Available online at www.sciencedirect.com
ScienceDirect
Procedia Social and Behavioral Sciences 2 (2010) 6355–6365
Procedia
Social and Behavioral Sciences

The Sixth International Conference on City Logistics

A classification of city logistics measures and connected impacts

Francesco Russo[a], Antonio Comi[b*]

[a]*Department of Computer Science, Mathematics, Electronics and Transportation, Mediterranea University of Reggio Calabria, Feo di Vito, 89060 Reggio Calabria, Italy*
[b]*Department of Civil Engineering, Tor Vergata University of Rome, Via del Politecnico 1, 00133 Rome, Italy*

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.

Keywords: City logistics; urban freight transport; urban freight measures

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

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

1877-0428 © 2010 Published by Elsevier Ltd.
doi:10.1016/j.sbspro.2010.04.044

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, but 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.

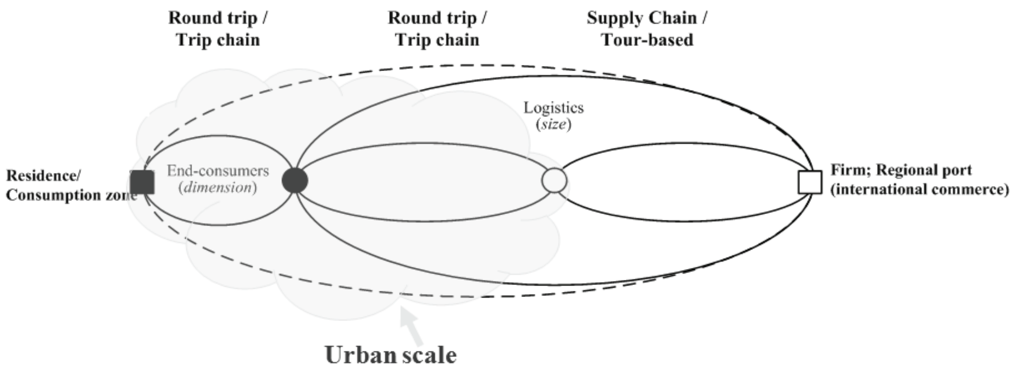

Figure 1 Functional relations and commercial schemes (Russo and Comi, 2006)

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 cargo-trams 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 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 promoter 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

BESTUFS (2007). *BESTUFS - Good practice guide on urban freight*. BESTUFS Consortium, www.bestufs.net.

Binsbergen, A. V., & Visser, J. (2001). *Innovation steps towards efficient goods distribution systems for urban areas. Efficiency improvement of goods distribution in urban areas*. TRAIL Thesis Series nr. T2001/5, The Netherlands TRAIL Research School.

Browne, M., Sweet, M., Woodburn, A., & Allen, J. (2005). *Urban freight consolidation centres - Final report.* Transport Studies Group, University of Westminster, United Kingdom.

City Ports (2005). *City Ports – project interim report*. Emilia-Romagna, Bologna, Italy.

Comi, A., Delle Site, P., Filippi, F., Marcucci, E., & Nuzzolo, A. (2008). Differentiated regulation of urban freight traffic: conceptual framework and examples from Italy. *Proceedings of 13th International Conference of Hong Kong Society for Transportation Studies*, Hong Kong, China.

COST 321 (1998). *Urban goods transport, Final report of the action*. Transport Research, European Commission Directorate General Transport, Belgium.

DfT (2003). A guide on how to set up and run freight quality partnerships. *Good practice guide 335*. Department of Transport, United Kingdom.

Dorner, R. (2001). Concepts for rail based city distribution requirements and case studies. *Proceedings of 5th BESTUFS Workshop*. Dresden, Germany.

Markworth, K., Jensen, H., & Mikelsen, B. (2005). Experiences of freight distribution in Denmark: Copenhagen and Aalborg. In ENEA (Ed), *Systems and advanced solutions for elogistics in the sustainable city*. Italy.

Nuzzolo A., Crisalli U., & Comi, A. (2008). Metropolitan freight distribution by railways. In E. Taniguchi, & R. G. Thompson (Eds.), *Innovations in city logistics*. Hauppauge NY: Nova Science Publishers, U.S.A.

ONU (2007). *Proceedings of United Nations Climate Change Conference of Bali*, www.un.org.

Paglione, G. (2008). *The policy framework in EU behind urban freight transport (UFT)*. Working paper, University of Rome 3, Rome, Italy.

Quak, H. J., & De Koster, M. B. M. (2006). *Urban distribution: the impacts of different governmental time window-schemes*. ERIM Report Series Research in Management.

Ruesch, M., & Glücker, C. (2001). *BESTUFS Deliverable D2.1 - Best practice handbook Year 1.* www.bestufs.net.

Russo, F., & Comi, A. (2006). Demand models for city logistics: a state of the art and a proposed integrated system. In E. Taniguchi, & R. G. Thompson (Eds.), *Recent advances in city logistics - proceedings of the 4th international conference on city logistics.* Elsevier, United Kingdom.

Russo, F., & Rindone, C. (2007). *Dalla pianificazione alla progettazione dei sistemi di trasporto: processi e prodotti*. Franco Angeli, Milan, Italy.

Stefan, W. (2008). Cityporto Padova. *Proceedings of H2 Rome - Mobilità sostenibile delle merci nelle aree urbane*, Rome, Italy.

SURFF (2003). *Sustainable urban and regional freight flows TR 1053*. Summary report.

Taniguchi, E., and Tamagawa, D. (2005). Evaluating city logistics measures considering the behavior of several stakeholders. *Journal of the Eastern Asia Society for Transportation Studies*, 6, 3062-3076.

Taniguchi, E., Noritake, M., Yamada, T., & Izumitani, T. (1999). Optimal size and location planning of public logistics terminals. *Transportation Research Part E*, 35(3), 207-222.

Taniguchi, E., Thompson, R. G., Yamada, T., & Van Duin, R. (2001). *City logistics – Network modelling and intelligent transport systems*. Pergamon.

TELLUS (2005). *Final evaluation report Göteborg*. TELLUS Project. European Commission, CIVITAS Initiative, Fifth Framework Programme.

Wisetjindawat, W., Sano, K., Matsumoto, S., & Raothanachonkun, P. (2007). Microsimulation model for modeling freight agents interactions in urban freight movement. *Proceedings of TRB 2007 Annual Meeting*, Washington D. C., U.S.A.