and PM), a depth desk-research has been carried out. It has to note that, in the paper, we mainly refer to European cities and to urban structure (location) typically found
in Europe and in the East coast of North American (USA and Canada) and Australia. Although around the world we found very different urban structures characterizing the megalopolis of countries as China, India, Central and South American, and Africa that differ from European cities (in terms of population and width), many of the results presented in the paper can be extended to other metropolises that can be considered extensions of cities.

The Table 1 lists the investigated cities with the impacted population and density. It should be noted that, generally, in the cities we find a city logistics scenario defined as mix of previous recalled measures. Thus, it makes the identification and quantification of specific measure outcomes near to very difficult. Thus, only the cities, where the outcomes related to a given measure can be extracted with a good approximation, have been considered. Moreover, the city center is interested by both passenger and commercial vehicles, but many times the local administrators implement the city logistics scenario without modifying the passenger regulations. Then, the outcomes related to freight due to city logistics scenario implementation can be estimated. Moreover, it should be noted that the following analyses are only based on data and *ex-post* assessment directly available in literature.

<table>
<thead>
<tr>
<th>City</th>
<th>Population * [inhabitants]</th>
<th>Density * [inh./km²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam</td>
<td>767,849</td>
<td>4,618</td>
</tr>
<tr>
<td>Bordeaux</td>
<td>215,374</td>
<td>4,672</td>
</tr>
<tr>
<td>Bremen</td>
<td>547,685</td>
<td>1,676</td>
</tr>
<tr>
<td>Bristol</td>
<td>433,100</td>
<td>3,639</td>
</tr>
<tr>
<td>Canton Thurgau</td>
<td>244,33</td>
<td>247</td>
</tr>
<tr>
<td>Enschede</td>
<td>157,321</td>
<td>1,116</td>
</tr>
<tr>
<td>Genoa</td>
<td>59,883</td>
<td>2,5</td>
</tr>
<tr>
<td>Gothenburg</td>
<td>240,000</td>
<td>5,714</td>
</tr>
<tr>
<td>Gyir</td>
<td>130,476</td>
<td>731</td>
</tr>
<tr>
<td>Kassel</td>
<td>194,774</td>
<td>1,824</td>
</tr>
<tr>
<td>La Rochelle</td>
<td>76,711</td>
<td>2,737</td>
</tr>
<tr>
<td>Lisbon</td>
<td>564,657</td>
<td>6,643</td>
</tr>
<tr>
<td>London</td>
<td>1,806,200</td>
<td>10,792</td>
</tr>
<tr>
<td>Lucca</td>
<td>84,939</td>
<td>458</td>
</tr>
<tr>
<td>Milan</td>
<td>77,000</td>
<td>9,39</td>
</tr>
<tr>
<td>Padua</td>
<td>213,941</td>
<td>2,304</td>
</tr>
<tr>
<td>Paris</td>
<td>2,203,817</td>
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</tr>
<tr>
<td>Regensburg</td>
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<td>1,845</td>
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<tr>
<td>Rome</td>
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</tr>
<tr>
<td>Siena</td>
<td>54,391</td>
<td>461</td>
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<tr>
<td>Sorrentina Peninsula</td>
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<td>1,156</td>
</tr>
<tr>
<td>Stockholm</td>
<td>1,440,000</td>
<td>1,176</td>
</tr>
<tr>
<td>Tilburg - Eindhoven</td>
<td>214,036</td>
<td>2,441</td>
</tr>
<tr>
<td>Utrecht</td>
<td>16,596</td>
<td>3,093</td>
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<tr>
<td>Vilnius</td>
<td>560,192</td>
<td>1,397</td>
</tr>
<tr>
<td>Zurich</td>
<td>1,284,052</td>
<td>743</td>
</tr>
</tbody>
</table>

* impacted /involved by city logistics measures

The reduction of pollutants per month has been investigated for the following set of measures: material measures (i.e. sub-network, urban distribution center and nearby delivery area), non-material measures (i.e. intelligent transportation system), equipment measures (i.e. sustainable performance and railway) and governance measures (i.e. time windows and area-pricing).

The outcomes to be obtained by each measure are analyzed in function of specific characteristics of cities (e.g. population, density). In the following the results will be analyzed both for class of measures
(aggregate) and for specific ones (disaggregate). This analysis should be considered a pre-guide that should be a useful source of information to identify the measures which have the potential to be applied in a specific city. In other words, given a city the study wants to evidence the existing relations among environmental outcomes and city logistics measures.

3.1. Aggregate class outcomes

For each investigated city, the monthly reduction of CO₂, CO, NOₓ, SOₓ and PM has been expressed as a function of attributes related to the city (i.e. population) and class of city logistics measures. For each city, the monthly reduction of greenhouse gas and air pollutants ($ROP_z$) has been expressed as follows:

$$ROP_z = \beta_{POP,z} \cdot POP + \sum_h \beta_{h,z} \cdot X_h$$

where $POP$ is the impacted population, $X_h$ is a dummy variable specific for each class of city logistics measures $h$, and $\beta_{,h}$ is the parameter to be calibrated.

The following pictures (Figure 2 and 3) report the obtained results in terms of sustainable outcomes and allow us to do a comparison among the four measure classes. It should be noted that no available data have been found for PM reduction due to ITS implementation. In general, the material infrastructures measures produce averagely not good results. The best results could be obtained by the implementation of governance measures as well as time windows and area-pricing. This analysis does not consider the investment costs, but it has to note the investment costs are one of the most important factors for city logistics measures assessments. Further analyses are in progress in order to study the relationships between city logistics outcomes and investment costs.

The Figure 3 highlights, given a city, which could be the average contribution of each class of measures in relation to the sustainability goals. We can note that the incidence of non-material infrastructure is always higher than 32%, exception for CO emission for which is it is 21%. If we refer to the CO₂ emission (it can be considered a proxy of energy consumption and air pollutant emissions), we can see that the better results are always given by non-material infrastructure, but similar results could be also obtained by equipment measures (Figure 4).
Figure 2. The monthly reduction of air pollutants for class of measures (direct measures).
**Figure 3.** The incidence of each class of measures on the monthly reduction of air pollutants (direct measures).

**Figure 4.** The monthly reduction of greenhouse gas and incidence of each class of measures (indirect measures).
3.2. Disaggregate measures outcomes

Starting from the previous aggregate results, the analysis has been deepened for each specific implemented measure. A monthly reduction index \((IR_z)\) has been calculated as follows:

\[
IR_z = \sum_k \beta_{k,z} \cdot X_k
\]  

where \(IR_z\) is the monthly reduction of greenhouse gas or air pollutant \(z\) (\(ROP_z\), see eq. 1) respect to density of the given city, \(X_k\) is a dummy variable specific for each city logistics measure \(k\), and \(\beta_k\) is the parameter to be calibrated.

The results for greenhouse gas and air pollutants are reported in Figures 5 and 6. Given a city, the best results in terms of index reduction (i.e. monthly reduction respect to city density) could be obtained by sustainable performance and ITS and time window measures. The lower values refer to material infrastructure measures that also require high investments. Further analysis should be required to consolidate these first results.

The results show the large differences in the index among the analyzed city logistics measures; the material infrastructure (i.e. urban distribution center and sub-network) and equipment (i.e. sustainable performance) measures produce lower reduction of index than other classes of measures do. The non-material measures as well as governance measures allow us to obtain higher values of reduction.

In Figures 6, the estimated parameters have been plotted in a graph in order to better evidence the incidence of reduction of externalities that can be obtained by a given city logistics measure in relation to a specific city. The diagram evidences that, starting from the equipment measures (sustainable performance) toward higher-sustainable performance measures (railway), the higher values of monthly reduction of air pollutants could be obtained by governance measures (i.e. time windows or area-pricing) and ITS. These last measures are those that also present the lower investment costs. Finally, Figure 7 reports this analysis in terms of greenhouse gas emissions. It confirms the role that could have the ITS and governance measures against the air pollutant emissions.
Figure 5. The monthly reduction of greenhouse and air pollutants for measure (direct measures).
Figure 6. The incidence of each measure on the monthly reduction of greenhouse and air pollutants (direct measures).

Figure 7. The monthly reduction of greenhouse gas and incidence of each class of measures (indirect measures).
4. Conclusions

This paper reviewed some city logistics measures that can be taken to regulate freight transport and logistics within urban and metropolitan areas. The focus is on that measures that have been frequently found around the European cities. The paper recalls a city logistics measure classification proposed by the authors, and analyses some ex-post assessments carried out in many cities around the Europe. The paper provides an outline of measures that can be considered by analyst in the definition of project/scenario in relation to the goals to be pursued in his community, and gives some environmental results for each measures (magnitude); in this way the analyst can have some main indications about the results that he can wait in his community by their implementation. Each measure has been interpreted in terms of actors/decision-makers involved, temporal reference scale (strategic, tactical, operational), theoretical expected goals and tested results (outcomes).

The study focuses on environmental goals to be expected by their implementations. The analysis has been deepened in terms of greenhouse gas and air pollutants. The indications of this study can be considered a useful guide for: city authorities when designing measures, need to verify whether their expected results match the results obtained in the other cities in the way of defined goals; experts, when designing and assessing city logistics scenario and needing to identify who must take decisions or who has to abide by them, with strong references to the goals of sustainability.

In fact, from public utility point of view, the most important aspect is to promote a sustainable development strategy, monitoring and controlling the different types of costs generated by freight mobility in the urban area. These costs are mainly connected with the impact on traffic congestion of vehicles circulating for freight transport, as well as of the road capacity reduction caused by vehicle stops for loading or unloading operations, and of goods vehicle pollutant emissions. Thus, in order to make urban mobility more sustainable, measures to reduce the impacts of freight transport have to be implemented. Consequently, for ex-ante assessment, identification and classification of implementable measures, and models useful for the simulation of different scenarios are required. Then, the paper has wanted to define a tool that can be used in order to define a first set of implementable measures that can be used to reach the environmental sustainability goals.

It should be also evidenced that governance measures have positive effects by the point of view of end-consumer actors, but they are often rejected by logistics operators because they could determine an increasing of transportation costs. Thus, it is important to recognize and adequately understand the concerns of different actors and their problem identification with respect to urban freight transportation in order to introduce city logistic policies successfully.

While some measures are easier to implement and at least show a higher degree of acceptability among stakeholders, they could require a sound surveillance system to enforce compliance. For this purpose a consultation forum or public-private partnership should be pursued.

The results obtained and described in the paper evidence that not high cost investments are required to obtain good results in terms of environmental goals. Further analyses are in progress in order to find relationships among outcomes and investment costs. Finally, other developments could aim to improve the presented results and to investigate the other fields of sustainability (i.e. economic and social) in order to verify if relationships similar to those presented for environmental sustainability exist. Analogously, other fields within the environmental sustainability should be investigated such as noise, view and so on.
Conflict of Interest

The authors declare no conflict of interest.

References


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A system of models for the assessment of an urban distribution center in a city logistic plan

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Abstract

The ex-ante assessment of the impacts generated by city logistics measures cannot be separated by the use of simulation models able to reproduce the process of distribution of final products.

The paper reports the use of urban freight demand models and proposes an aggregate simulation approach to support the ex-ante assessment of a specific distribution service connected to a nodal physical infrastructure, in particular an Urban Distribution Center (UDC).

Models have been tested in a town of southern Italy (Reggio Calabria), where a UDC has been planned. The UDC could offer a competitive service to retailers and generate positive impacts on traffic and environment, in order to balance the increasing cost of transhipment for each carrier.

Keywords: city logistics, urban freight demand models, urban distribution center.

1 Introduction

One of the main objectives of city logistics concerns the reduction of negative externalities generated by freight transport without depressing economic and social vitality of urban areas.

From the public utility point of view, the above objective is part of a more general goal concerning sustainability, which should ‘ensure that transport systems meet society's economic, social and environmental needs, at the same time minimizing negative repercussions on the economy, society and environment’ (reported in [1] as a synthesis of the international debate).
Thus, in order to make urban mobility more sustainable, it is necessary to implement city logistics measures in order to reduce the impacts of freight transport in urban areas. A review of measures and their results is presented in [2–4]. In many cases, implemented measures have been proved ineffective, or have given contrary results to the expected ones. This was due to the fact that many of them have been implemented without an ex-ante assessment, supported by simulation models considering all the involved actors. In order to estimate and evaluate the performance and impacts generated by urban freight measures, a key role is played by simulation models which should be able to reproduce the process of distribution of final products.

In the above context, the paper reports the use of urban freight demand models and proposes an aggregate simulation approach able to support an ex-ante assessment of the impacts of a city logistics measure. The measure considered is a specific distribution service connected to a nodal physical infrastructure, in particular an Urban Distribution Center (UDC).

The system of models has been tested in a town of southern Italy (Reggio Calabria), where a new UDC, oriented to small and independent retailers, has been planned. The thesis is that the planned UDC could offer a competitive service to retailers and could generate positive impacts on traffic and environment.

The paper is structured into four sections. Section 2 synthetically presents the characteristics of the UDCs and the lessons learned from the review of the studies existing in literature. In Section 3 the main elements concerning the system of models for analysis of the freight distribution processes in urban areas is presented. Section 4 reports the preliminary results of the application aimed to simulate the impacts of the introduction of a UDC in terms of distances travelled and travel time. These metrics have been ex-ante estimated by comparing pre- and post-UDC conditions, and thus the measured improvement are related to the traffic diverted through the UDC.

2 Review on urban distribution centers

There is a wide range of city logistics measures that can be grouped into four categories [1, 5, 6]:

- measure related to governance, such as delivery/pick up time windows, road pricing;
- measures on equipment, relevant to loading units (new standards) or transport units (e.g. low impact vehicles);
- measures relevant to immaterial infrastructures, such as research and education, Intelligent Transport Systems (telematics);
- measures relevant to physical infrastructures, that can be divided into linear infrastructures (i.e. roads reserved to freight vehicles only) and surface infrastructures (and/or nodal) such as loading/unloading areas, distribution centres).

An UDC is a nodal physical infrastructure, which can be defined as “a facility involving the transhipment of goods directed to urban areas, aiming to
consolidate deliveries, and thus provide greater efficiency (and effectiveness) in the distribution process by increasing the truck load factor and decreasing the number of trucks used, which help mitigate urban congestion and air pollution” (see [7]).

The presence of an UDC allows shaping a new service in the urban freight distribution process, which allows freight to be carried by means of larger vehicles outside the city and, after the transhipment, by means of smaller and less polluting vehicles inside the city.

The transhipment operation increases the costs connected to handling, ordering, inventory, damage and loss; but it could give benefits connected to the consolidation of the consignments and the optimization of freight vehicle routes and loads. Several studies on the design of optimal routes of freight vehicles in urban area are reported in [8–10].

The entity of costs and benefits connected to the UDC depends on several elements connected to [7, 11–13]:

- structure and regulations of urban transport facilities and services: size and configuration of roads, traffic conditions and regulation, pedestrian areas;
- characteristics of the UDC
  - physical and organizational: size, location, store capacity, types of vehicles, presence of additional services;
  - governance: degree of financial support from public institutions, presence of public in the ownership and management, characteristic of operational agreement, market areas to be covered;
- carriers freight transport operators (e.g. own account or third party, available vehicles and drivers, number of consignments in the urban area, availability of warehouses, ....) and retailers (e.g. freight received per day, store capacity, location, parking availability);
- type of freight to be delivered.

Although UDCs have been planned and implemented in several European cities (in Italy, there are the examples of Padua and Geneva), few initiatives continue to operate after some years from their implementation.

Some general lessons learned from the review of the existing studies are reported in the following. Bottom-up initiatives seem to be more successful than top-down ones because shippers, carriers and retailers are involved since the early stages of the implementation, providing their decisive contribution in the achievement and maintenance of the break-even threshold of activity level [14].

The introduction of traffic restrictions to freight transport operations, which range from time windows, to vehicle weight or speed limits, to clean vehicles, tend to favour UDCs if the restrictions are accepted by operators (e.g. by using clean vehicles, or incrementing load coefficient) or if they are fully or partly exempted from the restrictions. UDC initiatives seem to potentially work better for deliveries with a high frequency, low volume, and that contain simple products. As far as concerns logistics trips, the major potential beneficiaries of an UDC are independent and small retailers, since their deliveries are generally
not optimized (in contrast to those of retail chains), as well as carriers making small multi-drop deliveries in areas where restrictions on delivery conditions exists (e.g. restricting regulations or congestion) (see [15]).

The above elements concerning the failures or the (potential) benefits of the planned UDCs emerged after their implementation in the different urban contexts. They are the result of a long and costly ‘trial and error’ approach, which emphasize the need of urban freight demand models able to simulate the effects of a planned UDC, verifying its technical compatibility and evaluating its convenience. In particular, it is necessary to finalize the research to link model system and experimental counts in terms of freight vehicles specified for typologies (capacity, refreshed,..) and for the time of day. The model system used belongs to the topological-behavioral approach that has a very large literature [16, 17], recently enlarged by the contemporary use of different data sources, that give the reverse problem formulation [18].

3 Urban freight demand models

Freight travel demand in urban area is mainly generated by two types of trips [1, 5, 6]:

- shopping (attraction) trips, made by end-consumers (residents, workers) that travel from a residential (working), or consumption, zone to a purchasing zone;
- restocking (acquisition) trips, made by retailers, carriers, forwarders, that allow delivering the freight to the warehouses and shops, or directly to the end-consumer.

The two classes of trips may be performed by means of so-called pull or push movements (see Figure 1). In the former case, the final consumer (retailer) buys (stocks up) directly from a shop (warehouse) and he can be considered the decision-maker of the shopping (restocking) process. In the latter case, other actors choose how and from where the freight must be delivered to the final consumer (retailer), who can give some indications regarding the delivery time.

Moreover, the shopping (restocking) trip can be assumed to be a round trip if it has one residential or working zone (the shop) as origin and one shop (warehouse) as destination, or a chain trip if it has one residential or working zone (the shop) as origin and multiple shops (warehouses) as destinations.

The round (chain) trip may be open if the origin of the on-going trip is different from the destination of the coming back trip (e.g. final consumers who go out from home, make a stop in a (or more) shop(s) and reach their workplace) or closed otherwise (e.g. final consumers who go out from home, make a stop in a (or more) shop(s) and come back at home). The round (chain) trip for logistic pull movements is open if the retailer starts her/his trip from the shop, makes stop(s) in one (or more) warehouses and reach her/his own warehouse located in a different area from the shop. The round (chain) trip for logistic push movements is generally closed, because the trip starts and ends at the same point (warehouse).
The ex-ante assessment of the impacts on traffic due to the introduction of an UDC requires the specification, calibration and validation of freight demand models, which allow simulating the choices of the decision-makers involved in the urban freight transport and logistics.

The system of models used in this work consists of two levels, as shown in Figure 2.

Figure 1: Schemes of urban freight mobility (source: [1]).

Figure 2: General framework of freight demand models.
The former is the \textit{commodity level}, which simulates the attraction and acquisition movements which are the results of respectively end-consumer and retailers/carriers/wholesalers choices. It concerns the estimation of demand flows in quantity for each freight type by \( o-d \) consumption pair and by \( d-w \) (or \( d-z \)) restocking pair.

The latter is the \textit{vehicle level}, which focuses both on the shopping (by end consumer) and restocking (by retailer) processes. It allows converting quantity flows into vehicle flows. The models concern the determination of the service, vehicle and time used as well as the path chosen for restocking sales outlets, and in similar pattern for shopping. In case of retailer the models have the same structure for movements of push and pull type; while in case of end consumer the structure of the models differ when the movement is of push type (equal to the push type of retailer) or of pull type.

3.1 Models for commodity level

Models for commodity level can be subdivided into:

- attraction macro-models, for connection between zones in which the goods are bought by the end-consumer and zones where the goods are consumed
- acquisition macro-models, for connection between zones where the retailers take the goods and zones where they sell them

3.1.1 Attraction macro-models

It is necessary, preliminary, to introduce some definitions and notations concerning:

- the identification of study area as spatial definition problem of zoning
  \( o \), internal zone in which the end-consumer (e.g. family) consumes (uses) the goods and the residences and services (offices) are located; in these zones the goods are consumed, or their use starts;
  \( d \), internal zone in which the end-consumer (e.g. family) can purchase the goods which the retailer sells; the shops are located in these zones;
  \( w \), internal zone to which the retailer can bring goods sold in his shop;
  \( z \), zone outside the study area where the end-consumer can purchase the goods which an out-retailer (or other) sells, or the (internal) retailer can bring the complementary goods sold in his/her shops.

- the socio-economic characteristics of end consumers and the types of goods
  \( \text{pop}_o (\forall o \in I_o) \), number of residents;
  \( \text{fo}_o (\forall o \in I_o) \), number of families;
  \( \text{mo}_o (\forall o \in I_o) \), average number of members per family
  \( s \), good typology (e.g. non-perishable food) that the end consumer (e.g. family) can purchase;
  \( J_o \), set of goods typologies \( s \).
Assuming that the decision-maker (end consumer) is the family, the quantity of good purchased by each family is obtained as:

\[ q_{sto} = \sum_j \beta_{js} y_{js} \quad \forall \; o \in I_o, s \in J_s \quad (1) \]

with

- \( q_{sto} \): quantity purchased of good typology \( s \) by family in zone \( o \) in the reference time period \( t \);
- \( y_{js} \): attribute \( j \) of family related to good typology \( s \);
- \( \beta_{js} \): parameter.

The total quantity of good \( s \) purchased by all families living in zone \( o \) in the reference time period \( t \), \( Q_{sto} \), is:

\[ Q_{sto} = \sum_o q_{sto} \quad \forall \; o \in I_o, s \in J_s \quad (2) \]

A distribution model estimates the probability to purchase goods in a zone of the study area:

\[ p[d/ost] = \frac{\exp(V_{d0})}{\sum_{d'} \exp(V_{d'o})} \quad \forall \; o \in I_o, d, d' \in I_d \quad (3) \]

where:

- \( p[d/ost] \): probability of purchasing good of type \( s \) by family in zone \( d \) conditional upon leaving from \( o \) in reference time period \( t \);
- \( V_{d(d')o} \): systematic utility associated to purchasing in zone \( d(d') \).

### 3.1.2 Acquisition macro-models

The total quantity of good \( s \) acquired by retailers located in zone \( d \) in reference time period \( t \), \( Q_{std} \), is estimated as:

\[ Q_{std} = \sum_o p[d/ost] Q_{sto} \quad \forall \; o \in I_o, d \in I_d \quad (4) \]

where the quantities \( p[d/ost] \) and \( Q_{sto} \) are obtained respectively by means of eqs (2) and (3).

### 3.2 Models for vehicle level

Different classes of urban freight vehicles are used to delivery good, which differ according to loading capacity. Each class belongs to the set of Large Good Vehicles, \( I_{lgv} \), characterized by a loading capacity \( C_{lgv}^g \) (\( \forall \; lgv \in I_{lgv} \)).

The number of vehicles for each \( lgv \) class is estimated as:

\[ F_{lgv_{std}} = \frac{Q_{std}}{\eta_{lgv} C_{lgv}} \quad (5) \]

where
$F^{lgv}_{std}$ is the number of vehicles delivering good typology $s$ having zone $d$ as
destination in time period $t$; 

$\eta^{lgv}_{s}$ is the loading factor of lgv vehicle delivering good typology $s$;

The target time of each restocking trip is estimated by means of a time model:

$$p[\tau/dst,lgv] = \text{prob}[U_{\tau} > U_{\tau'}] \quad \forall \tau \neq \tau'; \; \tau' \in t$$  \hspace{0.5cm} (6)

where

$p[\tau/dst,lgv]$ is the probability to deliver goods of type $s$ to zone $d$ by means of an
lgv vehicle at time $\tau$ belonging to reference time period $t$;

$\tau$ is the desired departure/arrival time from/to zone $d$;

$U_{\tau(\tau')}$ is the perceived utility associated at target time $\tau(\tau')$.

Therefore, the flow of lgv vehicles delivering goods of typology $s$ towards zone
$d$ at target time $\tau$, $F^{lgv}_{std}$, is estimated as:

$$F^{lgv}_{std} = p[\tau/st,lgv,d] F^{lgv}_{std}$$  \hspace{0.5cm} (7)

where the quantities $F^{lgv}_{std}$ and $p[\tau/st,lgv,d]$ are obtained respectively by means
of eqs (5) and (6).

The probability of choosing the restocking area $w$ for a retailer located in zone
$d$ which acquires good of typology $s$ in time period $t$, $p[w/std]$, is estimated by
means of a restocking area choice model:

$$p[w/dst] = \exp (V_{wd}) / \sum_{w'} \exp (V_{w'd})$$  \hspace{0.5cm} (8)

where $V_{wd(d')}^{std}$ is the systematic utility associated to reach the restocking area $w$
conditional upon leaving from $d(d')$.

Finally, the flow of lgv vehicles delivering the good of typology $s$ from zone
$w$ to zone $d$ in reference time period $t$ is obtained as:

$$F^{lgv}_{std} = \sum_{d \in da} p[w/std] F^{lgv}_{std}$$  \hspace{0.5cm} (9)

where the quantities $F^{lgv}_{std}$ and $p[w/std]$ are obtained respectively by means
of eqs (7) and (8).

4 Application

The proposed system of demand models has been tested in a town of southern
Italy (Reggio Calabria), where a new UDC, oriented to small and independent
retailers, has been planned. The thesis is that the planned UDC could offer a
competitive service to these retailers and could generate positive impacts on
traffic and environment, in order to balance the increasing cost of transhipment
for each carrier.
The application started with the definition of the study area, which included the municipality of Reggio Calabria (180,000 inhabitants and an extension of 236.02 Km²). It consists of a central district with mixed residential and retail activities and clustered educational and public services; and of suburban districts with manufacturing activities and scattered residences.

The central district was the portion of the study area where the system of models has been applied (Figure 3(a)–(b)).

The application of models for the commodity level has regarded:

- the estimation of the quantities of not-perishable food purchased in independent retailers located in the central district, by means of the acquisition model;
- the estimation of the restocking process and the links between retailers and wholesalers, by means of the attraction model;

![Figure 3: Study area (a) and portion of the central district with zones (b).](image)

The application of models for the vehicle level has concerned the estimation of pull movements connected to the restocking trips, the path (or routes) performed during the restocking trips.

Paths of freight vehicles, performing pull movements, have been estimated by means of a stochastic path choice model, which was calibrated with data obtained from a congested network model. The link cost functions of the congested network model were calibrated with traffic counts and travel times measured on some selected links.

The following elements related to the zoning and to the types of goods were specified.

- \(I_o\) and \(I_d\) are composed by nine zones and they are coincident: \(I_d = I_o\).
- \(I_w\) is composed of two zones in the current situation pre-UDC: \(I_w = \{w_1, w_2\}\), with \(w_1\) located in southern area and \(w_2\) located in the northern area (see Figure 3.a).
- \(J_s\) is composed by the nine typologies of not-perishable food: \(J_s = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9\}\), with \(s_1 = \) pasta and rice, \(s_2 = \) biscuits, \(s_3 = \) milk and cheese, \(s_4 = \) eggs, \(s_5 = \) oil, \(s_6 = \) sugar, \(s_7 = \) coffee, \(s_8 = \) tea and cocoa, \(s_9 = \) wine, beer and water.
4.1 Outcomes of freight demand models

The application of the freight demand models allowed estimating the following quantities (see table 1):

- \(Q_{\text{std}} = \sum_{s=1}^{9} Q_{\text{std}s}\), total quantity of not-perishable food (belonging to the set of typologies \(J_s\)) acquired by retailers located in each zone \(d\) of the examined area in one week (t=week);
- \(F_{\text{lgv}}^{wd} = \sum_{s=1}^{9} F_{\text{lgv}}^{swd}\), number of vehicles delivering not-perishable food having zone \(d\) as destination in one week (t=week).

Five \(lgv\) classes of vehicles have been identified: 0, over 18000 kg; 1, between 3600 and 18000 kg; 2, between 1600 and 3600 kg; 3, between 1000 and 1600 kg; 4, up to 1000 kg.

Table 1: Estimated freight quantities and vehicles delivered in the examined area.

<table>
<thead>
<tr>
<th>zone d</th>
<th>(Q_{\text{std}}) [kg/w]</th>
<th>(F_{0}^{\text{std}}) [veic/w]</th>
<th>(F_{1}^{\text{std}}) [veic/w]</th>
<th>(F_{2}^{\text{std}}) [veic/w]</th>
<th>(F_{3}^{\text{std}}) [veic/w]</th>
<th>(F_{4}^{\text{std}}) [veic/w]</th>
<th>(F_{\text{std}}) [veic/w]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19875</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>49212</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>19</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>15756</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>42903</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>4928</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>9276</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>20238</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>40100</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>total</td>
<td>202288</td>
<td>0</td>
<td>4</td>
<td>15</td>
<td>30</td>
<td>79</td>
<td>128</td>
</tr>
</tbody>
</table>

\(w=\)week

In order to validate the outcomes of models, freight vehicles entering in the examined area in the peak period (7:00 am – 9:00 am) of a working day have been counted and classified according to the five classes defined. The counting includes freight vehicles delivering perishable food, building materials, materials for maintenance and services and other durable goods.

Table 2: Counted vehicles entering in the examined area.

<table>
<thead>
<tr>
<th>Vehicle class ([lgv]) ([\text{veh/2 hours}])</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>[veh/2 hours]</td>
<td>13</td>
<td>126</td>
<td>123</td>
<td>120</td>
<td>246</td>
</tr>
<tr>
<td>[%]</td>
<td>2.1</td>
<td>20.1</td>
<td>19.6</td>
<td>19.1</td>
<td>39.2</td>
</tr>
</tbody>
</table>

4.2 Outcomes of network model: scenarios pre and post UDC

The effects of the planned UDC have been estimated in terms of kilometers travelled and travel times by freight vehicles during the restocking process of the retailers located in the examined area. The following traffic metrics have been specified and calculated by means of the congested road network model:
• the minimum distance and travel time on the network between each retailer-warehouse/wholesaler origin-destination couple (pre-UDC scenario);
• the minimum distance and travel time on the network between each retailer-UDC origin-destination couple (post-UDC scenario).

The assumptions on the restocking trips are the following: (i) pull movements, the decision-maker is the retailer; (ii) closed ring trips, after restocking the retailer goes back to his shop, the trip origin is the shop and the destination is the warehouse/UDC.

We considered different combinations of restocking alternatives (warehouse) for each retailer: in the pre-UDC scenario the choice set is composed by the two existing warehouses, or by one of the two ones; in the post-UDC scenario the choice set is composed by the UDC or by the warehouse with the minimum cost (related to each retailer) in the pre-UDC scenario and the UDC.

The results of the simulations are reported in Table 3, which reports the values of distance travelled and congested travel time estimated for all the retailers for the five different combinations of available alternatives connected to the two scenarios. In the combinations with more than one restocking alternative, the probability \( p[w/td] \) is estimated by means of the restocking area choice model of eq. (8).

Table 3: Traffic metrics estimated for the pre and post-UDC scenarios.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Available alternatives</th>
<th>Distance travelled [km]</th>
<th>Congested travel time [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-UDC</td>
<td>w2</td>
<td>387.2</td>
<td>738.4</td>
</tr>
<tr>
<td></td>
<td>w1</td>
<td>214.2</td>
<td>670.2</td>
</tr>
<tr>
<td></td>
<td>w1, w2</td>
<td>257.4</td>
<td>519.7</td>
</tr>
<tr>
<td>Post-UDC</td>
<td>UDC</td>
<td>75.0</td>
<td>342.9</td>
</tr>
<tr>
<td></td>
<td>w1/w2, UDC</td>
<td>86.9</td>
<td>338.5</td>
</tr>
</tbody>
</table>

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European plans for the smart city: from theories and rules to logistics test case

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ABSTRACT
City evolution is connected to social, economic and technological evolutions. New technologies induce further changes, which are highly innovative, which again affect the urban and territorial systems. The city once again adjusts to new opportunities in relation to information and communications technologies, energy and mobility. In this paper, smart city, configured as a set of interacting systems with people, is focused as a possible model to follow for pursuing sustainability in real cities of the twenty-first century. Three processes are recalled: city development, city planning theories and city rules. Smart city seems to be the convergent point for all processes evolving in European urban areas. Theoretical definitions of smart city are recalled. At the same time, the European Commission is promoting smart city rules for implementation. Moreover, in the last years some local decision-makers implemented specific measures that today can be considered in the class of smart city measures. The objective of the paper is to analyse the European perspectives for smart city, trying to separate the three processes that are strongly integrated, but without formal links. To verify the European smart city approach, a study case concerning city logistics is considered.

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Urban planning; European plans; innovation; smart city; city logistics

1. Introduction
In the last few years, most of the challenges related to the economy, climate, environment and society have a strong urban dimension. In Europe, around 70% of the population live in urban areas and it is here that about 85% of European gross domestic product is generated (European Commission, 2014a).

A retrospective analysis of the evolution of (i) city development, (ii) planning theories and (iii) rules, from the past centuries to the present, can offer a framework within which researchers can study and analyse current urban challenges, and planners and city decision-makers can operate in a coherent way, with European Union (EU) priorities.

The general aim of the paper is to look into the unifying paradigmatic evolution for city development, planning theories and rules. Transport and logistics planning is focused on particularly.
The specific aim of the paper is to extract from each process evolution, the magmatic complex literature and the reality of the European urban areas the common and convergent elements towards which the city could be evolving.

1.1. Historical evolution of city developments, planning theories and rules

The Industrial Revolution of the nineteenth century marks the beginning of city development (Benevolo, 1989). This revolution dramatically changed the structure of the consolidated medieval European cities, and synthetically defined market towns. The phenomenon of urbanization led to a new model of the city called the industrial city, which developed from almost nothing (Samonà, 1959). The abnormal increase in territorial and demographic dimensions, determined by industries, caused uncontrolled urban growth.

City rules were beginning to be introduced, for instance, with the UK law for London and around (UK Government, 1844) which defined the minimum hygiene requirements. Another example is the French law on expropriation (French Government, 1852) by which Haussmann carried out the transformation of Paris. These laws allowed for the great urban developments in European cities at the end of 1800, generating the territorial structures for the modern twentieth-century city. City government carried out new infrastructures and prototypical transport services. This interference with human and social needs required a new city model.

Different authors captured some key aspects of the changes that occurred in the city and in the science, which studied the city which gave birth to planning. At the same time city rules, which implied the policy, were formalized. For instance, in Italy the first planning law established new rules for the city (Italian Government, 1942). While new regulatory instruments for the control and use of territorial planning were defined, city planning theories began. The modern urban and regional planning responds to emerging social and economic problems (Hall, 2002).

The city planning theories ‘were the application of a scientific method to policy-making’ (Faludi, 1973). It is very important to treat the problems of urban areas, analysing the social phenomena. The key proposition of the Marxist theory is that urban areas must be understood and analysed. Allmendinger (2009) draws up the evolution of the planning theory. Taylor (1998, p. 62) confirms that ‘planning is a form of system analysis and control’. Systems have dynamic characteristics and change through the competitive behavior of those involved which act in an optimizing way.

Plans should not be seen as static documents but rather as dynamic and changing like the systems themselves. The heart of the evaluation of a proposal is the model of the system into which there are clear inputs (the proposal) and outputs (the predicted impact). (Allmendinger, 2009, p. 55)

The speed and unpredictability of the new social, cultural and economic processes have produced different scenarios from those planned. Different factors influence cities’ development: the new importance of transportation planning; the link between city-region planning and economic planning; the use of informatic tools; the pressure on environmental quality; the growing concern about social planning and the increase in management techniques in local authorities.
Forester (1985) asserts that planning ‘is a highly practical activity that is based upon solving problems and making things happen’.

The modern society is immeasurably more technically and socially complex, than previous societies. [...] The whole planning process is more clearly articulated, it is more logical and more explicit. [...] Modern plan methodology identifies three stages: goal formulation, identification of objectives and target setting. (Hall, 2002, pages: 2, 7, 215)

This is an attempt to introduce common elements in planning.

Over the last few years, the EU has attempted to introduce common city rules in spatial planning (Cirianni, Panuccio, & Rindone, 2013).

In synthesis, from the analysis of state of the art, three main aspects of city evolution emerge: real city development, city planning theories and city rules.

Referring to real city development, the city today can be considered a megasystem that includes very different and traditionally autonomous complex systems. The territorial borders of the city blend through the agglomeration of smaller urban centres interposed between them. This results in the phenomenon of conurbation. The two extreme processes identify, on one hand, the new town and, on the other, the megalopolis.

The new town project represents the ideal of a town, perfectly consistent with the size of the built infrastructure, service functions and activities.

The megalopolis includes a very large urbanized area, with a regional dimension, characterized by a concentration of highly skilled functions and actions (Gottmann, 1970). The megalopolis and the new town are two opposite city developments to which the real city tends. The megalopolis represents an uncontrolled real phenomenon.

The new town represents a model in which each element is controlled by a project.

The historic European city is located between the ideal city and the megalopolis.

Referring to city planning theories, the two opposite city developments demonstrate how prevision sciences and quantitative methods are not exhaustive to control the real city evolution. This problem was treated by different theorists. For instance Friedmann (1998), ‘after five decades of active theorizing’, poses the question on the formal definition of planning theories highlighting principal limits and identifying the themes to study in depth.

Referring to city rules, it is necessary to underline the diversity of planning systems and practices in Europe, coming from the specific history and geography of particular national contexts. At the same time, quality of life represents a common cultural value in the cities that is a starting point to reach convergence in city rules, through European urban planning system (Healey & Williams, 1993).

1.2. Three interconnected processes to study and to interpret the city

From the analysis of this synthetic overview, it is possible to identify schematically three interconnected processes to study and to interpret the city:

(i) real city development, analysing the literature about historic city evolutions in terms of public and private realization;
(ii) city planning theory, analysing the evolution of theoretical planning frameworks;
(iii) city rules, analysing guidelines and laws, stated by the national to the local level, that govern the city.
It is difficult to distinguish the three identifying processes, because each of them influences and is influenced by the other two. In the few cases where the three processes are strongly convergent, these cities represent reference models.

In this work, the smart city is considered a possible perspective where the identifying processes converge, allowing for European cities to improve the urban quality of life, as it is possible to observe in the reference models.

The smart city summarizes some of the paradigmatic factors for the European city of the twenty-first century, strongly interacting. While there are formal differences in the conception of a smart city, in academia (theories), government (rules and policy) and business (real development), there are no extensive fieldworks where the three processes converge (Kitchin, 2014).

The European Commission is programming a process to define city rules for smart city development. In particular, the European Commission is promoting guidelines for city rules by means of the creation of a partnership bringing together cities, industry and citizens; the introduction of official definitions; the summarization of the main requirements expressed by stakeholders; indication of strategies, actions and resources to realize smart cities in a real urban context and inviting the partners to commit themselves.

### 1.3. Aim and structure of the paper

Starting from the analysis of historical city development, planning theories and rules, shortly recalled in this section, the smart city is presented as a possible convergence point of the three schematic processes. To achieve this convergence, two circular stages are possible. In the first way, the city planning theory (ii) is transposed by decision-makers into city rules (iii) to address city development (i). In the second way, city development (i) influences city rules (iii) from which city planning theory (ii) are syntetised (Figure 1). The reality follows a mix of both the ways.

The main objective of this paper is to open an urban planning reflection within the European perspective on Smart Cities. Problems related to the complexity of urban systems, in relation to different dimensions (transport, energy and Information and Communication Technology (ICT)) and to different related issues, clearly demand for a

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**Figure 1.** Circular stages among the processes.
renovated planning effort. In particular, the paper attempts to clearly face the still unclear situation of the smart city conception and implementation by means of the following:

- a discussion on city planning theories analysing smart city as a paradigm for the future of the city (Section 2);
- an analysis of common city rules and policies considering the European guidelines to develop the smart city (Section 3);
- an analysis of city development considering logistics as a test case for a smart city (Section 4).

The focus is on the sustainable urban mobility of goods that represents one of the principal dimensions of urban complexity. A new approach to integrate planning, which considers all urban dimensions and issues, is needed, as highlighted in planning theories, European rules, policies and city development.

Each section can be considered an update of the relative process with current links with the other two processes. In fact, the three processes are dynamically interlinked.

Ultimately, the three processes are considered with smart city as a potential convergence point for EU urban areas.

2. City planning theories: smart city paradigm of an urban system of systems

City planning theories study to identify the future perspective for the city.

Considering current advances in technologies, design and social relationships, smart city is one of the possible paradigms for the future of the city. In this context, although there is no pertinent city planning theory, different disciplines are studying the smart city concept to identify common trends (Deakin, 2014).

The smart concept has been gradually enhanced, from the identification of micro objects and materials used in technological devices, to macro. Today it is associated with the city, using the idiomatic phrase: smart city.

Multidisciplinary topics use the term smart city. Each topic adopts its own language, defining actions to pursue specific objectives. Consequently, there is no unique definition that includes all aspects of the smart city.

In the context of the international debate concerning smart cities, the main recent definitions, introduced by academics and experts from different disciplines, are reported below chronologically.

The term smart city has been used by Giffinger, Fertner, Kramar, Meijers, and Pichler-Milanović (2007) to underline the role of ICT: ‘The idea of smart cities is rooted in the creation and connection of human capital, social capital and ICT infrastructure in order to generate greater and more sustainable economic development and a better quality of life’.

The quality of life as the final goal of urban planning is anticipated by Jacobs (1961) who highlights the need to include a social phenomenon into city planning theory and development. Social interactions increase in pedestrian-friendly cities, which favour walking, biking and public transit over cars. Today this last aspect is included in the sustainable mobility paradigm, as proposed by Banister (2008) who produced relevant
modifications in the traditional planning approach. Actions to reduce the need to travel (less trips), to encourage modal shift, to reduce trip length and to encourage greater efficiency in the transport system have to be planned and realized.

An extension of the definition could be found in Hollands (2008) where the role is extended to all the networks that are interconnected, and not only the ICT: ‘The Smart City uses the infrastructure network to improve economic and political efficiency, and to allow social, cultural and urban development’. The network concept is introduced in this definition.

A further specification is proposed in Schaffers et al. (2011) in which the role of the new participatory governance is introduced, but the network role is lacking: ‘A city may be called “smart” when investments in human and social capital and traditional and modern communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance’. This city model identifies functional urban hierarchies and it correlates the physical infrastructure with human capital, the intellectual and social development of those who live there, using the mobility, energy and ICT, in order to determine a new optimal state for the organization of urban systems and improve the quality of citizen life.

Anthopoulos and Vakali (2012) consider the smart city an architecture that ‘contains four layers. These are the user, service, infrastructure and data. Layers can describe all the different types of attributes needed to support the smart city context, which typically include’ Web or Virtual Cities (e.g. Kyoto and Amsterdam); Knowledge-based Cities (e.g. Copenhagen and Edinburgh); Broadband City/Broadband Metropolis (e.g. Seoul, Beijing, Antwerp, Geneva and Amsterdam); Mobile Cities (e.g. New York and San Francisco); Digital Cities (e.g. Hull, Cape Town and Trikala); Smart or Intelligent Cities (e.g. Brisbane, Blacksbourgh, Malta, Dubai, Kochi, Helsinki, Barcelona and Austin); Ubiquitous Cities (e.g. New Songdo, Manhattan, Kentucky, Masdar, Abu Dhabi and Osaka) and Eco-cities (e.g. Dongtan, Tianjin, Masdar and Abu Dhabi).

The Smart Cities Group of Cambridge defines smart cities as ‘systems of systems, and that there are emerging opportunities to introduce digital nervous systems, intelligent responsiveness, and optimization at every level of system integration’ (Mitchell, 2013). This definition expresses a significant conceptual advance. The smart city as a system overcomes the network concept that implies only the problem related to the supply.

In synthesis, while the first definitions consider only supply and network concepts, there is an evolution towards the network set, and then to systems. Any definition formalizes the network system where people and then supply-demand interactions are considered explicitly. When more city systems (mobility, energy and ICT) are taken into account in an integrated way, a system of system concept is introduced and it is crucial
to relate the city systems with the people component. Only this proposed unifying definition could take in to account all the components of a paradigmatic smart city.

3. Common city rules: European guidelines for the smart city

In the last few years, a large number of smart city initiatives have been implemented in Europe. However, these initiatives have not referred to a common framework in terms of language, objectives and recommended actions.

While the debate on the theoretical definition and initiative implementations of the smart city has been taking place, European organisms have developed an intense process of city rules formalization. In the following a tree is proposed, from which the European smart city framework emerges. The tree is built and analysed, referring to different regulations and laws, books, guidelines and operative documents.

The following subsections present the main elements of the European framework for smart city developments, from the general strategy to the operative guidelines.

The milestones of the European body are recalled and underlined, rebuilding a subjective essential path from the top European goals to the guidelines in order to stress the common smart city rules and propose a synthetic interpretation, linking the common rules to the scientific debate. At the same time, the definition of European rules for the smart city needs must have compliance with the real measures implemented in urban areas. In this way, a complex merge has been operated, with the participation of the public and private stakeholders, that produces the experience of the implementation. Then the European rules intervene in a dynamic evolution of theories, on one side, and real urban areas, on the other side.

The proposed ex post reconstruction of the European framework approach to the smart city is represented in the tree synthetized in Figure 2. The reader must consider that a European document that reconstructs the global EU approach to the smart city does not exist.

3.1. EU 2020 strategy

The EU’s 10-year growth and jobs strategy (‘Europe 2020 strategy’) was launched in 2010, considering the long-term trends affecting growth (social change, globalization, productivity developments and ICT). The strategy is focuses on into three priorities for growth and seven flagship initiatives (European Commission, 2010a):

- ‘sustainable growth’ in terms of actions moving towards a low-carbon economy; the connected flagship initiatives are ‘resource efficient Europe, an industrial policy for the globalization era’;
- ‘smart growth’ in terms of effective investments in education, research and innovation; the connected flagship initiatives are ‘innovation union, digital agenda for Europe, youth on the move’;
- ‘inclusive growth’ in terms of actions to create job and to reduce poverty; the connected flagship initiatives are ‘an agenda for new skills and jobs, the European platform against poverty’.
Five measurable headline targets for Europe 2020 are defined for employment, for research and innovation, for climate change and energy, for education and for combating poverty. The quantitative targets represent success, which helps to measure and guide the different aspects of the strategy, at both the national and EU levels. The ‘Europe 2020 strategy’ and its flagship initiatives are the reference points to guide investments in education, research and innovation in order to achieve the headline targets related to growth (European Commission, 2010a).

In the following, the ‘smart growth’ dimension is specified, concentrating attention on EU plans concerning innovation, research and education. In this dimension, the European Commission is challenging implicitly current planning theories, stimulating their innovation.

3.2. Innovation Union flagship initiative

To develop the ‘Innovation Union’ flagship initiative (European Commission, 2010b), two stakeholder advisory platforms are defined:

- ‘European Technology Platforms (ETPs)’ are ‘industry-led stakeholder forum’ with the aim of defining medium to long-term research and technological objectives. These platforms will also develop roadmaps to achieve them (‘industry-driven’) (European Commission, 2013b);
- ‘European Innovation Partnerships (EIPs)’ is a new approach to EU research and innovation which aims to bring together public and private stakeholders, ‘to accelerate the deployment of major innovations by committing them to undertaking supply and demand side measures (funding, regulation, standards, procurements, etc.) across

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**Figure 2.** The smart city European process.
sectors and the entire innovation system ("demand-driven") (European Commission, 2012a, p. 3). The areas of EIPs are Water (EIP-W); Active and Healthy Ageing (EIP-AHA); Smart Cities and Communities (EIP-SCC); Agricultural Sustainability and Productivity (EIP-AGRI); Raw Materials (EIPRM).

Among ‘Innovation Union’ initiatives, the smart city, through EIP-SCC, assumes a relevant role. Researchers, industries and public administration work together to combine their knowledge and technologies to pursue EU urban goals.

The European Commission, by means of EIP-SCC, aims at developing smart cities connecting research resources involving energy, transport and ICT and ‘concentrating them on a small number of demonstration projects which will be implemented in partnership with cities’ (European Commission, 2014a). The smart city constitutes a challenge and an opportunity to enable city planning theorists and researchers, planners and local political decision-makers, and public and private businesses to work together on sustainability goals.

### 3.3. EIP for smart cities and communities

The EIP-SCC ‘brings together cities, industry and citizens to improve urban life through more sustainable integrated solutions’. The partnership, through the focus areas of energy, transport and ICT, has the main objective to catalyse progress in these ‘closely linked areas and to offer new interdisciplinary opportunities to improve services reducing energy and resource consumption’ (Figure 3). The partnership includes applied innovation, better planning, a more participatory approach, higher energy efficiency, better transport solutions and intelligent use of ICT (European Commission, 2012b).

In the first step in 2012, the EIP-SCC has oriented the Seventh Framework Programme (FP7) – 2013 Work Programme ‘to reflect the integrated nature of urban energy, transport and ICT topics’ (European Commission, 2012b).

Further implementations of smart cities are oriented by ‘governance bodies’ of the EIP-SCC (European Commission, 2014b):

![Figure 3. The EIP-SCC focus areas (European Commission, 2012b).](image-url)
• the ‘High Level Group (HLG)’ that comprehends the high-level representatives from industry, research and cities; HLG is supported by ‘Sherpa Group’ that is made up of HLG representatives and a set of additional associated members; HLG will be led by the three Commissioners for Energy, Transport and Digital Agenda;
• the ‘Smart Cities Stakeholder Platform (SCSP)’, which is a collaborative, networking and knowledge-sharing tool of the EIP-SCC, was established in 2011.

The two interconnected governance bodies incorporate inputs from relevant stakeholders. SCSP, together with the HLG, ‘from a bottom-up perspective, contributes to the discussion about Smart Cities in Europe’.

Governance bodies (HLG, supported by a Sherpa group and SCSP) produced guidelines to implement SCC initiatives: the ‘Strategic Implementation Plan (SIP)’ adopted in 2013 (European Commission, 2013a) and the ‘Operational Implementation Plan (OIP)’ drafted in 2014 (European Commission, 2014c). The EIP-SCC and their implementation plans are neither a new funding programme nor an instrument nor a legal entity. EIP-SCC plans are European guidelines, including city rules, addressing smart city developments.

In the guidelines, the following definition is assumed:

smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services and financing to catalyse sustainable economic development, resilience, and a high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society.

Then the system of system concept, with an explicit consideration of the people component, is adopted by the European Commission in order to increase sustainability and the quality of life. The European smart city concept is according to the main recent definitions reviewed in Section 2. The European Commission endorses city planning theories to identify a renewed urban planning process, in order to face the city complexity.

The guidelines, in order to address smart city initiatives, have identified the following (European Commission, 2013a):

• three specific vertical areas: sustainable urban mobility that includes actions related to public transport, urban freight logistics and alternative energies; sustainable districts and built environment that include actions related to improving the energy efficiency of buildings and districts, increasing the share of renewable energy sources used and the liveability of our communities; integrated infrastructures and processes across energy, ICT and transport that include actions related to connected infrastructure to improve the efficiency and sustainability of cities;
• eight horizontal enabling themes grouped into three classes: Decisions (citizen focus, policy and regulation, and integrated planning and management), Insight (knowledge sharing, metrics and indicators, open data and standards) and Funds (business models, procurement and funding).
Vertical areas and horizontal themes can be interconnected identifying common working areas to develop a smart city. It is possible to rebuild 24 main intersections constituting elements of a matrix with 8 rows (horizontal enabling themes) and 3 columns (vertical area and related actions) (Figure 4). Each cell of the matrix represents a potential working area that includes a horizontal enabling theme related to the vertical area and actions. Each working area integrates a system of actions and enabling themes to develop the smart city. In this way, European plans try to reach a convergence of the three interconnected processes introduced in Sections 1 and 2.

Guidelines, including stakeholder commitments, represent a set of European city rules that empower current planning theories about the smart city. The rules are defined, according to smart city theories, to address smart city development, integrating system of systems and people, in order to increase the quality of life in European cities.

The EU is dedicating specific financial funding instruments to implement smart cities based on smart city guidelines and relative working areas (European Commission, 2013c).

In the following section, among the 24 possible working areas, the city logistics case study is derived from the intersection between sustainable urban mobility (vertical area) and integrated planning and management (horizontal enabling theme).

**Figure 4.** The 24 possible working areas indicated in SIP and OIP.
4. City developments: logistics as test case for smart city

Today, for city planners and for managers of logistics companies, problems connected to urban freight distribution are relevant.

In this section, European guidelines (SIP and OIP), for planning urban freight distribution in a smart city (top-down), are compared with the measures implemented (bottom-up) in the city to solve freight distribution problems. SIP and OIP recommend potential actions to plan and to implement city logistics in a smart city, in line with the best European practices in this sector.

The distribution problems are connected to the conflicts of interests related to urban freight transportation. On the one hand, freight distribution is fundamental to daily life in the cities, ensuring their competitiveness with respect to the extra-urban commercial centres, while, on the other hand, the negative impacts of freight transportation, deriving from the goods vehicles, should be limited.

Inefficient planning and management of this mobility component produce impacts on congestion, noise, air pollution and greenhouse gas emissions, considering that total urban goods transport accounts for 14% of the vehicle kilometres, 19% of energy use and 21% of CO2 emissions in urban areas (European Parliament, 2014). However, logistics needs are often neglected in urban planning and management. A set of measures to balance conflicting interests have to be studied, and implemented at the local level.

4.1. Implemented measures of city logistics

In the last years, models and best practices to design and implement city logistics measures have been produced. The models give to planning the quantitative base to analyse the design.

In the literature, different models used to simulate urban freight movement are proposed (Russo, 2013). Simulation models are needed to analyse city logistic measures prior to implementation, in order to evaluate ex ante the possible impacts that can be caused (Russo & Comi, 2010) also in relation to ITS (Chilà et al., 2016).

Integrated planning and management of city logistic measures represent an example connected to the intersection between the vertical ‘area sustainable urban mobility’ and the horizontal theme ‘integrated planning and management’ linkable to the measures applied in the city.

European city logistics measures experimented in different real-life contexts (bottom-up approach) have elements in common with the European process of implementing a smart city initiative (top-down approach). The measures are stable and accepted by the users and by the citizen, and constitute effectively a development for the city. The first city that implements the measures for freight distribution is in fact paradigmatic for the others.

In the last years, models and best practices to design and to implement city logistics measures are produced for contributing to urban sustainability goals (Russo & Comi, 2011). Many European city administrators have implemented city logistics measures to mitigate the negative effects of freight transport. Different European studies have analysed city logistics measures implemented in urban areas (e.g. COST 321 in 1998, City Ports in 2005 and BESTUFS in 2007).
A possible classification of city logistics implemented measures is proposed in Russo and Comi (2011):

- measures related to material infrastructure, including linear measures, with reference to urban/metropolitan transportation network and surface (or nodal) measures and to areas reserved for freight operations; the ‘Truck Guidance Network’ in the city of Bremen, which was implemented in 1998 to reduce the impact on urban truck traffic, can be cited as an example of a linear measure; in the city of Rome, the authorities are considering the introduction of approximately 700 new areas for handling operations all equipped by intelligent transportation system (ITS) to manage and control usage; this is an example of a nodal measure;
- measures related to immaterial infrastructure including not only consolidated ones (e.g. research, learning and training), but also telematics or ITS; electronic access control, traffic monitoring, traffic control and real-time traffic information have been applied in several cities, namely Maribor, Brno, Salzburg and Rome;
- measures related to equipment including measures concerning loading units, with reference to the introduction of new standards or low-emission vehicles and measures on the characteristics of transportation units; an increasing number of cities offer limited access to central urban areas only for zero-emission vehicles, electric vehicles or low-emission hybrid vehicles; an example is the low-emission zone introduced in the city of Utrecht (Netherlands);
- measures related to the governance of the traffic network including traffic regulations such as time window access, heavy vehicle network and road pricing; the congestion charging schemes in London and Stockholm are two examples applied to both passenger and freight vehicles.

On different temporal scales, these measures have contributed to the increase in social sustainability (e.g. reduction of road accidents), economic sustainability (e.g. reduction of congestion and travel times) and environmental sustainability (e.g. reduction of air pollution). However, reviewing City, VITALity and Sustainability initiatives, some city logistics initiatives have not reached the expected results, due to incomplete implementing of provided initiatives. The main reason is related to the lack of private company participation, being that measures take place in a competitive market. Other reasons are related to the implementation of further transportation planning measures, such as traffic management, public transport and infrastructural developments (van Rooijen & Quak, 2014). The incomplete implementation of initiatives to improve urban freight mobility is one of the main dangers facing smart city development.

4.2. Sustainable urban mobility (vertical) in terms of city logistics

In the context of urban freight mobility, guidelines highlight the fact that commercial vehicles are essential for the city economy. However, they contribute to and suffer from congestion. Substantial changes have to be activated in order to influence the mobility behaviours of businesses.
The results obtained by city experimented measures (recalled in the previous section) suggest the guidelines, and the guidelines propose to the other cities a similar approach to city logistics.

In the ‘sustainable urban mobility’ vertical area, three priorities have been defined:

- to reduce the environmental impact, by reducing the use of ‘emission-intensive transport modes and facilitating the increased mobility of people, goods and information and ensuring efficient transport’;
- ‘to shift from more energy intensive and environmentally harmful modes of transport to less polluting, better integrated and more efficient modes’;
- ‘to promote cleaner transport technology and policy solutions, driven by better management of mobility; zero- and low-emission vehicles will connect with each other, with infrastructure and with the smart grid’.

To pursue these priorities, a set of ‘potential actions’ is recommended. The specific potential action ‘clean, efficient urban logistics’ is detailed, including sub-actions ‘to better address supply’ and sub-actions ‘to better address demand’. For instance, development of models and standards; reviewing and adaptation of regulations on access to urban city centres (e.g. time window restrictions for clean vehicles); introduction of labelling and certification programmes and integration of freight into local planning and land-use policies (e.g. into Sustainable Urban Mobility Plans (SUMP)) (European Commission, 2014d).

The final goals of the city logistics in a smart city are to increase efficiency, and to reduce emissions and energy use ‘through using smart urban technologies and services’ while adopting innovative planning and governance.

### 4.3. Integrated planning and management (horizontal) in terms of city logistics

Planning and management processes are needed to support decision-making processes in order to design and operate urban transport infrastructures and services. Policies for city logistics are developed in some European cities.

‘Integrated planning and management’ horizontal theme involves ‘spatial, temporal and technical coordination of diverse policy areas and planning resources to achieve defined goals using specified instruments’. A ‘comprehensive involvement’ of citizen, public and private players is required. This is challenging because ‘long-term planning perspectives and short-term actions’ must be integrated.

This is the same aim of SUMP, recalled in SIP and OIP as a possible tool to create ‘synergies and links between transport, energy and ICT in urban transport effectively and engage citizens’. SUMP are strategic plans, which focus on the mobility needs of people and businesses in urban areas. The primary objectives are to increase urban sustainability and the quality of life. The SUMP approach introduces a planning process based on integration, participation and evaluation principles. An integrated set of technical, infrastructural, policy-based and soft measures to improve performance and cost-effectiveness has been identified. To implement the SUMP approach, a citizen and stakeholder engagement is needed, as well as fostering changes in mobility behaviour. However, to ensure that the SUMP approach is broadly taken up, the mobility plan concept should
be adapted to the existing planning practices in each Member State. Urban logistics constitutes one of the main SUMP topics.

In the set of recommended potential SIP and OIP actions related to integrated planning and management, actions directly connected to the implementation of city logistics measures are as follows:

- ‘improving collaborative governance mechanisms’ to demonstrate benefits in European cities, involving governance mechanisms adopted to implement smart city initiatives, springing from best practices;
- ‘using urban simulation models and planning’ to quantify the impact of urban development and policies, under different context conditions;
- ‘focusing on the use of energy-models and energy-mapping from district to city-wide scale’ in order to support the visualization of ‘direct and indirect production and consumption of energy over sectors’.

Examples of potential actions for integrated planning and management of city logistics measures are available in scientific literature and in real context, as proposed in Section 4.1.

5. Conclusions

The city is a result of three interconnected processes: city development, city planning theories and city rules and policy.

- City development is connected to the evolution of social, economic and technological processes.
- City planning theories observe, study and analyse, defining theoretical frameworks for planning.
- City rules, following a top-down approach, address city developments, attempting to integrate planning theories.

City development follows social and historical events, but often does not wait for the instructions of city planning theories, and fortunately/unfortunately nor for the rules.

The smart city, in the frame of the three interconnected processes tends to be a set of interacting systems with people.

In this paper, the actual situation of the smart city regarding the three processes has been evidenced. The result is notable because there is the possibility to better address the different processes, for researchers, for politicians and planners and for private and public business.

The European official ‘rules’ approach to the smart city can be considered an attempt to find an equilibrium in order to pursue sustainability and to increase the urban quality of life.

The European Commission is indicating city rules, in order to adapt the territory according to smart city development. In the meantime, some European cities are developing smart cities initiatives. These initiatives, in some cases, are coherent with EU plans for a smart city. In the cases, where it is possible to find this coherence, city rules address city
development towards sustainability. This occurs through agreements between government authorities, public bodies, private companies and citizens. The two processes are linked to the third one, developed by the researchers, which sometimes is anticipated and sometime follows the real processes. In this case, it is hard to fit planning theories with adequate definitions and modelling, because a strong collaboration of different and new knowledge is needed. Traditionally, the urban planner needed only to interact mainly with the infrastructural engineering department. A smart city implies the collaboration with the new branch of transport, ICT and energy systems.

Highlighting the three processes, as in the paper, it is possible to evidence new ways for urban theories.

Sustainability and the quality of life goals are focal elements common to theoretical frameworks, EU plans and smart city development. EU plans for the smart city, according to a sustainable growth strategy, are challenging, modifying, integrating, confirming and empowering current planning theories and traditions. Integrated planning and sustainable urban mobility are two of the main EU recommended actions for the smart city development. Intersection between these two selected actions is an example of the EU concept of smart city development. In this intersection, city logistics in terms of developments, theories and rules is studied as a smart city test case. EU guidelines (SIP and OIP) indicate that city logistics in a smart city that includes urban mobility, ICT and energy efficiency has to be elaborate following an integrated form of planning. Implementation of an integrated planning approach, across these three areas, is required to avoid the pitfalls connected to a purely technologic orientation.

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References


From the analysis of European accident data to safety assessment for planning: the role of good vehicles in urban area

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Purpose Within the field of goods vehicles mobility, the paper points out the road safety that has impacts on both social and economic sustainability spheres. The contribution of goods vehicles is investigated and the results obtained for the larger European countries are discussed.

Methods The used methodology is statistic-descriptive, extracting from a large available database successive and more in-depth information. Starting from aggregated (at national level) data for accidents involving goods vehicles in urban area, the paper evidences the urban junctions as the main critical situation for accidents.

Results One of the main findings is that urban goods vehicle accidents received little attention, but being an important segment of urban mobility, much remains to do for reaching the zero-accident EU goal by 2050 in this segment.

Conclusions The paper, in the context of European urban planning, finalises the analysis results, reviewing the main methods to assess road accidents, and linking mobility simulation and safety simulation models. The findings of this study can represent the base for developing successful city plan. In fact, paper provides some indications to researchers and city planners for identifying which are the main factors to be investigated and monitored for improving urban road safety.

Keywords Road accidents · Goods vehicles safety · Urban junction · Pedestrian safety · Safety models · Safety plan · SUMP

1 Introduction

The importance of urban goods transport is related to increase in urban populations and continued economic growth in urban areas (Browne et al. [1]). Furthermore, the freight transportation contributes to congestion, air pollution, noise and to raise logistic costs, and hence the price of products. Besides, about the 69% of EU road accidents occur in cities (White Paper [2]).

In relation to the sustainability, the costs due to road accidents can be referred to the accident victim (social) and to the road accident (economic). The former ones refer to human costs, such as cost of human life (lost productivity, non-pecuniary damage - moral and biological) and health care costs (costs of medical treatment). The latter ones are general costs due to the accident, such as property damage (damage to vehicles, buildings, roads and so on) or administrative costs (costs of intervention of the emergency services, litigation costs and administration).

In this context, the local administrators are looking at city logistics measures to limit these types of urban freight impacts (Russo and Comi [3]; Lindhom and Behrends [4]; Danielis et al. [5]; Ville et al. [6]), and models for ex-ante plan safety assessment have to be used.

In a general urban planning process, the analysis, presented below, can provide some indications to researchers and planners for identifying which are the main factors to be investigated and monitored to reach the zero-accident goal given as a focal target by the EU within 2050. The paper evolves analysing subsequent stages from the safety at urban level to
the localization of accidents, skipping in-depth disaggregated statistical analysis and using simple statistical formulation to focus on the main factors to be obtained from the European national dataset.

Although, urban areas represent the areas with highest percentages of accidents (Section 2), their contribution has not been investigated and a safety policy for urban roads as made for highways and motorways (with very important and performing outcomes) is missing. Then, a first objective of the paper is to extract from the European big data, often unreadable, the main evidences for road accidents in urban areas, focusing on the different decreasing trends realized in the larger European countries.

Goods vehicle contribution to accident is high because of consequences occurring when they are involved (Section 3) in relation to the differential dimension with car and pedestrian. Following this physical notation, a second macro objective is to stress the contribution of goods vehicles to road accidents in European urban areas: first resuming the weight on accidents, deaths and injuries and subsequently the weight for each country, conditioned to the total vehicle*kilometres travel in urban areas.

Leaving from urban general results, a successive analysis could give a benchmark for identifying potential places of accident (Section 4). The third objective is to investigate and obtain the reference situations for the accidents involving urban goods vehicles. The urban junctions result the most critical situations for accidents. A specific focus is also developed for the road accidents involving urban goods vehicles and pedestrians for the high visibility impact in the natural commercial city centre.

Into a sustainable urban mobility plan, specific parts on road safety must be developed (SUMP [7]) including a general urban safety assessment procedure (Section 5) that allows safety indicators describing the status of transport and mobility in the city, in relation to single link and single junction, to be identified. The paper has also the objective to define a procedure for computing indicator values. The procedure has to start ex ante from the results (i.e. in terms of vehicle flows) obtained by passenger/freight urban mobility simulation models. Subsequently, the main elements of potential accidents can be recognized by applying analysis and safety simulation models.

Some conclusions and operative indications to meet the future safety goals, for good vehicles in urban areas, are given in Section 6.

2 The road safety in European urban areas

Road traffic accidents in the Member States of the European Union annually claim about 43,000 lives and leave more than 1.8 million people injured, representing estimated costs of 160 billion euros (ERSO [8]). About 36% of deaths in the EU-19 occurred within urban areas. As revealed by national European surveys, the main actions have been addressed to improve road safety at extra urban level driven to the consequences that are usually more dangerous than those in urban environment are. Therefore, below, first the urban road safety in all Europe is discussed, subsequently a zoom on the larger European countries is provided.

2.1 The road safety in Europe at urban level

Referring to road safety, in urban areas there is a combination of different types of vehicles on the road that increases the risk of accidents. In the EU-19, the total number of fatalities within urban areas each year has fallen, while the proportion on total has increased slightly (DaCoTA [9]; Nghiem et al. [10]). By 2050, the EU should move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road fatalities by 2020 (White Paper [2]). Unfortunately, in 2014, the results show about 1% fewer deaths than reported in 2013. In order to half the number of road deaths by 2020, the road fatality numbers must go down at a higher speed from today and onwards (EU [11]). Unfortunately, as shown along the paper, goods vehicle contribution has not satisfactory pointed out.

At European level, in the 2009, the goods vehicles caused the 4% of fatalities in urban areas and the 60% of it was due to lorries (under 3.5 tons; DaCoTA [12]). It should be noted that goods vehicle flows are driven by end-consumer demand. As revealed by some surveys carried out in the larger European cities (Schoemaker et al. [13]; Gonzalez-Feliu et al. [14]), the 69% of urban distances (veh * km) covered each day by motorized vehicles consist of shopping trips, 24% of restocking trips (e.g. deliveries to shops, hotel, restaurant or catering activities) and the remaining 7% result from urban management (e.g. building sites, waste collection, network maintenance). Besides, shopping is the second most frequent type of urban travel for passenger. The average distance travelled per inhabitant is less than 2 km, against 0.8 km due to deliveries and urban management flows. Trucks tend to produce serious consequences when involved in collisions with passenger cars or pedestrians. A number of studies has examined truck involvement in road accidents (Lemp et al. [15]; Gitelman et al. [16]), although only few of them have focussed upon accidents in urban areas. As discussed in the following, although the level of detail of the main European safety statistics (e.g. CARE database) is insufficient to provide a fully accurate view (Tavasszy and de Jong [17]; Yannis et al. [18]), some analyses can be performed and subsequent indications can be drawn.

2.2 The urban accident trends in the larger European countries

In the following, the analysis is detailed for the larger European countries for which data on road accidents were available
according to CARE database (i.e. European centralised database on road accidents, which result in death or injury across the EU): France, Germany, Italy, Spain and United Kingdom. The available data cover the time between the 1995 and 2010. Although, CARE database could present some limits due to the different standards used in the past for collecting road accident data, it remains the main available and complete dataset for these types of analyses. For each country, the data are stored according to some key-criteria: area type (i.e. urban and non-urban), junction (i.e. junction, non-junction, no-defined), motorway (i.e. motorway, no-motor way, no-defined), transport mode (i.e. agricultural tractor, bus or coach, car and taxi, heavy and light goods vehicle, moped, motor cycle, pedal cycle, pe- destrian, other), vehicle age, number of pedestrians, number of persons, number of vehicles, accidents, killed at 30 days and injured people.

As confirmed by the literature (WHO [19]; White Paper [2]), some major countries in Europe have managed to reduce their number of road accidents in the last years, but for some of them (e.g. France and Spain) the downward trends in road traffic accidents have started to flatten, suggesting that extra steps are needed to reduce these rates further. Using regression methods for analysing road safety, Table 1 reports the trend factors of the total yearly national road accidents (Nna) in the five countries. The value of adjusted R-square good-of-fit statistic ($R^2_{\text{adjusted}}$) was computed as (Washington et al., [20]):

$$R^2_{\text{adjusted}} = 1 - \frac{\text{SSE}/(n-p)}{\text{SST}/(n-1)} = 1 - \frac{n-1}{n-p} \frac{\text{SSE}}{\text{SST}},$$

where

- SSE is the sum of square errors;
- SST is the total sum of squares;
- n and p are the number of available observations and the number of parameters used to estimate the fitted regression line.

From data, it emerges the high average slope of Germany, Italy, United Kingdom and France with respect to Spain, for which the average modelled slope of number of deaths is positive. Specific variables defined by the ratio between the number of accidents and the population, or the total national vehicular pax*km can be also developed to point out this phenomenon.

In particular, although the number of accidents has fallen, those within urban areas are more than 60% for the larger European countries and it is remained quite constant along the last decades (yearly percentage of urban road accidents - $P_{\text{nua}}$; Table 2). For example, the last Italian official statistics confirm that, in 2012, the percentage of urban accidents is quite constant and equal to 75% (Istat [21]) and shows that local administrators have to point out the problems and to promote different and further actions in order to improve the sustain-ability and liveability of cities. In addition, according to the results summarised in Tables 1 and 2, there are countries (e.g. Germany) that are reducing the total number of road accidents but their urban percentages are increasing, and countries (e.g. Italy) that have high and/or increasing percentages of urban accidents.

Focusing on the percentage of killed (at 30 days) and in-jured people in urban areas, the analysis shows that the yearly percentage of deaths (i.e. ratio between number of deaths occurred inside urban area and total number of deaths at national level - $P_{\text{nud}}$) is quite constant along the decades (i.e. low values of estimated slope) and varies from 19% of Spain to 43% of Italy (Table 2). On the other hand, the yearly percentage of injuries (i.e. ratio between number of injuries occurred inside urban area and total number of injuries at national level - $P_{\text{nui}}$) is higher than 60% with positive trends and only for Spain it has negative slope (even if very limited) and is less than 50% (Table 2). More in-depth, these results show that, for all investigated European countries, the percentages of urban road accidents, deaths and injuries represent significant portions of national values and more attention should be paid if the safety goals have to be reached by 2050. Then, the existing EU safety problems have to be also stressed analysing the different flows components, for example as detailed below for the goods vehicles.

### 3 The contribution of goods vehicles to road accidents in European urban areas

#### 3.1 The absolute national weight

According to the limitations of the main European safety statistics (e.g. CARE database [22]), in the following, some analyses based on number of accidents, number of deaths and injuries are provided focusing on urban areas.

Zooming on data available after the 2000 in Italy, Germany and United Kingdom, the percentage of accidents involving goods vehicles in urban areas ($P_{\text{nuig}}$) is quite constant among the three countries and is higher in United Kingdom (6.7%; Table 3). The percentage of deaths ($P_{\text{ndig}}$) and injuries ($P_{\text{nugi}}$) with respect to the number of accidents involving goods vehicles is lower in United Kingdom, while is averagely higher in Germany and Italy (Table 3). The comparison of these results with previous ones, in the recent years, shows that the many actions proposed by National and European Governments have allowed the total number of fatalities in road accidents to be reduced, but percentages of fatalities due to goods vehicles remained quite constant. Therefore, specific actions need because the accidents of goods vehicles often have serious consequences on human life and goods damage.
Table 1: Factors of the total yearly national road accidents (from 1995 to 2010)

<table>
<thead>
<tr>
<th>Population**</th>
<th>Accident</th>
<th></th>
<th>Death</th>
<th></th>
<th>Injury</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of accidents</td>
<td>Average modelled slope</td>
<td>$R^2_{adjusted}$</td>
<td>Number of deaths</td>
<td>Average modelled slope</td>
<td>$R^2_{adjusted}$</td>
</tr>
<tr>
<td>Germany*</td>
<td>81,802,257</td>
<td>-15,163 (-13.4)</td>
<td>0.95</td>
<td>8283</td>
<td>-156 (-17.9)</td>
<td>0.97</td>
</tr>
<tr>
<td>France</td>
<td>64,658,856</td>
<td>-8390 (-15.0)</td>
<td>0.94</td>
<td>4727</td>
<td>-153 (-7.2)</td>
<td>0.79</td>
</tr>
<tr>
<td>Italy*</td>
<td>59,190,143</td>
<td>-10,292 (-17.4)</td>
<td>0.97</td>
<td>4305</td>
<td>-32 (-2.5)</td>
<td>0.74</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>62,510,197</td>
<td>-9171 (-11.7)</td>
<td>0.91</td>
<td>2552</td>
<td>-52 (-6.7)</td>
<td>0.76</td>
</tr>
<tr>
<td>Spain</td>
<td>46,486,619</td>
<td>-189 (-0.3)</td>
<td>0.68</td>
<td>6057</td>
<td>102 (5.2)</td>
<td>0.75</td>
</tr>
</tbody>
</table>

(−) t-st value; * after 2000; ** at 2010

Zooming the trends of yearly number of deaths ($N_{nuag}$) and injuries ($N_{nuiag}$) in road accidents within urban areas involving goods vehicles, in the last three years (i.e. 2007–2010), it emerges that: in Italy, the average slope of yearly number of deaths is 2.8, in Germany it is quite constant, while in United Kingdom it is negative and equal to 1.6. It shows that, in particular in Italy, further actions should be implemented in order to meet the 2050 goal of safety. Besides, the lines representing Italy and United Kingdom have a higher slope (the sixth column of Table 4; death - average modelled slope), while Germany’s line is quite flat as justified that, with respect to Italy, the number of deaths in 2000 are half of Italy. Besides, although in the first investigated period (2000–2003) the number of injuries in the three countries is quite similar, the United Kingdom’s trend has a slope about twice of Italy and Germany (Table 4).

3.2 The relative national weight

In order to compare and rank different traffic safety problems, the key information is the exposure. According to OECD [23], the exposure can be described in different ways, for example, involved units, distance travelled, time spent in traffic, number of trips or traffic situations related to different accident types (i.e. vehicle mileage, user mileage). These variables are not usually collected for safety purposes but for road and transport (economic) planning assessments. Referring to urban freight transport and, in particular, to the contribution of goods vehicle, the presented analysis was performed in order to investigate the relation between road accidents (in terms of number of accidents, deaths and injuries) and the dimension of goods vehicle flows measured in terms of yearly tons moved and yearly vehicle-kilometres ($K_{nuag}$). Then, the number of accidents (including deaths and injuries occurred) per thousands of tons and (million) vehicle-kilometres performed by goods vehicles were estimated. The single accident rate was calculated for each years and each country for the years 2002–2010.

The Fig. 1 reports the national rate of yearly urban accidents ($NK_{nuag} = N_{nuag} / K_{nuag}$) involving goods vehicles occurred per million of vehicle-kilometres performed by goods vehicles in urban areas. The different trends of Italy and United Kingdom with respect to Germany can be pointed out. Although Germany had the higher values of road accidents ($N_{nuag}$) involving goods vehicles in urban area, Germany reduced, in the investigated period, the number of accidents ($NK_{nuag}$) and the yearly vehicle-kilometres of about 15%. Besides, the United Kingdom, with the lower number of accidents ($N_{nuag}$) in 2002, presents a high negative yearly slope until 2007 determined by a reduction of $N_{nuag}$ (about 27%) with a growth of $K_{nuag}$ (about 22%). In the following year (i.e. from

Table 2: Factors of yearly national percentages of urban road accidents, deaths and injuries (from 1995 to 2010)

<table>
<thead>
<tr>
<th>Accident</th>
<th></th>
<th>Death</th>
<th></th>
<th>Injury</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average yearly percentage</td>
<td>Average modelled slope</td>
<td>$R^2_{adjusted}$</td>
<td>Average yearly percentage</td>
<td>Average modelled slope</td>
</tr>
<tr>
<td>Germany</td>
<td>69%</td>
<td>0.5% (8.8)</td>
<td>0.90</td>
<td>30%</td>
<td>0.5% (6.8)</td>
</tr>
<tr>
<td>France</td>
<td>70%</td>
<td>0.1% (2.4)</td>
<td>0.89</td>
<td>29%</td>
<td>-0.2% (-1.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>78%</td>
<td>0.2% (3.6)</td>
<td>0.78</td>
<td>43%</td>
<td>0.3% (2.1)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>75%</td>
<td>0.0% (-0.5)</td>
<td>0.71</td>
<td>40%</td>
<td>0.0% (-0.6)</td>
</tr>
<tr>
<td>Spain</td>
<td>58%</td>
<td>-0.2% (-3.1)</td>
<td>0.84</td>
<td>19%</td>
<td>0.1% (1.1)</td>
</tr>
</tbody>
</table>

(−) t-st value
2008 to 2010), there was a reduction of accidents, but an increasing of above index (i.e. about 15%). On the other hand, a total reduction of accidents ($N_{nuag}$) from more than 32% in 2010 compared to 2002 has been reached. Finally, even if Italy remains the country with the higher level of accidents, it has had the reduction slope ($NK_{nuag}$) similar to United Kingdom, but it remains quite negative for all investigate period. Similarly, it happens for deaths with the only difference that both Germany and United Kingdom start from a low value of deaths and their trends are quite constant. The Italian decrease rate (2010 vs 2002) is about equal to 80%. This result has been obtained thanks to a reduction of number of deaths (i.e. 30%) and an increasing of vehicle-kilometres of about 26%. It demonstrates that Italy is implementing useful actions (e.g. point driving licences, tutor system for revealing the average speed), but other efforts should be done.

4 The reference scenarios for the accidents involving urban goods vehicles in Europe

4.1 The urban junction as critical situation

The subsequent reported analysis refers to the location of accidents. More than 60% involving goods vehicles happens at urban junctions and as argued by Luona and Sivak [24] measures addressed to improve safety in these places can have environmental benefits, contributing hence to improve urban sustainability. The number of deaths ($N_{nudg}$) at these points is averagely comprised between 23% (in Germany) and 46% (in United Kingdom) that seems to be quite constant along the years and for all the three considered countries, while the percentages of injuries ($P_{nudg}$) are averagely higher than 50% (Table 5).

Then, the analysis on junctions was detailed in order to estimate the average slope of percentage lines. The results show that the average slope of line for accidents occurred at junctions is positive for Italy, while it is negative for the Germany and United Kingdom. The same happens for injuries: the Italian average slope is positive contrarily to what it has been estimated for Germany and United Kingdom. The average number of deaths is going down for all three investigated countries (Table 5).

The analyses were hence performed excluding the accidents on urban motorways. The percentages of accidents involving goods vehicles in urban areas ($P_{nuag}$) from 2000 to 2010 are averagely the 68% in the United Kingdom, 59% in Germany and 52% in Italy. The average percentage of deaths ($P_{nudg}$) are respectively 46%, 23% and 34%. Furthermore, in the United Kingdom, these percentages are quite constant along the investigated period for accidents and injuries ($P_{nui}$, average slope for both equal to −0.43%). Table 3 shows the percentage of accidents, deaths and injuries involving goods vehicles in urban areas (from 2000 to 2010).

Table 3 Percentages of the accidents, deaths and injuries involving goods vehicles in urban areas (from 2000 to 2010)

<table>
<thead>
<tr>
<th></th>
<th>Accident</th>
<th>Death</th>
<th>Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>5.0%</td>
<td>1.6%</td>
<td>20.4%</td>
</tr>
<tr>
<td>Italy</td>
<td>5.0%</td>
<td>1.7%</td>
<td>26.4%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6.7%</td>
<td>1.1%</td>
<td>26.4%</td>
</tr>
</tbody>
</table>

($-t$-value)
average slope equal to \(-0.9\%\). Germany presents the higher yearly average reductions: 0.3% (accidents), 0.9% (deaths) and 0.5% (injuries). The Italian situation is quite different: the yearly average percentages of accidents and injuries increase respectively of 0.1% and 0.3%, while the deaths reduce of 0.6%. Such analysis showed that only for the United Kingdom different modelled slopes have been revealed considering the presence of urban freeway in the analysis data: higher value for deaths (from \(-0.6\%\) to \(-0.9\%\)) and lower value for injuries (from \(-0.1\%\) to 0.0%).

All the above estimated slopes are quite low with respect to the yearly average values. In fact, according to the estimated trends many years need before to have a reasonable reduction of accidents, deaths and injuries.

### 4.2 The road accidents involving urban goods vehicles and pedestrians

The below analysis was developed in order to estimate the involvement of pedestrians, to point out if further actions should be planned for improving capacity to take users away from goods vehicles. In fact, people in the urban area would like to make on foot, and then to adapt the road system to create a network of safe and attractive routes for them (Basile et al. [25]; Dommes et al. [26]; Saidul Islam et al. [27]).

According to COM [28], about 11,000 people die in road traffic in EU urban areas every year. The majority of fatal or serious road traffic accidents involving vulnerable road users take place inside urban areas. Around two thirds of pedestrian fatalities take place in urban areas and 50% of those died in accidents in urban areas are pedestrians or cyclists. During the last decade, the number of pedestrian deaths decreased by only 39% compared to 49% for car driver ones. Therefore, based on this statement, additional effort needs to enhance urban road safety and protects, in particular, the vulnerable users from death and serious injury (Safenet [29]). Then, below, some details on the three investigated countries are reported and the contribution of goods vehicles is pointed out, being very dangerous the outcomes when pedestrians and goods vehicles are involved in accidents.

The obtained results show that the three investigated countries have different trends. United Kingdom has a decreasing trend for number of accidents involving pedestrians and goods vehicles, number of involved pedestrians and percentages of accidents involving goods vehicles and pedestrians. In Italy, although the low significance of modelled slope (probably due to possible seasonal or irregular movements of time series that the few available data do not allowed to investigate more in-depth), all these statistics remained quite constant along the
investigated years, while the United Kingdom has the yearly slope higher than Germany and Italy. Besides, the United Kingdom presents the higher percentage of accidents involving pedestrians, and unfortunately, these percentages have increasing trends for all countries (Table 6). In addition, although other trends are negative, the low values of yearly slope have to be point out, showing that much has to do in order to preserve vulnerable users.

Detailing the above analyses at junctions, it emerges that: the low level refers to Italy and the higher one occurs in United Kingdom (Fig. 2). All investigated countries present rising trends, and this shows the centrality of the problem and more analyses should be carried out in order to implement specific and more performing actions.

According to the high level of attention to road safety, it is hence important to identify how the urban transportation network can most appropriately perform the functions required by the area. Therefore, each road and subsequently each junction in the network need to be examined in terms of their current functions and their observed performances. Much of the focus in traffic engineering is on junctions where congestion occurs, where the number of potential conflicts increases with the possible range of vehicle movements, and hence where vehicle to vehicle road crashes concentrate. Besides, pedestrians are channelled to cross roads at junctions. Following Cantillo et al. [30], Elvik [31] and Agarwal [32], some variables could be hence investigated in order to evaluate the performances of junctions according to the various characteristics of the road layout and traffic control at the pedestrian crossings. This includes the number of directions from which vehicles may approach a pedestrian crossing (arms: an indicator of the number of traffic movements that a pedestrian or cyclist must attend to when crossing the road),

the number of lanes, the presence of a refuge, the presence of traffic signal control, speed limit and the 85th percentile speed of approaching motor vehicles. Then, a single joint safety index can be obtained combining different junction characteristics related to traffic, design, visibility and accessibility (macro-characteristics, MC). For example, a joint index could be defined as follows:

$$J_{I} = \sum_{m} w_{m} \cdot \sum_{j} \left( w_{m,j} \cdot C_{j} \right)$$

where

- $w_{m,j}$ is the weight of characteristic $C_{j}$ (e.g. pedestrian-vehicle conflict points) associated to general macro-characteristics $MC$ (e.g. design);
- $w_{m}$ is the weight of general macro-characteristics $MC$ contributing to the general safety goal.

An application of such an index is provided by Basile et al. [25], which index was used for evaluating and ranking more than 200 junctions in 17 European cities.

### 5 Methods to safety assessment of road accidents for planning

Continuous monitoring and effective understanding are required to afford public decision makers the ability to successfully design and implement transport policies while responding adequately to new challenges (Gudmundsson et al. [33]; Ben-Akiva et al. [34]), especially in the freight transport field.

<table>
<thead>
<tr>
<th></th>
<th>Yearly average</th>
<th>Average modelled slope</th>
<th>$R^{2}_{\text{adjusted}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of accidents with pedestrians involved</td>
<td>1918</td>
<td>-14.4 ($-2.1$)</td>
<td>0.77</td>
</tr>
<tr>
<td>Number of pedestrians involved</td>
<td>2004</td>
<td>-16.25 ($-2.2$)</td>
<td>0.76</td>
</tr>
<tr>
<td>Percentage of accidents with pedestrians involved</td>
<td>9.2%</td>
<td>0.14% ($5.0$)</td>
<td>0.84</td>
</tr>
<tr>
<td>Italy*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of pedestrians involved</td>
<td>1171</td>
<td>-2.5 ($-0.5$)</td>
<td>0.61</td>
</tr>
<tr>
<td>Number of accidents with pedestrians involved</td>
<td>1030</td>
<td>-2.2 ($-0.5$)</td>
<td>0.22</td>
</tr>
<tr>
<td>Percentage of accidents with pedestrians involved</td>
<td>6.7%</td>
<td>0.17% ($4.4$)</td>
<td>0.81</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of pedestrians involved</td>
<td>1341</td>
<td>-60.6 ($-14.6$)</td>
<td>0.96</td>
</tr>
<tr>
<td>Number of accidents with pedestrians involved</td>
<td>1262</td>
<td>-57.0 ($-14.2$)</td>
<td>0.96</td>
</tr>
<tr>
<td>Percentage of accidents with pedestrians involved</td>
<td>12.2%</td>
<td>0.08% ($2.02$)</td>
<td>0.81</td>
</tr>
</tbody>
</table>

($- t$-st value; * = after 2001)
The European Commission has promoted the concept of sustainable urban mobility and has supported guidelines for developing Sustainable Urban Mobility Plans (SUMP [7]). To meet the EU goal, the analysis of the mobility situation and the development of future scenarios to be implement has to be supported ex ante in a quantitative and qualitative way as summarised below.

According to main data evidenced in the previous sections, urban areas and, in particular, urban goods vehicles have to be point out if the zero-accident EU goal must be pursued. In this context, the study of road accidents requires specific data analysis to obtain the risk factors and the safety performances. Several actors and choice dimensions are involved in this process. Therefore, it is important to have methods and models able to assess the effectiveness of the actions to be implemented. The current models were mainly developed to simulate some aspects of urban freight mobility (Comi et al. [35]), the integration with road safety model according to goods vehicles is quite neglected (Tsai and Su [36]). They are mainly not integrated in a general framework able to forecast many impacts of implementing traffic, transportation and safety measures at an urban scale.

Then, in planning phase, a general assessment framework that integrates mobility simulation and safety simulation models needs to be used (Fig. 3). The former one allows assessing ex ante road network performances (particularly flow in the junctions, and crossing flows of good vehicles, cars and pedestrians), while the latter provides the identification of potential black-spots (urban places where the frequency of accidents is higher than other). Merging the two results, the study of specific infrastructural points (such as a road, junction, or parking area) where accidents occur can be carried out.

The results ex ante obtained can address iteratively the changes in plan proposal in order to identify better the solutions for reaching the safety goal.

5.1 Mobility simulation models

Simulation models play a key-role to evaluate the performance of road network in terms of specific indications for each class of sustainability. A large literature exists on passenger mobility but fewer studies have been done on goods vehicles mobility, and, in particular, on analyses that link passenger and goods mobility. The literature review (de Jong et al. [37]; Russo [38]; Holguín-Veras et al. [39]; Comi et al. [35]) shows that, in the past, many of the models, used for simulating urban mobility, do not explicitly consider urban freight mobility and many of them were only theoretical. In particular, the urban freight models have been mainly developed, by researchers, to simulate some aspects of the restocking process and do not start from the end consumer (freight is mainly moved in urban area for satisfying the end consumers’ requests).

Few recent studies have analysed shopping mobility as a component determinant for goods mobility and considered that changes in shopping attitudes or actions impacting on purchasing behaviour of end consumers (e.g. location of shopping zone, transport mode used for shopping) can also affect restocking mobility (e.g. vehicle used for shop restocking, delivery frequency and shipment size). Hence, it is difficult to consider the link between the old urban models (developed mainly for logistic trips) and end-consumer models (which are those developed for passenger mobility), and to analyse the complexity of urban transport systems with all the components that make up urban mobility.

According to the earlier analysis, the junctions and the involvement of pedestrians have to be pointed out. Then, the outcome to reduce the interferences among the different components of urban mobility (i.e. passenger and goods movements), able to limit the cause of accidents, requires that the measures to be implemented have to be assessed by models (Tavasszy and De Jong [40]; Ben-Akiva et al. [41]). On the
other hand, in the global urban planning other single urban attractive points have to be studied, such as schools, public offices and so on, to fully reduce the interferences.

The road network should achieve the overall objectives of safety whilst not inhibiting the movement of vehicles and people to any significant extent. Each link (e.g. road) and subsequently each point (e.g. junction) in the network need to be examined in terms of its current function and its observed performance for that role. In this context, the models allow goods vehicle flows on each link (e.g. at each junction branch) to be estimated and accidents, that may result from a combination of factors including conflicting turning movements, speed differentials between motor vehicles and other traffic entities, pedestrians’ need to cross roads, to be investigated.

Besides, the above models represent tools that allow to obtain the data required for the disaggregate accident analysis useful for pursuing the safety goals. According to the high level of attention to road safety, there is a range of measures that may be implemented to reduce the number of goods vehicles involved in road accidents and/or their impacts (Elvik et al. [42]). It is hence important to identify how the urban network can most appropriately perform the functions required by the area.

Finally, the model results provide data for improving capacity to take passenger vehicles away from goods vehicles (because they provide paths used by goods vehicles and pedestrians), to calculate quantitative indicators, and to ordinate the road infrastructures in a list to be used by public decision makers as a quantitative and ordinate sequence of intervention priority. For example, the corresponding provision for walking should begin from identifying the pattern of journeys that people in the area would like to make on foot, and then the road system should be adapted to create a network of safe and attractive routes for them.

### 5.2 Safety simulation models

Traditionally, the safety models focus on data from accidents occurred. This study of road accidents requires specific data analysis in order to obtain the risk factors and the safety performances. Two different methodological analyses can be used (Delfino et al. [43]): aggregate or disaggregate. Although the disaggregate one could be more performing because of providing detailed indications on single accident scenario, the lack of detailed data, especially when goods vehicles are involved, makes difficult their use and addressed research to investigate more in-depth the aggregate one. Besides, when disaggregate analysis is performed, simulation models play a key-role to evaluate the performance of road network in terms of safety (i.e. number of accidents at nodes and on links) and to calibrate the scenarios from the accidents.

The aggregate analysis should be applied to the accidents that occur in an area where the frequency of accidents is higher than the other ones (i.e. black-spots). The aggregate analysis concerns a large area (such as an urban area or a central business district) and estimates the probability of an accident occurring in relation to a set of attributes that generally are macro. These data are often held by public organizations, can be updated through monitoring surveys, and are used to define and to characterize the phenomenon (e.g. type, temporal trend) as well as to locate the black-spots and to define strategies and measures (Vorko-Jovic et al. [44]). Statistical techniques are commonly used for this type of analysis (Yannis et al. [45]). For example, multiple linear regression, Poisson regression, and negative binomial regression models have been used to...
identify the relationship among accidents and contributing factors (e.g. data on mobility or on involved users). Besides, due to the increasing potentiality supplied by GIS, some researchers used mapping tools to link road accident with land use factors (Archer [46]; Elvik et al. [42]).

The quantification (in terms of absolute value and frequency) and characterization of accidents are based on available data obtained from Institutional Agencies (e.g. Italian National Institute of Statistics, EuroStat). This type of analysis allows to estimate the number of accidents in an extended area or in relation to particular type of accidents. In the former, the infrastructural black-spots can be identified, while in the latter it is possible to estimate the weight of accident classes in relation to the total number of accidents.

The main outputs of this type of analysis consist in results expressed in terms of absolute or percentage values (PSSU [47]). The absolute values give the dimension of phenomenon, in space and time. These percentages allow us to identify the relevant characteristics of accidents (e.g. number of deaths with respect to the total number of accidents), to verify the incidence of specific factors (e.g. type of involved vehicles). The analysis of these values also provides indications for the existence of black-spots and for comparing different areas (Van Raemdonck and Macharis [48]).

The *disaggregate* analysis concerns an infrastructural element (such as a road, junction, or parking area) and defines common elements in the accidents in order to identify safety measures to avoid impacts in relation to a set of attributes that are generally referred to the single vehicle or element of external environment. Through the disaggregate analysis, the accident scenario can be generated, and different methods have been proposed. According to Delfino et al. [43], they can be classified in collision diagram, cinematic reconstruction and accident scenario.

The collision diagram (Litvin and Datta [49]) is a schematic representation of accidents occurred in a specific place and time. Then, they are drawn with schematic conventional signs (segments, lines, circles). Each conventional sign represents a kind of accident or a kind of collision and each accident is defined with the drawing. All the data relative to the accidents are reported and classified in a table, in order to select the factors that have produced the accidents. This type of method synthetises the major information referring to accident, such as type and severity of accident, date and time, road conditions and so on.

The cinematic reconstruction (Della Valle and Tartaro [50]) of the accident considering as input data the final position of the vehicle after the accident and all the other measured data at the site of the accident. This method allows the accident to be simulated and the effects of the various measures that can be implemented on the accident site to be verified.

Based on the statement that accidents could be aggregated in relation to deeper similitudes, some research linked the accidents within the accident scenario approach (Brenac et al. [51]; Brenac and Megherby [52]). Although the accident scenario approach was proposed some years ago in France, it is still in a research phase. Some developments concern the quantitative formalization of the methodology and its application outside France in order to test the transferability of results and increase the number of available scenarios (Vitetta and Marcianò [53]).

6 Conclusions and operative indications

The paper, within the field of goods vehicles mobility, proposed an analysis on accidents occurred in urban areas showing that much has to be done for meeting the zero-accident goal by 2050 in terms of actions and, indirectly, in terms of data collecting (useful for studying phenomenon). Some preliminary conclusions together with operative indications can be synthetized, referring to the paper objectives.

The lack of harmonization of terminology among countries, and even among sectors within them, limits comparability of national data. This problem becomes more relevant when the impact of different types of vehicles are investigated. In fact, few data allow us to explore the impact of goods vehicles in urban areas where more than 50% of worldwide population lives, up to 80% in Europe.

According to the actions that should be implemented to meet the zero-accident goal, the analysis showed that significant results have been obtained on extra-urban roads, but within the cities, the reduction trends are quite flaten, with some warnings. The study showed that differences exist among countries and among some factors (i.e. number of accidents, deaths and injuries). There are countries where the majority of accidents happen in urban area (e.g. the 78% in Italy) and countries where the percentages of urban accidents with respect to the extra-urban are growing (e.g. +0.5% per year in Germany).

Considering urban goods vehicle accidents, important finding concerns of junctions and pedestrians. More than 50% of urban accidents happen at junctions with a significant involvement of pedestrians.

Urban policy-makers when designing urban measures have to deal with a large number of trucks and vans delivering goods in the urban area whilst preserving the economic viability of city businesses and ensuring social sustainability.

The above findings represent the base for developing successful city plans whose ex-ante assessment has to start from the results of freight and passenger simulation models, in terms of vehicle and pedestrian flows. In this respect, the models for city mobility simulation have been recalled showing that a maturity has been reached by literature in this field.

In conclusion, the importance to point out goods vehicles in analysing urban accidents has been detailed and the lines
for future development of researches can be identified. The research should be addressed to improve the results discussed in this paper through the development of advanced statistical methods in order to point out in the available time series the seasonal or irregular movements, to develop general city plan procedures that take into account, among the other, also the contribution of goods vehicles to safety because they need for moving goods required by city users.

Finally, the paper would like to stress the new roles played by the road network flows, obtained by mobility models, if they are linked with the safety models. This seems one of the main challenge for the researchers in the next future. Such models could allow to: estimate the commercial vehicle flows at each road infrastructure; estimate a proxy variable of pedestrian flow in each intersection; merge calculated flows with the infrastructural characteristics of the road network; calculate the safety risk; and hence ordinate the urban infrastructures in a list of decreasing risk in order to give to the decision maker a quantitative and ordinate priority of interventions.

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