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Environmental Issues in Logistics and Manufacturing

Jesus Gonzalez-Feliu
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Sustainable Urban Logistics: Concepts, Methods and Information Systems

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Sustainable Urban Logistics: Concepts, Methods and Information Systems

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Preface

Urban logistics is a wide studied subject. Indeed, since more than 20 years, several researchers and practitioners deal daily with different issues concerning planning and management of urban freight transport systems. Nowadays, two definitions of city/urban logistics are retained. The first is that of Taniguchi et al. (2001) who define city logistics as "*the process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy*". The second, more related to the vision of Ambrosini and Routhier (2004) and Anderson et al. (2005), is not related to the notion of optimization but to organization. In this sense, we can define urban logistics as the pluridisciplinary field that aims to understand, study and analyze the different organizations, logistics schemes, stakeholders and planning actions related to the improvement of the different goods transport systems in an urban zone and link them in a synergic way to decrease the main nuisances related to it. Although the field has been studied for almost 40 years, it is only at the end of the Twentieth Century that we observe the main coordinated actions of research having a direct impact into practice

Nowadays, we can observe thousands of specific actions in urban logistics, many directly issued from research programs, but not all of them are still operational. This is mainly due to the different stakeholders that are seen in urban logistics, as well as the wide variety of aims and stakes and to the consequent difficulties to pursuit collaborative actions. Public stakeholders (politicians, city planners, public transport managers, regional or national technical services) are on a collective welfare vision and aim to reduce the main nuisance attributed to freight transport, i.e., congestion, pollution, global warming and noise without penalizing urban areas and also while creating employment when possible. Private stakeholders (shippers, transport and logistics operators, retailers, wholesalers, craftsmen, real state stakeholders, tertiary activities, etc.) are on an economic efficiency vision and aim to reduce costs and/or increase service quality, of course with an eye on the environment but not as a primordial criterion. It is clear that for each stakeholder the notion of sustainability is not the same. Although all of them refer to the Kyoto protocol, the importance that they give to each of its components (economic, environmental and social) is not the same, and it is often difficult to provide a unified vision to compare proposals and solutions. Furthermore, those issues are amplified due to the high constrained environment of urban goods transport and the interaction that it makes with personal transport (although goods transport is often indicated as source of nuisance, it is proven that its inefficiency is a consequence of the nuisances personal transport have on goods transport).

In this context we think important to make the links between research and practice, and provide a general framework to help both public and private stakeholders in managing and planning urban logistics systems. This book aims to provide both a conceptual framework for urban logistics planning and management and to create a basis for deploying solutions that aim to reduce the main nuisances related to urban goods. In addition to public authorities' aims and goals, the book highlights the importance of private actors, and shows how supply chain management can deal with the problems of the last urban mile and its integration in global logistics chains.

The book is divided in four parts. The first aims to describe and set the current situation, not only on the (historical) viewpoint of city planners but also on that of sustainable managers. The second part proposes a set of methodological chapters, written by key authors, which aim to support decision makers in terms of understanding and simulating the current situation in terms of urban goods flows. The third part is more related to tactical planning actions, including both public and private viewpoints. The fourth part is focused on strategic planning issues, also on both viewpoints.

The first part is composed on four chapters, two related to the links of urban logistics with supply chain management, and two focused on the relations between local governance and logistics development.

In the "Supply Chains and Urban Logistics Platforms", Daniel Boudouin, Christian Morel and Mathieu Gardrat present the main links between supply chain management and urban logistics, focusing on the natural interfaces between both of them: urban logistics platforms. Those links are presented from public and private sector viewpoints. A typology of urban logistics platforms is proposed, based on the structure of present and hypothetical future demand in terms of urban goods movements. Finally, the authors formulate several recommendations on new forms of organizations, technologies and governance.

If the "Supply Chains and Urban Logistics Platforms" focuses on urban logistics to see the links to global supply chain management (bottom-up), the second one has a top-down approach. Joëlle Morana presents the main concepts of sustainable supply chain management and applies them to urban logistics. In this chapter, the links are not physical but organizational, and are more related to private stakeholders. The place of urban goods transport in a sustainable supply chain management process is shown, and illustrated via the example of the Urban Consolidation Center of Padova (Italy). This example illustrates the need of collaboration among both private and public stakeholders and the importance of a sustainable thinking which do not focuses only on environmental hopes but also on economic and social facts.

The "Sustainable Supply Chain Management in Urban Logistics" adopts clearly a public planner's perspective. Erica Ballantyne and Maria Lindholm show, via an interview-based study, the issues related to including the identification of goods transport demand needs into urban plans. The authors present the similarities in the way that local authorities from Sweden, the UK, and Baltic Sea Region countries perceive urban freight problems, and discuss the relationships between local authorities and freight stakeholders. The main findings show that local authorities have begun to acknowledge freight transport more often but the issues faced by the freight industry are still not fully understood. Finally, they highlight the potential benefits of including freight stakeholders in the transport planning process, encouraging more meaningful discussions with key freight stakeholders at an early stage in the transport planning process.

Laetitia Dablanc shows in "Logistics Sprawl and Urban Freight Planning Issues in a Major Gateway City", via a Case Study on the Los Angeles mega-region, the main stakes and issues of North American authorities in terms of logistics needs and platform location and development. Moreover, an in-depth analysis of the logistics sprawl phenomena in Los Angeles allows the author to focus on the links between local governance and logistics activities deployment, especially for the jobs and tax revenues they can generate in a time of economic difficulties. She examines two cases in Los Angeles: the first is a traditionally industrial city close to downtown; the second is the sprawling community of the "Inland Empire," east of the L.A. metropolitan area. In both cases, the author observes the influence that the warehousing/logistics industry has on the economic life of working class areas, raising questions about the pros and cons of logistics activities for local communities.

The second part is centered on data production, more precisely on the methods that allow surveying, collecting, processing and/or reconstructing the information which can be needed to define and understand the current situation in terms of urban goods flows. It contains three chapters. "Data Collection for Understanding Urban Goods Movement" and "Comprehensive Freight Demand Data Collection Framework for Large Urban Areas" are related on survey and data collection methods, and "Estimated Data Production for Urban Goods Transport Diagnosis" on statistical methods for estimating data from current databases.

Julian Allen, Christian Ambrosini, Michale Browne, Daniele Patier, Jean-Louis Routhier and Alan Woodburn propose a wide review of survey methods that have been carried in Europe, based on the conclusions of the BESTUFS II project. From survey work carried out with experts in eleven European countries, a comparison of urban freight transport data collection efforts is made to better understand what currently takes place and to identify examples of good practice. Authors observe that the extent of urban freight data collection varies significantly between the European countries, as existing urban freight data comes mainly from the disaggregation of national survey results. Finally, authors identify a set of gaps in data collection, as well as the need for greater standardization in data collection methods and in analysis and reporting of this data.

The same subject is studied by José Holguin-Veras and Miguel Jaller, who analyse characteristics and unique features of the freight system, focusing on data requirements of different modeling techniques. Although both chapters refer to data collection, authors here focus on modeling and estimation, and study the roles of various data collection procedures. The analyses produce a set of findings of relevance to the design of comprehensive freight data collection frameworks for mid-size and large urban areas like those that can be seen in North America. From those findings, authors propose a modular data collection framework to support urban stakeholders' decisions concerning data collection methods depending on their needs and constraints.

Jesus Gonzalez-Feliu, Christian Ambrosini, Florence Toilier and Jean-Louis Routhier propose in "Estimated Data Production for Urban Goods Transport Diagnosis" a statistical-based modeling approach to propose a data estimation tool that can be transposed to different cities, avoiding the needs of making very costly surveys. The proposed framework needs standard inputs able to be obtained by public authorities and/or private stakeholders to make a diagnosis of urban logistics in current situations. The joint process of collecting data and modeling is described, and the different modules of the framework are presented. The authors conclude by presenting the main applications and further developments.

The third part deals with tactical planning. In other words, chapters of this part propose different methods to support stakeholders in middle-term decisions (Crainic and Laporte 1997), i.e., at a monthly-weekly horizon. Two main subjects are studied: consolidation and time constraints.

In "Planning and Optimization Methods for Advanced Urban Logistics Systems at Tactical Level", Simona Mancini, Jesus Gonzalez-Feliu and Teodor Gabriel Crainic focus on combinatorial optimization, more precisely on vehicle routing problems. The authors focus on methods related to advanced consolidation systems. The authors present the main categories of systems related to consolidation, and relate to each category a group of problems. Then they focus on optimization methods, presenting the main variants and making a critical discussion of its suitability. Finally, the authors propose a socio-economic analysis to study the leverages and limits of urban consolidation systems, based on a set of interviews.

Jesus Munuzuri and Ron Van Duin deal with the issue of access time windows. First, the authors motivate the importance of access times policies, and present a panorama of Dutch cities. After that, the authors present and apply a VRP-based methodology to estimate these costs, which should be brought into the overall cost-benefit analysis of urban time constraint policies. The main notions of vehicle routing optimization with access time windows are presented, and a genetic algorithm is presented. Finally, an example of application is shown as illustration.

Finally, the last part of the book focuses on strategic planning and assessment. "Urban Consolidation and Logistics Pooling: Planning, Management and Scenario Assessment Issues" is related to the notion of logistics pooling, which can be seen as an alternative to classical urban consolidation tactics. Authors propose a framework for strategic planning and ex-ante evaluation of logistics pooling systems. First, the authors present the main concepts of logistics pooling and their applications to urban delivery services. Then, an information systems-based framework for planning and evaluation is described, from which a set of indicators are identified. To illustrate this framework, the authors present a case study from a French urban logistics pooling system.

Agostino Nuzzolo and Antonio Comi propose in "Direct Effects of City Logistics Measures and Urban Freight Demand Models" a framework to forecast the direct effects of urban logistics measures. Such effects can be internal (transportation cost variations) or external (variations of pollution, noise and road accidents). First the authors consider the shopping and restocking components of urban freight mobility and the relative actor's choices that can be influenced by city logistics measures. After that they consider the road system with its various components, and the demand models are analyzed with particular attention to shopping demand models. The model is calibrated and the possible applications are enounced.

Edoardo Marcucci and Valerio Gatta lead with the heterogeneity in retailers' choices concerning the acceptability of urban logistics measures. The authors report the result of a stated ranking exercise conducted in the Limited Traffic Zone of Rome (Italy) in 2009 focusing on retailers and their acceptability to pay for different measures concerning urban deliveries. The authors make a comparison between two model specifications and study the non-linear effects for the variations of the levels of the attributes considered. The results obtained are very interesting and meaningful from a policy perspective since they show potentially differentiated effects of the policy implemented in deep contrast with the, often assumed, homogenous effect hypothesis.

Finally, Jesus Gonzalez-Feliu, Eiichi Taniguchi and Bruno Faivre-d'Arcier propose an overview on one important but little studied issue in urban logistics: that of financing and/or refunding urban logistics solutions. After presenting the main refunding strategies in urban economics and relating them to urban logistics, the authors propose to analyze the potential of cost benefit analysis in urban logistics. The general method and an application to the deployment of delivery space booking systems are proposed, and results discussed. Finally, authors list the main fields where public–private partnerships can be applied and identify the main refunding issues related to them.

With that plethora of approaches, proposed by key authors, this book aims to give readers a basis for understanding, planning and managing urban logistics systems with the respect of the sustainability development conditions, allowing a wide variety of stakeholders a unified and pluridisciplinary overview of the main subjects concerning sustainable urban logistics.

Jesus Gonzalez-Feliu
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Contents

Supply Chains and Urban Logistics Platforms

Daniel Boudoin, Christian Morel and Mathieu Gardat

Abstract This chapter introduces the stakes of urban goods transport integration in city development, through a supply chain and platforms approach. The urban logistics subject is analysed both from the public and private sector point of view. By identifying the structure of present and hypothetical future demand in terms of urban goods movements, various types of logistics platform are suggested as possible solutions for the improvement of goods distribution within urban areas. The chapter ends with recommendations on new forms of organizations, technologies and governance.

Keywords Platforms · Supply chain · Typology · Urban logistics

1 Introduction

The cities are major economic places which influence on territorial dynamics is constantly increasing. It indeed gathers traditional commercial functions, but also essential services to our society. Moreover, the rush in researching productivity at a global scale drives the evolution of productive systems, and we are presently noticing the fragmentation of industrial groups with a need in specializing and mechanizing. This trend is sustained by multiple material and immaterial exchanges which are more and more efficient as they take place in dense urban environments (Ambrosini and Routhier 2004).

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This leads naturally in thinking the urban subjects in the centre of development policies, and subsequently the logistics (a fundamental function to any economic and social practice) takes a central role in the organizational choices made by producers and/or consumers of goods as well as urban decision makers. This state is justified by the fact that multiplied and accelerated exchanges face the high quality of life required by 80 % of the inhabitants of Europe who live inside urban areas, therefore causing disturbances in the urban system (Dufour et al. 2007).

It is thus essential to think about the integration of the urban goods movements in cities (Patier 2001; Lindholm 2013) at a time where, on the first hand, the supply chain are recomposing to cope with new challenges (globalization, cost optimizing, flexibility, differentiation in a mutualized framework) and on the other hand, the cities try to reinforce their attractiveness by modifying their environment (global state of mind, activity mixing, dense cities, nuisance limitation,…). This obligation to take simultaneously into account the points of view (frequently contradictory) of logisticians and urban planners tends to promulgate solutions based on the consolidation of input and output flows, in order to limit the number of vehicles. In fact, loading vehicles to their maximum capacity—which is determined by the market (goods to deliver) and the regulations (possibilities of use)—is unavoidable if the objective is to contain or even reduce the costs but also the environmental impacts for delivering cities.

The consequence in the application of such a choice is the need to create new transhipping points necessary to recompose the flows (Verlinde et al. 2012). These places have to be at the closest range from the barycentre of the distributed zone. However, the places answering to these geographical requirements are rare and expensive, therefore logistics is systematically competing with other functions (living spaces, shops, services,…), in a frame highly constrained by the history and the past of the city, as well as present practices and future projects. The public sector has to intervene to reintroduce the skills related to goods movements in the urban fabric by opening dedicated spaces. This implies equipments that have to be integrated in a complex system where private and public sector, geography and history, economics and environment are at work. These various subjects are approached in three parts: the stakes linked to urban logistics platforms, the demand expressed and predictable in urban areas and the conceivable responses for “better” exchanges in cities.

2 The Stakes of Urban Logistics Integration

The logistics organizations develop essentially on geographical and economic criteria. It is mainly with data on production, consumption and infrastructures that companies invest in indispensable tools for the management of their flows. In parallel with (and as a consequence of) these needs, territories—whatever scale is defined: a country, a region, a city—set up infrastructures and capacities that result from land opportunities, pre-existing transport equipment, or even a market perception.

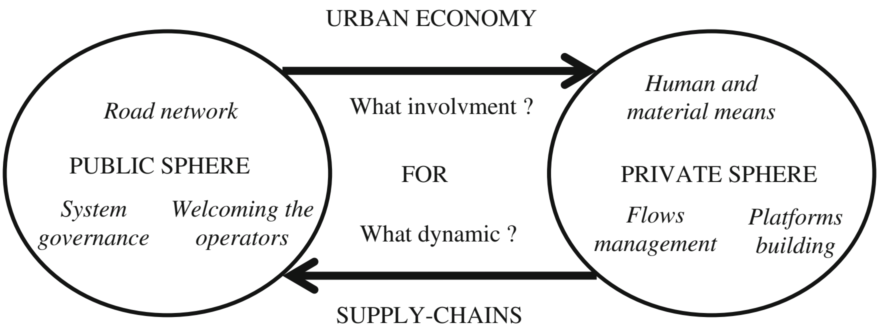

Fig. 1 The urban system through the urban logistics angle (adapted from Boudouin and Morel 2002)

In every case, logistics by its importance in terms of consumed surfaces, generated traffics and employment created is a major component of the urban planning. This is widely verified for the supply chains set up by industrials and distributors that led, since 1980, to create large platforms in key places of the territory (buildings larger than 5000 m^2 represent more than 40 millions of square meters in France according OBLOG 2007). These tools designed to link the production and the commercialization, are located in the peripheral zones of the conurbations, where the offer was physically, functionally and economically acceptable.

The last (or first[1]) link of the supply chain connecting these large logistics bases to the urban customers has only been taken into account lately. The reflections on this subject only started in the years 2000 with institutional actors and professionals concerned by this link, the most disturbing in the research for quality and representing one quarter to one third of logistics costs.[2] Today, the city as a geographical and economic space is the centre of attention for decision makers of the private and public sectors, considering that the performance of the logistics system depends also greatly on the coherence of the decisions taken by these two categories of actors (Fig. 1).

The urban logistics spaces, also known as ULS,[3] are in the core of the goods distribution device, as they are interfaces between interurban and urban, private and public, producer and consumer.

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[1] When operating pick-ups.

[2] High variations exist according to the products, organizations, chains, but this average value is generally accepted.

[3] This designation covers all the equipments designed to optimize the urban goods deliveries through the use of transhipping (Boudouin 2006).

2.1 Stakes for the Public Sector

This group gathers the institutional actors and the users, integrating the urban decision makers, the citizens and their representatives. The motives linked to the research for organization of goods traffic can be classified in three domains: environmental (quality of life, positive image), economic (general dynamic and capacity to attract added value activities), functional (fluidity of exchanges and answer to the needs). All these elements are very frequently connected with each other—for example, efficient and well-managed flows generate only few nuisances and reinforce the activity—and are essentially linked to the field of urbanism.

The various members if this public "sphere" do not necessarily have the same vision of the importance of urban logistics and their sensibility is focused (depending on the case) on a particular problem or another. For the users of public space (namely citizens and their representatives) the urban goods distribution is perceived as a hindrance to the improvement of the quality of living. For politics, police and public technical services, the subject of goods distribution is left aside to focus on people's mobility, which is both considered as more important in terms of flows and as a political stake. These tendencies are known[4] under quantitative and qualitative angles (Ambrosini et al. 1998); we can find them in the urban movement plans in France, which made obligatory the consideration of goods in conurbation larger than 100,000 inhabitants. In Italy, a few main cities include the urban goods in their city plan, and the main measures concern cargo consolidation, access regulation and improvement of the vehicle fleet (Spinedi 2008). In Germany, most of the main cities take into account the urban goods movements but there are also national rules concerning vehicle performances (emission standard labelling). The German approach tends to integrate all the stakeholders concerned by urban goods transports in the research of a consensus for the entire urban community. All these approaches are usually carried-out on a large geographical scale (urban areas covering several cities, regions…). Thus a frame of objectives is displayed at a national or regional level and contributes to a clearer view of the stakes. The main orientations of the regulations are based on the evolution of the notion of necessary "evil" to a more pertinent approach based on the research of answers for the next five subjects:

- Rationalizing the urban supply with the ambition to reduce the negative consequences of the multiplication of movements (Taniguchi et al. 2001).
- Maintain the commercial activity and craftsmanship in cities, guaranteeing satisfying conditions for their supplying (Dufour et al. 2007).
- Set in coherence the regulation on deliveries inside the urban transport perimeter (Dablanc 1998).

[4] Various works carried out noticeably in the «Marchandises en ville» program allowed to understand the fundamental motives of the public policies.

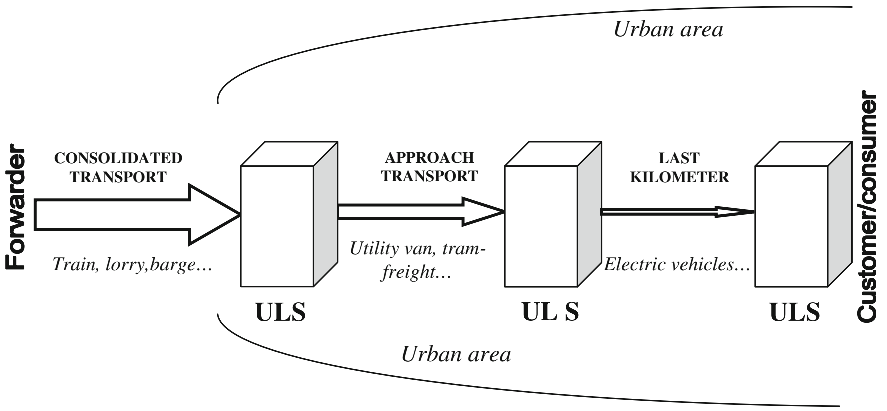

Fig. 2 Possible organizational scheme for Urban logistics

- Take into account the needs in surface necessary to sustain the activities of urban logistics.
- Lead a reflection on the existing and future infrastructures in the perspective of a multimodal offer.

In this approach, the reorganization of flows in judiciously chosen places is required. Indeed, the environmental, economic and functional conditions are different depending on the location (periphery, city centre…). Local authorities must then determine the orientations of the transport policy according to the location in order to favour an efficient supply chain in terms of urban insertion and quality of service. These sorts of policies imply points of articulation (ULSs) that can take various forms depending on the type of activity and demand (volumes and products to deliver, surfaces…).

The possible organizational schemes are multiple and reversible as they are affected to inputs (goods consumption) and outputs (production and waste) of products. The main principles can be represented in the Fig. 2.

The stakes linked to the implementation of such tools are connected to the targets defined by the urban planners. We can quote three main subjects.

Environmental stakes: they are essentially the consequences of the actions of goods movements. Considered the energetic assessment is a pertinent indicator to measure these effects, it is noticeable that goods movements represent 30 % of the global impacts of urban transports (in vehicle.km, also equivalent for green-house gases). A more precise approach (Ségalou et al. 2004) for each pollutant emission allows to determine that nitrogen oxides is accountable for 40 %, and even 45 % for particulate matter, of the global impacts of transport in cities. These data are directly concern in the health of individuals are now proven and cannot be ignored by local authorities. In a larger point of view, the effects on traffic are today the most perceptible facts and city-dwellers[5] do not hesitate to judge severely the results of past where environmental preservation did probably not have the attention it should have had.

Economic stakes: in average the costs of distribution of a product represent, for the urban part only, 3–4 % of the global value of a product.[6] Every increase of the cost of distribution is followed mechanically by consumers (companies and individuals) researching a limitation of these costs with the temptation of avoiding additional costs by relocating in peripheral regions. The challenge is real when we consider the role of the commercial functions and services in the animation and influence of a conurbation. While everyone agrees on the necessity of densifying cities and evolving towards a greater mix of primary components of the activity, public authorities must favour the traffic of goods which is in the centre of the balance and attractiveness of the city centres. In that case ULSs have a fundamental role as they allow to get closer to the customers, without multiplying the means of transport. This implies an action on the real estate in order to offer satisfying spaces at a reasonable price.

Functional stakes: a courier van stopped in front of a shop, a heavy lorry delivering furniture for a showroom, a moving van parked in front of a building, a postal service vehicle, a garbage lorry, a car with shopping items in its trunk… all of these are manifestations of the urban life. No one contests this obligation of delivering, and this ambition of development leads to more circulating products. It is necessary to adapt -or at least make compatible- the city to its needs in terms of goods movements, because if not, the repercussions on the global functioning of the urban system can be severe. The challenge is important since 15–20 % (Dablanc 2007; Routhier et al. 2009) of the road network occupancy of motorized vehicles is imputable to goods movements (included the movements of individuals for shopping motives).

Other stakes, noticeably social (maintaining or creating employment in dense areas), exist and reinforce the necessity for actors of the public sector to integrate ULSs in their planning process. This integration would impulse regulatory actions from the public sector, mainly to monitor the land-use.

2.2 The Stakes for the Private Sector

The look of professionals on urban logistics is different, even if they treat with the same components of the urban system. The financial filter is in this case fundamental when it comes to explain the choices made in a frame where actors just have one part of the determining factors under control. This is applicable for the two main groups of concerned professionals: on one hand the shippers (receiving

[5] Who are also voters.

[6] With a high dispersion according to the weight, volume, value of the analysed goods.

or sending the goods), and on the other hand the logisticians[7] (operating the transport, the storing, the conditioning). Every actor is restrained by the market and the urban environment, in an ever more competitive context (Morana and Gonzalez-Feliu 2011).

For these actors, practices cannot ignore social prerequisites, innovation is often related to marketing, rigidity of supply chains have to be associated with flexible segments and the value of time is always kept in mind.

The extreme diversity of needs leads to a multitude of cases channelled by urban realities (infrastructures, sites of activity, regulations). Hence, these platforms have varied roles, ranging from a simple relay allowing the solving a particular difficulty, to a piloting centre for all the administrative and technical operations necessary to deliver a city. If the objective is always to reach a better organization of exchanges, it is obvious that logisticians are the most concerned actors, being the operators of the system, whereas shippers are the clients. It is however possible to define the main stakes attached to the UDC through the perception of transport professionals, by using the same approach as for the institutional actors.

Environmental stakes: the companies generally consider that promoting a better life in urban areas is not their role.[8] Even if they are "citizen-friendly", they remain economic operators, having to sustain a financial health, which is a condition of survival. However they are aware of the growing interference of the environment in the competition and some even develop[9] aggressive tools to acquire an advantage (i.e. "clean" vehicles, waste management, carbon footprint…). Subsequently, platforms are an essential component of transport organizations, as they enable to finely lean segments of the supply chain by adapting the practices to each step of the delivery process. The upcoming hardening of the rules defining limits in air pollution and noise incites the creation of goods flows nodes inside the cities. Numerous providers already integrate these criteria in their offer, as well as distributors, artisans, service companies, are more and more conscious of their role. The increasing number of agreements related to logistics practices is a proof of this state.

- Economic stakes: these are the real motives behind the behaviour of transport professionals, as their competitiveness is linked to their skill to offer efficient logistics (Gonzalez-Feliu and Morana 2011). For shippers, the quality of service (often measured in terms of respect of the schedules) and the cost of their supplies is a key element in the choice of their locations; every dysfunction increasing their weakness against their competitors located outside of the city is a potential motive for leaving a dense zone. In this case ULS are strong elements in an attractive policy (in particular commercially), as long as transhipping does

[7] These professionals can also be shippers: a distributor can operate its supplying without needing the help of a service provider.

[8] Companies consider that the rules have to be clearly defined by policies.

[9] But also promote.

not cause heightened delivery (or shipping) costs. The main consequence is that professionals whish for public authorities to intervene directly (help to use certain techniques) or indirectly (decrease of the real-estate prices) to limit the tariffs. For their part, logisticians are more and more disposed to split up the operations all along the supply chain linking producers to customers, this approach allows to adjust the tasks to the client's requirements. The urban platforms are not only elements used to recompose the flows; they are also part of the chain of value of the transport companies. Hence, these tools have to be adapted to the selling process.

- Functional stakes: In order to manage the goods exchanges and control the time, it is necessary to use control nodes to manage the goods flows in urban areas. In fact, transport infrastructures in cities are often saturated (in particular when the needs in logistics services are high[10]) and local authorities search to regulate their use by limiting the conditions of traffic and light vehicles parking. According to this, it becomes essential to come closer to customers in order to operate the last kilometre with less disturbing means of transport for the environment (on foot, clean vehicles, electrically assisted tricycles…) and generally perceived as acceptable by public actors who are in charge of defining the regulations. Higher functional constraints[11] also mean higher needs in ULS. If during a long time providers could answer the requirements of the customers - frequently by ignoring the rules in terms of traffic and/or parking- the diversification of demand shows the limits of traditional schemes based on the relation with a platform located outside the conurbation (direct delivery or rounds).

This summary of stakes related to logistics shows the opportunities linked to ULS. The actors of the private sector mainly take actions on organizations to develop those opportunities. We will now review the characteristics of the demand.

3 The Demand

Public and private spheres are the components of a complex urban system (Ambrosini et al. 1998). At the same time distinct and complementary, they have different needs, functions and temporalities. However, "bridges" exist and are under development. Institutions and companies meet to organize solutions satisfying both economic and urban planning needs.

Nonetheless, the accessibility to urban areas is more and more constrained, atrophied by harder regulatory frames (access hours, conditions of delivery stops), and in addition more and more random due to the congestions of the road network.

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[10] The 7–10 h period is the one when light goods transport vehicles enter dense areas, often being in conflicts with the transport of people (cars, buses, motorbikes…).

[11] Caused by a difficult topography, a particular history, or even regulations.

The classical logistics schemes lead to the consolidation of flows towards platform or depots based on the barycentric location, the capacity (space and operations), and the optimization of the delivery rounds. The static delivery points are characterized by their number and dispersion. The logistics is monotype and the schemes are relatively individualistic.

For their part, urban logistics schemes come within the scope of already existing logistics schemes, also benefiting of the experiences of these last. They will integrate the notions of proximity and multiplicity of delivery points and access modes. The approach is more collective, trying to cope with the global increase of the delivery volumes for the various activities and inhabitants of the cities. Parallel to that, we can notice the higher frequencies of supply and the fragmentation of shipping due to the high dispersion of the addressees, imposing different cycles and longer delivery amplitudes.

In both schemes (classical and urban) the coordination of flows is at the centre of the problematic. These new habits of consumption and distribution standards lead the shippers and logisticians to question their supply chains.

3.1 The Demand at the Present Time

The expression of the demand shows the number and diversity of the implicated actors. Traditionally, two main categories of participants are regrouped in a public sphere for some and a private sphere for the others.

3.1.1 Demands Expressed by the Public Sphere

Among the public actors, the city planners are at the front row for deciding and applying actions allowing the enhancement of the urban traffic flows. However, as well as private actors cannot, on their own, resolve the transversal problems related to internal and external interactions of the urban logistics system, the tools available for public actors are not sufficient to understand and monitor globally the phenomenon. An urban logistics device ignoring exchanges and interactions between institutional actors, economic actors and residents can only lead to a failure.

On the opposite, letting the market apply its own solutions does not allow to bring satisfying answers to the complexity of a system of actors having sometimes contradictory targets. The local authority (a city, a conurbation) is the only actor capable of arbitrating and orienting the structure of urban logistics activity (through the organization of the road network) and its capacity to act on infrastructures and their use (through regulations). Moreover, being responsible for the general interest, the local authority can monitor the possible solutions in a way that it can be profitable to the greater number, hence going beyond the differences and potential problems. In the logic of environmental respect, it contributes to reinforce the acceptability of urban goods transport.

For its part the requests of cities inhabitants can be seen as schizophrenic. Indeed, the majority of city-dwellers refuse to see the installation of equipments made for activities they perceive as a degradation of their environment (essentially due to visual and phonic nuisances). This position is often relayed by decision makers, which leads to planning documents limiting the possibilities of installation for logistics activity. Paradoxically, their behaviour as consumers requires the goods to be available near their home, or be delivered to them directly in quantity and on time. Thus, the behaviours and expectations of the consumers are usually incompatible and in total rupture with those of a citizen.

3.1.2 The Demand Expressed by Companies (Business to Business)

It is expressed differently according to nature of the addressee (professional or individual), and the nature of his activity. Indeed, depending on the sector, the logistics expectations are radically different. The expectations of the logistician-carrier bear on the enhancement of their conditions of activity. They are echoing the "extreme" external constraints met in a city:

- Conflicts of use of the road network between the others modes of transport (congestion, pollution, nuisances): enhance the fluidity of the traffic, managing the parking of vehicles, acknowledge the most virtuous operators and help the use of low-carbon vehicles.
- Difficulty to perform delivery and shipping operations (regulatory incoherencies from an area to another, enlargement of pedestrian zones, clients-addressees with different expectations in time and space): bring to coherence the regulatory measures to the scale of the conurbation; make responsible customers about their requirements in terms of deliveries.
- Dispersion and remoteness of logistics equipments of the city (multiplication of vehicle movements, increased supply costs and environmental degradation): possessing sites in the city (multi-modal if possible), to implant logistics equipments in the proximity and reduce approach costs.

3.1.3 Exchanges Destined to Individuals: Business to Customer

We live in a period where the commercial tool is in complete mutation. The supermarkets come back in the city centres through new formats of shops that can be classified as convenience stores, but also with shopping malls implanted in the heart of cities. The e-commerce segment is widely expanding and pulls new schemes of urban deliveries and other organizations. Hence, customers are now delivered at home, at their workplace or through relays, and depending on the nature and the quantity of ordered products, these deliveries are performed from traditional regional platforms, platform located near large cities or from shops used as proximity picking sites.

The goal is to mix transports and logistics activities of all kinds of shops (hypermarket, supermarket, convenience store…). To cope with this many various needs supply chains are reset, taking into account three dimensioning factors:

- The delivered volume: if a hypermarket needs the deliveries of ten articulated vehicles a day, a small shop will only need ten palettes, and sometimes not even every day!
- The delivery frequency: the suppression of storage on the selling spot imposes a just-in-time organization, increasing the number of deliveries and thus the time spent by vehicles in the city.
- The location of the shops in the delivery route: their position relatively to efficient transport infrastructures, the accessibility will impact the delivery time.

The final target of this approach is to limit the frequencies of delivery to two or three times a week for small shops. The chosen logistics scheme will be the one offering the best balance between delivery frequency, environmental impacts and stockout rates.

3.2 Tomorrow's Predictable Demand

The future demand will ease the evolution from the stage of experiment to the industrial deployment of innovative solutions. Nowadays too few companies take the risk of innovation, the initiatives being mostly private, shippers are just following the initiatives led by the logistics providers. The allocation of resources to this cause is necessary to enter in an applicative step. The factors of the evolution of demand can be related to a development of:

- Delivery at home (Durand et al. 2010): a consequence of the increasing prices of fuels is the progressive abandon of cars by city-dwellers,[12] individuals will use more frequently this type of service. This trend evolves in parallel of the use of relays.
- Relays: the use of relays where the goods are stored during a short period of time, allows the disconnection between the delivery itself, and the moment when the goods come to the hands of the customers. It is mainly characterized by the fact that the customer can pick the shipment up whenever he wants without constraining the delivery operation. This sort of tool facilitates the transport operation and gives higher comfort to customers who can pick-up their

[12] In Paris, one out of two households is not motorized.

goods at any time (Augereau and Dablanc 2008; Durand and Gonzalez-Feliu 2012).

- Consumer to consumer: exchanges between individuals are developing. They will give birth to new needs in terms of logistics at a conurbation, city, district or neighbourhood scale.
- This heightened need for proximity already made emerge new delivery services using "soft modes", that remind in a way of on-foot delivery men, common in Europe during a close past, or today's "Dabbawallahs", lunch delivery men that combine train and bike to deliver about 175,000 meals in standardized box to people in Mumbai (India) each day (Baindur and Macario 2012). Services like "La Tournée", "Distripolis", "Urbancab", "Vert chez vous", prefigure the needs of future supply chains, namely to preserve their penetration capacities of urban centres in capillarity and in capacity.
- Multi and cross-channel purchases: the logistics becomes "agile" and "ubiquitous". It is quite paradoxical to observe that from one side, the logistics tries to mobilize more and more sophisticated tools to monitor and synchronize flows of ever more dispersed information using different channels. And on the other side the effort is put on dispatching physical flows, resulting from the informational flows, through the use of technical and human means which main quality is the consolidated and multimodal penetrative force in ever more difficult places to reach. Consequently urban logisticians will favour the intermodality, the mix of means and transport networks.

In the heart of these new devices, the transhipping, considered as the "sworn enemy" of the logistician -synonym of supplementary costs and risks of failure, thus dysfunctions- becomes an ally. Indeed, the diversity of delivered customers and their requirements (quantities, hours, units of operation), imply in order to satisfy them to come closer. Relay spots will become more frequent upstream the supply chain to interface or even desynchronize the interurban and urban flows.

4 Possible Solutions

The urban goods traffic cannot be considered only as a consequence of a social and economic organization, it is a particular component of this structure. Local authorities are more conscious of this fact and many of them are now involved[13] to control the flows running through the conurbations. Hence, the urban planning documents (SCOT, PDU, PLU[14] in France) integrate this dimension, noticeably through a reflection on the localization and dimensions of platforms.

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[13] This involvement is quite recent and really took consistence around 2000.

[14] SCOT : Territorial coherence scheme, PDU : Urban mobility plan, PLU : Local Urbanism plan.

The urban planners rely on these equipments to answer quality of living objectives and balanced development, for professionals these tools of flows management are fundamental for the optimization of the cost/quality duet along the supply chain (Boudouin 2006).

ULSs can be classified in two categories: generalists and specialists. The first would rather be dedicated to urban logistics professionals, the latter would be used for vehicles or goods going to specific zones.

4.1 Generalist ULSs

High turnover storage platforms (as articulation points between urban and inter-urban flows), have in most of the cases left dense urban areas. This tendency, started in the 1970s, is explained by multiple reasons: urbanism (regulatory impossibilities to settle), politics (rejection of tools perceived as a nuisance), economics (prohibitive prices). However, a remote localization from the urban barycentre induces longer delivery distances implying congestion of the road network, a loss in the global efficiency leading to higher delivery costs and an increase in GHG and other pollutants emissions resulting in environmental degradations.

Hence, an INRETS[15] study on hauliers' platforms in the region of Paris shows that the average distance from the centre increased from 6 to 16 km (300 m a year) between 1974 and 2008 (Dablanc and Rakotonarivo 2010).

The integration of platforms in cities recently became a major stake, but cannot really be operable without the public sector involvement. Indeed, these sites have to be easily accessible and located near delivery zones, making them very coveted spaces. The added value of this segment of activity is however insufficient to generate enough benefits and to win a highly competitive market against shops, accommodations, or other services.

Concretely these platforms designed for transport and logistics professionals can takes many forms: we will distinguish three of them, described in the next parts.

4.2 Urban Logistics Zones (ULZ)

These dedicated zones allow the actors of urban logistics to position themselves near their clients in order to limit their vehicles movements. The ULZs have two functions: firstly the transhipping and secondly the operations before the final delivery (for example: short storage). The delivery practices remain unchanged.

[15] French Institute of Transport and Security Research.

These platforms are supplied (if possible) by consolidated modes of transport. Dimensioned by the demand confronted to the available offer, these sites are linked to the urban planning and their size has to be significant in the urban space (50,000 m^2 at least). Railway stations (that have been for long a privileged location for hauliers), inland ports (in cities possessing inland waterways), wholesale markets (which role is to supply the city in food or other products), are relevant in this group of ULS.

4.3 Urban Distribution Centres[16] (UDC)

The ambition of this sort of installation is to manage the flows running through the city by channelling them towards a site where they are consolidated/dispatched, before the terminal (or original) goods movements. This sort of equipment is designed for professionals to drop off their shipments which are hence delivered by a specialized operator in urban logistics. The role of these tools is to operate all the dense areas during difficult hours (notably between 9 a.m. and 12 p.m.).

This type of equipment is conceived as a public service for goods distribution. It modifies the usual organization by integrating a new actor in the supply chain (playing the role of a subcontractor for the operator realizing the main relation). This implies a change in the procedures, guaranteeing the administrative and financial continuity of operations. Similarly to public transports, public authorities generally concede to a private company the management of the UDC according to precise specifications of transport conditions (hours, types of vehicles,…).

4.4 Logistics Hotels: Multi-Functional Buildings

The logistics hotel consists in a multi-purpose building, welcoming various types of activities (offices, shops, restaurants…) articulated around the logistics and distribution function. The main characteristics of this innovative solution can be described as followed:

- A building with a large scope: the range of activity integrating this sort of place must be sufficiently spacious to make it attractive and assuring its economic and social durability.
- A conception according to its location: every project is unique and must be constrained to an urban mimicry, in order to assure its settlement and afterwards its survival in the urban environment (Fig. 3).

[16] This concept is also referred as Urban Consolidation Centre or City Distribution Centre (BESTUFS 2009, Gonzalez-Feliu and Morana 2010).

- Exogenous constraints are mastered: the efficiency of such an equipment is based on its capacity to integrate different activities and to find a legitimacy and an acceptability at a local scale. From this point of view, communicating with local residents is essential. It must impulse a will of involvement et responsibility on necessary conditions of a street, neighbourhood, district and fight efficiently against the NIMBY (Not In My Back Yard—used to describe the rejection of some people to new infrastructures) syndrome.
- Responding to multiple users: the layout and access must be adapted and secured according to the practices ensued by the users.
- Taking also into account the vagueness of transport and logistics professionals' demands: New markets (such as e-business in B2B, B2C and C2C), induce new mobility practices (travellers and freight) and new patterns of deliveries (multi and cross-canal). We are entering in an era where logistics must prove "agility and ubiquity". This trend reinforces the need of proximity to clients and forces a reinvestment in urban centres. These new spaces of rupture are however considered by professionals as centres of costs and not as centres of profit, because the potential places of implantation are generally unsuited to the new challenges of urban supplies. They can however represent for urban planners key tools for favouring functional diversity by welcoming a wide range of activities.
- The acceptability is not completely acquired: the actors involved still have to be convinced (residents and politics) and are not aware on the subject of urban logistics. There is a need to create a communication strategy.
- The financial profitability of the logistics hotel concept remains undefined: this point lies on the locative price of the building, the maintenance, the operation of the concept and the locative potential.

4.5 Specialist ULSs

The possible responses to the problematic of urban deliveries are not unique. Every city, every neighbourhood has its own specificities and according the social and economic characteristics of the urban area and the ambitions of the urban planners, various solutions can be considered.

Thus, unlike the generalist ULSs are adapted to a wider range of products and customers, specialist ULSs, concentrated spatially and functionally, are possible solutions. We classified them in three groups:

4.6 Vehicles Reception Point (VRP)

Utility vehicle parking is one of the "black spots" of the action of delivery for two reasons: because of the negative effects on other users of the road network (congestion, various nuisances…) and because of the difficulty for drivers to find an appropriate location to park (time loss, security…). Moreover, the fact that most of

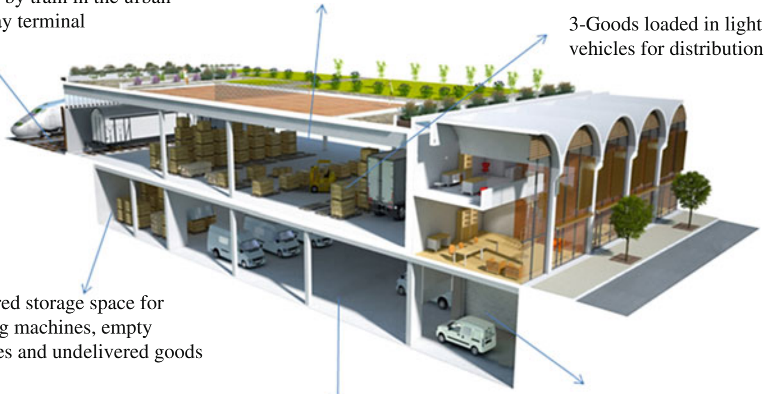

Fig. 3 Project of logistics hotel by Sogaris (currently in progress), Porte de la Chapelle, Paris, France *(credit: Sogaris)*

the deliveries are made in the margin of the law, leaves an impression of anarchy going against every organization policy of the urban centres.

To cope with these difficulties, a possible solution is to create places that guarantee a secured access for delivery-men to operate their deliveries or pick-ups, during a defined period of time. From these points, two solutions can be applied: either operating the delivery (or pick-up) on foot, with a possible help from the personnel or handling tools, or using services to forward the goods by smaller vehicles or tricycles, more environmental-friendly.

4.7 Goods Reception Points (GRP)

Some zones, because of topographical, functional ore regulatory reasons are difficult to access, subsequently making the deliveries harder to process. In order to contain the loss of dynamism and attractiveness of these places, strategically located relay points can be set up. These interfaces are substitute to the addressee (or shipper) to avoid the "last meters"; the division is both spatial (transfer to the arrival or departure point of the shipment) and temporal (delivery or pick-up in a period according to the interests of both parties).

The relations between the GRP and urban customers can be conceived in multiple ways (with or without the intervention of vehicles, service providers or loan of handling machines) and can cover a wider or lesser range of products (from regular boxes to reverse logistics shipments). Private structures (transport professionals or others) are the main promoters of these sorts of tools.

Fig. 4 DHL Packstation *(credit: DHL)*

4.8 Urban Logistics Boxes ULB

These ULSs are interfaces between the carrier and the customer without any human presence needed in the transhipment place. The advantage of this sort of solution is mainly the control of time; indeed, the notion of delivery hour is particularly important for all the actors of the urban system (however, frequently with diverging needs). The "urban logistics boxes" (ULB) can be fixed (sieves, deposits, parcel boxes) or mobile (container with varied shapes and dimensions). They are implanted in accessible private or public places (Fig. 4).

The classic procedure (reception of the parcel/acknowledgment of the delivery) is therefore changed. This implies a disconnection between transport and administrative operations, the latter being realized closely after the first (2 days maximum and rarely exceeding 2 h). These equipments, declined in various shapes (premises, lockers, automatons), are particularly adapted to online purchase (e-commerce).

5 Conclusion

5.1 A Necessary Arbitration to Preserve the Equilibrium of a Threatened Urban "Ecosystem"

Pollution, nuisances will be difficult to jugulate if the paradigm of urban supplies does not change. But do we have to reach this threshold to react?

In France, each year, 4,000 people die in accidents involving a heavy lorry. But nearly 42,000 "anticipated" deaths every year are the consequences of an exposition to pollutants and especially particulate matter which density is very high in urban areas. In fact, urban goods movements could be the origin of 70 % of particulate matter, 35 % of Nitrogen oxides and 25 % of GHG emissions.

5.2 More Sustainable and New Forms of Organizations

Supply-chains are continuously evolving and are submitted to strong mutations. Cooperative solutions only are able to cope with the stakes of revitalizing environmentally, socially and economically large urban structures. The efficiency of these solutions will be based on their articulation with the territories in which they are implemented. Urban planners involvement is essential on the subjects of urban logistics which have to be integrated as early as possible in the planning process. Two main axes of change are available for decision-makers to diminish the impacts of urban goods movements on the urban environment:

5.2.1 First Axis: Mutualizing the Means

We will divide the means implicated in the distribution of goods into two classes:

- Dynamic means: it is preferable to share the transport capacities, to favour concentrated means of transport (rail or inland waterways transport) upstream of the supply chain. In parallel, the last kilometre should be a segment of consolidation of already existing road transport (i.e. LUMD program[17]). It also turns out that sharing goods transports with public transport dedicated infrastructures (like railways, stations, bus lanes…) and vehicles (buses, tram, underground) is a possible solution. The positive impact expected for these types of measures will be a reduction of the number of vehicles operating delivery rounds as a consequence of a higher load rate and a modal shift towards railway or waterways transports.
- Static means: As well as above, it is advantageous to share flow processing capacities in storage facilities implanted nearby cities or in urban areas, with a preference for cross-docking operations (with adapted urban containers) in smaller (thus cheaper) surfaces. These collective efforts will minimize the approach links, allowing energy savings while reducing GHG and other pollutants emissions.

5.2.2 Second Axis: Using Alternate Engines

We can first list the different existing solutions: combustion engines for alternate fuels : bio fuels, gas, LPG; hybrids: diesel or gasoline/electric for heavy vehicles; electric: all types traffics/goods are not fit for electric deliveries, but those who are fit are easily predictable in terms of demands and specifications (range, distances, etc.).The combined effort of mutualisation and new "clean" technologies could divide the price of the negative effects of urban goods transports by 80 (Sia Conseil

[17] Sustainable and Mutualized Urban Logistics, a French PREDIT project.

France 2012). In order to be efficient, these two axes of change will have to converge towards new interfaces, new equipments for urban logistics which are fundamental back-ups to balance the new forms of the supply chains.

5.2.3 Sustainable Vision and Promotion of the Public Sector

Public and private actors are today aware of the necessity to act rapidly and to anticipate the next logistics organizations that will emerge for an efficient and acceptable urban supplying. This bet relies on the obligation to preserve an economic and social equilibrium in the different spaces of the city-centres while reducing the induced nuisances. It is now for public authorities to define the frame of intervention and its limits, that is why a political promotion is essential.

The capacity of local authorities to preserve and anticipate urban zones that answer the new challenges of proximity, mutuality, multimodality, set by ever more complex consuming behaviours, is a critical point and brings on the foreground the stakes of coordination between urban policies at a conurbation or even at a regional scale. This suggests a strategic approach of territorial balance and real estate management.

In order to have the benefit of a competitive urban logistics system, it is decisive to integrate and associate every actor of the public and private sector in the work of reflection for new goods distribution organizations. The performance of the system will be linked to the capacity of the actors to cooperate. Hence, the interest of urbanism in logistics is to conciliate urban planning and urban logistics for mobility schemes, space consumption and visual impact. This measure is even more important considering that logistics activities that were driven out of the cities towards peripheral areas during the 80s, are now trying to settle back in dense urban areas since 2000, with the obligation to reduce their costs while maintaining high levels of service for their clients.

Taking into account the needs in logistics spaces upstream of the urban planning process is thus fundamental: goods distribution systems have the same right to exist in cities as water, energy or telecommunication distribution systems. If not, adapting logistics to cities will only be made possible by using -and wasting-massive financial and material means. In a close future, urban planners will have to face this unavoidable challenge.

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Sustainable Supply Chain Management in Urban Logistics

Joëlle Morana

Abstract Urban logistics is a field that studies the best solutions for urban freight distribution with high environmental objectives. However, most actions are started by public authorities without taking into account the impacts of the new organizational schemas in the existing distribution enterprises' organization. This chapter proposes a conceptual framework for urban green logistics planning and evaluation, in order to relate urban logistics to green supply chain management, i.e. the public authorities' perspective to the enterprise's vision. Therefore, a dashboard is proposed and illustrated, as well as the conceptual framework, via a case study: the urban logistics system Cityporto (Padua, Italy).

Keywords Case study · Dashboard indicators · Sustainable SCM · Urban freight distribution

1 Introduction

Sustainable logistics and transportation constitute a primordial research axis in the enterprises' governance. For example, in 2009, at the International Meeting of Logistics Solutions (SITL[1]) in Paris (France), the Environment and Logistics

[1] http://www.sitl.eu

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Demeter Club and the French Agency of the Energy (ADEME) have validated 10 categories of "good practices" for a better respect of the environment.[2] Sustainable transportation and logistics needs to refer to the concept of sustainable development (Rio of Janeiro summit 1992). Its practice needs to be focused in a generational horizon (more then 25 years) and to join three consubstantial elements, which are respectively related to the economical, the environmental and the social spheres of the sustainable development. However, and as stated in Routhier et al. (2009), although some fields like building and manufacturing industries and energy production are doing quite well, there are still som "bas elements", from which freight transport and urban logistics energy management.

Before the 1980s, the management of freight flows for urban supples did not had an important impact to road congestion and air pollution in urban areas. Moreover, public authorities' actions related to logistics and freight transportation policy and planning in urban contexts were limited to specific measures to deal with emergencies (Gonzalez-Feliu and Morana 2010). With urban traffic increasing, and the raise of congestion not only in big but also in medium cities, some public administrations have affronted the problematic of urban freight distribution, that was managed traditionally only by the transportation carriers. Between the 1990s and the beginning of the twenty first century, with the contribution of public administrations and other support funds, several studies and pilot tests have been made to learn how to organise urban freight distribution in order to decrease traffic and pollution derived from this transportation sector. Most of these studies are oriented to support public authorities in decisions related to urban freight transportation planning. However, and since the urban logistics are mainly related to the last mile of classical supply chains, the enterprise's strategies have to be confronted to the collective interests related to urban freight transportation and logistics operations.

This chapter aims to identify and present the relations between the enterprise's interests and the public authorities' goals through collaborative sustainable urban logistics systems. The chapter is organized as follows. First, the chapter presents the main principles of Sustainable Supply Chain Management (SuSCM) and relates them to urban logistics through a synthetic literature review. Then, such principles are illustrated by their practice at Cityporto, a sustainable urban freight distribution system in Padua, Italy. This experience shows however that, although this project incorporates practices that can be considered as part of a SuSCM approach, the global reflection is only at its beginnings.

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[2] Information retrieved from *Les Echos Magazine* professional magazine, of 2009/03/24, p. 30. We thus find (1) In advance of the transport phase (upstream), design products differently, (2) Reorganize the company's production and purchasing, (3) Organize your logistics and transport better, (4) Combat unnecessary miles and speeds, (5) Reduce consumption of the means of transport, (6) Consolidate transport operations so as to reduce unitary costs and emissions, (7) Mutualize and cooperate between carriers and providers, (8) Optimize your storage and distribution platforms, (9) Improve the later links in your distribution chain, and (10) Communicate in order to lend value to pioneering approaches.

2 Urban Distribution in Sustainable Supply Shain Management

Traditionally, urban freight transportation planning has been made by the operating companies. In the last 20 years, we see that the public authorities have started to get involved into the development of solutions to deal with the major problems of freight transportation in city centres (Ambrosini and Routhier 2004; Munuzuri et al. 2005): congestion, air pollution, noise and other nuisances. Therefore, urban logistics researches are in general related to public authorities or to public—private collaboration, and supply chain management theories and methods are seldom used when evaluating urban logistics (Gonzalez-Feliu and Morana 2012). However, the main organisational aspects of urban logistics schemes are closer to those of many logistics operators, and a city logistics solution needs to be considered in a global (sustainable) supply chain management point of view, integrated in the global chain(s) of the delivered products (Allen and Browne 2010). For this reason, it is important to include urban logistics developments on sustainable supply chain management logic in order to make a strong link between a city logistics solution and the supply chain(s) it is related to.

Considering the current economic, environmental and social/societal context, it is imperative that an enterprise thinks “sustainably”. More and more academic works are interested to the link between logistics and sustainable development (Belin-Munier 2010). Regarding SuSCM, Seuring and Müller (2008) consider the pressures as such legal demands and regulation, customer demands, response to stakeholders, competitive advantage, environmental and social pressure groups and reputation. Effectively, logistics is often considered by the different actors as the “reason to be” of each firm belonging to a supply chain. Without logistics, no raw material can be extracted, transformed and delivered to the final user. As a natural continuation of the last works on logistics, more concretely those related to SCM, we reckon that it is now primordial to focus on Sustainable SCM that associates, reassociates and integrates all the works and reflections on the SCM, the Green SCM, the Social/Societal SCM, and, of course, all considerations about the transportation’s improvements.

Let us explore first the economic component of SuSCM, i.e. classical SCM. From the literature in logistics we can retain that Supply Chain Management (SCM) must be considered by the definition done by CSCMP (Council of Supply Chain Management Professionals[3]): “*Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across*

[3] http://cscmp.org

companies. Supply Chain Management is an integrated function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology".

Generally, SCM can be examined on the basis of three types of prerequisites: co-operation, customer satisfaction and performance (GRLT 1995; Lambert et al. 1998; Mentzer et al. 2001; Min and Mentzer 2004). But, nowadays, considering the non-negligible weight of the human factor in the transportation and logistics fields; we think that the human factor has to be specially studied in the Social/Societal SCM. In fact, SCM approach focuses on the co-operation of intra and inter-enterprise processes and the measure of its performance.

Firstly, and in a general way, the co-operation prerequisite highlights the importance of a clear product/service design and process along the supply chain. In this context, a reflection must be done on the entire supply chain (upstream, production and downstream). Two elements are important in this prerequisite: traceability (ability to trace and follow a product) and transportation (physical transport of each product from point A to point B, defined respectively an origin and a destination point). Secondly, the performance prerequisite consists of simplifying a complex process for each organization in the business network. It highlights the driving role of information systems such as Advanced Planning Scheduling (APS), Enterprise Resource Planning (ERP), Electronic Data Interface (EDI), etc. But also, its recognition, from an organizational, tactical and strategic perspective, requires in an end result the definition of Key Performance Indicators or metrics in order to appreciate the competitive advantage through Balanced Scorecard (Morana 2002).

Specifically on the transportation component of the SCM, it is important to carefully think about and to adapt the distribution (or upstream) network to the economical, geographical, organizational and quality constraints (Gonzalez-Feliu 2012). More precisely, the main questions in freight distribution tactical and operational planning are related to supply and inventory policies (warehousing), vehicle routing and scheduling (transportation management), vehicle assignment to a route and crew assignment to each operation. In city logistics solutions, many aspects have to be considered in strategic planning (Gonzalez-Feliu 2008; Ville et al. 2012):

- ***Financial aspects***: financing is important for such systems. Many of them are based on public–private-partnerships (PPP), or in strong public authorities' subventions.
- ***Infrastructural aspects***: the infrastructures' usage, alongside to the need of realizing new infrastructures, is evaluated.
- ***Organisational aspects***: the distribution system has also to be defined.
- ***Vehicle-related technological aspects***: once the distribution system is defined, it is important to find the adequate technological solution.
- ***Information and Communication Technologies***: mainly related to traceability, assistance to drivers, communication tools and intelligent transportation systems.

- ***Transportation planning tools***: to optimise routes, to manage vehicles and crews (even in real time situations), or to model the traffic in order to evaluate the different solutions.

The second element of SuSCM concerns the Green SCM that highlights the environmental aspects of the supply chain. We have to note that since the main goals of urban logistics solutions are environmental, so mental work must be done on how to integrate them into Green Supply Chain Management strategies. It is in the 1990s that the Green SCM found a recognition in the scientific literature (Srivastava 2007). In this field, we find several concepts like the eco-conception and eco-design (Michelini and Razzoli 2004; ADEME 2006), the reverse distribution (Carter and Ellram 1998) and the reverse logistics (Rogers and Tibben-Lembke 1999). Eco-conception and eco-design (related to product design, building and infrastructures with environmental respect targets) are similar concepts that have become popular in the 1990s decade (Michelini and Razzoli 2004; Le Pochat et al. 2007). Eco-designing products and eco-conceiving infrastructures for logistics purposes encourage a global approach designed to prevent or minimise impacts emerging throughout the whole life cycle of products and infrastructures concerning all types of environmental impacts.

In GrSCM, another important concept is that of reverse logistics, defined by Lambert and Riopel (2003) as the environmentally efficient practices of recycling, reusing and reducing amounts of material used. Dekker et al. (2004) refer to it as the logistics process that concerns the integration of used and obsolete products back into the supply chain as valuable resources. According to Rogers and Tibben-Lembke (2001), it is important to distinguish the green logistics and the reverse logistics concepts because they don't follow the same schemas, although several common points can be found (see Fig. 1). The vision of Green logistics proposed by the authors involve eleven domains, i.e. (1) energy and (2) materials conservation, (3) efficient land-use, (4) traffic and congestion reduction, (5) air, (7) water (8) visual, (9) smell and (10) acoustic pollution reduction and waste management, for both (10) conventional and (11) hazardous materials.

Another "global vision" of reverse logistics is that of Lambert and Riopel (2003), who propose a combination of reverse distribution, green logistics and reverse logistics measures and approaches and where the definition of each component does not exactly meet that of Rogers and Tibben-Lembke (2001) (Fig. 2).

Fig. 1 Connections between reverse logistics and green logistics, according to Rogers and Tibben-Lembke (2001)

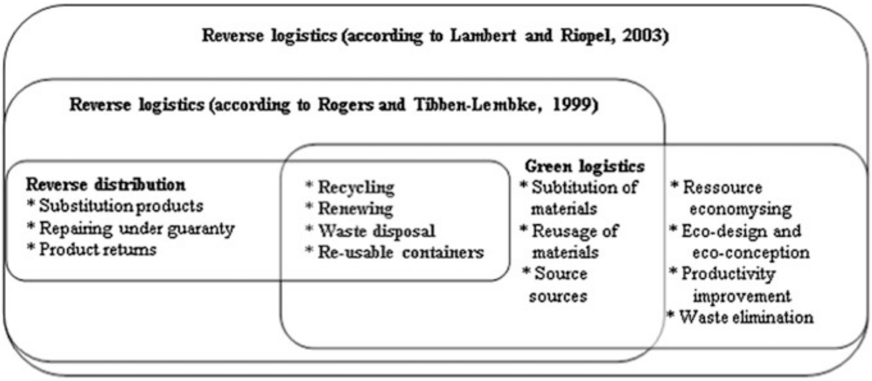

Fig. 2 The main principles of reverse logistics (Lambert and Riopel 2003)

In conclusion, we retain the definition of Green SCM proposed by Srivastava (2007): the "*integration of the environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life*". It can then be consolidated by three elements: (1) the consideration on the necessity and importance of GrSCM as crucial by all directors, (2) the green design that includes the eco-conception criteria, developing an '*understanding of how design decisions affect a product's environmental compatibility*' and (3) the green operations that symbolise all the reflections about waste management or, in a more general way, the reverse logistics management.

We have seen above the importance of the economic and environmental aspects of supply chains. However, the human factor is central to the management of any organization. If genuine attention is not paid to the role of individuals within the organization and between organizations, the gains that arise from SuSCM may be diminished. It is primordial to develop a Social/Societal SCM, in other words, to incorporate social/societal issues (in terms of data, network, and interactions) into the management methods and processes of a supply chain. To make it, we refer to Gond' work (2006), who addresses the convergence between human resources and sustainable development. Indeed, for this author, the sustainable development needs to be based on the human resource management. In this way, it is important to consider both the intra-organizational stakeholders (the employees of the company or the trade unions, for instance) and the inter-organizational ones (recognition made from all others stakeholders).

New trends on Human Resources Management have to be taken into account. In literature, we find several works that analyse the expected competencies by the logistical responsible figures (But following the thoughts made by Gond (2006), the Social/Societal SCM needs to consider each actor in a sustainable development approach. And, according to Morana et al. (2008), it becomes necessary to define a

Social/Societal SCM that integrates a social thought into the SCM. In the same order of idea, Ciliberti et al. (2008) consider a Corporate Social Responsibility where the motivation and the loyalty of the employees increase. In this context, the SA8000 certification must be the norm. In consequence, we suggest to follow the model proposed by Gond (2006), including the literature's social/societal dimensions applied to the SCM field (for example: the general behavioural context, to be reconciled with the managerial and behavioural components + common culture/ definition of roles/sharing of risks and rewards, rythms of work, reduction of conflict, training, suggestion box), and to Green SCM (for example: professional health and safety).

In brief, from the literature review, we can deduce a general framework for a SuSCM approach of urban logistics. We propose to define the components of SuSCM following Morana's (2013) representation and include the last-mile transport component as shown in the Fig. 3.

According the importance of sustainable development, we consider that it is important to define clearly a SuSCM. It becomes so convenient to conceptualize a specific aspect for economic SCM, green SCM and social/societal SCM which include sustainable transport. However, we should not forget that SCM (and also SuSCM) is a transverse concept. De facto, each dimension has to be inter-connected. Considering the few studies that analyse the links between logistics and sustainable development, we built an interview guide. The definition of this guide was a long and difficult task, because this guide has to be flexible enough to allow the two actors of the interview (the interviewed vs. the interviewer) to adapt their interventions to each another's constraints and needs. For example, maximum quantity of responses must be in concordance with the highly restrictive constraint

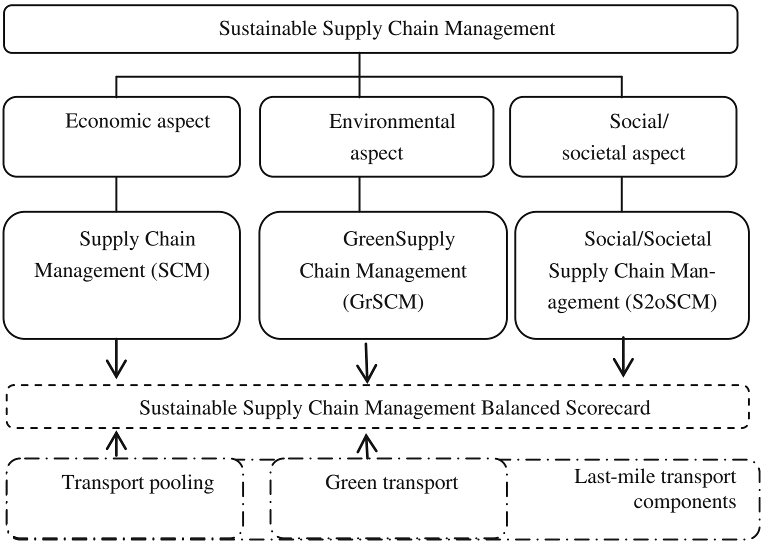

Fig. 3 Main components of the SuSCM (adapted from Morana 2013)

of time availability of the interviewed, which is in general a decisional figure in the enterprise or in the organisation of the public entity.

Taking into account this pre-requisite and having as references the different works presented in the literature review above, we have defined the following interview guide (box 1):

Box 1: Interview Guide

Economic variables

- Identification and analysis of each activity included in the enterprise's supply chain (infrastructures, standard procedures)
- Planning methods and technologies (information flows)
- Long term relations (contracts, partnerships) : gain's repartition among actors
- Measuring methodologies and indicators

Environmental variables

- Description of the environmental approach:
  - Actors' roles
  - Environmental performance measures
  - Internal waste management
  - Resource's conservation (CO_2, Energy)
  - Reverse logistics

Social variables

- Internal actions:
  - Formation
  - Idea's boxes
  - Management of stress situations
  - Friction reduction
  - Primes
  - Final consumer
- External actions:
  - Actions undertaken on external stakeholders
  - Syndicates and external stakeholders' support (transportation operator's consortiums and associations)
  - Attractiveness
  - Reputation and image

This guide is a support to business case research for the identification of the main SuSCM issues related to urban logistics planning and management.

3 An Illustration: Cityporto Padua

Padua is an Italian medium city (about 2,50,000 inhabitants) that has a historical city centre recently classified as Human Patrimony by the UNESCO. The main urban transport problems in Padua are traffic congestion and noise, low air quality and large commercial road traffic into the city centre. Like other medium Italian cities, the municipality has defined a restricted access zone (in Italian, Zona a Traffico Limitato), here noted ZTL (local policy) to deal with this congestion. Further regulations are proposed by the Veneto region (regional policy). These regulations establish a time window within it is possible to enter the ZTL. In the rest of the day, only the residents and other authorised categories are allowed to enter. An electronic tag identification system has been adopted to increase the access control at the "gates" of the zone.

Interporto di Padova S.p.A. is a mixed capital company that operates as both logistics real estate company and platform management operator. This company was created to deal with the management and planning of the intermodal platform of Padua (Italy). This platform hosts nowadays about 80 companies and its inducted activity involves more than 3,000 employees. Its surface is about 2 km^2 and has both a railway infrastructure and terminal facilities, like warehouses and cross-docks. Located in the North East of Italy, Interporto di Padova is connected to the main national and international railways and roads; it is thus a "strategic" logistic hub. Cityporto is an urban logistics service proposed by Interporto di Padova S.p.A. The main purpose is to reduce the number of trips by maximizing the loading rates of vehicles and the usage of low-pollution. Further than that, Cityporto is a new service for freight transport operators destined to enhance the delivery flows of goods as well as to improve the quality of the city life. Operative since the twenty first of April 2004, Cityporto of Padua is one of the few experiences of this kind successfully operating in Italy.

The project, promoted by the Municipality and Interporto di Padova, in collaboration with the Province, the local Chamber of Commerce and A.P.S. Holding S.p.A.—Mobility Division, is the result of more than 18 months of an experience which involved also the transport operators. The Protocol of Agreement which established Cityporto has been signed on the fifth of April 2004 and considered, among other things, a 4 year long contribution. The project forecasted a 12 months long first pilot stage directly managed by Interporto. The model laying on the basis of Padua urban consolidation centre is extremely simple: the transport operators or the self-transporting stakeholders deliver the goods to a logistics platform (a warehouse property of Interporto di Padova S.p.A.) located on the city surrounds where they are temporary stored; from this site depart the low-emission vehicles, i.e., those that have a low environmental impact in terms of CO_2 emissions and other air polluting gazes, which are intended for the distribution of goods in the city centre, i.e., the last mile of the supply chain. Nowadays, Cityporto's fleet has 9 vehicles: 7 methane small lorries (3, 5 t), one electric small lorry and one methane light commercial vehicle (2, 5 t). In the following analysis, the small lorries will be called city freighters and the other vehicle light freight-delivery vehicle (LFV). It is important to highlight that Cityporto is not an enterprise but a brand of Interporto di Padova S.p.A. The number of employees working partially on this service are three: two managers and one assistant. The logistics and commercial operations are made by a co-operative enterprise, where 12 people are affected to this service, plus one logistics advisor, who is an external consultant engaged full and long time on Cityporto's operational and commercial management.

The main activities of Interporto di Padova S.p.A. are oriented on two main axes: intermodality and sustainability. The company manages an intermodal terminal, providing logistics and real estate services to providers and operators. The company's logistics department holds a specific know-how to answer all technical and service logistics needs proposing a wide variety of services: consultancy, goods storage and management services, and assistance to national and international transportation, focusing on rail-road intermodal terminal services.

Cityporto is one of the sustainable logistics solutions of Interporto di Padova, more precisely the city logistics solution adopted in five Italian cities, where Padua was the first of them and the place of the project's conception and testing. The main activities of Cityporto are destined to transportation operators, although some self-transportation companies like furniture retailers are also customers of the service. The term customer will be used to define the transportation contractor, i.e. the operator or retailer asking Cityporto's services. The retailer will be the actor receiving the freight, although B2C transportation operations can also take place.

The main activities are related to last mile urban freight transportation, and include transportation, cross-docking, warehousing, and management of rejected freight by the retailer or other non-delivering situations. In this case, Cityporto finds a solution in agreement with its customer to satisfy the main needs as soon as possible. The platform operations are assured by a co-operative enterprise, which are paid proportionally to the quantity of freight that passes through the platform. The tariffs of the service are contracted with each customer, in base of the quantity of freight to be delivered.

3.1 Economic Dimension

Although the project was developed for environmental reasons, it is important to assure its continuity by a strong economic performance. For this reason, in 2003, after the signature of an agreement between the institutional stakeholders and Interporto di Padova S.p.A. related to Cityporto project initial founding and main guidelines, an industrial plan was developed. This industrial plan is based on the fact that the benefits of a city logistics system in a small or medium urban area has to be to reach the balance in order to do not depend on public funding contributions to maintain it.

As a support to tactical and operational planning, a strong information system has to be developed. Cityporto has developed its own information system in synergy with Cityporto services. This information system allows to make a follow-up of the freight (traceability functions) and the preparation of the different commands to be delivered to each retailer. The freight traceability is made by the following procedures:

- Each received parcel at the platform is identified. Then, a new tag containing a Cityporto barcode is applied to the parcel. If the customer uses EDI to transfer the command documents, the tags are automatically prepared in advance by the system. Else, an operator prepares them when the parcel arrives.
- The parcel code is activated in the system. A GPS-based tool sends the code and the geographical position to the central server of the system.
- The central server is informed regularly about the position of the freight and which commands have arrived at final destination, in order to make a complete follow-up process.
- The customers (transportation operators, service providers or self-transportation commercial activities) can follow online the vehicle where their freight is on and see the state of their commands.

The basis of Cityporto is its economical sustainability. Each year, an important economical performance analysis is made. The main used indicators are the number of parcels that pass each month through the platform, the monthly average loading factor for the two categories of vehicles (city freighters and light vehicles) and the results of the year's cost-benefit analysis. Cityporto's targets were to achieve a non-negative balance at the end of the fourth year, and they were met in the second. In 2008, the costs were covered by ¾ of the total income.

More specifically, the costs of Cityporto are mainly related to the logistics operations at the platform. The infrastructures and buildings belong to Interporto di Padova S.p.A., so they do not constitute an explicit cost to Cityporto. Moreover, the first six vehicles were bought by the local public transport operator with provincial and municipal subventions, and lent to Cityporto, who become the legal owner in 2007. Another vehicle, the electric one, has been also bought with a subvention of the region and also a municipal financial aid. Finally, the remaining vehicles have been financed with Cityporto's benefits. In conclusion, only the operational and platform management costs have to be met, and the system reaches the balance conditions each year, having also small benefits to reinvest in the development of the city logistics system (as for example more vehicles or material to manage other classes of freight).

The goals of Cityporto involve the companies that follow a global approach. This approach will favourise the development of collaborative agreements and partnerships. At the beginning of the project, the number of customers was near 20. In 2008, considering that Cityporto makes only parcel-logistics services, the number of customers is more than 50, which is big for a city like Padua. Most of the transportation operators are engaged for long-term collaborations with Cityporto. Moreover, a soft drinks distribution company operating in Padua has signed a partnership with Cityporto for restaurant and bar deliveries.

If the environmental performance is a success (as shown below), it is also the case of the financial and economic balance of the urban distribution solution.

3.2 Environmental Dimension

City logistics solutions like Cityporto are essentially developed for environmental reasons. Moreover, the environmental performance of Cityporto's services have to met several targets, because its connection to legislation and to public entities' environmental actions. For these reasons, a study has been commanded to the Bocconi University of Milan, Italy, to evaluate Cityporto's environmental performance (Vaghi and Pastanella 2006). In that study it is estimated that the environmental and social gains would have a monetary value of about 174.600 €/year. In terms of environmental weights, the most benefic elements concern a reduction on (1) the subtle powders [PM10], (2) the acoustic pollution and (3) the road incidents. This calculation highlights the viability of the project and justifies the investments made by the public entities in the first years. After this survey, environmental indicators are calculated yearly on the basis of the methodology proposed by Vaghi and Pastanella (2006). They are presented as the absolute gains (in tones) respect to the situation in 2003. These results are difficult to understand without a global vision of the emissions in the urban areas. For these reasons, we propose another set of environmental indicators expressed as the percentage gains of pollution emissions respect to those measured before the pilot tests (2003) (Table 1).

Another important aspect is the internal waste management procedures. In a system like Cityporto, the waste is basically empty boxes and packages, most of them recyclable. A specific container in the platform is filled in by Cityporto's operators. Its position in the platform has been chosen by practical rules to improve the time performance of the operations. This container is emptied in the corresponding place for recycling for all the industrial area where the platform is located. The reverse logistics procedures are not very important because the only materials that can follow them are the empty pallets. However, the management of returned freight that has not been able to reach its destination for several reasons is an important question that is daily answered. A special area of the platform is reserved to undelivered commands and the customer is informed immediately, in order to quickly find a solution to deliver it to the retailer or to return it to the customer.

3.3 Social Dimension

The number of employees in charge of Cityporto is small (only three) makes the system a family structure. For Cityporto's operational planning and management, a co-operative enterprise is contracted. These people are administratively external

Table 1 Pollution gains of urban transport in Padova's city centre ZTL with respect to 2003 (including Cityporto)

Polluting emission	2006	2007	2008	2009
Greenhouse gas emission gains	−67 %	−67 %	−68 %	−67 %
NOx emission gain	−70 %	−70 %	−71 %	−70 %
Particle emission gains	−60 %	−61 %	−62 %	−61 %
Number of vehicles of Cityporto	9	9	9	9

but they can be considered as internal stakeholders in an organisation point of view. This situation leads to a huge autonomy of the vehicle drivers because the routes are managed manually and the vehicles are loaded by their own drivers. The platform operators are assuring the administrative and warehousing activities. In fact, the relation between the drivers and the retailers is very good. During the visit, a follow-up of a route was made, and four retailers were quickly interviewed. They agree that the service is efficient and the human relations are good. Moreover, the logistics advisor has also commercial and customers' relations functions.

The environmental performance leads to a quality image that is reinforced by the social/societal aspects explained above. Moreover, the good relations with the customers and the operability of the information system have leaded to a transferability of Cityporto to other cities. So, in 2007, Modena adopted the Cityporto system, and in 2009, Como and Abano Terme, other medium Italian cities, started a city logistics system derived from Cityporto's know-how. Moreover, other two similar cities, Aosta and Rovigo, are in a study phase to integrate what Cityporto expects will become a network of city logistics solutions that follow the same model and the same information system.

As seen above, the social/societal impact can be appreciated not only on the environmental aspects, but also on the economic performance and on standardisation questions (the Cityporto network), which lead to a strong relation between customers and city logistics services. Moreover, a city logistics system is connected to a city, avoiding competition and concurrence questions between the different systems. For these reasons, partnerships not only between city logistics systems and customers but also with other city logistics systems are primordial to develop efficient urban freight solutions. Currently, long-term partnerships with local wine producers and a big drinks distribution company are settled.

Recently, a documentary video of Cityporto has been made by the Centre-Ville en Mouvement association (Stefan 2009). During the making-of, several interviews with the retailers dealing with Cityporto have been undertaken. Most retailers are satisfied of this delivery service, which is more personalised than the classical systems.

4 Conclusion

Sustainable SCM constitutes, in our opinion, an important investigation key for each stakeholder of the supply chain. This seems to be more and more urgent since the environment as a whole follows such variations that the actors (enterprises, public entities, customers, retailers, consumers, etc.) have to change their practices in order to improve, or at least to stabilise, the industrial model established in the XIXth century. The SuSCM approaches constitute an important support to this improvement.

The case study shows that a city logistics system can be based on a SuSCM approach. The three dimensions (economical, environmental and social/societal) are observed and strongly connected. Moreover, the social/societal dimension has an important impact on economic and on environmental aspects. We observe however that even when a project is developed with environmental goals, the economic dimension is primordial to assure its continuity. In this sense, the responsible figure of Cityporto's services affirms that without money, the activity cannot sustain. Finally, it is important to observe the impacts of the current economic crisis to the economic rentability in current logistics schemas. In consequence, the environmental and social/societal dimensions will be conditioned by the economic one, although they must remain fundamental for Sustainable SCM as a whole.

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Identifying the Need for Freight to be Included in Local Authority Transport Planning

Erica E. F. Ballantyne and Maria Lindholm

Abstract Local authorities are slowly beginning to acknowledge the need to consider freight transport in their policy decision making processes and, over the last decade research in the field of urban freight transport has increased. The purpose of this chapter is to present similarities in the way that local authorities from Sweden, the UK, and Baltic Sea Region countries perceive urban freight problems, in order to motivate a more thorough transport planning process. Interviews have been conducted in these countries, and analysed to draw out the factors that influence local authorities and freight operator perceptions of urban freight transport issues. The relationships between local authorities and freight stakeholders are also discussed. Findings from the research show that despite local authorities having begun to acknowledge freight transport more often, the issues faced by the freight industry are still not fully understood. This research is intended to highlight to local authorities the potential benefits of including freight stakeholders in the transport planning process by contributing to a better understanding on how best to approach urban freight stakeholders. The research attempts to encourage more meaningful discussions with key freight stakeholders at an early stage in the transport planning process.

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1 Introduction

Urban freight transport has during the last couple of decades gained more and more attention, both in the research arena and in the large amount of policy measures that have been trialled throughout Europe. Local authorities are slowly beginning to acknowledge the need to consider freight transport in their transport planning processes. Even though urban areas and freight movement activities are different around the world, they all have in common that they are complex and difficult to understand (Dablanc 2011). This chapter addresses the common perceptions about what constitutes urban freight and the similarities of interactions between local authorities and freight transport stakeholders in different urban areas. The purpose is to present the similarities in the way that local authorities perceive urban freight problems and to motivate a more thorough transport planning process. Furthermore, to demonstrate that by including a wider variety of freight stakeholders in urban transport planning discussions, the urban transport planning process could be improved.

The chapter is structured as follows: Firstly, we present an introduction to the urban freight transport planning and decision making process, followed with a description of the methodology adopted for the research. Thereafter the findings from the interviews are presented across four themes: how local authorities consider urban freight; how urban freight is recognised; how urban freight is managed; and the current levels of stakeholder involvement in the transport planning processes. The chapter concludes with a summary discussion of results and some final thoughts.

2 The Urban Freight Transport Planning and Decision Making Process

There are several references discussing the importance of integrated transport planning and decision support models for transport policy decision making (including: Bertolini et al. 2005; May and Roberts 1995; and Potter and Skinner 2000). However, there is a lack of appropriate theory and models aimed at specifically handling urban freight transport (Crainic et al. 2009). May et al. (2012) also highlights the need for better models and methods for decision support and suggests a generation tool for policy packages. In addition, several references (Muñuzuri et al. 2005; and Muñuzuri et al. 2012a) evaluate and suggest possible measures that could be implemented to solve various urban freight problems.

There are examples of models or computational processes and algorithms that try to solve or support transport planning by for example finding optimal locations for hubs of different kinds. Muñuzuri et al. (2012b) shows one example of optimal locating, which are referred to as 'mini hubs'. These 'mini hubs' would replace traditional loading zones and time window restrictions, which are currently used by many local authorities to manage urban freight movements. Tools of this kind can be helpful in understanding the effects of different relocations or costs of actions. However, it is difficult to find a model or computational process that would easily provide the optimal solution for freight transport in an urban area; since the destinations and amount of goods not only vary greatly throughout the year, but often the volume of goods received fluctuate throughout the week as larger volumes are received on Thursday's and Friday's to enable retailers to stock up for weekend trading. It is therefore necessary to understand the effects of different operations and activities in the urban area in order to judge their relevance and importance in relation to urban freight transport planning.

Based on a study of five of the most common urban freight transport policies: time windows, vehicle type restrictions, loading/unloading policies, fiscal policies and the promotion of transhipment and consolidation centres, Danielis et al. (2010) confirms that policies have differentiated impacts by type of goods and distribution channels. There is no one policy that can meet all the demands and requirements of urban freight transport, since each policy has different effects on freight operations. Furthermore, the area of city logistics is ever growing and there could never be a perfect ontology to describe it—the tools and frameworks need to be continuously developed and improved (Anand et al. 2012).

3 Methodology

Interviews were conducted in five countries across Northern Europe, with representatives from local authorities (LA's) and the freight transport industry. Since the research has originated from the authors' own individual investigations, interviews have been performed by the authors' independently, at different locations, and thereafter compared and analysed according to the common purpose of this chapter. In total seventy-four semi-structured interviews (see Table 1) each lasting approximately 1–2 hrs were conducted over the period of study 2008–2012. The interviews focused on the perceptions of urban freight; and the relationships between LA's and urban freight stakeholders to ascertain the variety in behaviour and attitudes towards urban freight.

On the whole, the interviews were conducted in a face to face, personal setting, with the exception of three telephone interviews. Halvorsen (1992) and Hellevik (1996) describe this type of interview as one where the questions asked are of an open-ended nature, as opposed to a multiple choice of closed questions. Multiple choice questions would have been selected if the interviews were intended to elicit

Table 1 Distribution of interviews in the five areas of study

Organisation type	UK	Sweden	Germany	Poland	Lithuania
Local authorities	16	9	4	3	4
Freight stakeholders	14	8	4	7	5

an exact answer to each question in order to directly compare different interviews. However, in this research, our purpose was to investigate the reasons behind the urban freight problem, for which it was necessary to ask questions of a more open-ended nature.

The interviewees were selected through both existing contacts with LA's and the freight industry, as well as through methods such as cold-calls, emails, and letters targeted at LA's and the freight transport industry operating in in urban areas. In addition, established freight networks and partnerships such as Freight Quality Partnerships (FQP's) were used to reach prospective participants in the UK and Sweden; whereas in Germany, Poland and Lithuania, the interviewees were recruited through the local authorities (both for local authority and freight stakeholder interviewees) in specific cities with the support of the EU project on Sustainable Urban Transport Plans (SUTP) (BUSTRIP project, 2005–2008).

Interview questions were grouped under two main themes, firstly general perceptions of urban freight, and secondly the relationships between LA's and the freight industry. Questions under the first theme aimed to determine perceptions on the following: the importance of freight in the urban economy, the extent to which local politicians and the general public recognise the role of urban freight, and the nature of urban freight problems.

The second theme examined aspects of relationships and interactions between the freight industry and policy makers, which included: the level of involvement between local authorities and the freight industry (willingness of both parties to interact with each other), and suggested ways for the freight industry to become more engaged in policy planning.

The following sections present the results from the interviews accompanied by a comparative analysis between findings from the UK and those from Sweden and the Baltic Sea countries.

4 Local Authorities' Consideration of Urban Freight Transport

In the UK, there was a general consensus amongst the majority transport planners interviewed that they "don't have much expertise on freight to be honest", which they in part attribute to the local authorities being "light on staff and technical expertise" to develop ideas, but also a lack of financial resources to subcontract the work to the private sector. The majority of local authorities interviewed admitted relying upon private sector consultants to conduct freight related scoping studies and to produce reports to support their Local Transport Plan's and City Region Transport Strategies. Other authorities displayed a tendency to lean upon a neighbouring authority for guidance from one individual with some background in freight, or on a regional transport strategy team that has people within it that have a specific responsibility for freight. Only three of the LA's interviewed expressed confidence in their ability to manage local freight movements, although one has a transport planner with previous experience working in the logistics industry, which had become a central resource in the region for queries regarding freight issues. Another LA had one officer heavily involved in organising their FQP and a freight steering group, as well as coordinating representatives from the local freight industry to develop policies and initiatives in the area.

In comparison, Sweden had one authority with a full time employee responsible for freight transport issues and a general good knowledge of freight transport in the urban area, which was mainly a result of several years of focus in this area. One authority in Germany also has a person responsible for freight transport issues, but those issues are mainly on a technical level regarding surveillance and statistics, and there is little work done regarding the matter of long-term planning. Amongst all other authorities interviewed in northeast Europe, there was a general lack of acknowledgement of the area of urban freight transport. The LA's trust the freight industry to handle transport operations as efficiently as possible, but at the same time they see the urban freight operations in the urban area as a disturbing factor. For example, a representative from a public transport company in a Baltic Sea Region city commented that: "They [freight vehicles] are in our way of transporting people", and therefore regard freight traffic as a disruption to passenger transport movements. This demonstrates that local authorities who hold equal responsibility for handling freight transport planning as they do passenger transport, have what Ogden (1984) describes as a lack of interest and time invested in freight movements in the urban area.

The findings highlight a general lack of freight transport expertise in local authorities across the countries studied; with the majority of the local authorities interviewed having no personnel at all working on freight transport issues.

5 Recognition of Freight Movements in Urban Areas

Freight transport movements are rarely considered in land use planning, with respondents commonly admitting that "we never thought of handling the freight issues". Local businesses are more concerned with how their customers will be able to access their amenities, rather than how they will get their goods to their premises. However, freight transport is recognised as a feature in most local transport plans as for example a driver of the urban economy and, therefore as an important issue. Nevertheless, in the same transport plans, the tasks or planned development measures outlined are rarely directly related to freight transport. Those that are, generally relate to bans and regulations aimed at minimising noise or damage to pavements caused by heavy vehicles. Furthermore, the cooperation between local authority internal departments regarding freight transport is generally lacking. In order to reach sustainability for freight transport more cooperation between departments (environmental, strategic planning and traffic departments) within local authorities should be encouraged, although currently there is little evidence from our interviews to suggest that this occurs on a regular basis.

Freight transport is recognised in urban areas at the local authority as something highlighted when complained about. Complaints come from both transport operators and from other stakeholders with regards to noise, safety and access mainly. For transport operators, a common complaint is the availability and access to loading/unloading space. Although UK interviewees from both the freight industry and LA's agreed that freight has a very important role to play in supporting the urban economy, most believe that freight is generally taken for granted by the general public, and is therefore not at the top of the political voting agenda. It was even observed that the politicians "like to think it's important but I'm not sure that a lot of politicians give it the attention it deserves". There was consensus amongst those interviewed that the general public have very little knowledge of the freight movements going on around them, and as a result they mostly notice the negative aspects of freight transport. One industry respondent commented that freight is "most probably misunderstood more than anything. I think when any individual goes to their corner store they're happy to pick up their loaf of bread but they're pretty [annoyed] that they can't park their vehicle… because the truck is in the way… people certainly want the convenience but they don't want the inconvenience of vehicles being in the inner cities or built up areas at the times when they are trying to go about their daily business."

For many of the authorities interviewed, freight plays a key role in the regions' manufacturing, quarrying, timber and agricultural industries where it provides a continual source of employment. Even in the areas where the economy is service sector dominated with a healthy tourism industry, the local authority recognises that for "the tourists that come here to buy the ice creams, the ice cream has got to get here… it probably came on a lorry".

It is also noteworthy that general knowledge of freight transport operations is relatively unknown, since there are seldom any reliable statistics available. In some of the localities it is possible to identify heavy vehicle movements from the regular traffic counts performed (however, those are not performed in all localities), although no statistics were formally published to identify freight transport volumes or intensity. Whilst very specific and detailed information exists about all public transport movements in some cities, freight transport by comparison appears to have been pushed further down the local authorities' agenda.

6 Managing Urban Freight

The most common way of managing freight transport in urban areas is by regulation and restrictions. For the localities interviewed, weight and time restrictions of some kind or infrastructure restrictions such as pedestrian only streets and one-way road systems are amongst the most frequently used. One of the main downsides described by operators of the weight limit restrictions imposed is that

HGV's are being forced to take longer routes to go around the limited zone to reach customers which contributes to higher fuel consumption and emissions. However, the reason behind those restrictions is not always in the interest of freight transport effectiveness or efficiency, but more often a very site-specific reason due to sensitive areas or specific demands by stakeholders.

All localities are somewhat hindered in their work with infrastructure networks and using certain kinds of regulations depending on National and European legislation. Other important factors that hinder their work are economic and political structures, for example local authority civil servants are responsible for the planning procedures, but it is the political representatives that are responsible for the decision making. Furthermore, historical reasons and cultural traditions could have great influence on the planning procedures. Often urban deliveries are made to premises that have undergone a change of use, for example a small high street convenience store may occupy premises that were constructed some 50 years ago for use as a hairdressers, and therefore delivery access to the store is limited since it had never previously been required from the outset.

Delivery time-window policies are one of the most commonly used demand management tools for regulating urban freight movements. In a survey of 33 Dutch local authorities, Quak and de Koster (2006) highlighted that over 90 % of officials sought to implement time-windows with the main objective of creating a more appealing shopping environment by improving the aesthetics of an urban centre, so as to attract more visitors and enhance local economic development. However, operators interviewed in the UK described the operational pitfalls of such policies. The majority of freight being distributed in and around urban centres begins its journey at a regionally centred distribution centre, usually in close proximity of the motorway network and is therefore affected by major incidents occurring on the motorway network. When these delays occur it can cause missed city centre delivery time windows, often resulting in either a failed delivery or forcing hauliers to park a significant distance from their delivery point, perhaps parking illegally and compounding the delayed schedule.

Some hauliers operating in a UK pallet network noted that they make their deliveries within a specific postcode area where freight comes in overnight and has a short turn-around time to ensure next day delivery within the specific time window to deliver that freight. City centre pedestrian precincts were highlighted as being particularly difficult locations, although operators recognise that local authorities have to strike a balance between the needs of operators and the safety of pedestrians. However, with growing regeneration and city centre developments, volumes of freight being delivered into central urban areas are increasing. From a business perspective, hauliers would ideally split deliveries over the course of the day, thereby achieving maximum utilisation of their vehicles.

Freight forwarders in smaller localities, particularly in Poland, Lithuania and Sweden recognize that time windows could be a problematic issue when harmonized in several neighbouring localities. This is due to freight forwarders needing to operate more vehicles simultaneously in order to serve all the areas with the coordinated time window. Without these time windows in place, a single vehicle could have covered all the deliveries in the area. With regards to parking and legislation, government and local councils are very restrictive. Access to and provision of adequate loading/unloading facilities was a commonly reported impediment by operators interviewed in all localities. Penalty Charge Notices (PCN's) in response to parking offences are frequently received as operators struggle to make deliveries to city centre commercial premises such as restaurants and pharmacies where access may be poor and often a lack of loading bays prevail. For operators covering central London, dealing with the sheer volume of parking tickets and bus lane fines can often be a full time occupation. Over the period Q1 2009–Q2 2011, a survey of twenty-six Freight Transport Association (FTA) members revealed that over 80,000 Penalty Charge Notices (PCN's) had been accumulated, totalling £3.86 million in revenue for London Councils, with the average PCN cost per operator being £148,349 (Chapman 2012). Furthermore, unauthorised parking at loading and unloading facilities by private cars for example was highlighted as a major hindrance for efficient transport operations in the majority of the localities interviewed. However, in Gothenburg, Sweden, a good example of enforcement has been demonstrated, since a higher surveillance of the traffic situation in the inner city resulted in a 90 % decrease in traffic violations (Jäderberg 2012).

Operators also identified a significant lack of suitable lorry parking in and around large urban conurbations. An issue, which has arisen following the European Union's introduction of legislation regarding drivers' working hours, which was established in April 2007. The EC regulation 561/2006 states that after a period of four-and-a-half hours driving time, a driver must take an uninterrupted 45 min break (Goel 2009). In response, some LA's in the UK had developed designated lorry parks that provide state-of-the-art facilities close to the boundary of their area; however many of these remain under-utilised by the freight transport industry. Some of the reasons for this as mentioned in the interviews included LA's appearing to over-charge for their use, or the park being sited too far away from public houses and other local amenities.

7 Current Levels of Freight Stakeholder Involvement in Transport Planning

As a consequence of the lack of awareness and knowledge regarding freight transport in the urban area, there is also a lack of stakeholder involvement in transport planning. The most common involvement is when the local authority responds to a complaint regarding freight transport in the urban area. Such complaints can originate directly from the transport operator, for example regarding problems with loading bays or road surfaces and pedestrian walkways affecting the ability to handle the final goods delivery to the receiver; or from residents or shop owners regarding noise, safety or heavy trucks blocking their display windows.

These complaints could then form the basis of a ‘stakeholder consultation’ aimed at solving a particular issue or problem that has occurred in the urban area.

Examples where a more regular stakeholder involvement takes place in urban areas do exist. The best recognised is perhaps that of the FQP’s in the UK (Allen et al. 2010), although similar partnerships also exist in Sweden, Holland and France, the UK example is better documented. Nevertheless, common for the cities or urban areas that have a working public–private partnership and stakeholder involvement is an acknowledgement from the local authority as well as from the stakeholders involved, of a common interest in working together to solve a problem. Therefore it is assumed that those local authorities should have in essence a better general understanding of freight transport, although they may not necessarily employ a person to work specifically with freight issues raised.

Over half of the private stakeholder representatives interviewed reported having no contact at all with local authority policy makers and planners. Less than half of the local authorities interviewed considered themselves as taking an active approach to engaging with the freight industry. Three reported regular attendance at local Chamber of Commerce meetings, in particular at transport themed meetings, where they are able to discuss the views and perspectives of their business stakeholders on things that need to be addressed, in addition to getting feedback on draft project proposals. For those local authorities demonstrating active engagement with industry in their area, involvement in the Local Strategic Partnership meetings was also seen as important. In locations where freight movements form a significant portion of the industry in the area, such as shipping and port activities, quarrying and forestry, the majority of engagement with industry occurs through a specific industry sector themed FQP or forum to discuss any issues arising from the routes travelled by commercial vehicles. However, for most of the local authorities interviewed, public consultations as part of the development of Local Transport Plans in the UK were the only opportunity provided for industry to comment on the proposed new policies that may affect their future operations.

Industry trade associations represent their members’ interests and it is often the road haulage or freight transport associations in each country that have the main contact with authorities on behalf of their members. The Freight Transport Association (FTA) is one of the largest trade associations in the UK; and is also responsible for representing its members at FQP meetings where possible. The interviews enquired about the role that these organisations have in influencing freight transport policy on behalf of the logistics industry. On the whole respondents felt that these organisations were good at voicing the concerns of hauliers and raising awareness of operational issues on a national basis. However they fall short with regard to addressing local issues, as their focus is mainly on influencing national policy. The same is evident in other countries where interviews took place, with trade associations having greater success at influencing issues that affect several localities or a large proportion of their members, as opposed to small and very location specific issues.

8 Conclusion

In this chapter we have introduced a view of the urban freight transport planning situation of today, which aims to address the *common perceptions* and *similarities* between different local authorities in selected European cities. Freight in general has a negative impact on urban sustainability. However, traditionally regulations imposed by local authorities (LEZ, charging, time windows, weight and length restrictions etc.) can form a major barrier towards effective, efficient and sustainable urban freight transport planning. Furthermore, a lack of enforcement of these regulations can sometimes become counter-productive. This is evident from the interview research discussed above, where operators highlighted the disparity in enforcement amongst neighbouring local authorities. In Spain a lack of sufficient surveillance and enforcement has led to huge problems with regulation compliance and therefore research has predicted difficulties with adopting city logistics schemes (Muñuzuri et al. 2012a). However, Jäderberg (2012) has demonstrated that improved city logistics schemes are possible, since they have been achieved relatively easily in Gothenburg with the help of improved surveillance and enforcement.

The analysis of the different local authorities strengthens previous results by Lindholm and Behrends (2012) which identified that the cities face common challenges in urban freight growth; that urban freight is seen as a disturbing factor; and that the awareness and knowledge of freight movements are low. The research performed as the basis for this chapter further develops earlier research by suggesting that although freight is recognised in most urban areas as important for the liveability of the urban area and its economy, the most common action by local authorities with regards to urban freight movements is a reaction to complaints from stakeholders (e.g. transport operators, shop owners or urban residents). Throughout the interview studies discussed, it has been shown that it is the perceptions of the individuals, combined with the individual local authorities having insufficient interaction with freight stakeholders that create the main problems and barrier to the integration of freight in urban transport planning. Discussions with some stakeholders are evident, on some occasions such as FQP meetings, however these rarely occur on a regular basis and there is little publication of their discussion topics and outcomes. Hesse (1995) concluded back in the 1990s, that stakeholder cooperation is a success factor for freight transport measures. However, the main findings from the research discussed in this chapter show that there still remains very little stakeholder cooperation within the local authority context today.

The research has demonstrated that there are several common perceptions amongst local authorities and many similarities between different urban areas with regard to urban freight transport. Therefore, we suggest that the focus should be pointed more towards those, with less focus on the differences. Such differences include for example that cities in Eastern Europe tend to oppose the trend towards regulations and cooperation between stakeholders that their Western counterparts have recalled positive experiences from, and raised knowledge and awareness of urban freight as something that need to be addressed. However, as a initial focus, there is a need to increase the awareness of the impacts of urban freight transport on a general level as well as the possibilities for local authorities to include freight as something equally important as passenger mobility in their planning processes. Since freight is not just a business problem that will be solved efficiently by private stakeholders, the local authorities have the possibility to create prerequisites that could potentially improve its efficiency.

There is no simple answer to how the local authorities could include the issue of freight transport in their planning processes, however it is recognised that interaction between stakeholders needs to be improved. The freight stakeholders interviewed have expressed a willingness to interact with the authorities and there have been attempts from the local authority side to find policy measures that help address the issue. Therefore we suggest that the first and foremost step towards including freight transport in the planning procedures needs to be a regular involvement of stakeholders. It is important that the inclusion of freight stakeholders goes beyond just the large freight forwarders and retail companies, and that other indirect stakeholders be considered as well. These may include for example, land and property owners, retailers, and trade. With improved interaction between local authorities and freight stakeholders there is greater opportunity for the LA's to improve their knowledge of urban freight issues, as well as to become more aware of any possible problems that may arise as a result of any transport policy measures under consideration.

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Logistics Sprawl and Urban Freight Planning Issues in a Major Gateway City

The Case of Los Angeles

Laetita Dablanc

Abstract This chapter examines the spatial patterns of freight and logistics activities and the planning and policy issues associated with them, using Los Angeles as a case study. The rapid increase in the number of freight facilities in Los Angeles in recent decades is discussed. An important aspect of the geography of the logistics industry in the Los Angeles metropolitan area is identified: "logistics sprawl", which is the spatial deconcentration of logistics facilities and distribution centers. Local governments give explicit consideration to logistics activities, especially for the jobs and tax revenues they can generate in a time of economic difficulties. Two cities are examined in detail: one is a traditionally industrial city close to the downtown area, the other is a sprawling community of the "Inland Empire," east of the L.A. metro area. Both cities tell the story of the seemingly inescapable rise in the importance of the warehousing/logistics industry in the economic life of working class areas, raising questions about the pros and cons of logistics activities for local communities.

Keywords Economic development · Logistics land use · Logistics sprawl · Urban planning · Warehouses

1 Introduction

The Los Angeles I am going to talk about in this chapter is a multi-polar urban area of 17 million people. It is made up of the city of Los Angeles (four million inhabitants), the County of Los Angeles (another 6 million), the Los Angeles

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Map. 1 Greater Los Angeles

metropolitan area (with Orange County and its 3 million residents), and the whole region, which also includes the "Inland Empire," i.e. the recently urbanized parts of Riverside and San Bernardino counties (another 4 million residents, in the eastern part of the region), as shown in Map 1.

Los Angeles presents a unique case in the study of urban freight and urban freight policy. Two aspects are especially worthy of attention: the sheer demographic size of the region, and its role as a maritime gateway for goods entering and leaving the region and the country. The result is a huge amount of goods, and the transportation equipment required to carry them, within the region. Vans, trucks and trains are an inescapable part of the daily life of Los Angeles. The number of warehouses has increased tremendously in the region over the past twenty years, because of an increase in the number of enormous distribution centers handling goods imported from overseas, and because many warehousing activities that were hitherto carried out in-house are now outsourced and managed outside the production sites through the intermediary of a logistics provider. Angelinos (as the residents of Los Angeles are known) who work in the logistics and transport sectors, or who live close to freight facilities and suffer from their impacts, know the current importance of freight and logistics activities for the city. However, many others, who live in more residential or affluent neighbourhoods, are unaware of these daily freight routines, taking the goods they shop for or have delivered to their door for granted.

This chapter is devoted to the location of freight facilities in Los Angeles and the policy issues related to the management of freight facilities and freight movements in the region. After Sect. 2, which presents the literature and background, Sect. 3 presents freight data for the Los Angeles region, and is followed by the results of a centrographic analysis showing the locational patterns of freight facilities throughout the region (Sects. 4 and 5). Section 6 covers the way local governments deal with the reality of logistics activities.

2 Background and Literature Review[1]

The warehousing industry has undergone major restructuring, transforming it into a distribution industry serving major importers (Christopherson and Belzer 2009) and big box retailers, based on direct access to consumption markets and hub and spoke networks. Starting in the 1980s, the U.S. and many other parts of the world entered a "new distribution economy" (Hesse and Rodrigue 2004), an economy largely dependent upon efficient and increasingly globalized networks of goods distribution and just-in-time operations. This has led to a reduction in large inventories of intermediate and end products and a concomitant rise in hub distribution centers (Movahedi et al. 2009). Modern distribution centers are large (over 500,000 square feet) and require substantial investments in material handling technology (EEOC 2004). Very large distribution centers, or "mega DCs" (Andreoli et al. 2010) have driven the recent growth in warehousing establishments. Between 1998 and 2005, the number of distribution centers with more than 100 employees increased twice as fast as smaller facilities (Andreoli et al. 2010).

Global supply chains require more logistics facilities, and the way these facilities are spatially organized has become a key feature of an efficient goods distribution network. The rise and characteristics of today's distribution centers are directly responsible for the polarization of freight facilities in large conurbations. The efficiency of goods distribution depends upon the optimal location and sizing of freight terminals rather than directly upon transport costs. Freight transportation costs have decreased dramatically over the last thirty years, and for many industries they have become "trivial" (Glaeser and Kohlhase 2004). "Improvements in transport technologies, the massive enlargement of infrastructure and falling transport costs, not least thanks to cheap oil, changed the role of transport in the second half of the 20th century (…) putting transport out of consideration in economic geography" (Hall et al. 2006). Low freight costs create what Rodrigue (2004) calls an "increased locational flexibility" for freight and logistics facilities. The opportunity for good regional and national networking between facilities within a supply chain is a key factor. "Ultimately, the changed geography of warehousing is not just about the restructuring of space within metropolitan areas, it is about the spaces connecting metropolitan, regional and national economies. The proliferation and expansion of warehouses and their predilection for easily accessed suburban sites is being driven by the thickening of long-distance linkages among distant economies" (Bowen 2008, p. 386).

[1] This section is adapted from Dablanc and Ross (2012).

The new distribution centers required by the current organization of supply chains and a consumer-based economy are directly responsible for logistics sprawl, i.e. the tendency for warehouses to move from urban to suburban and exurban areas (Dablanc and Ross 2012). In metropolitan areas, logistics sprawl has been the dominant spatial pattern for many years. Historically, warehouses and freight terminals have tended to be close to city centers and rail stations (Chinitz 1960). Today, they need more space and are located as close as possible to highway networks and airports Dablanc (2007). Woudsma et al. (2008) have shown the importance of accessibility to highway nodes and airports when selecting the location of a logistics facility. Suburban and exurban areas are attractive because of the availability and low cost of land and also because it is possible to connect to a more complex system of regional and national flows from suburban areas. This generates economies of scale for the logistics industry but has an impact on urban landscapes. Logistics sprawl contributes significantly to the unsustainable nature of large metropolitan areas by generating congestion, CO_2 emissions and local atmospheric pollution. These impacts are the result of additional vehicle-miles travelled (VMT) generated by the changes in the location of freight terminals and the increase in distances travelled by trucks and vans to deliver commodities to urban areas where jobs and households remain concentrated. Dablanc and Rakotonarivo (2010) calculate that cross-dock terminals[2] for parcel and express transport companies moved an average of 6 miles further away from the center of Paris between 1975 and 2008. During the same period, jobs in general moved only 1.3 miles, meaning that logistics sprawl is much more prevalent than the general sprawl of economic activities in metropolitan areas. They estimated the net increase in annual CO_2 emissions resulting from the relocation of facilities serving the Paris region to be 16,500 tonnes in 2008 compared with 1974.

The issue of logistics sprawl has recently generated some discussion among scholars, particularly economic geographers. “It is the availability of huge parcels of cheap land that drove the emergence of exurban logistics hot spots at the beginning of this decade” (Christopherson and Belzer 2009, pp. 212–213). Cidell (2010) has shown that in 47 of the 50 large metropolitan areas she surveyed, “decentralization” of freight activity had occurred over the last 20 years (1986–2005), as measured via Gini coefficients. Because data were aggregated at county level, however, it was difficult to account for some of the relocation patterns, as central counties can be large and locational changes within counties were not covered in Cidell’s study. I will address this issue in Sect. 3 by looking at data for Los Angeles at the sub-county (zip-code) level.

Bowen (2008) used the County Business Patterns for 1998 and 2005 to show the changing geography of warehousing in the U.S. He confirms that these activities have experienced enormous, largely unnoticed, growth in recent years. “Almost no other industry that employs so many people has grown as fast as the

[2] Cross-dock facilities are the terminals used in the parcel (less than truck load) and express transport industries.

warehousing industry in the past few years" (Bowen 2008, p. 383). According to his calculation, the number of jobs in the U.S. warehousing and storage industry rose 384 % between 1998 and 2005. He shows that the growth in warehousing was more marked in suburban counties than in central and rural counties: central city MSA counties saw warehousing establishments grow at an annual growth rate of 10.2 %, while the increase for non-MSA counties and other MSA counties were respectively 9.3 and 11.8 %. Bowen calculates that accessibility to air and highway transportation networks increasingly influences the location of warehousing establishments, even though other factors also play a role.

Hesse (2004, p. 171), using two case studies from Germany, concludes that logistics activities favor distant locations for many reasons, some of which are specific to this industry while others apply to many economic sectors: "firms try to get rid of traffic jams, the rigidities of planning requirements, or the power of trade unions." He explains how these changes are embedded in a general transformation of the logistics real estate industry, which is increasingly dominated by global players organizing national or even larger networks of distribution centers. "Once the spatial scale increases, such commodification of land leads to a certain 'abstraction' from the concrete place, in favor of the network structure" (Hesse 2004, p. 166).

3 Freight Flows and Freight Facilities in Los Angeles

3.1 Recent Studies on Freight in the L.A. Area

Although freight data are not easily available in U.S. metropolitan areas (Giuliano et al. 2012), a series of recent studies has shed light on what freight flows represent for the Los Angeles area. A *Goods Movement Truck and Rail Study* (Tioga Group and Cambridge Systematics 2003) carried out for the Southern California Association of Governments (SCAG) provided interesting data. In 2004, the Los Angeles Metropolitan Transportation Authority (known as "Metro") published a *Compendium of truck/freight information for the greater Los Angeles metropolitan area* (LACMTA 2004). The *Multi-County Goods Movement Study* (Wilbur Smith Associates 2008), carried out for all region's the main transportation authorities and California DOT, constitutes a first attempt at a comprehensive assessment of freight flows in the region and regional level freight data collection. A study by METRANS[3] in 2008, called *Integrating Inland Ports into the Intermodal Goods Movement System for Ports of Los Angeles and Long Beach* (METRANS 2008) provides a facility location model which aims to explain the operational relationships between the San Pedro Bay ports and inland regional freight terminals.

[3] METRANS is a joint research center from the University of Southern California and California State University of Long Beach.

In 2009, the US Department of Transportation launched a series of urban freight case studies, including Washington, New York City, Orlando and Los Angeles. The Los Angeles study provides some data and information on the most urban part of the region, with a focus on the downtown area. Caltrans, the State DOT, sponsored a multi government study called *Healthy Communities and Healthy Economies, A Toolkit for Goods Movement* (Caltrans 2009), that can also be used by other governments such as Riverside County. In 2010, SCAG commissioned Cambridge Systematics to carry out a comprehensive study on warehousing in the region (*Comprehensive Regional Goods Movement Plan and Implementation Strategy, Industrial Space in Southern California: Future Supply and Demand for Warehousing and Intermodal Facilities*) (Cambridge Systematics 2010). It provides much valuable information. In April 2012, SCAG published a draft of its *Regional Transportation Plan 2012–2035* with a *Goods Movement Appendix* that provides a large amount of information about the region's goods movement system (SCAG 2011).

By compiling these diverse studies, we can state the following about freight flows in the Los Angeles area.

As mentioned in SCAG (2012), 1.15 billion tons of cargo valued at almost $2 trillion passed through the region in 2010. The data are taken from the Freight Analysis Framework.[4] Los Angeles' two main seaports, the Port of Los Angeles and the Port of Long Beach, accounted for 120 million tons of cargo imports and exports. These were valued at $336 billion. It is interesting to compare this with the amount of goods passing through Mexican border crossings, whose value amounted to $10.4 billion in the same year. The two ports handled 14.1 million TEUs (Twenty-foot Equivalent Units) in 2010 (13.7 in 2011). The region's highways with the highest concentration of truck trips are the I710, I605, SR60 and SR91 (see Map 1). Some of these highways have sections that carry over 25,000 trucks a day. If we turn to warehousing and distribution centers, in 2008, these represented about 837 million square feet of warehousing space with an estimated 15 % used for port-related activities. As we shall see in Sect. 3, demand for warehousing is actually very high. The SCAG report (SCAG 2011) foresees a shortfall of 228 million square feet by 2035.

The Los Angeles region has a very dynamic economy. SCAG (2012) makes a distinction between two main types of activities: "services" on the one hand, representing 65 % of the economy, and "goods movement dependent industries—retail, wholesale, manufacturing, …" on the other, representing 35 %. In 2009, Los Angeles County was the top manufacturing county in the US in terms of manufacturing shipment volume. Within SCAG, manufacturing is dominated by computers and electronics. One-third of manufacturing is for local uses, one-third is exported nationally, and one-third is exported abroad. Manufacturing in SCAG requires $17 billion of spending on transport, while retail requires $11 billion

[4] FAF is a compilation of freight databases made by the US DOT. http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/.

(SCAG 2011). The SCAG report points out that an overwhelming majority of goods movement activity in the SCAG region is generated by local businesses moving goods to local customers. Local movements represent 85 % of the region's truck trips. Every day, more than 1 million truck trips are made in the region, but only 50,000 are directly linked to port traffic (see below for a discussion of the San Pedro bay ports). More specifically, using the 1997 Commodity Flow Survey and the 2000 SCAG Heavy Duty Truck Model, the Tioga Group and Cambridge Systematics (2003) showed that:

80 % of the tonnages originating in Southern California stays within SCAG
90 % of the tonnages originating in Southern California stays within the state
Over 75 % of truck tonnages move less than 50 miles
64 % of tonnages from for-hire trucking move less than 50 miles
82 % of tonnages from private trucking move less than 50 miles
20 % of Parcel and USPS (the US postal service) move less than 50 miles.

The main freight-related issues affecting the region mentioned in the various freight reports are a shortage of drivers, rising wage, fuel and insurance costs, and environmental restrictions and regulations which increase the financial burdens on freight companies. Rising congestion is also a major issue.

As regards rail, 250 intermodal trains run every week in the intermodal trains run every week in L.A. area (as this figure dates from 1998, it underestimates current flows, as intermodal traffic has increased rapidly over the last decade). Freight rail is provided by BNSF and Union Pacific, as well as three short line railroads (Pacific Harbor Line, Los Angeles Junction Railway and Ventura County Railway). Another short line (San Jacinto Branch Line) is BNSF-operated and controlled by Riverside County. According to the Tioga Group and Cambridge Systematics (2003, p. 17) however, "the long-term potential for greater short line rail service in SCAG is limited, as United Pacific and BNSF have completed their branch line abandonment and rationalization programs…(and) railroad branch lines and secondary main lines are attractive candidates for high priority rail passenger and commuter services."

The Tioga Group and Cambridge Systematics (2003) study points out that California is somewhat isolated from the Nation's large consumer and economic markets. The state is close to many markets within a 250–500 mile range (including California itself, Nevada and Arizona), and is connected to national markets that are over 1200 miles away. In between, there are not many delivery markets with the exception of Salt Lake City, El Paso and Albuquerque.

3.2 The San Pedro Bay Ports

The San Pedro bay ports consist of the twin ports of Los Angeles and Long Beach. They are two different institutional entities, competing for ships and clients but sharing many operational activities and strategies. Erie (2004) provides a fascinating account of the development of the San Pedro bay ports. Although San

Diego was the natural port of the south-west (the bay in L.A. was shallower than San Diego bay for example), Erie identifies the success factors that made it possible for the L.A. ports to develop and become the largest U.S. port complex today. These factors include what he calls “entrepreneurial bureaucrats” and a strong tradition of public involvement in mega projects. The competition between the two ports was also a positive factor. Some collaborative attitudes were crucial for special projects, such as, in the 1980s, what would later become the Alameda corridor,[5] as well as ICTF, an intermodal transfer facility located in the port area. The ports also had two extremely important advantages over their West Coast rivals: a huge regional market and rail connections.

The two ports handled 14.1 million TEUs in 2010, 13.7 in 2011.[6] We can identify two types of containerized traffic: local and discretionary. Local traffic involves goods that are ultimately consumed in Southern California or nearby states. It represents 23 % of the traffic through the San Pedro bay ports. So-called discretionary traffic, which accounts for 77 % of San Pedro bay’s container traffic, travels further. Goods can be carried by direct shipping (the maritime container remains intact), or can be transferred from the maritime container into another type of container. More than one-third (35 %) of maritime containers leaving the ports are unmodified, meaning they are transloaded directly onto intermodal trains, either on-dock (no truck involved) or near-dock (a short truck trip is included). The proportion of on-dock train loading has been increasing in recent years (see Table 1). Leachman (2012) provides additional figures, and claims that 73 % of Asian imports via the San Pedro bay ports are consumed in other regions, and half of these are shipped intact in marine boxes to other regions. This proportion was significantly higher in 2001 (64 %). The rest are re-shipped from Southern California to other regions in domestic boxes, requiring transloading of some sort. This decreasing share of direct re-shipping (in maritime containers) is one of the signs of the growing importance of local warehouses/distribution centers.

Table 1 Direct intermodal volumes as a percentage of total container throughput for the ports of L.A. and LB

	2003	2004	2005	2006	2007	2008	2009	2010
% On-dock	15.9	18.1	20.7	24.1	23.0	23.7	24.6	23.5
% Near-/off-dock	23.4	21.2	19.5	18.7	18.4	18.5	15.3	11.7
Total throughput (millions of TEUs)	11.8	13.1	14.2	15.8	15.7	14.3	11.8	14.1

Source SCAG 2011, Table 10, p. 31. Data from Ports of L.A. and LB

[5] The Alameda Corridor is a 20 mile freight rail infrastructure connecting the ports of Los Angeles and Long Beach to intermodal railyards in downtown Los Angeles.

[6] These are fiscal years, i.e. from July 1 to June 30.

3.3 The "Warehousizing" of Los Angeles

As we shall see in Sect. 3, the number of warehouses in Los Angeles seems to be increasing very rapidly, by 200 % over the past ten years, as calculated using the NAICS[7] code 493 ("warehouses"). As we have seen in Sect. 1, there is evidence for similar growth in other large metropolitan areas around the US. We can suggest several explanations for this change. Some warehousing activities which were previously performed as part of a manufacturing or distribution activity (and on the same premises), have been outsourced to logistics providers, automatically increasing the number of warehouses. In some cases business owners have gained a specific warehousing/logistics facility when previously they used to perform logistics tasks (which required less time and space) within the manufacturing facility itself. In other cases new warehousing activities, demanded by today's import-based economy, were added *en masse* to the metropolitan areas that could provide the workforce, the infrastructure, the connection to freight gateways and had the necessary available land.

For the purpose of clarification and to try to quantify these varied potential factors, I conducted a detailed study of the increase in warehousing/logistics activities by comparing the business listings of the city of Vernon between 2002 and 2011. Vernon is an interesting case of urban manufacturing/logistics activities within the Los Angeles area (see Sect. 4). The Vernon business listings I surveyed provide two pieces of information annually for each individual business located in Vernon: the "Business Type" and the "SIC code" (the SIC being the national Standard Industrial Classification).[8] This analysis gives the following results. The number of businesses located in Vernon remained almost the same between 2002 and 2011 (1598 in 2002 and 1584 in 2011), but these businesses have changed in nature, and the importance of logistics/warehousing activities has increased at the expense of manufacturing. In Table 2, the second column shows the rate of growth for a sample[9] of business types from 2002 to 2011. The third column shows the change in the percentage of businesses whose activity is classified as "warehousing" in the SIC.[10]

The number of businesses classified as (unspecified) warehouses has not increased much in Vernon since 2002 (by 8 %—from 158 to 170 businesses), but specialized warehouses have increased a great deal (Garment Warehouses by 1150 %, General Merchandise Warehouses by 124 %). At the same time also, the

[7] North American Industry Classification System.

[8] The NAICS replaced the SIC in 1997 to take better account of new and expanding industries. Correspondence tables between SIC and NAICS exist. The city of Vernon's business listings continue to use the SIC coding system.

[9] I have selected 20 business types out of a total of 128 in the databases. These 20 types selected are those more obviously dealing with warehousing and distribution activities.

[10] General Warehousing and Storage, Refrigerated Warehousing and Storage, Special Warehousing and Storage, Not Elsewhere Classified.

Table 2 Increase in warehousing activities in the City of Vernon 2002–2011

Business type	Growth rate 2002–2011 (%)	% of warehousing SIC
Garment warehouse	+1300	From 0 to 56 %
Cold storage	+136	From 64 % to 73 %
Produce distribution	+130	From 0 to 22 %
General merchandise-warehouse	+124	From 12 to 60 %
Food distribution	+100	From 29 to 29 %
Garment wholesale	+80	From 0 to 11 %
General merchandise/wholesale	+35	From 24 to 55 %
Produce broker/wholesale	+30	From 0 to 15 %
Storage	+28	From 47 to 64 %
Warehouses	+8	From 22 to 41 %
Distribution	−20	From 1 to 28 %
Trucking/freight/delivery	−24	From 1 to 1 %
Wholesale	−25	From 6 to 23 %
Meat distribution	−37	From 25 to 20 %
Food warehousing	−50	From 10 to 0 %
Furniture/house wholesale	−57	From 0 to 33 %
Records storage	−60	From 0 to 100 %
Fabric/textile warehouse	−80	From 0 to 0 %
Fabric/textile wholesale	−83	From 0 to 0 %
Import/export	−87	From 20 to 50 %

Source L. Dablanc, data from Vernon business listings

industrial classifications called “warehouse” have increased. For the Wholesale business (business type), the proportion of warehousing activities (SIC) increased from 6 to 23 %. In other words, nearly a quarter of all the facilities in the wholesaling business are actually warehouses. For Import/Export (business type), the proportion of warehousing SICs has increased from 20 to 50 %: half of the facilities in the Import/Export business are actually warehouses. For Warehouses (business type), the proportion of warehousing (SIC) grew from 22 to 41 %. All business categories (with a few exceptions) display an increase in the proportion of warehousing SICs.

4 The Location of Warehouses in Los Angeles: A Centrographic Analysis

Warehouses are now a dominant feature of the Los Angeles landscape. They can be found in three types of location within the region.

Historical warehousing locations are situated near the San Pedro bay ports and Los Angeles airport as well as all along the 710 highway corridor joining the ports to downtown Los Angeles. Warehouses are located in the city or County of L.A., as well as in independent cities with a historical industrial past (and very eloquent names such as the City of Industry or the City of Commerce). These are traditional manufacturing cities that have remained industrial, and where logistics has always gone hand in hand with manufacturing activities. The facilities used for logistics are often aging, rather small, with low ceilings and insufficient parking, and lack services such as cables or optical fibers. Many of them have been renovated. In any case, they are all conveniently located to minimize distances to and from ports, railyards and consumer markets. They have very low vacancy rates, which shows they satisfy a specific part of the demand for logistics space.

Eastern developments along SR60 through the San Gabriel valley towards the Inland Empire, in Riverside County, and all the way up to the western part of the Coachella Valley. These include cities such as Moreno Valley, Chino, Beaumont or Banning. All have engaged in promotional activities to attract logistics. These promotional activities are part of a story that has been very nicely recounted by Husing (2010). For the Coachella Valley Economic Partnership, for example, which is at L.A.'s current frontier of urbanization to the East, the development of warehousing is a stated priority. Some recent photos of logistics developments in this area are given in Fig. 1 and Moreno Valley is discussed in Sect. 4.

New logistics developments in the north, including the High Desert, Kern County, and the north of Los Angeles County. For the latter, a few cities stand out such as Santa Clarita, which has seen a recent surge in large warehousing developments, Lancaster with several mega distribution centers, and Palmdale which has been active in developing a Business Park where FedEx and Rite Aid distribution centers are already sited.

Fig. 1 Photos of recent logistics developments in the Inland Empire (Moreno Valley and Ontario/Fontana areas). *Source* courtesy of Steven Cuevas, KPCC

Introducing a new scale of analysis for the spatial issues associated with warehouses in the L.A. area, I have studied the locational patterns of logistics facilities at the zip-code level. I have considered the warehouses in the NAICS[11] database (NAICS code 493). The data were obtained from the U.S. Census Bureau County Business Patterns Survey.[12] This provides an analysis of the number of establishments in all the counties and zip codes in the United States based on a detailed breakdown of industrial sectors and according to nine employment size classes.

The technique I have used is centrography, which is the spatial analysis of geographical data based on descriptive spatial statistics (Isard 1982). This is well-suited to identifying and quantifying sprawl patterns and providing data for their cartographic representation. Centrographic analysis consists of finding the weighted geometric center, or barycenter, of a geographic distribution. Once this has been done for each data set, the "directional distribution," or the spatially weighted distance of one standard deviation of the distribution is determined. The directional distribution provides an indication of the decentralization and direction of movement of establishments (an establishment is defined as a facility; a single company can have a number of establishments or sites). The mean distance from the barycenter for each distribution is then determined. This method provides data for a cartographic representation of logistics sprawl.

Figures 2 and 3 show two different images of the relocation of warehouses in Los Angeles since 1998. Figure 2 shows the warehouses in the five county area, while Fig. 3 shows the results for a wider area, which extends to San Diego and includes San Diego County and Imperial County. It also includes Kern County in the north where some recent logistics developments have occurred.

A centrographic analysis of the location of warehouses (NAICS code 493) was completed for the five county area (Fig. 2) between 1998 and 2009. This analysis is compared with the location of all the establishments (representing all economic sectors) and how this has changed over time. The results are the following:

The average distance of warehousing establishments from their barycenter increased from 25.907 to 31.963 miles, but the average distance of all establishments from their barycenter remained stable, changing from 41.748 to 41.714 miles.

This means that while establishments in the L.A. metropolitan area have not sprawled, warehouses have, moved out an average of 6 miles. This suggests that within the L.A. metropolitan area, more truck miles are required to reach customers (for shipments or deliveries) in 2009 than was the case in 1998. This is "relative sprawl," i.e. when logistics facilities move further away than the businesses they serve for pick-ups and deliveries.

[11] North American Industry Classification System.

[12] http://www.census.gov/econ/cbp/index.html (last accessed on April 26, 2012).

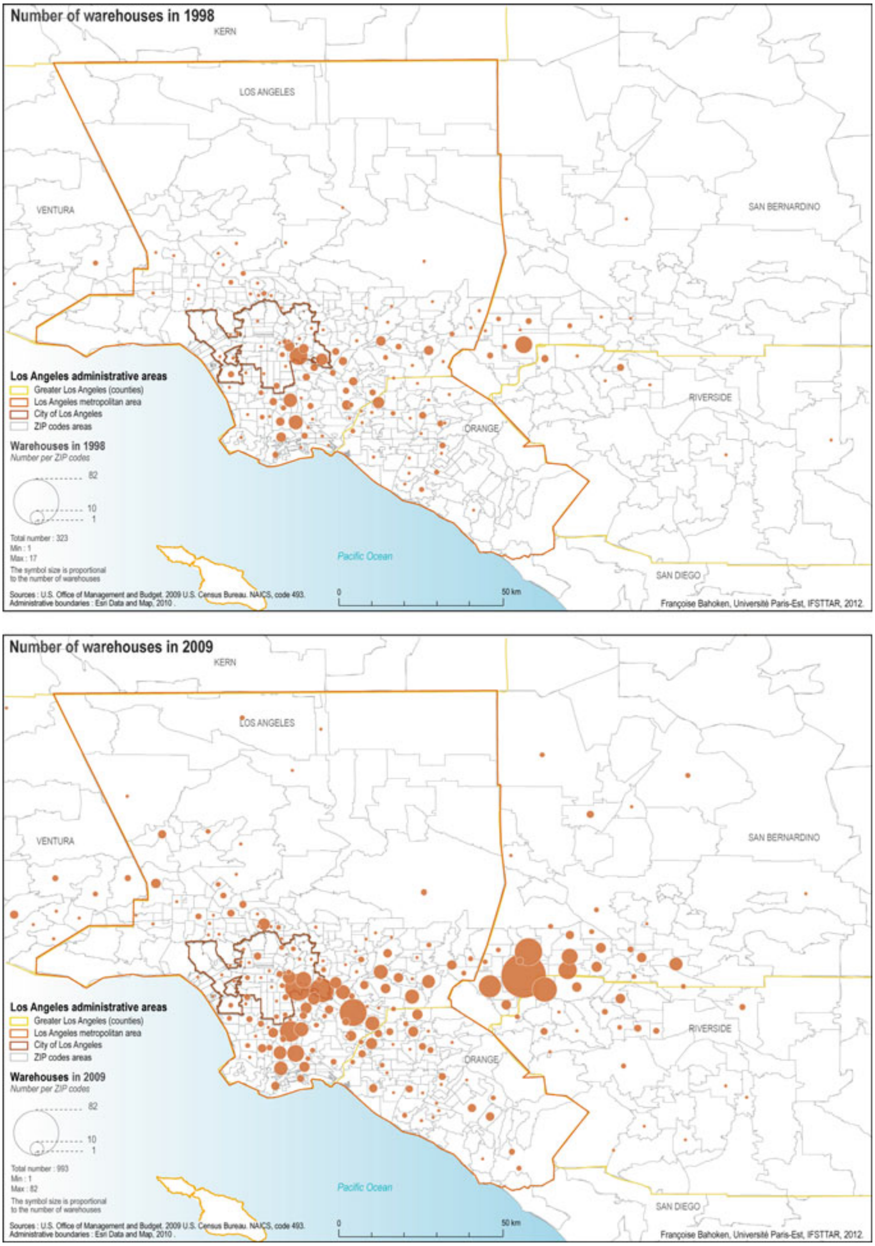

Fig. 2 Five county area: location of warehouses, 1998–2009

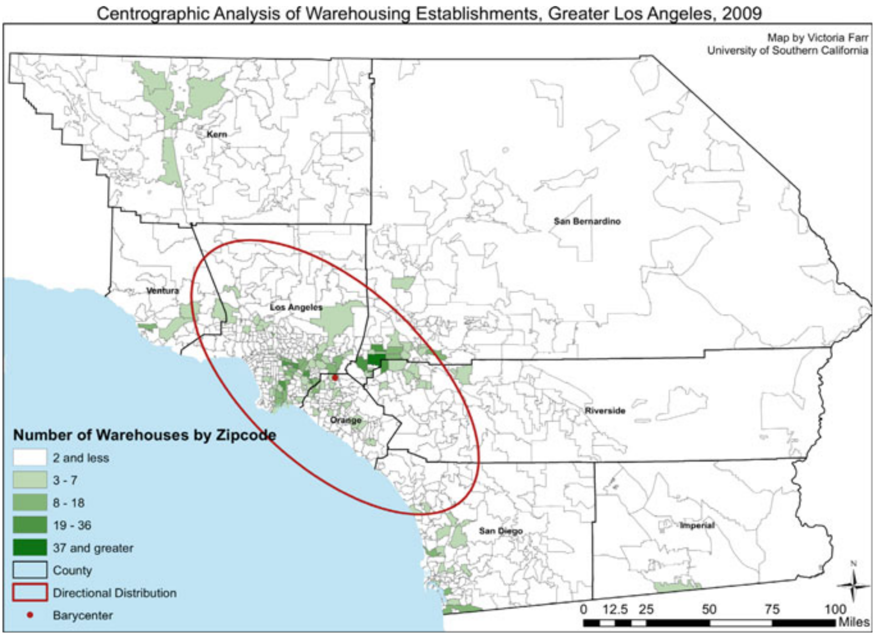

Fig. 3 Eight county area: location of warehouses, 1998–2009

5 Local Governments and Warehouses in the Los Angeles Area

What account is taken of freight and logistics activities in planning processes? In one of the few academic studies of local planning and freight issues, Cidell (2011, p. 832) notes the inherent challenges facing local governments confronted with the development of freight facilities: "in a world of flows and networks, [planners] work within bounded territories." Local planners take land use, zoning and permitting decisions based on a spatial mental representation of the different stages of the history of their municipality's development, from initial rural settlements to rapid residential and commercial development. The recent sudden addition of industrial (mostly logistics) activities to this pattern encounters mixed reactions, mostly unenthusiastic. New jobs are welcome, but the low per-acre tax revenues and absence of sales taxes associated with this type of development are often resented. Looking at how municipalities in Northern California cope with distribution centers, Hesse (2002) also notes a reluctance to attract logistics land uses, even though, according to the surveys he conducted there, most cities, even those with a focus on high technology do not actually discourage goods distribution firms. He also notes, interestingly, that environmental issues related to freight activities are more inclined to generate a degree of indifference than much concern. In Atlanta (Dablanc and Ross 2012), counties and municipalities have a generally positive attitude towards logistics, and local governments compete with each other to attract logistics activities at the expense of neighboring localities.

To explore this further for the Los Angeles area, and better identify the ways local planners react to logistics facilities, I conducted interviews with planning managers of several local governments in the Los Angeles metropolitan area.[13] In this Section, I have chosen to present the details of two cases that are typical of the changes in attitudes and practices brought by "warehousizing" as I have described it in Sect. 3. One is the municipality of Vernon, close to downtown Los Angeles, one of the historical manufacturing areas of Los Angeles, and the other is Moreno Valley, a "new city" in the Inland Empire, which has experienced (and promoted) rapid logistics growth in recent years.

5.1 The City of Vernon

Vernon was founded in 1905 as an "Industrial City," with very few inhabitants (700 originally). Today, it counts 112 inhabitants, 1,800 businesses and 55,000 jobs. The city recently faced a threat of de-incorporation by the state, in the midst of allegations of corruption and as the number of voters was considered too small. The city is exceptional in several ways: it is one of the smallest incorporated communities in the U.S., its residents to jobs ratio is exceptionally low, and it is very centrally located, keeping a highly active industrial area right in the core of Los Angeles. Vernon is located five miles south of downtown Los Angeles. The city reached full development about forty years ago and there are no more new parcels available for development. Nearly all of the current economic activity is industrial, and land parcels or buildings are constantly being renovated, transformed and sold to new businesses.

The city wishes to maintain its manufacturing character, and to promote manufacturing jobs. "We do realize there is a transition at work, and that manufacturing jobs are endangered as they are exported to China. Buildings are converted into warehouses and other types of logistics facilities, as there is such an important need to manipulate and transload all these imported goods arriving to the ports. But as much as we can, we are going to favor true manufacturing jobs over logistics ones" (Kevin Wilson). There are two main reasons for the city's preference for manufacturing over logistics jobs. The first is the low job density of logistics activities (with usual ratios of about 30–100 jobs per hectare). Another complaint from the city regarding logistics facilities is that they do not generate

[13] Interviews: city of Moreno Valley, John Terell, AICP, Planning Official, April 18, 2012; city of Vernon, Kevin Wilson, Director of Community, Services and Water, May 7, 2012; WRCOG (Western Riverside Council of Government), Ruthanne Taylor-Berger, Deputy Executive Director, May 23, 2012; Gateway Cities, Jerry Wood, Director of Transportation and Engineering, May 30, 2012; Los Angeles County, Connie Chung, Supervising Regional Planner, June 18, 2012. Questionnaires filled: cities of Santa Clarita and Palmdale.

their fair share of tax revenue, as they spend less on electricity (which is produced and sold by the city itself) than more traditional manufacturing plants. Warehouses account for 27 % of the city's property but generate less than 5 % of its revenue. City officials also argue that warehouses generate much of the truck traffic, requiring expensive repairs, and causing road congestion.

Two strategies have been identified in order to prevent logistics from assuming too much importance in Vernon:

Between 1989 and 2005, a municipal regulation prohibited warehousing uses for all buildings over 50,000 square feet, "because we had started to understand that the logistics industry required increasingly large buildings" (Kevin Wilson, Director of Community, Services and Water)
Since the end of the 1990s, the parcel tax[14] has been applied to all facilities involved in warehousing, distribution and trucking, with the exception of refrigerated warehouses. This is a very unusual type of tax target in the U.S. The measure increased the warehouse parcel tax from 1 cent per square foot of land to 20 cents per square foot. A proposal made in February 2012 to increase the tax by a further 3 cents is under discussion.[15]

Despite the parcel tax, warehouses have continued to settle in Vernon, thanks to its very central position in the metropolitan area. The industries that have left or are leaving are textile, garment and paper manufacturing. Many manufacturing activities remain or are even developing, for example food processing, but logistics related activities are becoming very important (see Table 1) and some, cold storage for example, have gained a specific position in the city, giving it a new specialization. Two intermodal yards are also located in the city (and in the nearby City of Commerce), used by BNSF and Union Pacific. According to the city, these companies are difficult to deal with, as they tend to buy land and convert it into parking areas. They have refused to pay the parcel tax so far, arguing that they have inter-state operations.

Overall, half of the buildings in Vernon are owner occupied, while the other half is tenant occupied. The city is not directly involved in parcel development or

[14] Parcel, here, is to be understood in its planning sense (land lot). California parcel taxes are 'qualified special taxes' on specific properties whose revenue can be earmarked for any kind of specific target, such as schools.

[15] Press release, February 9, 2012: "City staff has unveiled a proposal for enacting a special 23-cents-per-square-foot parcel tax assessment to raise $16 million in new revenue for the city general fund budget.… The $16 million in general fund revenues raised through the special parcel tax would be earmarked for support of police, fire, environmental health services and capital improvements…. Under the staff's proposal, approximately 900 property owners in Vernon would be taxed 23-cents-per-square-foot as an assessment on the total land space on which their businesses operate. On average, the special parcel tax would amount to less than $50.00 per day per business assessed. Warehouse business owners presently paying a warehouse parcel tax would not be "double-taxed" on that portion of their property already subject to the warehouse parcel tax assessment."

the search for new occupants. Industrial realtors do this for building owners. The municipality can preempt properties, buy them and renovate them to make them better suited for some types of businesses the municipality wishes to attract. As in many other areas of California, a re-development agency existed in Vernon but the State of California dissolved all municipal community redevelopment agencies in early 2012. The city, however, never had major problems in finding new occupants, thanks to its location. The size of land parcels, which is a problem now for many new activities, particularly in the logistics sector, does not appear to be one yet in Vernon. Several 20-acre parcels have recently been subdivided, demonstrating that there is still a considerable need for small parcels. Nevertheless, some warehouses have reached 500,000 square feet.

As the city's objective is to be business friendly, its zoning code is not very strict. There is no height limit, and some buildings can reach 60 feet. The California Building Code has introduced strict regulations related to fire hazards but the city does not have any additional rules. In some areas in Los Angeles, industrial buildings are so large that tunnels have to be provided to give employees easy access to an exit (in California, all employees must have an exit access less than 400 feet away). In Vernon, there is no such need. There are no requirements for landscaping, although the city is currently thinking about a general upgrading of its urban environment, and landscaping will be emphasized in future developments. Companies can still build surface parking, as the cost of land is not yet prohibitive. The city is its own electricity provider. As such, it has to follow the State regulation that 20 % of electricity must come from renewable sources. Buildings must be energy efficient, according to gradual rules. Vernon has enforced the compulsory parts of the regulation, and is getting prepared for upcoming tighter rules.

5.2 Moreno Valley

Moreno Valley, in Riverside County, is located in the heart of the "Inland Empire". The city grew from 6,067 people in 1950 to 193,365 in 2011, with the highest percentages of growth in the 1980s then in 2005–2006. The city exhibits a great imbalance between housing and jobs, with many unskilled workers looking for unskilled jobs. The unemployment rate is 16 %, higher than the County's (which is higher than the State's, which in turn is higher than the Nation's average.) This is why Moreno Valley's 2011 Economic Development Action Plan sets out to "create jobs locally and address the City's high unemployment rate." In this regard, logistics is among the city's two priorities for future economic development (together with medical facilities.) The main employers in the city are the military (9000), the public sector (3500), the medical sector (2400), retail (such as Moreno Valley Mall) (1700), then the distribution centers which have from 200 to 600 employees individually.

There are already several developed warehousing areas in Moreno Valley. The older one close to the city center is already home to distribution centers belonging to six major corporations, and there are several other projects approved or soon to be constructed in the area. In the south, an incorporated industrial area on the site of an abandoned navy base has been developed for logistics. Walgreens' regional DC has been located there for ten years. Many construction projects are currently under way in the area, with 3.6 million square feet in building plan check, 3.5 million approved/entitled, and 3.1 million currently undergoing environmental impact reviews. A third, more recent, logistics area is located in the eastern part of Moreno Valley, in a more protected residential area. The first distribution center there was built for Skechers, a sport shoes retailer, and, with a single building covering 1.9 million square feet, is now one of the largest warehouses in California (see photos in Fig. 1). Building the Skechers warehouse generated opposition and litigation, which was settled in exchange for environmental improvements to the project (such as solar panels on the roof). Still further east in Moreno Valley, a vast area is targeted for future logistics development, with a developer's project for a 41 million square foot "World Logistics Center", enthusiastically supported by the municipality.

Warehousing jobs represent the highest paid blue collar jobs in the Inland Empire, even though "they are not the best jobs in the world" (J. Terrell, Planning Official). Some, but not all, companies will provide medical benefits, especially those that organize their own distribution centers. Cities know that warehousing activities do not provide a lot of jobs compared with a traditional manufacturing activity. The Skechers warehouse requires 30 jobs per hectare (550 employees for 1.8 million square feet). Warehouses provide revenues in terms of property tax, and in some rare instances some sales tax (when wholesaling activities are also done in the warehouse).

The city has recently established another standard, soon to be included in the city code: *an amount of renewably-sourced energy that is equivalent to that used in the building's office areas must be purchased or produced locally*.

Because of past litigation, present-day logistics development projects are better prepared and more environmentally-friendly. Most of them are LEED certified[16] even when this is not yet a city requirement. Many of the projects for new freight facilities are the subject of litigation but they usually prevail, with better design and more environmentally-friendly features.

The city of Moreno Valley has landscaping standards that apply to freight facilities. The objective *is to do away with the impression of being surrounded by big boxes*. Recently, there has been a noticeable effort on the part of logistics developers regarding colors and shapes. In the case of the Skechers' distribution center, a famous architecture firm was hired to design the facility, resulting in an original all-white building (see first two photos in Fig. 1).

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[16] LEED: Leadership in Energy and Environmental Design. A set of standards for the design of green buildings.

6 Conclusion

This chapter has examined the spatial patterns of freight and logistics activities and the planning and policy issues associated with them, using Los Angeles as a case study, and discussed the rapid increase in the number of freight facilities in Los Angeles over the last decades. An important aspect of the geography of the logistics industry in the Los Angeles metropolitan area has been identified: "logistics sprawl", which is the spatial deconcentration of logistics facilities and distribution centers. The chapter has also shown how local governments give explicit consideration to logistics activities, especially for the jobs and tax revenues they can generate in a time of economic difficulties.

Two cities were examined in detail, one is a traditionally industrial city close to the downtown area, and the other is a sprawling community of the "Inland Empire," east of the L.A. metro area. Both cities tell the story of the seemingly inescapable rise in the importance of the warehousing/logistics industry in the economic life of working class areas. The city of Vernon has, rather unsuccessfully, implemented several strategies to slow down the pace of logistics developments. Vernon city managers consider that manufacturing activities provide a higher number of jobs and municipal revenue per square foot of building than logistics activities. However, these preferred activities have been hit hard by the changes in the economy. Logistics activities have settled in Vernon, warehouses represent a common feature of the city's landscape today, as well as a growing share of the activities performed. The city of Moreno Valley has anticipated, supported and promoted logistics developments, because the demand for warehousing space kept growing even after the economic downturn of 2008. The warehousing industry is among the two priorities for the city's future economic development. The city's strategy towards warehouses has changed recently, with the adoption of new landscaping provisions and an increase in the attention paid to environmental performance for warehousing facilities.

Warehouses and distribution centers are now very visible and represent an increasing share of the industrial activity in Los Angeles. This brings with it new questions for the city's economic and social development. Today's warehouses occupy large parcels of land with a low jobs density. These jobs are not as "good" (in terms of salary and benefits) as more traditional manufacturing jobs. Warehouses and logistics sprawl also bring with them truck traffic, pollution and physical impacts on roadways that are ultimately local and the duty of the State government to offset. However, freight facilities are of fundamental importance for logistics, an industry which has become key to the growth and well-being of the entire region, helping to confirm the status of Los Angeles as a provider of a substantial share of the Nation's trade with the rest of the world. Local governments have to cope with, and make the best of, the material impacts of a conquering global industry on which they have very little leverage.

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Data Collection for Understanding Urban Goods Movement

Comparison of Collection Methods and Approaches in European Countries

Julian Allen, Christian Ambrosini, Michael Browne, Danièle Patier, Jean-Louis Routhier and Allan Woodburn

Abstract This chapter addresses the topic of urban freight data collection. Survey work was carried out with experts in eleven European countries to describe and compare urban freight transport data collection efforts to better understand what currently takes place and to identify examples of good practice. The extent of urban freight data collection varies significantly between the European countries surveyed. Much of the existing urban freight data comes from the disaggregation of national survey results. The chapter identifies the most commonly identified gaps in data collection, as well as the need for greater standardisation in data collection methods and in analysis and reporting of this data.

Keywords Data collection · European synthesis · Surveys · Urban goods movement

1 Introduction

Urban freight data is nowadays collected for a wide range of reasons (Browne et al. 2007), often related to different objectives and stakeholders. For example, local, regional and national governments finance projects and actions in the field of urban logistics. In order to measure the performance and pertinence of those projects, data needs to be collected, processed and analyzed. Moreover, to investigate specific projects and initiatives and the interest of developing and financing them, governments and other public authorities need also to collect data

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of different nature and with different degrees of detail with respect to project evaluation. Freight data is also required to ensure that requirements of European Commission Directives are met, to produce national estimates (also related to public authorities), for security and safety controls (for both public authorities and transport carriers), commercial monitoring, strategic development and market analysis (transport carriers and loaders) but also for legal requirements and crime investigations.

In most countries the national government is the main collector of freight transport data. This usually takes place as part of larger, national surveys made for regional and inter-regional freight transport, but can include an urban component. Much of this freight data collected by national governments is reported at a national scale (i.e. it does not distinguish between urban and non-urban freight). It can be possible to disaggregate some urban freight data from these sources. However, extracting urban freight data from those national surveys is not always easy for the following reasons. First is that the data granularity and accuracy on national surveys is usually dependent on time availability of the national government survey staff and the budget that is disposed to invest on such campaigns (Holguin-Veras and Jaller 2013). The second reason is that several surveys are often based on vehicle activity[1] or on shipment tracking,[2] not specific geographical location, so both urban and non-urban data is collected (and is sometimes difficult to separate). Last but not least, it is important to highlight that sample sizes for smaller urban areas are likely to be relatively small in such surveys (Allen et al. 2012).

Many urban authorities also carry out either periodic or occasional vehicle traffic counts that include goods vehicles but do not tend to carry out surveys of goods vehicle operations. Often, the only data collection efforts that focus solely on urban freight transport are surveys carried out in specific towns or cities. These have usually been conducted on a one-off basis as part of a review of urban freight strategy or to assist in making an urban planning decision.

This chapter is based on work carried out in the EC established the Co-ordination Action (CA) on BEST Urban Freight Solutions II (BESTUFS). The purpose of the task carried out in BESTUFS was to collect, compare and describe urban freight transport data collection approaches in different European countries in order to better understand what currently takes place and to identify examples of good practice. The chapter contains a synthesis of information provided by freight transport experts to the questionnaire carried out at a national level in the following European countries: Belgium, France, Germany, Hungary, Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. The chapter is organized as follows. First of all we propose a synthesis of the current state of urban freight data collection, including national reviews of freight data collection, the

[1] This is the case of vehicle operator surveys carried out to meet the requirements of the EU Directive on Freight Statistics or German Commercial Transport Surveys, made at regional level.

[2] This is the case of French Loader's surveys (ECHO), whose urban flows are difficult to be identified and analysed (Dablanc and Routhier 2009).

current extent of urban freight data collection, methodologies used, and gaps in freight data that have been identified. After that, we identify the range of urban freight data currently collected in each country including the most useful and innovative data collection exercises, then we introduce a set of urban freight transport indicators used in the countries surveyed. The final section provides conclusions and recommendations for future urban freight data collection based on the findings of the survey work. This includes consideration of important gaps in the data, and the methodologies and approaches used in collecting the data.

2 National Reviews of Freight Data Collection

Reviews of freight data collection have taken place in a few of the countries surveyed, as well as in other countries outside the European Union. Such reviews are typically used to establish what data is being collected, why and how it is being collected, and the extent to which the data being collected meets the data requirements in terms of factors such as supporting freight policy decision-making and freight modelling. However, where such reviews have taken place, they tend to be concerned with freight data at a national level, rather than specifically at an urban level.

In Germany, an inventory of all data collected that concerned commercial traffic was carried out between 1997 and 2000 by a special research team on behalf of the German Ministry of Transport (BESTUFS 2003). The objective was to review the available data on commercial traffic to identify possible extensions to existing data collections and also to produce recommendations to overcome possible deficits in the existing data collected. In the UK, the Department for Transport commissioned “The Review of Freight Modelling Project” which took place between 2001 and 2003 (WSP 2002). This project considered data requirements and data sources currently available in UK for freight modelling purposes. Much of the review was at the national and regional scales, but urban scale was considered. Work by the University of Westminster for Transport for London (TfL) has reviewed freight data sources for London (Browne et al. 2004). In France, a review carried out on behalf of the French Ministry of Transport in 1994 concluded that there was a major lack of urban freight data collection (Ambrosini and Routhier 2004) and that more adapted survey methods needed to be developed (Ambrosini et al. 2010). Similar considerations were made in Italy by the Emilia Romagna Region, where existing data collection methods were examined in the early 2000s (Rosini 2005; Spinedi et al. 2008).

In the USA, a review was carried out by the US Transportation Research Board (TRB) into national freight data in 2003 (TRB 2003). A scoping study was recently completed in Australia on freight data issues. Again, the consideration were focused on national rather than urban freight data (Austroads 2006). A brief review of urban freight data in member countries took place as part of the OECD report on urban freight transport in 2003 (OECD 2003). The BESTUFS project has also previously examined urban freight data in 17 selected European countries, in terms of the availability of such data (BESTUFS 2000, 2003).

The methodology for road freight data that is required to be collected and submitted to Eurostat by Member States under Council Regulation 1172/98 is also reviewed at regular meetings of members of national transport ministries/departments. This road freight data is typically published at a national level but contains data about urban freight transport activity within it (Eurostat 2006).

3 Changes in Urban Freight Data Collection

The availability of urban freight data has tended to remain the same or improve in the surveyed countries over the last five years (Browne et al. 2007). In countries in which urban freight data availability has improved this has either been the result of new national freight surveys from which urban activity can be disaggregated (for example, the company-registered van survey by the UK Government Department for Transport and the KID survey carried out in Germany in 2002), or one-off projects and data collection efforts at an urban scale (for example survey work in the Italian cities of Rome, Milan and the Emilia Romanga region, data collection in Liege and Ghent in Belgium, urban freight transport profiling in the Dutch cities of Amsterdam, Utrecht and Rotterdam as part of the Connekt MG-11 project, and survey work in UK urban areas including Ealing and Bexleyheath in London, and Newton Abbot in Devon as part of Freight Quality Partnerships).

Some of the most innovative, large-scale urban freight transport data collection and modelling exercises in Europe took place in France approximately twelve years ago. Some one-off urban surveys have taken place in French cities since then but on a far smaller scale.

It should be noted that in some of the countries surveyed such as Hungary and Portugal there have been few efforts to collect urban freight data in mid 90s. However, this situation is expected to improve in Portugal over the next five years as a result of increasing congestion and concern about environmental problems.

In several other countries, experts expect urban freight data collection to improve over the next five years as a result of it receiving greater attention from policymakers as they attempt to improve its efficiency and reduce its negative impacts.

4 Country Comparison of Urban Freight Data Collected

The freight experts surveyed were asked about the existence of a range of categories of urban freight data in their country. The experts identified relevant urban freight data sources for each of these categories and provided information about the issues concerning these sources including the name of the survey/data source, the reason for the data collection, the frequency of data collection, the type of data collected, sample size and units of measurement used.

The responses provided by the freight experts were used to distinguish the types of urban freight data collected in each of the eleven countries surveyed, and it was possible to identify several key points:

- The range and quantity of urban freight data varies substantially between (and even within) countries.
- The regularity with which urban freight data is collected also varies between countries and between types of data. In some cases, data is collected on a continuous basis as part of a national government survey while, at the other extreme, data is sometimes only collected in a single one-off survey that is never repeated.
- The body responsible for organising the data collection also varies depending on the type of urban freight data in question. In many cases the data is collected by the public sector (either by a tier of government or by academics as part of a research project). However, in some cases (especially with data concerning operating costs, the structure of the freight transport and logistics industry, thefts from goods vehicles, freight activity using non-road modes, and goods vehicle data from vehicle tracking systems) private sector organisations are responsible for data collection. Such organisations can include individual companies, trade associations, chambers of commerce, insurance groups etc.
- In the case of data collected by public sector organisations, the tier of government at which the data collection takes place can vary. Some data is collected by national government (especially that data required to be collected by EU legislation—such as goods vehicle activity data), some is collected by regional government, and some is collected by urban/municipal authorities.
- It is not always the case, but urban freight data collected by national government is often collected on an on-going basis, while some of the freight data collected by urban authorities takes place on a one-off basis as part of a specific study.
- In some cases, freight data collected at an urban level is collected in all urban areas within a country (e.g. traffic count data). However, in other cases it is only collected in one or several urban areas (especially when it is collected as part of a specific study).
- Urban freight data that is collected by national governments as part of continuous or occasional national survey work needs to be disaggregated from the overall dataset in order to be useful for urban freight analysis. The level of difficulty involved in disaggregating urban data from national freight datasets varies depending on how the data has been collected and coded. In some cases, disaggregation is not possible.

Table 1 contains a summary and comparison of this information for all eleven countries. There are two columns in the table for each country. The first column indicates whether or not such urban freight data is collected. The second column indicates the level at which this data is collected (national, regional or urban government, or collected by commercial organisation). In the rows showing

Table 1 Urban freight data collected in the countries surveyed

Type of data collection exercise/ survey	Belgium	France	Germany	Hungary	Italy	Netherlands	Portugal	Spain	Sweden	Switerland	United Kingdom
Commodity flow survey	✔ NS	×	×	×	×	×	×	×	✔ NS	✔ NS	×
Site/land use/establishment surveys	✔ NS	✔ SUS	✔ NS	×	×	✔ RS	×	✔ OUS	×	✔	✔ SUS
Goods vehicle activity surveys (including driver diary surveys)	✔ NS	✔ NS	✔ NS	✔ SUS	✔ NS	✔ SUS	✔ NS	✔ NS	✔ NS	✔ NS	✔ NS
Shipper surveys	✔ OUS	✔ NS	✔ SUS	×	✔ CD	×	×	✔ SUS	×	✔ NS	×
Receiver surveys	✔ SUS	✔ SUS	✔ SUS	×	✔ SUS	✔ SUS	×	✔ SUS	×	✔ NS	✔ SUS
Good vechicle fleet licensing data	✔ NS	✔ NS	✔ NS	✔ SUS	✔ NS	✔ NS	✔ NS	✔ RS	✔ NS	✔ NS	✔ NS
Traffic counts	✔ AUS	✔ AUS	✔ NS	✔ SUS	✔ SUS	✔ SUS	✔ NS	✔ SUS	✔ NS	✔ SUS	✔ AUS
Distribution industry surveys	×	✔	✔ CD	×	✔ CD	✔ NS/CD	×	×	×	✔	✔ CD
Vehicle operating surveys	✔ NS	? NS	✔ CD	×	✔ NS	✔ CD	×	✔ RS	×	✔ CD	✔ CD
Loading/unloading/parking infrastructure data for goods vehicles	✔ OUS	✔ SUS	×	✔ OUS	×	✔ AUS	✔ SUS	✔ SUS	×	×	×
Data on road accidents involving goods vehicles	✔ NS	✔ NS	✔ NS	✔ OUS	✔ NS	✔ NS	✔ NS	✔ AUS	✔ NS	✔ NS	✔ NS
Data on lorry/lorry load thefts	✔ NS	✔ NS	✔ CD	×	? OUS	✔ NS	×	?	?	✔ CD	✔ NS
Employment surveys in freight transport and logistics industry	✔ NS	✔ NS	✔ NS	×	✔	✔ NS	✔ NS	✔ NS	?	?	✔ NS
Land use databases for town/city needed for freight modeling	×	✔	✔ NS	×	✔	×	✔ SUS	?	?	?	✔ NS
Port freight traffic data in the urban area	✔ OUS	✔ CD	✔ CD	×	×	✔ NS	×	?	?	?	✔ NS
Rail freight traffic data in the urban area	✔	?	✔ CD	×	×	✔ OUS	×	?	?	?	✔ NS

(continued)

Table 1 (continued)

Type of data collection exercise/ survey	Belgium	France	Germany	Hungary	Italy	Netherlands	Portugal	Spain	Sweden	Switerland	United Kingdom
Inland waterway freight traffic data in the urban area	✗	✔ CD	✔ CD	✗	✗	✔ NS	✗	?	?	?	✔ NS
Airport freight traffic data in the urban area	✔	✔ CD	✔ CD	✗	✗	✔ NS	✗	?	?	?	✔ NS
Freight informatics data (from cameras, sensors and other automatic data capture devices)	✗	✗	✗	✗	✗	✔ CD	✗	?	?	?	✔ CD
Vehicle safety and maintenance	✗	✗	?	✗	✗	✔ NS	✗	?	?	?	✔ NS

✔ freight data is collected, ✗ freight data is not collected, ? uncertainty exists about whether freight data is collected
NS national survey/data collection, *SUS* survey in some urban areas, *RS* regional survey/data collection, *OUS* survey in one urban area, *AUS* survey in all urban areas, *CD* data collected by companies, trade associations or other commercial organizations

information about rail, port, inland waterway and air freight traffic data inside the urban area, this refers to the existence of a rail terminal, sea port, river wharf or airport in the urban area rather than necessarily reflecting the use of these modes for freight transport destined for locations within the urban area.

5 Methodologies and Approaches in Freight Data Collection

The information provided by freight data experts has indicated the breadth of different techniques that are currently being used to collect urban freight data. Obviously the technique used to collect data will be influenced by the type of data that is being collected and the use to which it is being put (for instance data used to provide a quick snap-shot of the current situation[3] is likely to be collected using a different methodology and sampling approach to data used as an input to a freight model).

Traditionally traffic counts are the most common survey method for urban freight policy making support, since policy makers have the habits and experience on these techniques, already popular in personal trip planning. However, the variety of methods in people transport is wider, and in the last years, many urban freight transport studies attempt to go beyond vehicle traffic counts (Allen et al. 2012). Moreover, several categories of urban goods and commercial transport surveys have been identified recently (Ambrosini and Routhier 2004; Patier and Routhier 2009; Roorda et al. 2009; Allen et al. 2012; Pluvinet et al. 2012). According to Allen et al. (2012), Urban Goods Movement (UGM) data can be collected using different techniques, which are mainly the following:

- General surveys: they aim to collect global information (in a more or less detailed way) of generation variables and specific information about how transport flows are created. The main types of surveys in this category are the exhaustive UGM surveys (French national surveys, Emilia Romagna regional surveys in Italy), the commodity flow surveys (ECHO surveys in France, US commodity flow surveys) and commercial transport surveys (MID and KID in Germany).
- Stakeholder specific surveys, which are focused on extracting information from a given category of stakeholder, mainly establishments, shippers, service providers, retailers, freight operators or commercial agents. Each survey of this category refers to only one of those types of stakeholders.
- Vehicle specific surveys: they consist on following a vehicle, its usage and its driver practices, using different methods, such as driver interview or surveys, vehicle observations, vehicle trip diaries or GPS data loggers.

[3] For a given urban area and in terms of urban goods flows.

- Area specific surveys, which focus on a geographical area and are in general very descriptive. The main examples of such category of surveys are roadside interviews, parking observations and traffic counts, this last approach used in conjunction with the above techniques to give complementary information.

The general survey techniques are the most complete (and complex) data collection method: they provide broad but detailed data on the freight activity in cities and sometimes even beyond the urban area (i.e. the US commodity flow surveys). Every type of data (in the above typology) is collected during these surveys, except for the external elements (category 4). These general surveys are however the most expensive as it gathers fair amounts of resources (human and material) to survey the entire supply-chain related to urban goods movements. The inconvenient of this type of global survey is usually the lack of accuracy on urban freight operations: for example KID, and MID, commodity flow survey are not focused on the urban area but are national surveys (BESTUFS 2003). It is also difficult to generate the interest of the stakeholders in participating in such surveys if they are not statutory: the involvement of all the participants is a key in building substantial data. New approaches such as the French surveys on the urban goods movements are specifically designed for the urban area and therefore the most suitable to understand freight flows and their formation in the urban area (Patier and Routhier 2009).

Stakeholder surveys are related to the previous category as they can in fact be parts of general surveys. They provide understanding of the organization of transport and freight operations in the urban environment. As each stakeholder represents a part of the supply-chain, surveying one or the other stakeholder will give different (in quantity and quality) valuable information. The shippers and establishments surveys provide more information on shipment and handling operations, whereas freight operators and service provider surveys generate more information on the activity of carriers and vehicle operations, while still providing data on shipment and handling operation (maybe with lesser quality and quantity). This survey type requires substantial resources if carried out thoroughly on a large scale, but is very accurate. Again, as in the previous category, the involvement of the surveyed stakeholders presents an additional difficulty, but is fundamental if the goal is to build substantial sets of data.

The vehicles surveys can provide valuable information on the fleets, the characteristics, and journey details of the vehicle. It mainly concerns the "behaviours" of the vehicles and fleets in the urban area. While the collected data mainly concern the category 3 of the typology, it is also possible to gather precious information in the first and second categories, depending on whether it is a driver survey (which can give us information on pick-up/delivery operations and shipment) or a GPS survey that can only provide the path taken, but with an extreme accuracy on speeds, accelerations and routes (Pluvinet et al. 2012). Again the importance of communication with the actors of the urban freight transport is critical to the success of these survey techniques if the goal is to obtain extended information. However this category is not necessarily the most expensive of all, because it is (partly) based on the observations of diaries or GPS data, which can be obtained with minimum human resources.

The last category (area specific surveys), is not fundamental as it does not really give information on freight operations, but helps in understanding the environment in which urban goods movements take place. Indeed, the limit of these surveys is that they are somewhat disconnected from the organization of transport, and only give information on the use of the public road network, and the origin and destination of flows (Patier and Routhier 2009). But, these surveys are still useful to add insight to the other survey categories, with environmental analysis, to understand the influence of external elements on urban freight operations.

Each category of survey has its own specific characteristics, and results in different advantages and disadvantages. To compare these survey techniques and the synergies between them, it is necessary to consider the potential ability of each technique to collect the key information needed for urban goods and commercial transport diagnosis and public policy decision support. Important topics when comparing survey techniques include: the quantity and quality of data collected, sampling considerations, costs, and implementation and execution difficulties.

Each survey technique cannot provide every type of information on urban goods transport organization. To understand the specifics of each type of survey, a typology of the different data related to UGM is presented below (this list is not exhaustive):

1. First, we can identify all information related to the shipment itself: the nature and/or quantity (in weight, surface and/or volume) of the goods, the package and data related to its origin and/or destination.
2. Second is a set of data related to the pick-up or delivery operation: tools and equipment to carry-out the concerned commodities, consolidation-deconsolidation operations, time data (date, hour, frequency) and parking conditions
3. Third, information concerning the vehicle that transports such goods: the vehicle characteristics (type, capacity, special equipment, mode) and details about the journey (number of stops, duration of stops, travel path, speed, travel time)
4. Last, but not least, a set of external elements: the transport network (characteristics, traffic, incidents, etc.) or other exogenous elements like weather conditions, strikes, etc.

It can be observed that one type of survey is not usually sufficient to understand the urban goods movement system. The combination of several types of surveys is often necessary to obtain an extensive set of data to perform a full diagnosis of the urban goods transport in a city. It can also be noted that the most "efficient" methods are often also the most expensive and require substantial human and material resources. Indeed, each survey technique has limitations. It is important to combine the survey techniques in order to meet the survey targets: for example GPS-based techniques can provide more precise data about a number of parameters including routes, speeds, energy consumption, etc. whereas current mail-out/mail-back and face-to-face surveys give invaluable information about the behaviour of the stakeholders and of the logistics schemes.

Both face-to-face, postal and electronic questionnaires have been used for carrying out the various survey techniques discussed. Interviews have been conducted both face-to-face and by telephone. In the case of detailed interviews, these are often carried out face-to-face because the topics and questions can be both lengthy and complicated. Large-scale national freight surveys in the European countries surveyed tend to make use of postal questionnaires. These surveys usually have high response rates due to the fact that they are often statutory surveys. In addition, these surveys usually have a well developed and refined methodology and sampling approach—this is a reflection of the time over which the survey has been taking place and the resources available to carry it out.

Interviews and group discussion techniques tend to be more widely used in one-off or occasional data collection exercises that take place in a specific urban area. This is due to the cost of these approaches in a national survey. Data collection exercises in a specific urban area tend to also make use of all the other techniques listed above. As a result of budgetary and time constraints, sample sizes for one-off data collection exercises in specific towns and cities are often small and not statistically representative. This makes the comparison of data over time and between different urban areas very difficult.

New technology offers the possibility to collect significant quantities of urban freight data at relatively low cost (compared with previous techniques). However consideration of such techniques to collect urban freight data raises many questions about: (i) its legality (for instance the use of roadside cameras to record vehicle details is not currently allowed in Germany), (ii) the need to supplement this data with other data as these new technologies do not necessarily provide all the data that would have been collected in a traditional survey, and (iii) the co-operation and agreement needed between the public and private sector to share this data.

Finally, it is important to highlight that survey methods are expensive and policy makers do not always have the resources to carry out them with the detail level needed to ensure a minimum quantity and quality of results. To deal with this limit, a small group of tools are today available to assist policy makers. These tools are in general depending on a regional or national context and are not present in all countries. For more information on data production, see in this chapter and "Comprehensive Freight Demand Data Collection Framework for Large Urban Areas" of the present book (Holguin-Veras and Jaller 2013; Gonzalez-Feliu et al. 2013).

6 Gaps in Urban Freight Data

The responses provided by freight transport data experts in ten European countries carried out as part of this project have identified a range of urban freight data gaps. These gaps have implications both for understanding urban freight transport activity patterns and also for developing urban freight models. Issues that have been identified by the experts in considering urban freight data gaps include:

- In some countries relatively little urban freight data is collected. In these countries, data gaps are substantial. This lack of data is often based on a lack of appreciation of the need for urban freight data by national, regional and local (urban) authorities.
- Even when urban freight data is being collected, it is common for different data collection exercises (either in the same country or in another country) to use different data collection methodologies. This results in data gaps when comparisons between datasets are attempted. In addition, reporting of freight data and analysis of data varies between studies carried out.
- The experts have identified a wide range of specific urban freight data gaps. Common data gaps mentioned by several experts include: (i) data about light goods vehicle activity (i.e. up to 3.5 tonnes gross weight), (ii) data about the supply chain as a whole (i.e. the links between urban freight activity and the freight activity upstream in the supply chain), (iii) data about freight and logistics infrastructure to and from which urban freight activity takes place, (iv) sectoral data about urban freight activity (i.e. much urban freight data does not distinguish the type of supply chain involved and goods carried), (v) data about loading and unloading operations and infrastructure for goods vehicles, (vi) insufficient geographical detail about goods vehicle trips in urban areas, (vii) data collection concerning the trips carried out by consumers for the purposes of shopping (which is a form of urban freight transport but which is often not defined as such for the purposes of urban freight data collection exercises[4]), (viii) insufficient freight data for non-road modes, and (ix) often relatively little information is available about how data was collected and processed, and about the reliability of the data.
- In thinking about data gaps it is necessary to consider the different uses of urban freight data. It can be used in its own right by policymakers and researchers to understand existing patterns of freight flow and vehicle activity, to monitor freight performance and responses to policy measures. Freight data can also be used as an input to modelling exercises.

7 Urban Freight Transport Indicators

Respondents were asked to provide details of indicators used by governments or researchers to measure the performance of urban freight transport in their countries. They were also asked to include details of any urban freight transport indicators that they thought would be useful even if they were not aware of the indicator being used currently.

[4] Such data are collected via personal trip surveys and traffic counts, which are not adapted to urban goods movement characterisation.

The responses suggest that there are few indicators that are currently in use by national, regional or local governments in the surveyed countries to monitor the performance of urban freight transport. The most commonly used indicators are related to road freight and include: goods vehicle trips, and goods vehicle kilometres (usually based on traffic count data). However, even these indicators are not available in many European urban areas.

Other indicators that are commonly used by governments to measure and monitor freight transport at a national level include: tonnes lifted (by road and other modes), and tonnes moved (i.e. tonne-kilometres by road and other modes). However these indicators are often not available at an urban scale.

Other national freight transport indicators used by governments in one or more European countries include:

- Freight Intensity (of heavy goods vehicles—tonne-kilometres/GDP)
- Lorry traffic intensity (of heavy goods vehicles—vehicle kilometres/GDP)
- Energy intensity (Fuel consumed per tonne-kilometre)
- Average length of haul
- Lading factor
- Empty running

None of the indicators listed above has been calculated for urban freight transport (with the exception of average length of haul, lading factor and empty running in London, produced from data disaggregated from the national survey). This is due to the data requirements of doing so, and a lack of consideration of freight indicators at the urban scale by all tiers of government.

A few research projects have produced other indicators of urban freight transport. A selection of these from projects carried out in France and the UK are shown in Table 2. These indicators have been calculated from one-off data collection exercises that have not been repeated. In the case of France, all of the indicators shown in Table 2 can be calculated using the FRETURB model developed by Laboratoire d'Economie des Transports (LET) at the University of Lyon.

It is important to note that the questionnaire responses have highlighted that there is little common understanding or agreement about what constitutes an urban freight transport indicator. Also, it is not always clear from respondents' answers whether an indicator that they have identified is currently in use or is being suggested as a potentially useful indicator.

8 Synthesis, Discussion and Recommendations

In this section we propose first a synthesis and a discussion of the proposed overview then a set of recommendations for data collection in the context of urban logistics.

Table 2 Urban freight transport indicators used in research projects in France and the UK

Title and description of the urban freight indicator	Units in which the indicator is measured
Loading/unloading density	Number of deliveries and pick-ups per km^2 in a zone
Loading/unloading intensity per activity	Number of deliveries and pick-ups per activity in a zone
Loading/unloading time	Number of hours of on street double parking for delivery or pick-up in a zone, per vehicle, per activity
Ratio: number of loading/unloading	Number of deliveries and pick-ups per week per employee in an activity
Length covered for loading/unloading	Number of km for one delivery or pick-up in a zone, per vehicle, per activity
Average length of the first trip from platform to the delivery area	km
Average distance travelled per collection/delivery	km per collection or delivery
Total distance travelled on roads in urban area transporting goods by HGV, rigid lorries, and LGV (<3.5 t) used	Total vehicle km per week in urban areas
Average time taken per delivery	Minutes per delivery
Average speed per round (including and excluding stops to make deliveries)	km per hour
Greenhouse gas and pollution	- g pollutant per km travelled - g CO^2 per km travelled - litre of fuel per km according to the zone, the vehicle, the activity

A wide range of different techniques are currently being used to collect freight data in urban areas in Europe. These range from postal questionnaires and interviews to observation surveys and electronic data capture using satellite tracking and roadside cameras.

All of the techniques currently in use are likely to remain useful in future. However, new technology (such as satellite tracking, roadside camera and weigh-in-motion data) has major potential to provide significant quantities of urban freight data at relatively low cost (compared with other traditional techniques). Consideration is required in order to determine how these new data sources and collection techniques should be used, how they should be supplemented with other data and how best to manage this data and integrate it with other existing data. Although potentially very helpful, some of these new technologies do not necessarily provide all the data that would have been collected in a traditional survey (for example satellite tracking data does not provide the same amount of information about trip purpose and type and quantity of goods carried as a trip diary completed by a vehicle operator). In addition, some of these new technologies are not currently allowed in some countries. For example, in Germany the use of roadside cameras to record vehicle details is not currently legal.

The potential use of urban freight data collected by new technologies also raises issues about the extent of co-operation and agreement needed between the public and private sector to share this data. At present, satellite tracking data is the property of private companies. Public organisations need to work closely with these private companies to overcome issues concerned with funding and confidentiality in order to obtain access to it.

Large-scale national freight surveys in European countries are likely to continue to be of assistance in providing some insight into urban freight operations. These surveys usually have a well-developed and refined methodology and sampling approach. However, the level of insight they provide is determined by the ease with which urban freight data can be disaggregated from the total data. Therefore efforts to ease the disaggregation process should be encouraged. This is likely to include reconsideration of the level of geographical detail provided in the data collected and also in terms of the ways in which the data is coded.

However, there is little indication that the level of large-scale national freight surveys in many of the European countries studied is likely to increase in the coming years. Therefore urban freight data collection initiatives will be required to be carried out at an urban level and this is likely to require support and resources from urban/municipal authorities.

There is a need for greater standardisation in data collection methods and in analysis and reporting of this data. There is also a need for joint efforts between those working with urban freight data in different European countries to work jointly in establishing suitable urban freight transport methodologies and analyses (including indicators) so that data are more comparable. Also mechanisms should be established to encourage the sharing of data collection methodologies and actual freight data between projects, cities and countries.

Issues concerning the availability and reliability of the data required for urban freight modelling (together with the lack of resources available to develop such models in the first place) mean that, with a few exceptions, relatively little has taken place in urban freight modelling to date. This situation may improve as national, regional and urban authorities realise the importance of urban freight. However, major increases in resources to collect urban freight data are likely to be necessary in order to meet the data requirements of urban freight modelling exercises.

9 Addressing Gaps in Urban Freight Data Collection

A wide range of urban freight data gaps have been identified by the freight experts participating in this study. The most commonly mentioned data gaps include:

- data about light goods vehicle activity
- data about the supply chain as a whole

- data about freight and logistics infrastructure to and from which urban freight activity takes place
- data about loading and unloading operations and infrastructure for goods vehicles
- geographical data about goods vehicle trips in urban areas
- data about trips carried out by consumers for the purposes of shopping
- speed and route data for goods vehicles
- data for non-road modes

It should be noted that some of these data gaps exist at the national and regional as well as the urban scale. In some countries efforts are being made to fill some of these gaps through national freight data collection (e.g. the KID survey in Germany and the Company Van survey in the UK to collect data about light goods vehicle operations). Depending on the sample sizes involved, it may be possible to disaggregate these national surveys in order to obtain some urban data. In other cases, specific urban surveys can help to address some of these gaps (such as the surveys carried out by LET in France during the 1990s).

It would appear that in general there is little resource or desire among local, regional and national government officials in several of the countries surveyed to extend urban freight data collection at present. However, this is not the situation in all countries and cities. In London, for example, Transport for London has recognised the importance of freight transport in the city and is now making greater resources available for freight transport initiatives and data collection. The Transport for London example suggests that senior personnel in government need to be persuaded of the importance of urban freight transport and, linked to this, the need for urban freight data collection.

At present, there is a lack of co-ordination between different tiers of government in thinking about the collection of urban freight data. By working more closely together it would be possible for these governmental organisations to achieve more with their existing resource.

The survey work carried out as part of this report has identified that some urban freight data publications and reports contain relatively little information about how the data was collected and processed, and about the reliability of the data. This can be overcome through ensuring that freight data collection exercises are well documented. Improved information would assist others in using the data to make comparisons with data collected in other urban areas (both nationally and internationally).

It is important to recognise that urban freight data is required for different purposes. It can be required: (i) to provide an understanding freight operations and to monitor the effects of policy measures, and (ii) for forecasting with the help of urban freight models. The use for which the data is required can affect the data collection methodology, and the quantity of data required. In some urban areas sufficient urban freight data has been collected in order to have some understanding of freight operations, in other urban areas too little data has been collected to achieve even a basic understanding. Even in those urban areas in which much urban freight data has been collected in past surveys, the lack of repeat surveys in subsequent years can result in a deterioration in this understanding.

10 Conclusion

Urban freight data serves a wide range of uses and is extremely important in helping public and private sector decision-makers to ensure that urban freight transport takes place in as efficient and sustainable a manner as possible. Without such freight data it is extremely difficult for national, regional and urban authorities to make decisions about issues including road space allocation and congestion, freight transport's role in energy consumption and air quality, safety and security issues associated with freight transport, modal shift, and land use planning.

The extent of urban freight data collection varies significantly between the European countries surveyed. In addition, even in countries with the greatest quantity of urban freight data, most of this is derived from the disaggregation of data collections that take place at a greater geographical scale than the urban area. Freight data is currently collected by a large number of different organisations including: national, regional and urban governments, other public sector bodies and agencies on behalf of these governments, as part of one-off studies and projects, and by private sector organisations including industrial, retail, service and transport companies, trade associations and market research companies. These urban freight data collection efforts are not currently co-ordinated, and this results in many different data sources and data sets that vary widely in quality and methodology, making comparisons and combinations of them difficult or impossible. Even in the countries in which the greatest quantity of urban freight data is collected, when all of this urban freight data is brought together, it still does not provide a comprehensive picture of the urban freight transport system. Instead the picture provided is patchy and unreliable.

The quantity and coverage of available urban freight data in all countries surveyed is still far less than either: (i) freight data available at a national level, or (ii) urban passenger transport data. This is due to the fact that all levels of government have traditionally focussed on passenger transport data collection rather than freight data (at national, regional and urban levels), together with the fact that much freight data (urban and elsewhere) is held by private organisations and is not made generally available by them. In addition, urban authorities tend to have far fewer resources available for continuous or periodic freight data collection than national governments.

The description provided in this chapter is a first step towards a better understanding of the state of urban freight data collection in Europe. It is important to focus on how to make best use of existing national and urban freight data collection resources in order to maximise the usefulness of the urban freight data collected. As new resources for urban freight data collection are made available, it is important that steps have been taken to ensure that it is directed towards collecting the most important data (based on a prioritisation of urban freight data gaps and needs), and that suitable methodologies, data analysis approaches, and reporting standards have been put in place.

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Comprehensive Freight Demand Data Collection Framework for Large Urban Areas

José Holguín-Veras and Miguel Jaller

Abstract The chapter analyses characteristics and unique features of the freight system, data requirements of different modeling techniques, and the roles of various data collection procedures. The analyses produce a set of findings of relevance to the design of comprehensive freight data collection frameworks for mid-size and large urban areas. Building on these findings, the chapter identifies a modular data collection framework that would enable transportation agencies to mix and match data collection efforts depending on their needs and constraints.

1 Introduction

The freight transportation system could be understood as a physical manifestation of the economy, where monetary transactions create a flow of commodities from a set of origins to destinations. For that reason, the study of the movement of these flows or freight transportation system is of extreme importance. Among other things it will lead to a better understanding of the economic impacts of transportation investments which will enhance economic competitiveness. This point was emphasized two decades ago with the promulgation of the Intermodal Surface Transportation Efficiency Act of 1991 and the 1998 Transportation Equity Act for the twenty-first Century (National Cooperative Highway Research Program

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(NCHRP) 2007) in the United States. From this point on it was required for state and metropolitan planning organizations to include freight activities in their transportation planning processes. These pieces of legislation motivated a trend towards a more systematic and quantitative consideration of freight issues by transportation professionals. The creation of the National Cooperative Freight Research Program, the first program exclusively dedicated to support freight transportation research, is probably the most recent and notable example of this trend.

However, characterizing the freight system—a requirement for the development of policies and programs to improve its performance—has proven to be a difficult task as it is hard to think of any other component of the transportation system that is more varied, exhibits so many fundamentally different behaviors, has more interacting agents, and is so pervasive in modern life than freight. The multifaceted and heterogeneous nature, compounded with the lack of freight data has presented a challenge to both researchers and practitioners. The latter affects all steps of transportation modeling (generation, distribution, modal split, and traffic assignment) which are critical for: (1) developing improvement strategies for freight mobility; (2) system performance forecasting; (3) mitigating the impacts of truck traffic; (4) determining the impacts on air quality; and (5) improving traffic safety and network performance. Thus, it is important to develop efficient data collection procedures that can help collect the data at minimal cost and effort.

The objective of this chapter is to develop a comprehensive freight demand data collection framework for mid-size and large urban areas. The chapter briefly discusses the characteristics and dimensions of the freight demand. Building on this discussion, it describes the data needs for different modeling techniques, and potential data sources. The following section outlines data collection procedures, ranging from surveys to freight volume counts. Finally, the last two sections highlight data expectations and challenges, develop and describe the data collection framework, and discuss the costs associated with the different strategies.

2 The Freight System

The freight system is comprised of a set of interacting, interrelated economic agents, facilities and infrastructure that form a complex system that is in charge of producing, processing, transporting, distributing the supplies needed for manufacturing, human consumption, and trade. In general terms, there are a number of agents and facilities of relevance to the study of freight systems including: shippers, carriers, receivers and consumers, among others. The *shippers* are the agents that produce and ship freight at the supply points (e.g., raw material production sites, manufacturing, distribution or assembling companies, among others). They send cargoes to their destinations, which are transported using their own assets, or with the assets of other companies hired for that purpose. The companies that transport the goods are known as *carriers*, and in general, these could be for-hire carriers, those that provide services to the open market; and private carriers, i.e., those that only provide transportation services to a parent or related company. To transport freight, the shippers may contact the carrier companies directly or they can use the services of intermediary companies, namely the *third party logistics (3PL)* providers. Alternatively, shippers may use *freight forwarders*, i.e., a form of 3PL providers that make use of asset based carriers for shipping. The freight to be transported may have as its destination a distribution center/warehouse, retailers, wholesale traders, the end consumer or intermediate consumers. These agents and facilities act as *receivers* of the cargo. *Distribution centers* are a special case of facilities since they receive and distribute the cargo; at these locations the cargo may be stored, consolidated, split up, post-processed or assembled. These processes can have an impact on shipment size which in turn may affect the transportation mode to be used when shipping. Other agents worthy of mention are: *wholesale retailers* which in some occasions may act as distributors (shippers) of the cargo, *intermediate consumers* which may process or transform the cargo received and then ship it to the next destination and finally, the *end consumers*. It is important to note that delivering the cargoes to the end consumers, may require additional logistical services as part of the cargo received, when consumed, turn into waste that require further processing. In addition to the agents and facilities just described, one can find *intermodal centers* (e.g., airports, ports, intermodal terminals) that are facilities where the transfers between freight modes take place. An important aspect of these facilities and distribution centers is the basis on which they operate, i.e., in house or third party run, dedicated or general/shared user facility, which can also affect the operation and decision-making process.

As a consequence of the multiple agents and facilities involved, no single agent or facility operator can provide a complete picture of the freight system. This leads to a situation in which assembling a coherent description of the whole requires putting together the pieces provided by the different agents that are only aware of the aspects that concern their operation. A summary of the information they are aware of is shown in Table 1.

As shown, producers and shippers of cargo typically have knowledge of the characteristics of the cargo they receive/ship out. However, they do not know much about what happens once the freight vehicles leave their facilities. Carriers know the details of their operations—including the loaded and empty trips produced—though, quite frequently, they are not aware of the attributes of the cargo transported. They know who they deliver to, though they do not necessarily know who else is delivering to a particular customer. The consumers of the cargo, i.e., the receivers, know the details of the cargo they receive/ship out, though they do not always know how many vehicle-trips have been generated because many of them only observe the number of deliveries (a truck-trip could make multiple deliveries). Transportation agencies have an idea about truck traffic in the network and land use patterns. However, in most cases, they know very little about the freight flows in their jurisdictions. In summary, none of the agents and facility operators involved in freight has sufficient information to fully describe what

Table 1 Partial views of the freight system

Freight generation	Shipper/ Producers	Carriers	Distribution centers/ Warehouse	Consumers of cargos(receivers)	Transportation agencies
Amount of cargo	Yes[a]	Yes[a]	Yes[a]	Yes[b]	No
Number of loaded vehicle-trips	Yes[a]	Yes[a]	Yes[a]	Not always	At Key links(no distinction between loaded and empty)
Number of empty vehicle-trips	No	Yes[a]		No	
Number,frequency, of deliveries	Yes[a]	Yes[a]	Yes[a]	Yes[b]	No
Commodity type	Yes[a]	Not always	Yes[a]	Yes[b]	only at some Ports of entry
Shipment size	Yes[a]	Yes[a]	Yes[a]	Yes[b]	No
Cargo value	Yes[a]	Not always	Not always	Yes[b]	only at some Ports of entry
Land use patterns	Yes[a]	Yes[a]	Yes[a]	Yes[a]	All

Notes [a] Only of the cargo that they handle. [b] For all the cargo they receive

happens in the entire system. This has important implications for data collection efforts, as it implies that the surveys used to collect data from the participants in the freight activity would only be able to capture the information the agent surveyed could provide. The fundamental challenge is how to put together a comprehensive picture of the system that is relatively accurate, practical, and conceptually correct.

Another important aspect when characterizing the freight system is to understand that freight—and by extension its generation—can be measured by many metrics. These include the value of the cargo, the amount of cargo transported, the vehicle trips produced, and the number of stops and deliveries made. Following Holguín-Veras et al. (2011), it is important to make a distinction between freight and freight trip generation. Freight generation (FG) is related to the generation of demand, e.g., tons, while freight trip generation (FTG) is the generation of traffic, e.g., truck-trips. In Holguín-Veras et al. (2011), the authors discuss this difference based on logistical concepts, explaining how FG and FTG are related depending on logistical decisions of shipment sizes, frequencies and types of modes used. Furthermore, freight trip generation is also affected by logistic decisions about the locations of the facilities and agents involved. These differences are of great importance, since they have many implications for data collection. For instance while understanding the connection between the commodity flow between an origin and a destination may seem straightforward, the truck traffic may not follow the same pattern (because the distribution of these goods may follow a delivery tour). In addition, a large proportion of the truck traffic may be of empty trips, as has been found in previous studies (U.S. Census Bureau 2004), and not including these trips can have negative implication in freight modeling (Holguín-Veras and Thorson 2003).

Equally important when describing the system is to characterize the transportation modes, as they determine the transportation technology and infrastructure used, and operational needs. A clear understanding of how the goods are transported would help during the design of a data collection procedure when identifying who, where and how to survey.

As shown, characterizing the freight system could be a challenging endeavor due to the many facets that should be considered when designing a freight demand data collection framework. Building on the discussion about the components of the freight system, the following section analyzes the type of data required for freight transportation modeling and discusses the possible data sources.

3 Identification of Data Needs and Sources

Designing a comprehensive data collection framework requires the use of a systematic approach. In doing this, the initial step is to identify the data requirements for the freight modeling technique that would be used. To simplify the exposition, the authors used a classification system based on: modeling focus, modeling principle, and flow unit. In this context:

- *Modeling focus*, which could be trip interchanges linking an origin to a destination; or tours, i.e., a sequence of delivery stops.
- *Flow unit*, which could be commodity flow, value, vehicle trips, or other.
- *Modeling principle,* which refers to the techniques used in modeling.

Table 2 shows the model classification produced. It is important to mention that the table is by no means comprehensive, nor it is intended to be, as the ones listed only represent the main types. The endless combinations of modeling possibilities simply cannot be considered for reasons of space. When analyzing the process of model development and assessing data requirements, care must be taken to properly consider the fundamental structure and empirical foundation of the model, the computational algorithms and data structures, and the process to analyze modeling results. In general, the data or information required to address these issues fall under two main categories: data for model calibration (C) and data to make forecasts (F). For the sake of brevity and conciseness, the authors decided to identify the key data categories that are typically needed to develop, calibrate, and do forecasting of freight demand. Brief descriptions of these categories are provided next.

Information/insight into logistical patterns of flows. Developing a good freight demand model requires a basic understanding of the functioning of the system being modeled (i.e., agents, interactions, functions).

Freight generation data. Refers to the study of production and consumption of freight. It focuses on the analyses and quantification of the transactions between a producer of cargo and the next consumer.

Table 2 Modeling techniques classification

Modeling focus	Flow unit	Modeling technique/principle
Trip interchange models	Commodity based	Commodity generation: regression models, trip rates, cross classification analyses(simple, multiple)
		Distribution spatial interaction, opportunity, variants
		Input–output: single region, multi-regional, inter-regional
		Freight mode choice: ad-hoc procedures, without considering shipment size, considering shipment size(endogenous, exogenous)
		Empty trip: econometric, simplified trip chain
	Joint commodity flow and vehicle-trip based	Spatial price equilibrium: trip based, tour based
	Vehicle-trip based	Trip generation: regression models, trip rates, cross classification analyses(simple, multiple)
		Distribution models: spatial interaction, opportunity, etc.
Tour based models	Vehicle-trip based	Micro-simulation: logistic based, with/without behavioral models
	Join commodity flow and vehicle-trip based	Micro-simulation-hybrid: with modeling of commodity flows and routing of vehicles
		Spatial price equilibrium: tour based, static, dynamic
Both(trip or tour)	Both(commodity flow and vehicle-trip)	Freight origin–destination synthesis models; with and without empty trips, structured and unstructured approaches, and their variants

Freight trip generation data. This process is concerned with the estimation of the number of freight vehicle-trips that are needed to transport the freight generated. In essence, the freight trip generation is expression of the logistics used while the freight generation reflects the economics of production and consumption.

Delivery tours. This category refers to the information required to characterize delivery tours. It includes information about the sequence and location of the nodes visited by the delivery vehicles, and amount of cargo (or deliveries) picked up or delivered. In addition, data should be gathered about the commodity origin–destination (OD) flows along the tour and data about the empty vehicle trips—used for empty trip models.

Economic characteristics and spatial distribution/location of agents. Most modeling techniques require data to characterize the behavior of the agents involved. Important data include: business size, number of employees, number and type of trucks, frequency of deliveries, shipment size, inventory policies, hours of operations, sales, industry segment, spatial location and distribution of the businesses and of their respective suppliers and consumers, among others.

Network characteristics. All freight models will require a complete specification of network characteristics, which are required to model how the freight flows are going to use the transportation system. Traffic counts are also needed for calibration of the model, and in the case of origin–destination synthesis models, to estimate Origin–Destination (OD) matrices from secondary data.
Special choice processes. In addition, it is likely that a set of models aimed at studying specific processes are needed. Examples include: freight mode choice, decision concerning delivery times (which determines the response of the freight industry to congestion pricing), among others.
Other economic data. These types of data are intended to characterize specific aspects of freight demand not covered by the previous categories. These include production and demand functions of commodities in each region, which is information needed by spatial price equilibrium models, and technical coefficients of Input–Output (IO) models.

Table 2 shows a general classification of models that consider their mathematical structure, the flow unit being considered, and the modeling technique or principle that supports the model. As before, only the main types are considered for space reasons.

Table 3 presents the summary of the data requirements of the alternative modeling approaches, taking into consideration the data categories previously discussed. It is important to note that some modeling techniques are part of a modeling framework, where an input sometimes is the output of previous steps that in themselves could be one of the other modeling approaches.

3.1 Data Sources

After outlining the different modeling approaches and categorizing them based on data requirements, the authors identified the key data sources. In doing this, the authors used Holguín-Veras et al. (2001) as the starting point, because it contains a comprehensive assessment of the modeling alternatives available at the time. The authors analyzed the data sources available in the United States to assess their suitability to support a freight demand modeling exercise. The reader is referred to Holguín-Veras et al. (Holguín-Veras 2010) for the detailed analyses that led to Table 3.

The analysis revealed that there are major data gaps, shown in Table 4, that are not covered by the data available. The fundamental implication is that most of the data needed for the development of a freight demand model must be collected from scratch. However, since almost all freight demand modeling exercises entail one form or another of data or freight demand synthesis i.e., the estimation of data or freight demand from secondary sources, it is important to discuss the potential role of synthesis techniques. The reason is that synthesis serves the purpose of filling gaps in the data collected. Research has shown that, for instance, the

Table 3 Data needs for alternative modeling approaches

Data categories		Commodity generation models	Distribution models	Input–Output models	Freight mode choice	Empty trip models
Information/insight into logistical pattern of flows			C	C		
Freight generation data	Production	C		C, F		
	Consumption	C		C, F		
Delivery tours	Sequence					
	Location					
	OD flows		C, F	C, F		C, F
	Empty flows					C
Economic characteristics of participating agents	Shippers	C, F				
	Carriers	C, F				
	Receivers	C, F				
Spatial distribution/Location of participating agents	Shippers	C, F				
	Carriers	C, F				
	Receivers	C, F				
Network characteri stics	Travel times and costs		C, F	C, F		C, F
	Use restrictions		C, F	C, F		C, F
	Capacity		C, F	C, F		C, F
	Traffic volumes					
Special choice processes	Mode choice				C	
	Delivery time					
	Mode attributes				C, F	
Other economic data	Production functions					
	Demand functions					
	IO tech. coeffs.			C, F		

(continued)

Table 3 (continued)

Data categories		Spatial price equilibrium models	Trip generation model	Distribution models	Microsimulation models	Microsimulation hybrid	Spatial price equilibrium models	Freight origin destination models
Information/insight into logistical pattern of flows		C		C	C	C	C	
Freight generation data	Production		C		C, F	C	C	C, F
	Consumption		C		C, F	C	C	C, F
Delivery tours	Sequence				C, F	C	C, F	
	Location				C, F	C	C, F	
	OD flows			C, F	C, F	C, F	C, F	
	Empty flows							
Economic characteristics of participating agents	Shippers		C, F		C, F	C, F	C, F	
	Carriers		C, F		C, F	C, F	C, F	
	Receivers		C, F		C, F	C, F	C, F	
Spatial distribution/ Location of participating agents	Shippers				C, F	C, F	C, F	
	Carriers				C, F	C, F	C, F	
	Receivers				C, F	C, F	C, F	
Network characteristics	Travel times and costs			C, F	C, F	C, F	C, F	C, F
	Use restrictions			C, F	C, F	C, F	C, F	C, F
	Capacity			C, F	C, F	C, F	C, F	C, F
	Traffic volumes							C
Special choice processes	Mode choice							
	Delivery time							
	Mode attributes							
Other economic data	Production functions	C, F						
	Demand functions	C, F						
	IO tech. coeffs.							

Notes *OD* Origin–Destination *IO* Input–Output
C Calibration, *F* Forecast Blank Cells = Information not required for modeling approach

Table 4 Summary of key data gaps

Freight generation data	Production Consumption	No sources were identified[a, b]
Delivery tours	Sequence	Only Global Positioning System (GPS) data private vendors.
	Location	Low level of detail about location.
	OD flows	Some source but no complete information.
	Empty flows	No source identified.
Economic characteristics of participating agents	Shippers Carriers Receivers	Some source can provide some data.
Spatial distribution/ Location of participating agents	Shippers Carriers Receivers	Some source identified that can provide some data
Network characteristics	Travel time and costs Use restriction capacity Traffic volumes	Only a low level of detail is provided by the identified data sources
Special choice processes	Mode choice	Only the Commodity Flow Survey (CFS) provide some data [b]
	Delivery time	Low level of detail
	Mode attributes	Some level of detail
Other economic data	Production functions	No sources were identified
	Demand functions	No sources were identified
	Input–Output technical coefficients	Good level of detail from Regional Economic Information System(REIS) and 2002 Benchmark Input–Output Accounts of the USA

Notes[a] ITE Trip Generation Manual contain trip rates but no cargo attracted or produced information

[b] The Commodity Flow Survey microdata could provide this information. Access to the data is restricted

estimation of freight Origin–Destination (OD) matrices could be reasonably achieved using secondary sources such as traffic counts (Tamin and Willumsen 1988; Gedeon et al. 1993; Tavasszy et al. 1994; Nozick et al. 1996; List et al. 2002; Rios et al. 2002; Al-Battaineh and Kaysi 2005; Holguín-Veras and Patil 2007; Holguín-Veras and Patil 2008). In fact, the truck OD matrix in the New York City Metropolitan Planning Organization transportation planning model is the result of such process (List et al. 2002). As a result, there is a wide range of data collection possibilities that differ in the extent of the synthesis that is conducted. At one end of the spectrum, a modeler could undertake freight demand modeling with a minimal amount of data, which requires the use of a significant number of assumptions and demand synthesis techniques. In this context, synthesis techniques could indeed reduce data collection costs, though at the expense of weakening the behavioral considerations captured by the resulting demand model. This happens because most synthesis techniques require the use of simplifying behavioral assumptions. At the other end, a massive amount of data collection would cover all modeling needs and necessitates a minimal number of assumptions and almost no freight demand synthesis. This leads to a situation in which, the more resources spent in data collection, the lower the data error and the better the foundation for the modeling effort. However, data collection costs could become astronomical.

In between, there is a myriad of possibilities that represent different combinations of data error versus data collection costs, or freight demand synthesis versus actual data. Most freight demand models are found in between the end positions discussed above. The best approach is the one that best satisfies the needs and constraints of the user. For that reason, the planning organizations' staff should ponder what is the balance of data error and data cost that is most appropriate for them. The following section briefly discusses the different data collection procedures.

4 Review of Data Collection Procedures

In order to supplement the data sources currently available, it is necessary to collect data. This section describes the key findings from a comprehensive review of freight data collection approaches. As previously discussed, there are some issues involved in freight transportation that affect the efforts of conducting freight transportation surveys and the different means of collecting data. These issues are: (1) multiplicity of metrics to define/measure freight; (2) multiplicity of factors determine freight/freight trip generation, distribution and the other factors that determine demand; (3) multiplicity of economic agents involved; and (4) agents that only have a partial view of the freight system. All these aspects complicate tremendously the data collection process. Consequently, it seems clear that a comprehensive approach to collect freight data is the best, and to fully describe what happens in the system a combination of methods may be required.

In general, the different data collection techniques or surveys could be grouped depending on how the sampling frame is defined (i.e., on the basis of the establishments at the origin or the destination of the shipment, the truck traffic, cargo tour). This translates into collection procedures that focus on the origin or destination of the cargo, en-route as in a truck intercept survey, or along the supply chain following the shipment as it flows from shippers to receivers. Table 5 summarizes the different data collection methodologies depending on their sampling frame. For each case, the table discusses its application and the type and collection method generally used together with their strengths and limitations. An indication of the level of detail provided by each unit or sampling frame is shown in Table 6. As discussed before, no single sampling frame can provide a complete representation of all the data categories required for freight demand modeling.

Table 5 Summary of data collection methodologies

		Description	Application	Type/Collection methods	Strengths	Weakness
Establishment based	Shipper	Provides measures of total sales, market share, materials quantity/cost, modes, production hours, and location	Examples include: Commodity Flow Survey, and Annual Survey of Manufacturers	Self-administered or staff-assisted surveys to agents that ship out the cargoes	Ability to capture data about the characteristics of the cargo. May be complemented with shipment tracking	Questionable validity about routes, intermediaries, processing/transfer points, etc. data
	Receiver	Targets the receivers of the shipments	Freight/Freight Trip demand generation models	Self-administered or staff assisted surveys	Can provide excellent data about the goods received	Receivers are unaware of the cargo transportation aspects
	Carrier	Most widely used approach to collect freight data	Examples include: Freight Movement Survey and the Highway Carrier Attitude Survey	Based on Vehicle Registration samples. Provide vehicle detailed trip travel information. Mail-out or Computer Assisted Telephone Interviews (CATI) surveys	Target population relatively easily defined. Collects good travel patterns data. Vehicle list obtained from Department of Motor Vehicles	Questionable quality of cargo related data. Mismatch between vehicle registration lists and commercial vehicle population in urban areas

(continued)

Table 5 (continued)

	Description	Application	Type/Collection methods	Strengths	Weakness
Vehicle based	Individual vehicles as the sampling unit. Collect: origin, destination, trip mileage, travel time, routing, purpose, time of day, commodity, shipment size, truck type, land use, activity at trip end	Trip chaining, trip generation, and trip routing	Travel diaries. Collect travel diaries for a period of time from a sample of trucks operating in the region	Useful for understanding internal-internal truck trips in an urban area	Difficult sampling process. Using vehicle registration samples may produce biased results. Low response rates
			Assisted by Global Positioning System (GPS) to track the routing patterns inside he study area	Spatial/temporal movement data could be collected; real time data	Global Positioning Systems(GPS) cannot provide the data collected by traditional surveys
Tour based	Focus on data collection along the supply chain. Individual shipments are tracked long a supply chain	Use shipments as measurements units. Capture economic relations vital for transport policy	Longitudinal surveys: individual shipments are tracked long a supply chain	Provides a comprehensive description supply chains. Tracks each shipment from shipper to final receiver	Expensive, budget may condition their success or failure. Requires a very specific survey design
Trip intercept based	Focus on truck/vehicle trips. Collect: routing patterns, Origin–Destination(OD) locations, commodity/truck type, weights, shipper/receiver/carrier data	Freight modeling an planning applications	Roadside Interviews	Low costs. High response rates. Best statistical control and reliability. Capture trucks entering/existing and passing through the study area	Limited locations may lad to sampling bias. Potential traffic disruption. Cannot collect tours data. Not effective for internal-internal truck traffic data

(continued)

Table 5 (continued)

	Description	Application	Type/Collection methods	Strengths	Weakness
Cordon	Collect travel pattern data; origins/destinations at the perimeter of a region; routing patterns; truck/commodity type; vehicle/cargo weight; and, shipper/carrier/receiver information	Modeling/planning: the development of Origin–Destination(OD) freight flow matrices, commodity tonnage distribution to truck classes, empty and through truck factors	Roadside postcard survey distribution to be mailed back	Less likely to disrupt traffic than roadside interviews; requires fewer personnel.	Response rate is usually lower, which could result in significant non-response bias
			License plate recording/matching out to be returned	Does not disrupt traffic	Lag between observation and survey reception may lead to low repones rates (and bias) and high recollection errors

Sources: (Beagan et al. 2007, Jessup et al. 2004, Cambridge Systematics 1996, Miller et al. 1993, Rizet et al. 2003)

Table 6 Sampling frame of different data collection procedures

Level of detail: ■ Excellent; ◘ Good; ▣ Some; ⊡ Low; □ Only general

Unit/ Sampling Frame		Freight generation data		Delivery tours				Economic characteristics of participating agents			Spatial distribution / Location of participating agents			Network				Special choice processes		
		Production	Consumption	Sequence	Location	OD flows	Empty flows	Shippers	Carriers	Receivers	Shippers	Carriers	Receivers	Travel times, costs	Use restrictions	Capacity	Traffic volumes	Mode choice	Delivery time	Mode attributes
Establish-ment	Shipper	■				◘		■	▣	▣	■	▣	▣					□		⊡
	Carrier			■	■	■	■	⊡	■	⊡	◘	■	◘	▣	□				▣	▣
	Receiver		■			◘		▣	▣	■	▣	▣	■					▣		⊡
Trip intercepts		⊡	⊡	⊡	⊡	◘	▣	⊡	▣	⊡	⊡	▣	⊡	▣	⊡	⊡			⊡	⊡
Vehicle				■	■	■	■	⊡	■	⊡	◘	■	◘	▣	□				▣	
Tour				■	■	■	■	⊡	■	⊡	◘	■	◘	▣	□				▣	

Note: Blank cells indicate "No information provided."

Table 6 shows that the possible sampling frames do not provide data about freight traffic volumes, which are also needed, for instance, to assess the impact of freight volume on traffic congestion. Such traffic collection data is typically performed with Automatic Vehicle Classifier (AVC) or manual counting. Manual counting involves a trained observer collecting vehicle classification counts at a location based on direct observation of vehicles. Alternatively, this can be done using videography, which involves collecting vehicle classification counts using video tape recorders and tallying them manually by observing vehicles on the video with the ability to stop time and review data, if necessary (Beagan et al. 2007). On the other hand, AVC is usually based on techniques such as Weight-In-Motion (WIM), consisting of loop detectors, video cameras, or other types of detectors to automatically classify vehicles and collect freight volume (Sharma et al. 1998). The full installation of WIM, however, may be expensive and is only deployed at limited locations. The other AVC methods include: pneumatic tubes, loop detectors (or other types of magnetic detectors), and video cameras. Pneumatic tubes are easily portable and need just to be placed across travel lanes for automatic recording of vehicles. However, the classification accuracy degrades where there is simultaneous crossing of multiple vehicles, such as on high-volume, high-occupancy road segments. Loop detectors involve embedding one or more loops of wire in the pavement, which are very useful under all weather conditions, and are mainly used as permanent recorders at locations where counts are required for a longer time duration (Beagan et al. 2007).

4.1 Role of Global Positioning Systems (GPS) on Data Collection

In recent times, there has been a great deal of interest in the use of Global Positioning Systems (GPS) for freight demand modeling. Among other benefits, these data are: very accurate, increasingly common as the number of companies using GPS devices is increasing, and free as they are the byproduct of vehicle tracking and navigation systems. However, a fundamental limitation that has not been overcome is that GPS cannot collect key data that traditional surveys provide (e.g., commodity type, shipment size, trip purpose). For these reasons, GPS has had a limited role in freight demand modeling. There are a number of issues. First, there is no guarantee that the data are representative of the region under study, as in most cases, the data are biased toward medium and large firms. As a result, the data lack observations for the small companies that transport the bulk of the freight in urban areas. Second, although delivery tours can be estimated from the data, shipment sizes and the purpose of the stop are unknown. These are important implications that severely hamper the use of GPS for freight demand modeling.

As a result, the maximum utility of GPS is realized when it is combined with other data collection methods. For example, origin, destination and routing information received from GPS receivers can be used to validate and improve the information provided by truck drivers in manually completed travel diaries. Also, combining GPS truck trip information with Geographic Information System land use data can yield useful information on truck activity characteristics at trip ends (Beagan et al. 2007).

5 Identification of Data Collection Framework

This section discusses key components of a freight data collection framework, which are summarized in Table 7. The table shows the objectives for each data category, defines target population and data to be collected, the data collection approach suggested, as well as the output that would be produced with the data. The framework makes a distinction, in terms of the freight production and consumption patterns, between freight or non-freight related industry segments. Freight-related industries include: agriculture, forestry, and fisheries; mineral industries; construction industries; manufacturing; transportation, communication, and utilities; wholesale trade; retail trade; and, food. In essence, these industries are

Table 7 Data collection framework

Data	Objective	Target population	Data to be collected	Data collection approach	Output
Freight generation data	Support the development of models to express freight production and consumption as a function of economic characteristics	Primary: Businesses in freight related sectors. Secondary: Businesses in non-freight related sectors that may need o produce freight in a sporadic fashion	Comapany attributes; frequency of deliveries; amount of cargo received; commodities most frequently received/shipped; time of deliveries, among others[a]	Computer aided telephone interviews (CATI)	A dataset with estimates of number of deliveries, amount of cargo (tons), by commodity type, and company attributes
Delivery tour data	Development of econometric models of describe the geographic patterns of commodity flows, vehicle-trips, sequences of stops ana	Private and common carriers in the study area.	Company characteristics; tonnage; commodity types; vehicl-trips; tours and delivery sequence; amounts delivered and picked up; and time of travel[a]	Travel diaries complemented with Global Positioning System (GPS) data loggers	Dataset containing an expanded sample of tonnage transported, tours, vehicle trips, that could be used to produce origin–destination matrices
Cordon survey	Obtain travel patterns of internal-external, external-internal, and external-external trips	Freight traffic entering the study area within the sampling period	The same characteristics of the internal survey for the external trips	Roadside interviews or postcard surveys to be mailed back or answered through the internet handed out at toll booths	Dataset containing a sample of tonnage transported, tours, and vehicle trips, used to produce origin–destination matrices

(continued)

Table 7 (continued)

Data	Objective	Target population	Data to be collected	Data collection approach	Output
Agent spatial distribution	Describe the geographic patterns of location of the various agents involved in the freight system	Primary: Businesses in freight related sectors. Secondary: Businesses in non-freight related sectors that may need or produce freight in a sporadic fashion	Company attributes (e.g., number of employees, sales, industry sector, line of business)	Direct purchase of a sample from data aggregators	Dataset containing georeferenced locations of establishments involved in freight activity, together with company descriptors
Large traffic generators	Describe the freight production-consumption patterns, and the corresponding generation of freight trips at LTGs	Primary: Businesses in freight related sectors.Secondary: Businesses in non-freight related sectors that may need or produce freight in a sporadic fashion	Company attributes; frequency of deliveries; amount of cargo received; commodities most frequently received / shipped; time of deliveries; among others[a]	Large Establishments: interviews based on random sampling of potential participants. Large Buildings: Manual counts and interviews at the receiving stations	Dataset with estimates of number of deliveries, number of truck-trips produced, amount of cargo (tons), by commodity type, and company attributes
Special purpose models	Collect data to estimate behavioral models and to support the study of specific policy questions	Depends on the specific choice process to be modeled	Data required include company characteristics and stated preference (SP) and revealed preference (RP)	Computer aided telephone interviews (CATI) based on random sampling of potential participants	Dataset containing company characteristics and the Stated/Revealed Preference data needed for behavioral modeling

Note Some of the data could be purchased from data aggregators (e.g., Dun and Bradstreet, InfoUSA), but may not be as accurate as advertised

Table 8 Sampling alternatives

Data	Alternatives						
Freight generation data	Case 0: NDC. Use generation rates	Case 1: 5 surveys per county for each freight; 10 total for non-freight industries	Case 2: 10 surveys per county for each freight; 25 total for non-freight industries	Case 3: 25 surveys for each freight; 5 for each non-freight industries per county			
	A: Small investment	A: Support industry pooled models only	A: Support industry pooled models with county parameters	A: Support models by inidustry classification and county, pooled if desired			
	L: No connection to local conditions	L: No ability to consider county specific models	L: No ability to have county specific models by industry	L: None			
Delivery tour data	Case 0: NDC. Origin-Destination Synthesis	Case 1: Purchase sample from GPS data aggregators	Case 2: 1% of commercial vehicle registrations	Case 3: 2% of commercial vehicle registrations	Case 4: 3% of commercial vehicle registrations		
	A: Small investment	A: Lowest cost	A: Data appropriate for modeling. Low cost	A: Data with less gaps. Appropriate for modeling	A: Modeling needs likely met. Meets OD survey standards.		
	L: Weak/No trip determinant data	L: Potentially large bias in data. No trip determinant data	L: Some data gaps may be evident	L: Small industry segments may not be covered	L: None		
Cordon Survey	Case 7: NDC	Case 1: 1 day of data collection	Case 2: 2 days of data collection	Case 1: 3 days of data collection			
	A: No investment required	A: Relatively low cost	A: Data appropriate for modeling. Low cost	A: Modeling needs likely met. Meets OD survey standards. Available backup data			
	L: No I-E, E-I, E-E trips data	L: No backup data. No way to verify data soundness	L: In case of problems the amount of backup data is minimal	L: None			
Agent spatial distribution	Case 0: NDC	Case 1: ZIP code Business Patterns Data	Case 2: 30% of records	Case 3: 40% of records			
	A: No investment	A: Low Cost. Contains summaries of all observations	A: Accurate geolocation. Could be expanded to control totals	A: Accurate geolocation. Could be expanded to control totals			
	L: No data to do these analyses	L: Data at Zip code level. Unable to geolocate precisely	L: Data by aggregators may have errors	L: Data by aggregators may have errors			
Large traffic generators	Case 0: NDC	Case 1: 25% of large establishments	Case 2: 25% of large buildings	Case 3: 50% of large establishments	Case 4: 50% of large buildings	Case 5: Cases 1 and 2	Case 6: Cases 3 and 4
	A: No investment	A: Lower cost	A: Lower cost	A: Low cost	A: Low cost	A: Higher coverage	A: Needs likely met
	L: No data about LTGs	L: Gap in coverage. No data for large buildings	L: Gap in coverage. No data for large establishments	L: Some gaps in coverage. No data for large buildings	L: Some gaps in coverage. No data for large establishments	L: Some groups still not covered	L: None
Special purpose	Case 0: NDC	Case 1: 200 observations per choice	Case 2: 300 observations per choice	Case 3: 400 observations per choice			
	A: No investment	A: Data appropriate for modeling	A: Data appropriate for modeling	A: Data will satisfy most modeling needs			
	L: No data to do these analyses	L: Require careful design. Data validation not possible	L: Small data validation set	L: None			

Note [a] Some of the data could be purchased from data aggregators (e.g., Dun and Bradstreet, InfoUSA), but may not be as accurate as advertised

Note NDC No data collection, *A* Advantages, *L* Limitations, *I–E* Internal-External, *E–I* External-Internal, *E–E* External-External, *OD* Origin–Destination *GPS* Global Positioning System

expected to generate and attract the largest proportion of freight trips and cargo; thus, they should receive special attention during data collection. Non-freight related sectors are: finance, insurance and real estate; service industries; and, public administration. These sectors require or produce some supplies and services for their operations, which in turn generate freight vehicle trips. For a complete description and modeling of the freight system they should also be studied.

In addition, it is useful to design a modular strategy for the selection of the sample size for each data category. Estimates of the sample size are based on the analyses performed by the authors for the New York City metropolitan region. The cases shown in Table 8 result in a combinatorial number of potential data collection alternatives and are suggested as examples for implementation in other large urban areas. These alternatives would differ in the extent to which additional data are collected and that freight demand modeling is used to synthesize the missing elements. As typical of these situations, the most appropriate alternative would depend on the objectives the freight demand model is intended to fulfill, and the technical and financial constraints at the participating agencies.

An advantage of having such a modular set of alternatives is that they could be put together as part of a staggered investment in research, model development, and data collection. This, in turn, makes it easier for the agencies to deal with financial and technical constraints. For example, an initial investment on model development and data collection could be subsequently improved and enhanced as additional data collection and model development phases are completed. In this context, the subsequent stages of research and development would progressively address weaknesses and limitations of the initial work.

The base alternative is simply not to collect data (Case 0 for each category). In this case, analyses would be limited to the use of generation rates from the literature, and delivery tour data would heavily rely on OD synthesis, thus limiting the scope and applications of the resulting models. This approach could be improved by collecting additional data. With a limited budget, selecting Cases 1 for freight generation, delivery tour and agent spatial distribution data categories; although allowing the estimation of freight demand models for certain industry sectors, would not provide county specific models. In terms of tour data, the use of a sample from GPS aggregators could lead to potential bias in the data and the inability to understand the factors that determine the trip or the trip purpose. In addition, with the ZIP Code Business Pattern data it would not be possible to precisely geo-locate the agents, thus limiting the ability to complement the data with other commercially available economic/land use datasets.

The data collection effort could be progressively improved by selecting larger sample sizes (Cases 2–6). In summary, increasing the number of surveys for freight generation data would allow the estimation of disaggregate freight trip generation models for different industry segments and the ability to capture differences among areas. A larger delivery tour data collection effort would meet modeling needs and include all industry segments. Collecting cordon surveys provides internal-external, external-internal and external-external trip data that would complement the delivery tour collection effort granting access to a set of data for backup and validation purposes. Acquiring a larger sample of records from data aggregators allows accurate geo-location. Considering the freight/freight trip generation characteristics of large traffic generators (large establishments or building that generate a disproportionate number of freight trips or tonnage) would provide a more complete picture of freight demand in large urban areas, given that they—although small in quantity—can account for a large proportion of urban freight movements. For special purpose/choice analyses, any of the three cases proposed could be selected, bearing in mind that fewer observations would come at the expense of not having enough data for validation purposes. It is also important to stress that the alternatives have vastly different implications in terms of quality of the modeling effort that they could support. While not collecting any freight data would definitely minimize collection costs, it would lead to large (and of unknown magnitude) errors during the modeling process. On the other hand, conducting an extremely comprehensive data collection effort may not necessarily improve the quality of the modeling process because of the models inherent limitation to replicate the system under study.

6 Conclusions

This chapter discusses the key characteristics of the freight system and the data requirements of the different modeling techniques to design a comprehensive freight data collection framework for mid-size and large urban areas. In doing so, a number of findings of great importance are produced. First, the freight system is comprised of a set of interacting economic agents along the supply chain that produce, process, transport, distribute, or consume goods. As a result of their different roles, no single agent can provide a complete picture of the freight system. This complicates data collection, as assembling a description of the system requires collecting and putting together the information that each agent is aware of. Adding to the complexity is the fact that there are different ways to measure freight and its generation, including: value of the cargo, amount transported, vehicle trips produced, number of stops and deliveries made and received.

Second, data collection efforts must also take into consideration the data requirements of the different freight demand modeling techniques. Characteristics in terms of: the fundamental structure and empirical foundation of the model, the computational algorithms and data structures that perform the computations, and the process to analyze the modeling results. In addition, there are requirements for model development, model calibration and forecasting.

Third, an analysis of the different data sources showed that there are major data gaps. As a result, the data needed for the development of freight demand models must be collected practically from scratch. However, some data could be estimated from secondary sources, using data or synthesis. Data synthesis has been successfully used to estimate freight OD matrices using secondary sources such as traffic counts (Tamin and Willumsen 1988; Gedeon et al. 1993; Tavasszy et al. 1994; Nozick et al. 1996; List et al. 2002; Rios et al. 2002; Al-Battaineh and Kaysi 2005; Holguín-Veras and Patil 2007; Holguín-Veras and Patil 2008).

Fourth, the complexity of the freight system and the modeling data requirements determine the collection technique and data collection approach to be used. Considering that no single data collection approach can provide a good representation of all data categories, it seems clear that a comprehensive approach composed of a combination of methods may be required.

In order to fulfill the objective of the chapter, a modular set of data collection approaches is proposed. The alternatives range from no data collection and use of data synthesis, to extensive data collection efforts. Obviously, while no collecting data minimizes costs; this is at the expense of the modeling effort's quality. In essence, each alternative has advantages and disadvantages, and as typical of situations like this, the best approach would be the combination of alternatives that best fits the needs and constraints of the participating agencies.

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Estimated Data Production for Urban Goods Transport Diagnosis

The Freturb Methodology

Jesus Gonzalez-Feliu, Florence Toilier, Christian Ambrosini and Jean-Louis Routhier

Abstract Nowadays, it is crucial to obtain sound data for establishing diagnoses of urban goods movements (UGM). Since surveys are usually difficult to implement and become very expensive when large amounts of detailed data are required, they are not systematically carried out in various cities around the world. Moreover, unlike individual mobility, public authorities generally do not supervise urban goods transport as they depend essentially on the private sector. The research proposed here focuses on a framework for simulating data production using standard inputs that can be obtained by public authorities (and private stakeholders), in order to estimate the impacts of urban goods transport in the light of current practices, i.e. to make a diagnosis of urban logistics in current configurations. The joint process of collecting data and modelling is described after which the different modules and applications are presented.

Keywords Diagnosis · Shopping trips · Town management · Urban deliveries · Urban goods modelling

1 Introduction

For the last two decades, congestion, lack of space and environmental impacts have led to increasing concern given to the supply processes of urban areas (Routhier 2013). Moreover, both public authorities and private stakeholders are paying ever

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greater attention to the negative impacts of motorized traffic (pollution, noise and greenhouse gas emissions). In the current context, better knowledge of urban goods transport organization has become essential (Patier and Routhier 2009a). The impacts of urban goods movements (UGM) on the environment are not always well-explained and decision-making tools fail are inadequate due to the lack of pertinent information. This lack of information is due to the difficulty of collecting and producing the data needed to support public and private decisions, both in quantity and quality. According to Gonzalez-Feliu et al. (2013), two main categories of tools can be used to obtain UGM data for diagnosis and planning. The first is that of urban goods surveys (Ambrosini and Routhier 2004), which are presented in Chaps. "Data Collection for Understanding Urban Goods Movement: Comparison of Collection Methods and Approaches in European Countries" and "Comprehensive Freight Demand Data Collection Framework for Large Urban Areas "of the present book[1] but which suffer from a major drawback: the cost of obtaining sufficient and accurate data. The second is that of data estimation tools, which are currently rather scarce. The following examples can be cited: Wiver (Sonntag 1985), now part of VISUM-VISEVA (Lohse 2004), Nätra (Eriksson 1997), whose use has decreased in recent years, Freturb (Aubert and Routhier 1999), and City Goods, the latter being non-commercial software only available to public authorities and research institutes (Gentile and Vigo 2006).

In this chapter we present the methodology of the Freturb decision support system, i.e. the urban goods surveys initiated by the French Ministry of Transport and the Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME), and the proxy data simulation tool derived from their results. First, we present the main definitions and the methodological aspects of the Freturb model, introducing the main modules of the decision support system. Then, the four main components are presented (one for each category of urban goods movement and another for estimating environmental impacts). Finally, the strengths and limits of the modelling approach as well as a set of further improvements are proposed.

2 Context, Definitions and Motivation

Urban goods modelling is a very popular research subject (Ogden 1992; Ambrosini et al. 2008; Anand et al. 2012; Comi et al. 2012; Gonzalez-Feliu and Routhier 2012; Taniguchi et al. 2012; Holguin-Veras et al. 2013). However, and contrary to personal trip modelling, no standard exists and most models are limited to academic use, without direct application to operational tools (Gonzalez-Feliu et al. 2010a, b). Therefore, we observe that researchers and practitioners have considerable difficulties in proposing a single vision and predominant theoretical frameworks applied to specific calibration-based datasets, without real perspectives for application.

[1] Allen et al. (2013) and Holguin-Veras and Jaller (2013).

However, we find a small number of approaches that have given rise to operational tools used by public authorities and private stakeholders, mainly for diagnoses related to strategic planning.

At the end of the 1980s, the Senate of Berlin proposed a tool to West Germany's public authorities for including commercial transport flows in traffic studies. The result was the WIVER model (Meimbresse and Sonntag 2001) which was first presented at Sonntag (1985). It is based on several in-depth surveys carried out at nearly 9,000 premises (Munich, Berlin, Hamburg) and specific surveys of drivers regarding their traffic behaviour. This software tool has been used in more than 15 German cities for transport planning studies, as well in Rome and the Lazio region (Italy), Madrid and its hinterland (Spain) and the Brussels metropolitan region (Belgium). WIVER, initially integrated in the software program VISEVA to estimate both passenger and goods movements in urban areas, has been included recently in the VISUM modelling framework,[2] a commercial tool from PTV traffic, and one of the best-known transport demand models. However, nothing is known about the current uses of the commercial transport module of VISUM. Also in Germany, the company IVV Aachen developed a specific module to include goods transport in its urban transport planning software, VENUS (Janssen and Vollmer 2005). This model has a classical four-step framework (Ogden 1992) to estimate goods transport flows by vehicle type and trip purpose (Ambrosini et al. 2008). The software is currently available, but the acceptance and main use of the goods module is unknown (Gonzalez-Feliu et al. 2012a).

In Italy, the Emilia-Romagna Region developed the specific urban goods estimation model, CITY GOODS (Gentile and Vigo 2006), as part of the City Ports project of the INTERREG program (Rosini 2005). The model deals with two main questions: the search for the generation determinants (related to the movements and not to the quantity of freight) of the different supply chains, and constructing vehicle routes for urban deliveries and pickups (changing from movement to commodity). Although a hybrid model combining commodity and movement as modelling units (Comi et al. 2012) has been proposed by Slavin (1976), CITY GOODS is the first operational model of this category. The main scientific contribution of this model is the typology of economic activities to estimate generation determinants and their importance at urban level (Gentile and Vigo 2013). Several Italian cities have used CITY GOODS for their urban plans, mainly in Emilia Romagna, where the tool has been adopted by transport planning departments of the main cities.

Mention should also be made of the Nätra software in Sweden (Eriksson 1997) and the CROW framework in Norway. Such frameworks were applied in the late 90s in their respective countries. Moreover, some experimental works that have not yet been considered operable tools have been applied to real contexts and used for real planning issues (Wisetjindawat and Sano 2003; Hunt and Stefan 2007;

[2] This statement was made by a PTV engineer at the First Commercial/Goods Transport Conference in Berlin at the beginning of 2012.

Holguín-Veras and Patil 2008; Muñuzuri et al. 2010, 2011a, b). Whatever the case, these works have generally met with criticism since they failed to satisfy stakeholders' needs (Nuzzolo et al. 2011).

Last but not least, in France a specific tool for urban goods diagnosis was developed under the French National Urban Goods Movement Program (Dufour 2001): the FRETURB model. This framework is the first to consider the goods movement (i.e. the pickup and/or delivery operation) as a statistical unit (Aubert and Routhier 1999) and takes a wider view of what an urban goods movement is, as it includes shopping trips, already taken into account by Russo and Comi (2006, 2010), Crocco et al. (2010) and Gonzalez-Feliu et al. (2010a, b) but only at a theoretical level, without becoming into an operational tool). Available as a software application since 2000, FRETURB is now used in more than 20 French urban communities (including most large French cities like Paris, Lyon and Lille, among others), as well as in the cities of Geneva and Zurich (Switzerland). This chapter introduces the main elements that motivated the development of FRETURB and its different modules, the data collected to build them and the main methodological and mathematical issues underlying the FRETURB model.

This chapter aims to synthesise the general methodology of the FRETURB model, since several modules have already been introduced in previous works.[3] The main contributions of the present work are to outline the general framework of FRETURB, describe its construction methodology (not necessarily the mathematical framework), i.e. the way observed reality is converted into a model (or a representation), and introduce certain missing elements: the distance generation (for the simulation of both inter-establishment and end-consumer movement) and the simulation procedure for urban management movements.

2.1 What does Urban Goods Movement Encompass?

Urban goods movement is a term used by several researchers and practitioners. Although popular, the definition is far from being used in the same way and with the same meaning by the community of urban logistics academics and researchers. It is therefore important here to define what we mean by urban goods movement. The definition adopted is the widest one (Ségalou et al. 2004), which includes all the existing flows of goods and management flows of an urban zone, from factories to wholesalers, from wholesalers to retail distribution, and from shops to households. This also includes urban management flows like waste collection and construction logistics. In this sense, it includes not only a large share of commercial transport, but also a share of individual transport. According to

[3] Concerning inter-establishment movements: Aubert and Routhier (1999); Routhier and Toilier (2007); Bonnafous et al. (2013). For end-consumers' movements: Ségalou (1999); Routhier et al. (2001); Gonzalez-Feliu et al. (2010a, b, 2012a, b). The environmental module has been presented in Ségalou et al. (2004) and Toilier et al. (2005).

Routhier et al. (2001), it is possible to describe the components of urban goods movement, as follows[4]:

- Pickup and delivery flows by vehicles used for inter-establishment trade (commercial, industrial, services) and goods vehicles for business trips (artisans carrying goods from depot to work site, etc.). These flows, known as inter-establishment movement trips (IEM), represent between 35 and 40 % of total goods traffic in terms of road occupancy rates.[5]
- End-consumer movement flows (ECM), including shopping trips made by private car, home deliveries and other proximity tele-shopping services, which represent between 50 and 55 % of total goods traffic.
- Flows related to urban management movements (UMM), mainly related to waste collection, postal services, removals, hospital and public and construction works. These represent between 10 and 15 % of total goods traffic.

Concerning data collection, individual trips for purchase are more or less well captured in Mobility surveys, although they are collected for personal trips, so some information concerning purchased goods is not always notified (Gonzalez-Feliu et al. 2010a). Urban management is the most difficult UGM category to define quantitatively, due to the variety of flows in this category. Concerning inter-establishment movements, it is possible to comprehend this part of traffic through specific data collections such as the vehicle fleet involved in each activity (Ségalou et al. 2006, pp. 27–33). However, the flows generated by pick-ups and deliveries are currently not well known and are often considered as difficult to estimate.

2.2 What Data are Needed to Respond to the New Issues?

According to Patier and Routhier (2009b), three main issues related to urban goods movement can be identified:

- The economic dynamics of urban activities is weakened by risks of congestion in an increasingly restricted space.
- Logistics flows are increasingly driven by consumer demand, following just in time logic, but not by the productive system.
- The consideration of environmental requirements has become a major issue at every level of the transport activity, including urban links, at both local (noise, and pollution) and global (greenhouse gas) levels.

To take urban goods transport into account in the light of these stakes, the data collected have to satisfy the three following requirements:

[4] All ratios are extracted from Routhier et al. (2001).

[5] Road occupancy rates are in general estimated in Private Car Units (PCU): 1 private car = 1 PCU; 1 light goods vehicle = 1.5 PCU; 1 medium truck = 2 PCU; 1 heavy truck = 2.5 PCU.

- knowledge of the locations of the various economic activities in the city;
- knowledge of the management and organization of the transportation of goods which serve these activities;
- knowledge of the characteristics of the various modes and the various vehicles used.

2.3 Which Methods for which Objectives?

In order to answer the stakes described above, three main kinds of objectives have to be assigned:

- To understand how and by whom goods flows are generated: what is the importance of the different urban activities in the generation of pick-ups and deliveries?
- To obtain a thorough description of all the urban logistics involved: how many pick-ups and deliveries are carried out in the city and its surroundings? Who is ensuring the transport? How many kilometres are generated by these activities, which vehicles are used, who is running these vehicles, what goods and packaging are most often used, how many empty trips are made, how are they organized (direct trips, rounds of different sizes, according to the packaging and the weight of the shipments, etc.)?
- To help authorities in their decision-making: build decision aid models in order to answer how much traffic will be generated by new activities in the city. How can the indicators for urban goods transport be assessed in order to compare different territories and different policy measures? How can the impacts of different scenarios for the future be compared?

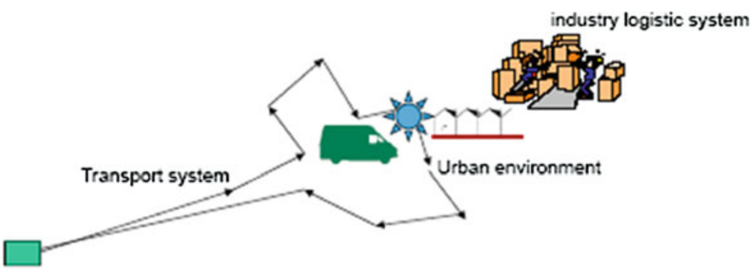
3 Methodological Aspects

To meet the stakes and objectives set out above, the French National Program on Urban Goods Movement ordered a set of quantitative surveys performed in three different cities. The aim of these surveys was twofold: on the one hand, they would lead to understanding of the behavioural and organizational aspects of urban pickups and deliveries; on the other hand, they would fuel a tool that would be used to make diagnoses of urban logistics without the need for collecting large amounts of data, thereby reducing costs. Therefore the survey methodology and the model architecture were strongly related and developed in parallel. In this section we define the methodology of both the survey and the diagnosis tool.

3.1 Observation and Modelling Unit

The question is how is it possible to build a database capable of solving the problem of the road occupancy. Current surveys such as the French “Transport routier de marchandises” (TRM) surveys describe the use of a stratified set of vehicles throughout the country. However, since no organization is described, it does not address the city or make it possible to answer the question of road occupancy (Which vehicles? Which activities? Which organization? How many kilometres?). Another unit usually taken into account is the commodity. It is generally used in optimization models for transport companies but it does not allow capturing the urban specificity of the organization deployed at urban scale (Gonzalez-Feliu and Routhier 2012). It was therefore necessary to build specific surveys, in order to answer the main stakes above, as was done for the description of individual mobility.

The statistical unit observed in individual mobility surveys is the trip associated with a reason for going to a destination. In a sample of households, the description of the set of trips made by each individual of a household in a day makes it possible to build the total number of trips in a city. What is the relevant observation unit for urban goods movement surveys? The deliveries and pick-up operations carried out by one vehicle was chosen (Bonnafous 2001). If all the operations (deliveries and pick-ups) in a week for a stratified sample of establishments (the premises belonging to each firm) are characterized accurately, it is possible to evaluate, by extension, the total deliveries and pick-ups carried out in the city. Furthermore, as for each operation, it is possible to observe the organization of the transport (by orienting the survey to the drivers) (Fig. 1).



: at this place it is possible to observe the formation of vehicle flows and their impact on the urban environment according to:

- the transport system,
- the logistics strategy of the company,
- the environment of the establishment.

Fig. 1 A statistical unit for solving the issue

3.2 Model Architecture

In order to produce proxy data with standard information (for example, national or regional census files and business registries), a diagnosis tool was developed in parallel to the surveys. The tool proposed was defined as a modular model. Moreover, when possible, the data collection procedure and the modelling framework were designed jointly in order to maximize the synergies between data collection (inputs) and data production (outputs). The following chart proposes the general organisation of the framework. This is an original approach that combines all the flows related to establishment supply (not only retailing activities but all the establishments of an urban area), motorized shopping trips and the other B2C flows, and urban management trips. This approach appears more relevant for estimating the impacts of urban goods transport on road occupancy appropriately. Consequently, the result is a significant improvement on existing aids for public decision-makers regarding urban logistics.

The model is organized in a modular structure, as shown in Fig. 2. Starting from standard data (like National Statistics files, census databases and Chamber of Commerce registries), each module produces results that can be used to feed the other modules. Consequently, it is possible to estimate the overall impacts of urban goods transport in an urban area on the basis of only the characteristics of establishments and those of the urban fabric. This is only possible if the modelling and simulation unit is the same for each module. If we try to focus on the management of the urban space to limit congestion and reduce nuisances, the main question on the transportation of goods in cities is the occupancy of the road network by delivery vehicles, which compete with the other vehicles (cars, public transport, soft transport tracks, and pedestrian precincts). The occupancy of the road network must be considered according to two components which are vehicles moving and parking for delivery, which explain congestion and conditions of accessibility.

4 IEM Estimation

The IEM estimation model was presented in Aubert and Routhier (1999) and Routhier and Toilier (2007). However, these papers only presented the mathematical framework, without laying stress on the data collection procedure. In this section we focus on this point.

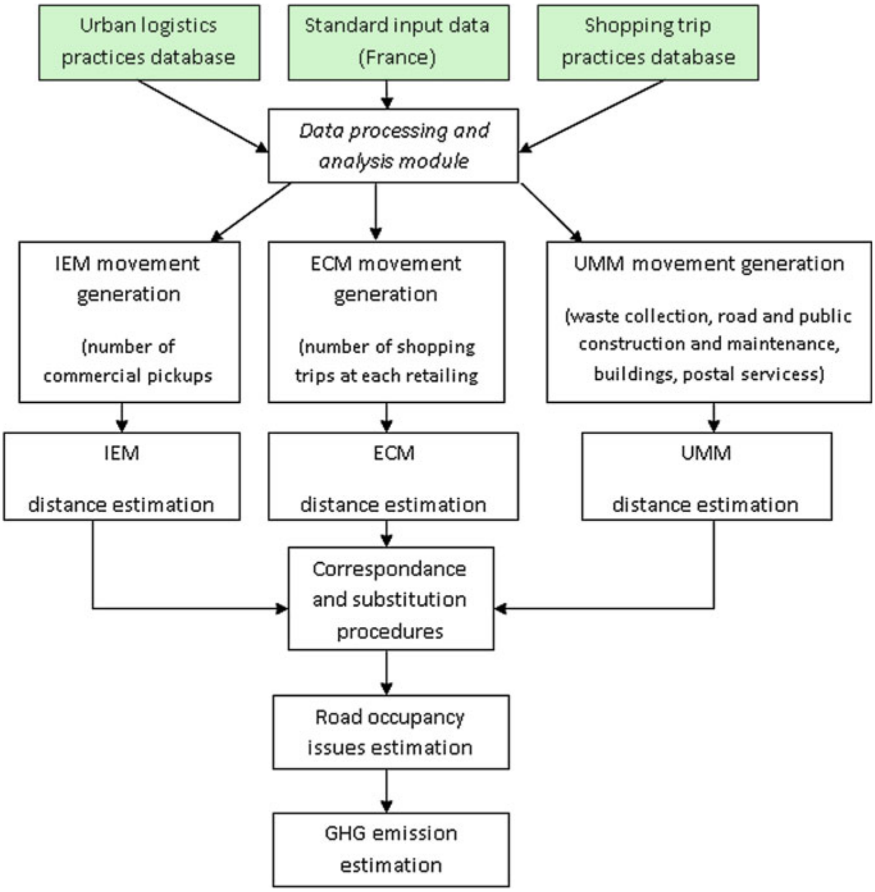


Fig. 2 Chart of the proposed framework

4.1 Data Collection Procedure

The development of the data collection procedure began in 1994 as part of the French National Program on Urban Goods Movement (Dufour and Patier, 1999). Three surveys were carried out and their results were fed into the Freturb model. The first survey was carried out in Bordeaux (1994–1995) and the two following ones in Marseille and Dijon (1996–1997) (Ambrosini et al. 1996, 1999a, b). Today, another is in progress in the Paris-Ile-de-France Region (2011–2012) and two other surveys are scheduled in Bordeaux (data collection starting January 2013) and Marseille (data collection scheduled to start in 2014).

As shown above, the most suitable statistical observation unit is the delivery or pick-up (or both) of goods by a single vehicle in one establishment. It has been designated as the "movement" in this context. Simultaneously with the implementation of the survey, it was important to think jointly on the capability of collecting pertinent data and how they could be used to model the impacts of UGM. Separate reflection would lead to incompatibilities or large gaps in data, and consequently to a less representative model due to a higher object reduction (Bonnafous 2001).

In order to capture the pertinent data, three surveys were carried out (Fig. 3):

- An "establishment survey" through a stratified sample (according to the activity and the number of jobs in each establishment). Each establishment describes all its delivery and pick-up operations during a week. As the questionnaire is rather long and hard to fill in, the best solution is face to face administration in two visits: during the first visit, information about the description of the establishment, its environment and the approximate number of trips made by drivers in a standard week is gathered and a log book is left for a week, in order to collect the description of all the deliveries and pick-ups. During the second visit, the log-book is controlled and collected by the pollster.
- A "driver survey", with the participation of the drivers who deliver or pick-up the goods in the establishment. A brief questionnaire is supplied by the establishment for the survey week. It is returned by mail. In addition, in order to obtain a more thorough description of the rounds, this survey is then supplemented by an "embedded survey", in which the pollster is taken on board the truck in which a GPS is installed.
- A third survey of the main transport companies ("haulier survey") operating in the city permits describing the main breakups of loads from the principal supply chains and to describe the main transfers of flows with the city's outskirts

An exhaustive registry of the establishments is regularly updated by the French Statistics Institute (SIRENE-INSEE). It contains the name, address, activity

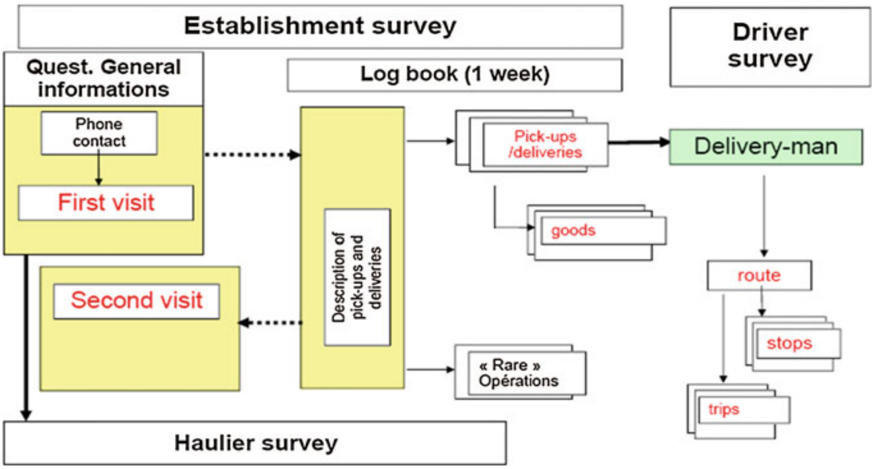


Fig. 3 The three linked French UGM surveys (Routhier 2013)

NACE[6] code and several relevant indicators such as the class of salaried staff, the number of establishments (premises) of the company, the status (headquarters or subsidiary premises) and the nature of the premises (sales area, warehouse, etc.). According to this information, the following stratification of 45 classes was obtained (Table 1):

The establishment survey had to cover a large number of establishments in order to obtain desirable results on the generation of movements (pick-ups or deliveries) in each stratum. In each urban area, and in order to take into account the whole activity, it was necessary to pick a sample of 1,500 establishments out of a total number of establishments (e.g. 40,466 in Bordeaux). Public services (school local authorities, post offices, hospitals, etc.) were covered by separate studies and were not included in the establishment survey. For each establishment, a general face to face interview was conducted in Bordeaux and by using Computer Assisted Telephone Interview (CATI) or "phone-paper" methods in Marseille and Dijon. A logbook was filled-in by the pollster during the week. A data sheet was filled in for each delivery and pick-up. Each sheet described the different movements made by the same carrier in a week, including the type of goods, the packaging, the weight of the payload, the outline of the vehicle and the origin–destination of the shipment. Each establishment provided five datasheets on average. In Marseilles and Dijon, 1,300 detailed questionnaires addressing the deliverymen were filled in (embedded surveys and at the end of the course surveys) in order to give a thorough information on the configuration of the course (number of stops, route, description of the payload at each delivery-point, time to deliver at each delivery place, distance and time).

In Bordeaux, the 1,500 establishments filled in a total of 6,600 operation data sheets, 6,000 driver questionnaires were distributed and 900 questionnaires were returned by the delivery-men (17 % of the total distributed).

Finally, the total database for the three urban areas accounts for 4,500 establishment questionnaires, 14,000 datasheets and 2,200 driver questionnaires.

The expansion of the sample results allows extrapolating the data observed to the whole urban area. This consists in weighting each entity measured. The weighting of the sample data was calculated as follows (Patier and Routhier 2009a):

Weighting of the establishments

The weight w_s is specific to each strata s. It is determined by the ratio r_s (number of establishments of the same strata in the sample)/(number of establishments of the strata in the conurbation):

$$W_s = 1/r_s$$

Weighting of the movements

In the dairy log, some movements were forgotten or wrong. It was necessary to amend each weight at establishment level in order to permit extending the results

[6] NACE: Statistical list of economic activities in the European Community.

Table 1 Categorization of urban activities (45-categories classification)

ST45 Codes	Nomenclature of the activity stratum	Group of activity
1	Agriculture	Agriculture
2–2	Craftsmen (repair)	Craftsmen
2–3	Craftsmen (manufacturing or installation)	Craftsmen
2–4	Craftsmen (light repair)	Craftsmen
26Ha	Other tertiary sector (Tertiary services: high flows)	Craftsmen
26Mi	Other tertiary sector (Tertiary services: mixed flows)	Craftsmen
26Mo	Other tertiary sector (Tertiary services: average flows)	Craftsmen
3	Chemical industry	Industry
34–2	Construction industry (repairs)	Industry
34–3	Construction industry (manufacturing or installation)	Industry
4–2	Industry (manufactured and intermediate goods—basic bulk)	Industry
4–6	Industry (manufactured and intermediate goods—small objects)	Industry
4–7	Industry (manufactured and intermediate goods—bulk)	Industry
5–2	Consumer goods industry (fragile foodstuffs)	Industry
5–4	Non-consumer goods industry (fragile foodstuffs)	Industry
5–5	Industry (non fragile consumer goods, household and personal equipment)	Industry
7–2	Wholesale (fragile intermediate products)	Wholesale
7–3	Wholesale (other intermediate products)	Wholesale
8–2	Wholesale (non food fragile consumer goods)	Wholesale
8–3	Wholesale (non food non fragile consumer goods)	Wholesale
9–2	Wholesale (fragile food consumer goods)	Wholesale
9–3	Wholesale (other food consumer goods)	Wholesale
10	Hypermarkets and big department stores	Department stores
11	Supermarkets	Department stores
12	Specialized department stores	Department stores
13	Minimarkets	Small retail stores
14	Retail trades, clothing, shoes, leather	Small retail stores
15	Butchers' shops	Small retail stores
16	Groceries	Small retail stores
17	Bakeries—Cake shops	Small retail stores
18	Cafés, hotels, restaurants	Small retail stores
19	Pharmacies	Small retail stores

(continued)

Table 1 (continued)

ST45 Codes	Nomenclature of the activity stratum	Group of activity
20	Hardware stores	Small retail stores
21	Furnishing shops	Small retail stores
22	Bookshops	Small retail stores
23	Other retail shops	Small retail stores
29	Street trading (outdoor trading centres)	Small retail stores
25	Pure tertiary sector (offices)	Tertiary
26Fa	Other tertiary sector((low flows)	Tertiary
27–2	Non tertiary offices (agriculture, wholesales)	Tertiary
27–3	Non tertiary offices (retail trade, industry, transport, administration)	Tertiary
6	Transport (except storage)	Tertiary
28–2	Warehouses (bulk)	Warehouses
28–3	Warehouses (including transport)	Warehouses
30	Quarries	Warehouses

from each movement data sheet. To perform the correction, the scaling factor c_e of the characteristics of each movement of e is such as:

$$c_e = m_{se} / \sum_{iOe} f_i$$

where m_{se} is the number of movements/week of an establishment e in the stratum s and $\sum f_i$ is the number of movements obtained by the sum of the frequencies f_i of data sheet movements of establishment e.

The total number of movements M_s of vehicles generated by the establishments of the stratum s is:

$$M_s = \sum_e m_{se} * w_s$$

For each stratum s, each movement i of e in the sample has a weight of mv_{sei} movements, such that:

$$mv_{sei} = w_s * c_{e^{\cdot}} * f_i$$

The hypothesis is that in each stratum, the distribution of establishments of the sample as a function of their number of generated movements is similar to the distribution of the establishments in the whole conurbation.

Weighting of driver trips:

2 biases were found in the driver sample:

- For each management mode, there was a distortion between the number of movements generated by the different types of activities of establishments delivered by the drivers and the number of movements generated by all the movement slips described in the establishment sample.
- Drivers working for the firm surveyed answered more frequently than third party drivers: the rate of questionnaires sent back differed according to the closeness of the driver and the establishment delivered.

In order to amend these biases, the following weighting of a round of the type *(m,a)* was used:

$$r - tour_{m,a} = Nbmv_{m,a} / nbmv - round_{m,a}$$

is the weight (in weighted number of rounds).

Where:

- *a:* branch of activity (industry, craftsman, wholesale, retail, large store, tertiary services, warehouses; agriculture);
- *m:* is the management mode in five classes: own account carried out by the establishment as consignee, own account not carried out by the establishment as consignee, own account carried out by the establishment as forwarder, own account not carried out by the establishment as forwarder, third party (carriers).

$Nbmv_{m,a}$: the weighted number of movements calculated in the urban area for the *(m,a)* establishments, $nbmv - round_{m,a}$ is the total number of stops of the *(m,a)* drivers' trips in the driver sample.

If *nbstop:* number of stops of a round for a driver of type *(m,a)*, the weight (in number of movements) of this driver is:

$$nbmvdriver_{m,a} = nbstop * r - tour_{m,a}$$

The size of the establishment sample and the quality of the responses guaranteed the correct estimation of the average number of movements generated by each activity stratum. The number of no-answers was high regarding the weight of the payload (40 % of NA) and the origin–destination of the goods. The number of movements obtained by computing the sum of the frequencies of movements in the data sheets was 20 % lower than the actual total described by the establishment interviewed.

Based on the pertinence of the weighting the expansion of these surveys made it possible to estimate several mean ratios (Patier 2001; Patier and Routhier 2009a, b; Routhier 2013). According to the city, the share of urban goods traffic (UGT) in the total traffic (in vehicles*km car units) varies from 9 to 15 % of trips, 13–20 % of vehicles*km, 15–25 % of vehicles*km in terms of road occupancy rates.

One of the main contributions of the surveys consisted in providing knowledge on urban management rules (the links between activities, operating mode, management mode, type of vehicles used, distance covered, number of delivered establishments, running time, parking place and parking time). The urban goods movements are directly linked with the type of activity, the number of deliveries and pickups, the operation structure, the management mode and the organizational mode.

The main relationships are the following:

- between management mode and organization mode (own account mostly carries out direct trips, third part transport uses rounds);
- between type of vehicle and management mode (own account uses more light commercial vehicles, third party transport uses trucks);
- between distances covered and management mode and organization modes (the rounds of third party transport are longer than those of own account);
- between the distance covered between 2 stops and the size of the round (the longer the round, the shorter the distance between two stops);
- between stop timing and round size (the more stops on the round, the shorter the delivery time).

A very important result is that the same relationships was observed in the three cities surveyed: the comparison of the results of the three French freight transport surveys highlighted a notable similarity in terms of the diagnostic, the number of deliveries generated by each type of activity, and inside each class of activity the number of deliveries performed by type of vehicles, the share of own account, and the share of the different types of rounds. This demonstrates that for each class of activity, the overall economic and logistic structure takes precedence over the size and the shape of the cities. This result permits transposing the knowledge deriving from these surveys to other cities and building a general model applicable for French and other European cities.

4.2 Modelling Methodology

The results of the survey were used to build the Freturb IEM estimation model. The main hypothesis of the model is that the number of pickups or deliveries at a given establishment depends on its activity (French NACE code), its size and its nature. Therefore, the model is based on the nature of the generators (shippers, forwarders, consignees) and the transport choices carried out by the latter. More precisely, the model is organized as follows:

- First, the number of movements (pickup or delivery operations) is generated at each establishment, before being grouped by each zone.
- Second, round movements are characterized (main stop or ordinary stop) using an empirical approach.
- Third, the distances travelled are estimated based on a typology of logistics practices and the geographical configuration of the urban area.

4.2.1 Movement Generation

We recall that a *movement* is defined in this context as a transport operation consisting of a delivery and/or a pick-up carried out by a type of vehicle for a given establishment. The relevant characteristics that explain the relationship between the urban activity and the generation of deliveries and pick-ups are as follows:

$$n_e = \varphi(a, p, o)$$

where n_e is the number of movements (deliveries, pick-ups and mixed operations) carried out each week for the establishment e, a the industrial category (45 types), p the nature of the premises (mainly store, warehouse, office or headquarter), o the number of jobs.

Each function is assigned using interpolation techniques from the survey data according to the number of jobs. A comprehensive description of this method and the details of each function can be found in Aubert and Routhier (1999) and Routhier et al. (2001). At the end of this step, we obtained the number of weekly movements for each establishment by:

- type of movement: delivery or shipment.
- class of vehicle used (less than 3.5 T, carrier, heavy truck).
- management mode (own account as consignee, own account as forwarder, third party).
- organization mode (direct trip or round).

4.2.2 Movement Characterization

Given a freight transport path, three types of stops and trips can be distinguished. If we consider FTL[7] transport, i.e. a direct route, we usually find two stops (one loading and one unloading operation) and two direct trips (outbound and return).

In an LTL[8] configuration, i.e. round, the main loading/unloading point corresponds to the establishment where the vehicle is loaded for the delivery rounds or unloaded for the pick-up rounds. Two trips are linked to this position, named starting and ending trip. Generally, one of them is an empty trip. Finally, we can define the ordinary delivery or pick-up positions (*dp* points), which are hit by a connecting trip (*c* trips) or by a starting or ending trip (Fig. 4).

Note that empty trips have to be considered in both FTL and LTL transport chains. The surveys made in parallel with FRETURB allowed defining the characteristics of each trip at each stage of a transport chain, either empty or transporting a load quantity. Thus in the trip chaining definition the load quantity is not

7 Full truckload.

8 Less than truckload.

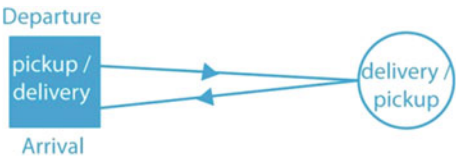


Fig. 4 An FTL transport chain

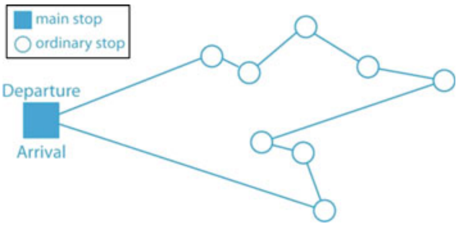


Fig. 5 An LTL transport chain

considered since the main determinants of a trip are related to the delivery or pickup operation, independently of the load transported (Fig. 5).

From the three surveys a grid was built to estimate the number of main and secondary stops for each establishment according to the activity served and the management mode. Knowing the type of vehicle used for the freight transport, it is also possible to determine the average size of the round by type of management mode (third party transport, own account as consignee or own account as forwarder). Thus round the movements simulated in step 1 can be characterized as main stop or ordinary stop.

The details on model calibration can be found in Routhier and Toilier (2007).

4.2.3 Distance Generation

In order to calculate the distances travelled, the FRETURB model proposes three types of functions. Each of them related to one of the trips described above (direct trips, starting/ending trips and connecting trips) (Table 2).

Table 2 Percentage of main trips in LTL trip chains Toilier et al. (2005)

Activity	Third party (%)	Own account as consignee (%)	Own account as forwarder (%)
Agriculture	0	100	75
Craftsmen	2.13	39.24	18.21
Small retail stores	1.85	65.38	7.43
Wholesale	6.7	68.62	31.76
Warehouses	65.06	58.33	62.67
Department stores	5.57	81.81	13.63
Industry	9.48	46.80	38.84
Tertiary	3.82	56.25	14.58

Concerning the direct trips, the most significant variables are vehicle type and city size. The relations for the direct trip lengths are the following:

$$l_{dt}(v) = \alpha_v * wr(T) + \beta_v$$

where: l_{dt} corresponds to the direct trip length and wr to the radius of the city T weighted by the number of d_t trips.

Concerning starting/ending trips, the main significant variable is the distance of the generator from the centre, the mode of transport management and the type of activity. A linear function was defined to adjust the length of the starting trip and can be defined by the following relation:

$$L_z = \alpha * dc(z) + \beta$$

where L_z is the length of a starting/ending trip in z and $dc(z)$ corresponds to the "as the crow flies" distance of zone z from the city centre.

Regarding the connecting trips, the main significant variables are the number of stops s in the round, the vehicle type v and the mode of management m. In order to take into account spatial effects, two other significant variables have to be added: the size of the city T (measured by the radius weighted by the number of movements $wr(T)$) and the density of movements δ_z carried out in zones z (the denser the zones, the shorter the round-trips are, because of congestion and more trading opportunities):

$$l = \varphi\left(v, m, s, wr(T), \delta_{i,j}\right)$$

Three classes of density δ were identified. The general function is given by:

$$l_{v,m,\delta}(s,T) = \alpha_{v,m,\delta^*} log(s) + \beta_{v,m,\delta^*} wr(T) + \gamma_{v,m,\delta}$$

where $\alpha < 0$.

A comprehensive description of the calculus including all the relations can be found in Routhier and Toilier (2007).

4.2.4 Trips generation and distribution

Although the main results of the FRETURB model are road occupancy issues (Bonnafous et al. 2013), the spatial distribution of freight transport flows can be useful, nevertheless. Without this step, it is not possible to define the main paths assigned to the road network, or model the impact of freight routes on traffic. Consequently, it is necessary to formulate a flow distribution leading to an origin–destination (O-D) matrix that first allows "feeding" urban traffic assignment models. Therefore it is useful to estimate the impact on congestion, energy consumption and local pollution.

According to Toilier et al. (2005), only TL transport flows can be represented by an oriented O-D matrix using a gravity model. Because of the predominance of urban rounds (75 %), flow distribution cannot be established using a gravity model as they are oriented and organized according to a fluctuating logic unknown to the modeller (Routhier and Toilier 2010). Thus the same round can be carried out in one direction or the other, or by serving points in various orders, these instantaneous changes being due to traffic conditions, retailers' opening hours and also other constraints external to the round itself.

This volatility in round itineraries did not lead to a round model, but simply to flows between points on the round. Consequently, a probabilistic distribution model was chosen (Toilier et al. 2005). Thus, for any delivery or pickup operation estimated using the simulated generation module and characterized by a set of criteria (area, vehicle used, type of organization, size of the round, management mode, etc.) we select a distance function from a 25 group-classification. This function indicates the average distance to the next point on the round. The neighbourhood of each zone is defined automatically. To estimate the distance between two zones z_i and z_j, a macro-network is built to link the centroids of contiguous zones. Then, the average time taken by transport T_{ij} to travel from z_i to z_j is obtained with the following relation:

$$T_{ij} = \left(RD_{i1}/\,s_{i1} + RD_{12}/\,s_{12} + \cdots + RD_{nj}/\,s_{nj}\right)$$

The choice of best path on the macro-network can be obtained on two ways. The first is to use an average distance database that relates each pair of zones. The second is that of using a shortest path algorithm (Dijkstra 1959) to estimate a suitable path to link two zones by a freight vehicle, in travel time (and not physical distance "as the crow flies"). For each distance function, a confidence threshold is defined to determine which zones are susceptible to exchange freight with the zone considered, given an operation type, a vehicle type and a management mode. For each zone z_i a set of zones is defined using a ring-based procedure, as illustrated below (Fig. 6):

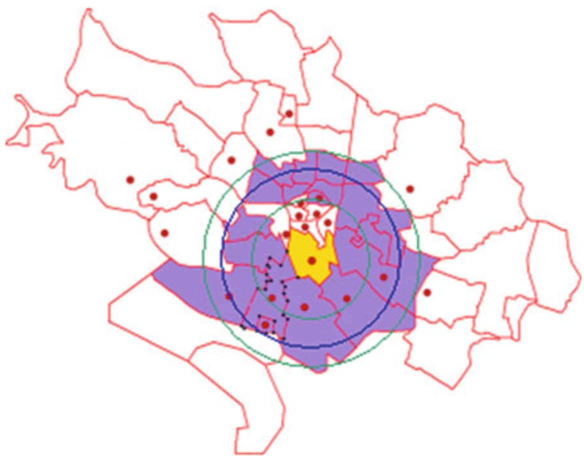


Fig. 6 Potential reception zones (in *dark*) eligible to receive trips generated by the emission zone (*lighter*), for the French city of Dijon (adapted from Toilier et al. 2005)

Then, an iterative procedure searches an operation within the radius thus defined whose characteristics are compatible with those of the transaction to which it is coupled. For example, a shop downtown, served by a professional carrier using a vehicle less than 3.5 tons on a round of 10–20 stops, will be linked to another delivery of similar characteristics (carried out by a professional carrier using the same type of vehicle taking a route of the same size category) and located within a range of distance imposed by the corresponding function. The O-D matrix deduced takes the following form:

$$T_{ij} = [t_{ij}] = \sum_{v} [t_{ij}(v)]$$

where t_{ij} is the overall number of TL trips (outbound and return) and the overall number of approaches, return and connection trips for LTL rounds between z_i and z_j. Gradually, all the transactions are matched to build an O-D matrix including all areas, and the number of operations detailed according to their characteristics. The O-D matrix is then broken down by time of day in order to distinguish traffic problems at morning peak, evening peak or off-peak hours. Finally, this O-D matrix can be linked to a traffic assignment model to include urban goods movements in car and public transport traffic and make an overall diagnosis of urban transport (Nicolas 2010).

5 ECM Estimation

The ECM estimation module is developed in a similar way to the IEM module, according to a two-step procedure of movement generation and distance calculation on an inferential statistics basis (Gonzalez-Feliu et al. 2012a). However, the data required were not collected in parallel to the development of the method; instead a standard personal trip survey was used. Indeed, although there is no database of pickup and delivery trips specific to urban areas in France, a standard database can be consulted for shopping trips, namely the National Urban Personal Trip Survey database. It can be used to characterize several cities in terms of shopping trip behaviour. Nevertheless, not all the cities present the same data granularity (for instance, the city of Lille has detailed data from Monday to Friday including the nature of purchased goods, and aggregated data for Saturday trips. Lyon has data from Monday to Saturday some years, but the most recent survey covered only trips from Monday to Friday and only the type of shop is recorded, but not the nature of purchased goods). In any case, such surveys can form the foundation for model construction, since specific surveys should be seen as redundant by public authorities and their costs can be higher than those of the data collection campaigns of existing databases.

5.1 Modelling Methodology

The model proposed is the result of a long conceptualization and calibration process (Ségalou 1999; Ségalou et al. 2002; Toilier et al. 2005; Gonzalez-Feliu et al. 2010a, b, 2012a, b). As seen above, the model structure is similar to that of the IEM module. However, the granularity of the database does not permit producing data up to the household or to the retailer, requires the use of aggregated data in zones. More precisely, the model is organized as follows:

- First, the number of movements (shopping trips at destination) is generated at each shopping zone (i.e. for each zone of the urban area, the number of shopping trips attracting private cars is generated).
- Second, this number of movements is distributed in order to link each shopping zone to each household zone (i.e. to link the shopping destinations to the zones where the households are located). This is done using a catchment area model.
- Third, the distances travelled are estimated based on a typology of shopping trip practices and the geographical configuration of the urban area. This is done empirically on the basis of a shopping-related trip chain database.

5.1.1 Trip Generation

In the shopping trips generation phase the number of trips attracted for purchasing is generated at each zone. The modelling methodology proposed assumes that shopping trip generation rates also depend on the type of urban space, classified as follows:

- The *main central urban area* (CUA) contains the main city of the urban region and also the urban suburbs that can be assimilated with the main city, due to the continuity of the urban landscape. This category of urban space is characterized by a dense household area, mainly with a variety of proximity retailing and service activities, and a lack of industrial activity zones. Moreover, the public transport network is very developed and interconnected.
- The *near periphery* (NP) includes the suburbs bordering the central urban area. This category of urban space is characterized by a mix of dense and less dense household areas. It often also includes industrial and commercial activity zones. Moreover, the public transport network connecting it to the city centre is well developed in certain directions (often radially) but public transport in the intra-zone is less developed.
- The *far periphery* (FP) contains the rest of the towns of the urban area. This category of urban space is characterized by low density, predominantly detached housing and high motorization rates. Indeed, public transport is essentially radial and closer to interurban rail and bus services than to urban public transport networks. The far periphery is also a mix of peri-urban industrial and commercial zones and semi-rural agricultural and forest areas.

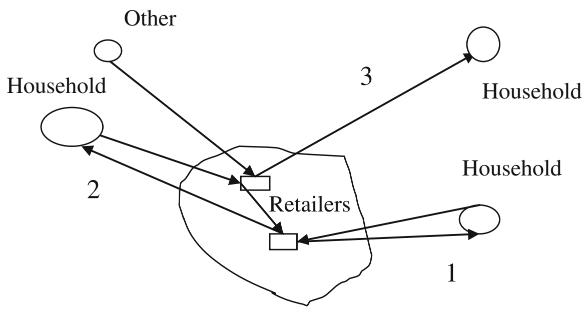


Fig. 7 Different types of shopping trip chains (Gonzalez-Feliu et al. 2012a)

The model proposed focuses on trip attraction rates, i.e. the number of trips that arrive at a zone for shopping purposes. This is done by assuming that all trips arriving at a retailing activity for shopping purposes are connected to a second trip, i.e., a purchasing activity is never the final point of a trip chain (see Fig. 7):

Figure 7 illustrates different trip chains focusing only on shopping trips that are related inside a given zone. As stated in Gonzalez-Feliu et al. (2010a), a shopping trip is related to a succession of trips with different purposes, and we feel that bit is important to see them as a part of a more complex trip structure that can be called the trip chain. From these considerations, we propose to generate shopping trip attraction according to the general methodology discussed in Cubukcu (2001); the number of private car shopping trips T_j attracted by a zone j can be formulated as follows: $T_j = f\left(Ret_j, X_j\right)$; where: T_j is the total number of shopping trips attracted to zone j; Ret_j the set of retailing activity characteristics vector in section j and X_j the set of socioeconomic characteristics of the people and households belonging to section j.

The trip attraction function can be defined in different ways. We propose a multi-linear function that depends on the category of urban space (Gonzalez-Feliu et al. 2012a). The model can be formulated as follows:

$$\begin{aligned} T_j^{CUA} &= a_1^{CUA}.POP_j + a_2^{CUA}.NrSMC_j + a_3^{CUA}.Emp - BS_j + a_4^{CUA}.CC_j \\ T_j^{NP} &= a_1^{NP}.POP_j + a_2^{NP}.Emp - BS_j + a_3^{NP}.CC_j + a_4^{NP}Dens_j \\ T_j^{FP} &= a_1^{FP}.POP_j + a_2^{FP}.Emp - BS_j + a_3^{FP}.CC_j \end{aligned}$$

Where *NrSMC* is the number of small and medium stores; *Emp-BS* the number of employees in the supermarkets and big commercial stores of the zone; *CC* is a binary variable that indicates the presence of a shopping centre (Ségalou 1999). This variable takes the value 1 if at least one extra-urban shopping centre is located inside the zone and 0 otherwise. These variables give the retailing activity characteristics of the zone. Moreover, *POP* is the population of the given zone and *Dens* the Population density of the attraction zone.

We observe from the equations that each model has a different set of variables from the others. This has been done to provide the strongest combination related to

Table 3 Linear regression results for the best attraction analysis (from Gonzalez-Feliu et al. (2012a))

Model	R^2	Degrees of freedom		F Value	Significance of F
		n	k		
3C– CUA	0.77	25	4	27.29	7.4 × 10–8
3C–NP	0.75	20	4	20.90	5.4 × 10–6
3C–FP	0.84	19	3	58.01	1.7 × 10–8

the Student's test of each coefficient. The calibration method and the main analyses are presented in Gonzalez-Feliu et al. (2012a). Taking into account the degrees of freedom and the quantity of data used for the analysis, the values are consistent and in all cases reject the hypothesis of the simultaneous nullity of all the coefficients (Table 3).

5.1.2 Catchment area Model

After the trips are generated as a function of their shopping destination, we propose to connect them to households using a catchment area model (Kubis and Hartman 2007). The approach proposed is a probabilistic retail gravity model which can be formulated as follows:

$$P_{ij} = \frac{T_{ij}}{T_j} = A_j \frac{E_j^{\alpha_1}}{E_i^{\alpha_2}} NrH_i c_{ij}^{\beta}$$

where: E_i and E_j are the number of employees in retailing activities for zones i and j respectively; NrH the number of households of zone i, and c_{ij} the cost of transportation between i and j. Moreover, we define A_j as follows, in order to ensure the flow balance (Ortuzar and Willumsen2001):

$$A_j = \frac{1}{\sum_k \frac{E_j^{\alpha_1}}{E_i^{\alpha_2}} NrH_i c_{ij}^{\beta}}$$

α_1, α_2 and β are parameters determined first by linear regression then readjusted using Hyman's (1969) iterative procedure to minimize the error between surveyed and estimated mean distances (a comprehensive description of the calibration method can be found in Gonzalez-Feliu et al. 2010b) (Table 4).

Table 4 Estimation results (from Gonzalez-Feliu et al. 2010a, b)

	Surveyed	Estimated	Error (%)
Number of trips per day	301629	296230	1.7
Distance (Millions of km/day)	4.34	4.44	2.1
Mean distance c (in km)	14.39	14.99	4.2
Initialization value β_0	–	0.89	–
Best β value	–	0.91	–

Table 5 Shopping trips in related trip chains (Gonzalez-Feliu et al. 2012b)

	Shopping trips in shopping related chains			Shopping trips in household-shopping-household rounds		
Household zone	Total	No private car (%)	Private car (%)	Total	No private car (%)	Private car (%)
CUA	172,923	79.5	20.5	134,313	76.6	23.4
NP	206,543	36.3	63.7	158,128	45.3	54.7
FP	251,865	29.5	70.5	182,621	30.6	69.4
Total	631,332	45.4	54.6	475,061	48.4	51.6

5.1.3 Distance Calculation

After assigning each trip to its household zone, the distances can be estimated. The procedure is similar to that of the IEM module, i.e., from a shopping trip chain database, we could estimate the composition of shopping trip chains from the Urban Personal Trip Survey of Lyon (Gonzalez-Feliu et al. 2012a), we extracted the main characteristics of shopping-related trip chains. Indeed, in Table 5 we report the number of trip chains whose main purpose was a purchasing activity. We observe that the use of private cars for shopping trips is strongly influenced by the urban zone where the household is located. Moreover, 94 % of these private car shopping trips are included in a round trip containing only shopping trips, the initial and final location of the round trip being the household. Note that trips belonging to these rounds represent about 80 % of the total shopping trips,[9] and work-shopping-household trips represent about 15 % of the total number shopping trips with an average distance of 3 km.

From the database obtained, we estimate for each Household-Shopping zone pair the percentage of shopping trip rounds (household-shopping-household), of shopping-based trip rounds (household-shopping-other-household) and work-shopping-household trip chains. Then we calculate the main trip distances (i.e. origin-first stop and last stop-household) and add the average distance of the inter-stop trips. The method is analogous with that of IEM estimation and allows direct comparison between the two categories of flows.

[9] According to a statistical extraction on the same data sample.

6 A Note on UMM Estimation

The purpose of the UMM module is to estimate the transport flows essentially corresponding to goods and raw materials for public and building works, and the vehicle flows generated by waste management and urban network maintenance (sewers, water, phone) and removals (Routhier and Toilier 2007). These flows represent about 10 % of UGM road occupancies but have different natures and temporal distributions. They are composed of a heterogeneous set of flows:

- Transport flows induced by building and infrastructure construction.
- Waste management trips.
- Physical logistics flows for urban network development and maintenance (water, electricity, gas, telecommunication)
- Trips related to personal and professional removals.
- Trips related to community needs like schools, hospitals and postal services (excluding parcel and express deliveries, already included in IEM movements).

Due to the heterogeneity of these categories it is not always easy to find a significant set of data to model them. Indeed, although the two last categories are more or less homogeneous or easily identifiable with a group of homogeneous sub-categories, the other three represent a wide variety of organizations and practices which are not always easy to identify and represent in a model. Consequently, UMM estimation is done using different and mostly partial sources (Ségalou et al. 2004), on the basis of specific studies that do not necessarily take into account the spatial context and the seasonal characteristics of certain flows (seasonal variation is often common for construction flows and other flows such as community needs and the waste management trips). The method proposed is therefore an overall estimation of road occupancy values (in km.PCU) in the flows concerned. Taking into account their relative distribution (Toilier et al. 2005), priority is given to the estimation of the two first categories of flows (in terms of data quantity and quality and estimation robustness).

Since most surveys do not clearly identify UMM flows, as they are often regarded as negligible and fluctuating in time or space (they are not subject to thorough surveys, according to Albergel et al. 2005), the method aims at generating weekly road occupancy values from annual estimations based on rough ratios (Table 6). Concerning construction flows, the annual mean travel distances depend on the size of the city and the location of dumps, quarries and cement works. The location of these flows is, however, not well known. That is why they are assigned only as flows generated by deliveries and pick-ups. The remaining flows are directly related to the urban population. The main sources for estimating the road occupancy for each category and defining the ratios (Ségalou et al. 2006) are presented in Table 6. It is noteworthy that such ratios are first presented in terms of Km per inhabitant and year then the percentage of heavy vehicles providing such transport (in distances travelled) is reported. For example, for construction, 12.1 km are generated per vehicle and year, of which 9.8 (81 %) was travelled by

Table 6 Distance covered in the Bordeaux urban area by urban management flows (adapted from Ségalou et al. 2004)

Activity	Method of computation	Km/inhab. each year (% HV[10])
Public works, demolition and building sites	500 trucks per week for 100,000 inhabitants 130 heavy vehicles per 1,000 m^2, numerous light commercial vehicles	12.1 (81)
Network management[a] and public services	Annual mileage of specific vehicles	17.9 (36)
Household refuse and industrial waste collection	Annual mileage of garbage trucks	23.1 (48)
House and enterprise moving (removals)	10 % of households, stores and firms move each year.	3.9 (22)
Public postal services	Annual mileage of specific vehicles in the urban area	8.6 (40)

[a] (cleansing, water, gas, electricity and telecommunication)

heavy vehicles. However, the percentage of semi-articulated vehicles and that of simple trucks is not described here.

7 From Road Occupancy to Environmental Impacts

The model proposed allows estimating road occupancy rates and then the main macroscopic road occupancy issues concerning urban goods movements. However, the environmental impacts are also a priority for many stakeholders. For this reason, an environmental module was added (Ségalou et al. 2004; Albergel et al. 2005). It is developed from the fact that the impacts of urban transport on the environment can be observed at two levels. On the local scale we find the best-known impacts, i.e. air, ground and water pollution, as well as noise. Congestion is not considered here since it was included in the basic version of the model (road occupancy issues obtained from the three modules presented above). On the global scale, we find two major impacts: energy consumption and greenhouse gas emissions.

The definition of UGM adopted above takes into account the overall goods movements carried out in an urban zone. Therefore the traffic generated by the three types of flows constitutes the total UGM needs to be compared with the two other types of flow: the freight through traffic (FTT) and the other motorized private and professional car trips. This typology has the advantage of being built on the basis of comprehensive data that is also generally statistically available. Two main models are applied successively, as in the following diagram:

[10] HV : Heavy vehicles.

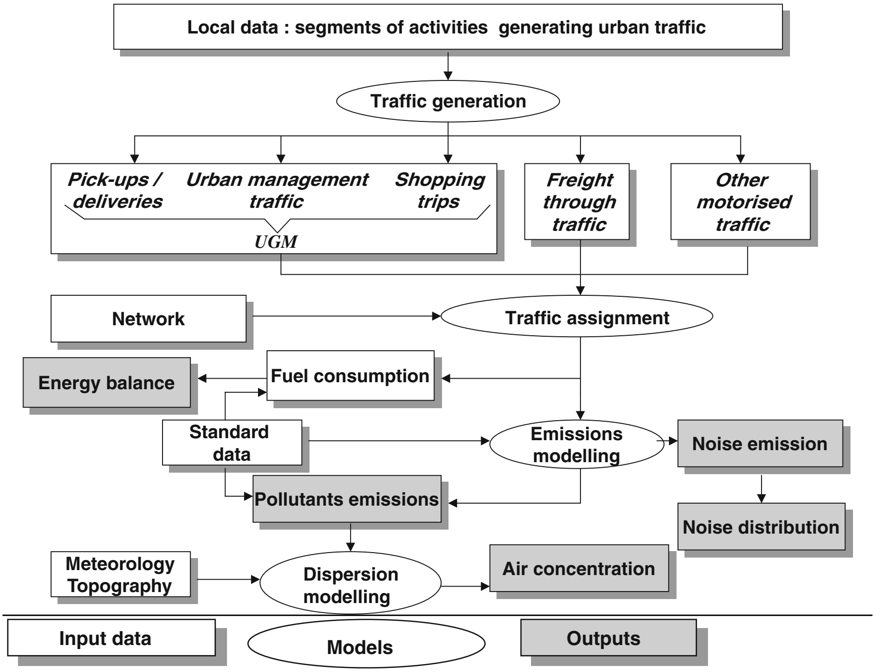


Fig. 8 The complete UGM environmental model (Ségalou et al. 2004)

1. A two-step traffic model:

- generation-distribution of the traffic (five segments);
- traffic assignment on the network with six types of vehicles, according to energy consumption: private vehicles (PV), light goods vehicles (<3.5 t), goods vehicles (3.5–7.5 t), GV (7.5–16 t), GV (16–32 t) and heavy goods vehicles (>32 t).

2. A two-step environmental model:

- a model of pollutant, greenhouse gas and noise emissions;
- a model of pollutant concentrations in the atmosphere.

The environmental module was calibrated and discussed in Ségalou et al. (2004) and Albergel et al. (2005). The reader should refer to these works for a more detailed description of the data generation and calibration procedures Fig. 8.

8 Conclusion

This chapter proposed the methodology of the FRETURB model for urban goods movement diagnosis. It is composed of four main modules: inter-establishment movement estimation, end-consumer movement estimation, urban management flow generation and environmental issue simulation. It is currently used in more than 20 cities (in France and Switzerland) for policy and planning decision support and has also been applied to Belgian and Italian cities. The model is able to estimate the impacts of urban goods movement with current configurations; however, simulating urban policies requires further developments which are in progress. These include an establishment generator, so that the method can be applied to cities that lack the required data, a scenario simulator, a proximity deliveries simulator, a route construction and substitution procedure and a mapping module.

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Planning and Optimization Methods for Advanced Urban Logistics Systems at Tactical Level

Simona Mancini, Jesus Gonzalez-Feliu and Teodor Gabriel Crainic

Abstract This chapter aims to review and present the main combinatorial optimization problems recently introduced in literature, arising in urban logistics, in which distribution systems are involved as well as to make a critical analysis of the economic and environmental advantages obtained by following this kind of approaches. First we present the different categories of systems where, due to geographic or political constraints, there are access limitations to customers' area for vehicles which do not respect given requirements. Second, the main definitions and characteristics of advanced consolidation systems are presented. Third, the main combinatorial optimization problems associated to such systems are presented, as well as the main heuristics methods to solve them. Finally, to complete this study, a socio-economic analysis based on a set of interviews is proposed.

Keywords Combinatorial optimization · Cross-docking · Freight distribution · Tactical planning · Urban logistics

1 Introduction

The sudden change of habits in the modern society, the advance of progress, the achievement of welfare and prosperity and a frenzy increase of life rhythms yielded to the need of finding new solutions for the management of freight

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distribution to reach a higher level of efficiency (Mancini 2013a). This goal may be achieved through a better exploitation of presently available resources, a clever planning of the whole distribution process, a smart network design and a strictly collaboration among shipping companies. Such kind of approach implies the consolidation of loads of different shippers and carriers on the same vehicle, or, more generally, on the same service, and an efficient coordination of the resulting transportation activities. One of the most efficient ways to implement goods consolidation is to adopt multi-stage LTL transport systems (Gonzalez-Feliu 2012a), which allow to split the transportation chains in different legs, in each one of which, goods are consolidated at facilities, where they are sorted and carried on other vehicles which perform the delivery to the customers or to another set of facilities.

The specificities of the last mile of the supply chains (mainly LTL transportation, with less optimized vehicles and confronted in many cases to big constraints and unexpected events related to the congestion of urban and peri-urban infrastructures) and the increase of customer satisfaction approaches in supply chain management make important to relate the quality to the logistics costs, making the economic aspects of the last mile an important component of supply chain design. In this context, the new advances in technologies have been a positive factor for the development of new markets and new consumer needs: the growth of e-commerce and postal shopping, as well as the pace of life, have reinforced the importance of "just in time" policies in freight distribution. Moreover, the service quality of a transportation carrier is often related to travel time, and can vary according to both socio-economics and trip characteristics. The total travel time of a vehicle trip depends on several aspects, like actual travel time, waiting and access time, congestion, deadlines or service features, etc. In addition, the new constraints of the generalised economic and financial crisis make a readjustment on the freight transportation strategies that have to be included in the main logistics tactical decisions. For these reasons, it is important for a distribution system to ensure the efficiency while maintaining a service quality defined by the time windows or other quality indices. For this reason, after defining the system, it is important to ensure that in a middle term period, the system is well-managed and controlled. To do this, several methods from the operations research and combinatorial optimization can be defined.

The aim of this chapter is to propose a guide for researchers and practitioners on the main methods related to tactical planning in urban logistics. Two main families of problems will be addressed: vehicle routing with time windows and multi-stage vehicle routing. The chapter is organised as follows. Next section provides a brief background of freight transportation problems in urban logistics and motivates the aim and scope of the chapter. After that, a focus on two-stage VRP will be made, presenting the main issues, problems and variants. Finally, a qualitative analysis on the development of such systems will be carried out.

2 Urban Consolidation and City Logistics Systems

Urban logistics involves different stakeholders, like retailers and other urban commercial and service premises, wholesalers and distribution companies, transport and logistics carriers, public administrations and real estate actors among others (Ambrosini and Routhier 2004). In order to deal with city logistics objectives (i.e. reduce congestion and environmental nuisances related to urban freight distribution without penalizing urban premises and inhabitants), several solutions and actions can be applied. Different types of actions can be defined in literature (Munuzuri et al. 2005; Benjelloun et al. 2010; Russo and Comi 2010; Ville et al. 2012); we can group them on three main categories:

- Policy and planning actions, related to public authorities;
- Organizational actions;
- Technological actions.

According to Gonzalez-Feliu et al. (2012a), the combination of all three categories of actions allows an efficient reduction of travelled distances then of congestion and environmental nuisances. However, we observe from their results that the impacts of each one are not the same. In other words, without organizational changes, both other categories have a limited impact on congestion reduction or transfer the problems to others sections of the city. So, innovative organizational strategies and models are needed, to improve the efficiency of freight transport (important for shippers, receivers and transport and logistics carriers), reduce vehicle flows and types (important for public authorities and citizens) and environmental issues (where most stakeholders are involved but public authorities are more sensible to). We have to note that those organizational changes have to be done without penalizing the economic activities of the city and ensuring the involvement of the different stakeholders related to urban logistics. For those reasons, city logistics offer great challenges and opportunities for operations research, management sciences and combinatorial optimization, in particular when dealing with vehicle routing and fleet management.

Because one of the most efficient ways to reduce the number of vehicles and improve their loading rates is commodity aggregation, urban consolidation has become one of the pillars of city logistics. Consolidation can take place at different stages of the urban supply chain (Danielis et al. 2012; Morana 2013) and using the different urban logistics facilities that exist in urban areas (Boudouin et al. 2013). Although different forms of consolidation can be defined, we focus on multi-actor approaches, i.e. schemes where different actors will bring freight to consolidation platforms, mainly in the surroundings of a city, from where commodity needs to be transported to customers within the city (Crainic et al. 2012). The fundamental idea of such schemes arises on the facto of considering shipments, carriers, vehicles and consignees not individually, but rather as components of an integrated logistics system (Crainic 2008). Then, the consolidation of shipments in a logistics pooling scheme (Gonzalez-Feliu and Morana 2011) is needed, in order to deliver the different customers on better loaded, more energy efficient, less road occupancy impacting and eventually green vehicles. To do this, it is important to ensure the coordination of shipments, carriers and consignees into collaborative transport systems that need to be accepted by both public and private stakeholders (Morana et al. 2013).

The most popular example of such systems is that of the city distribution center, also known as urban consolidation or distribution center (Boudouin et al. 2013), which is defined by Allen et al. (2007) as *"a logistics facility situated in relatively close proximity to the geographic area that it serves (a city centre, an entire town or a specific site such as a shopping centre), to which many logistics companies deliver goods destined for the area, from which consolidated deliveries are carried out within that area, in which a range of other value-added logistics and retail services can be provided"*. Those urban terminals emerged in the 1990s, when there were more than 100 of them, but they ran up against difficulties related to the difficulties of ensuring their economic balance without public funding support and the hesitancy by municipalities to continue subsidising them (Ville et al. 2012). Today, there are less than 20 genuinely significant consolidation terminals of this kind in Europe, notably in Italy (Morana et al. 2013), and less than 5 in Japan (Dablanc 2010).

UCCs are also called City Distribution Centers (CDCs, van Duin et al. 2008) or Urban Distribution Centers (UDCs, Boudouin et al. 2013). Although many distribution companies and logistics service providers have at their disposal facilities where shipments are consolidated prior to distribution, defining and developing urban consolidation centres involving different companies, sometimes in competition, is not evident. Beyond the fact that an efficient use of such facilities implies changing habits and current organizations, which is not always easy for several carriers, the possible locations of this type of platforms do not belong to large sets of alternatives. Indeed, city centres are expensive, in terms of real estate prizes, and logistics activities take part in peripheral areas of the conurbation (Dablanc and Rakotonarivo 2010; Adriankaja 2012). This fact concerns also existing platforms that would be adapted to become urban consolidations facilities. The most usual UCCs in practice are located at intermodal platforms, logistics centres or former wholesaling facilities that are adapted to have enhanced functionalities to provide coordinated and efficient freight movements within the urban zone. Hey can also be part of terminals (mainly maritime or fluvial ports, airports and train stations). However such facilities are usually located at the outskirts of cities (Gonzalez-Feliu and Morana 2010), close to highways. In any case, most UCCs are adapted facilities not originally built for City Logistics.

From those facilities, different distribution schemes can be defined. They can be grouped into two main categories (Benjelloun et al. 2010): single-tier systems derive from a direct shipping using LTL schemes to deliver customers from the UCCs; two-tier systems aim to better rationalise flows by grouping freight sent by well-loaded medium vehicles to cross-docking platforms call satellites, and then small vehicles deliver customers from satellites.

2.1 Single-Tier Distribution Systems

Single-tier distribution systems are the most common strategies to deliver customers from regional logistics platforms from customers. In such systems, at urban consolidation platforms, freight is consolidated, then a set of *direct shipping* routes is planned to serve customers in the city centre by vehicles operating tours starting and finishing at an urban consolidation facility (Crainic et al. 2012). Tactical planning issues related to direct shipping schemes using LTL routes are well-studied in literature (Toth and Vigo 2002; Golden et al. 2008).

As show in different works (Gonzalez-Feliu and Morana 2010; Trentini and Malhéné 2010; Allen et al. 2012; Crainic et al. 2012; Ville et al. 2012; Morana et al. 2013), urban consolidation platforms are often seen in small and medium cities and economically operational schemes are in general related to specific contexts of fields.

2.2 Two-Tier Distribution Systems

Two-tier systems (Crainic et al. 2004, 2009) are mainly planned for large cities, based on a so-called *consolidation-distribution* strategy, which uses a second stage of facilities and different vehicle fleets in order to avoid the presence of large vehicles in the city centre, reducing in that way the number and length of empty trips (Crainic 2008) (Fig. 1).

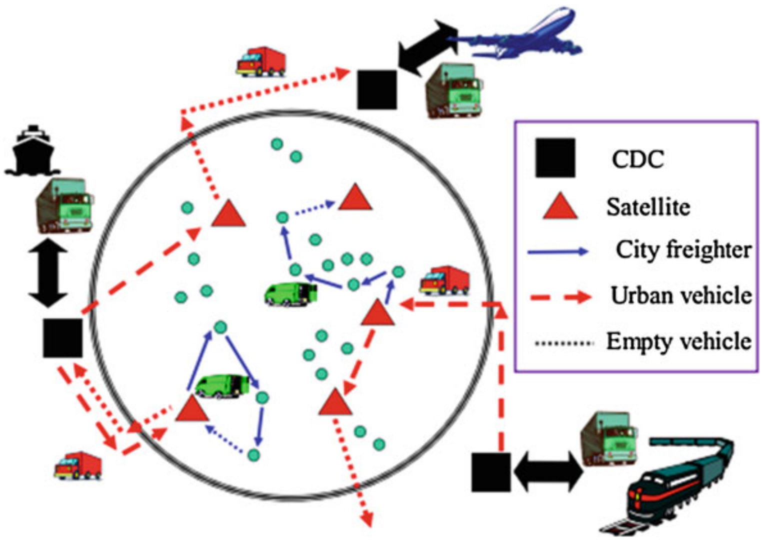

Fig. 1 An example of two-tier distribution system (Crainic et al. 2012)

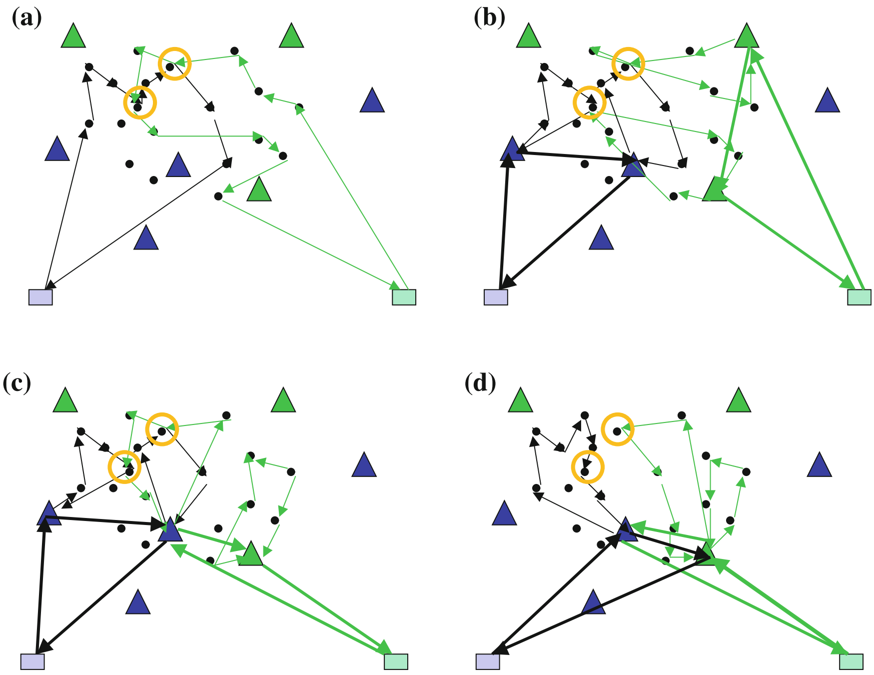

Fig. 2 A comparison between a single-tier (**a**) and three two-tier (**b–d**) distribution systems

The different operations in two-tier CL systems (command preparation, consolidation, sorting, etc.) are performed at facilities organized into a hierarchical structure, as illustrated in Fig. 2: major logistics terminals and depots are located in the urban periphery, in urban consolidation platforms, called here *city distribution centers* (Crainic et al. 2012) where it is loaded into urban trucks, which are of medium dimensions (ideally 9–12 t); then freight is transported city freighters (3.5) at *crossdocking satellites*, strategically located close to or within the city centre, from where final customers are delivered. Satellites are generally intended to be simple transhipment facilities like vehicle reception points (Boudouin et al. 2013) and operate according to a vehicle-synchronization and cross-dock transhipment model (Drexl 2012), i.e., urban vehicles and city freighters meet at satellites at appointed times, with only short waiting times being permitted. Indeed, no intermediate storage is allowed at satellites if not for a very small time (in general less than half an hour).

2.3 Challenges and Opportunities

Although urban consolidation centers have been studied by many researchers, the derived systems present several challenges and opportunities for city logistics research, more precisely related to operations research and management sciences.

Concerning strategic planning, the first issue we observe is that of culturally and socially-aware organization and business models, as for cultural impacts[1] of such schemes and need for somewhat tailored solutions (for example in North America). Then, we observe questions related to public policy (Dablanc 2010; Ballantine and Lindholm 2013), stakeholders behavior (Marcucci and Gatta 2013), partnerships and collaboration (Gonzalez-Feliu et al. 2013a; Morana et al. 2013), which have impacts on supply models. Another important questions is that of demand identification, using modeling techniques (Ambrosini et al. 2008; Anand et al. 2012; Comi et al. 2012; Gonzalez-Feliu and Routhier 2012). Another category of challenges is that of defining suitable on models and tools to evaluate city logistics impacts, to pursuit before-after analysis and study long-term implications of city logistics actions and solutions (Gonzalez-Feliu et al. 2012a, b).

In tactical planning, it is important to develop comprehensive urban transportation planning, taking into account the integration with personal and public transport, the impacts of ITS and the main issues related to day-before planning. The main issues in operations research refer to system, service and operations planning, including models, algorithms and instruments to support practitioners in their tasks.

Complementarily to strategic planning (related to system design, platform location and resource dimensioning) and to operational planning (real-time and short term organization, optimization and follow-up), tactical planning is related to service network design, to crew and vehicle scheduling, time issues and vehicle routing. Although such questions are in-depth studied for several versions of single-tier systems, it is not the same for multi-tier schemes (Gonzalez-Feliu 2012b, 2013a). In next section, tactical planning issues related to two-tier city logistics schemes are presented in order to support city planners and carrier managers in their tactical choices and planning issues.

3 Tactical Planning Issues for Advanced City Logistics Systems

In city logistics, when focusing on inter-establishments, we study the transport flows related to commodities into, out of and within the city or the urban area. Since the main component of third party transport is made of LTL circuits, the main combinatorial optimization problem related to city logistics is the vehicle routing, and this at all planning levels (refs.)

In single-tier systems, vehicle routing problems are close to classical problems studied in the literature (Toth and Vigo 2002; Golden et al. 2008). The main issues related to vehicle routing in city logistics arise on the dynamic and time-dependent

[1] In other words, the impacts of government actions on people and business, on business models, taxation and refunding mechanisms, among others.

nature of transport (Taniguchi et al. 2001; Taniguchi and Thompson 1999, 2001), on access restrictions (Munuzuri and Van Duin 2013) and on pickup and delivery strategies, among others. Since one-tier systems are well studied in the literature, we aim to extend Crainic's (2008) work for two-tier systems. Note that this chapter is directed to both researchers and practitioners of different disciplines so instead of an in-depth overview of operations research algorithms it presents the main categories of problems and methods. Detailed literature reviews on the subject are found in Drexl (2012), Gonzalez-Feliu (2013b) and Mancini (2013b).

In two-tier systems, two fleets of heterogeneous vehicles synchronize to deliver time-dependent freight demands within customer time windows, with little or no waiting room at (most) transfer stations. To deal with such systems, several new problems and challenges can be observed, but they can be grouped into two main categories. The first derives from the multi-stage nature of the transportation system, and all questions related to connexion among stages (Gonzalez-Feliu 2012a) and synchronization (Drexl 2012) and seeks to study the problem as a two-stage system following the concept of multi-stage transport systems (Kreutzberger 2008; Gonzalez-Feliu 2013a). The second is related to the multi-trip nature of second-stage transport schemes (Nguyen et al. 2012) and consists on taking into account different e tactical planning (Crainic 2008). Indeed, in such systems it is considered that the first tier vehicles are planned in a first time, giving an overall idea of the second tier, and this last is refined in a second time (Crainic et al. 2009). Other issues are the different types of transport modes, vehicles and routes that can be involved in such schemes (Crainic et al. 2012), collaboration among partners (Gonzalez-Feliu et al. 2013b) or the integration of new services like time-constrained deliveries or pickup and delivery services (Crainic et al. 2012) but they can be included in the two main categories of approaches.

We present below both categories of approaches, presenting the main concepts and assumptions related to them and the most popular solving methods shown in the literature.

3.1 Problem Definition and Variants

We observe in the literature several declinations of the problem, arising on two main questions of vocabulary. The first is related to the hierarchic nature of the problem (Min et al. 1998): several terms, like level, echelon, tier or stage are used. To make practitioners more familiar with the problems, and avoid confusion with multi-echelon logistics systems, we will use the definition of Min et al. (1998) and Gonzalez-Feliu (2013a), calling them multi-stage transport systems. The second is the name of the combinatorial optimization problem that can be defined to optimise such systems. Three main problems have been defined in literature (multi-stage vehicle routing, multi-stage location routing and truck-and-trailer vehicle routing). However, all three problems are declinations of the same model, as stated in Nagy and Salhi (2007). For that reason, we will call such problems multi-stage vehicle routing optimization problems (m-VRP). Such problems have been introduced for the first time in Laporte (1988) but formally presented in Gonzalez-Feliu (2012a). In urban logistics, the attention is focused on the Two-Stage version of the problem (2-VRP), a simplified version frequently arising in the context of Two-Stage distribution systems design. This system is composed by three interacting levels, linked by different vehicle fleets performing delivery operations:

- Primary facilities, also called depots: high capacitated facilities generally located far from the urban area, where freight is loaded on first stage vehicles.
- Secondary facilities, also called satellites: low capacitated facilities devoted to transhipment operations, in which freight arriving from primary facilities is transferred into smaller vehicles, referred as second stage vehicles, which perform the distribution to the final customers.
- Customers: End points of the distribution, which must be served by at least one second stage vehicle.

Given this structure, the 2-VRP consists in defining number and location of primary and secondary facilities, performs the allocation operations, i.e. assign each final customers to an open secondary facility, and each secondary facility to an open primary facility, satisfying capacity facility constraints, and solve the resulting routing problem, identifying how many vehicles, for each fleet, are used, by which vehicle each customer is served, and in which order the vehicle performs its deliveries. From a physical point of view, a General Two-Stage Capacitated Vehicle Routing system (G 2-VRP) operates as follows (see also Fig. 1):

- Freight arrives at an external zone, one depot, where it is consolidated into the 1st-stage vehicles, which constitute heterogeneous fleets.
- Each 1st-stage vehicle travels to a subset of satellites that will be determined by the model and then it will return to the depot.
- At each satellite, freight is transferred from 1st-stage vehicles to smaller, environmental friendly vehicles, belonging to 2nd-stage fleets (also heterogeneous).
- Each 2nd-stage vehicle performs a route to serve the designated customers, and then travels to a satellite (not necessarily its departure point).

The basic version of the problems is called Two-stage capacitated VRP (2-CVRP). This is the simplest version of multi-stage VRPs. At each stage, all vehicles belonging to that stage have the same fixed capacity. The size of the fleet of each stage is fixed and known in advance, and there exists an upper bound on the number of vehicle which can start from the same satellite. The objective is to serve customers by minimizing the total transportation cost, satisfying the capacity constraints of the vehicles. There is a single depot and a fixed number of capacitated satellites. All the customer demands are fixed, known in advance, and must be compulsorily satisfied. Moreover, no time window is defined for the deliveries and the satellite operations. For the 2nd stage, the demand of each customer is smaller than each vehicles capacity and cannot be split in multiple routes of the same stage. This problem can present several variants (Gonzalez-Feliu 2008; Mancini 2011, 2013a). Note that in more realistic situations, the basic version needs to be extended to a multi-depot, multi-carrier heterogeneous fleet case. In other words, more than one starting depot (corresponding to a CDC) is defined (Nguyen et al. 2012), and vehicles can be of different characteristics for the same stage (Gonzalez-Feliu and Salanova 2012). Moreover, more than one carrier can share platforms or even vehicles (Gonzalez-Feliu et al. 2010; Gonzalez-Feliu and Salanova 2012; Thompson and Hassall 2012). From those extensions of the basic version, other variants can be defined to include different constraints related to urban freight transport (Deflorio et al. 2012). More in details, variants may be grouped following a classification where we consider three main aspects: network and service features, and route limitations.

Route limitations are applied to one or more routes, on one or more stages. Two types of limitations can be considered, and are distance and time constraints. A 2-stage distance constrained VRP is a variant of the basic problem of the same family where one or more k-stages present maximum distance limits. These limits are expressed in terms of maximum distance that vehicles can travel, and they will be related to the vehicle's characteristics. This distance can be explained in terms or travel distance (in km), or in terms of travel time. In this second group of constraints, different factors like, times related to loading and unloading operations, and slack pauses can be considered, and represent the maximum time a vehicle can be on service, for maintenance, crew working hours and other reasons.

In network features variants, the main important problem should be the 2-stage multi-depot VRP. This problem, analogously to classical VRP, presents more than one depot, so the starting point of each 1st-stage route can be different to the others. In these problems, two main policies are considered. The first is that the freight type is the same for all customers and all depots have an enough quantity of freight to serve all customers. Analogously to MDVRP, in ME-MDVRP, freight requested can be assigned to one of the available depots. Additional constraints can be added to the depot availability, as for instance the depot capacity, time period for service (defined by the opening and closing hours which correspond to the limits beyond which it is not possible to arrive to the depot), but in all cases it is supposed that all customers can be assigned to all depots.

Service features variants refer to some aspects which the distribution service company offers in the transportation service. Two main families of variants are presented, analogously to classical VRP. The first of, and maybe the most important, due to time limitations, is the ME-VRP with Time Constraints. Several types of time constraints, which represent different temporal aspects of multi-echelon transport organization, can be considered. We will describe those which can be observed in most real applications where time constitutes one of the main factors describing the proposed service features.

The most common time limitation, analogously to classical VRP and distribution problems, is the Time Window (TW) in which the vehicle can visit a facility. The problem is called NE-CVRP with time windows (NE-VRPTW), and the TW are associated to nodes (usually, time limitations are not directly associated to arcs, but to customers or k-stage satellites, even if TW can also be associated to the depot). When the TW are associated only to customers, only the second stage follows VRPTW logics whereas for the first, time constraints will not influence it directly, but indirectly assuring that the freight arrives on time to satellites. When TW are associated to satellites, the complexity of the problem increases. This complexity increase can be directly imputed to connexion constraints between stages.

Other time constraints, which are more restrictive, are vehicle synchronization at satellites. In some real applications, satellites are not projected to store freight even for a small time interval, and vehicles cannot wait for a long time at satellites, waiting to be loaded or unloaded. We can formulate a problem that represents these cases, which can be noted as 2-stage Capacitated VRP with Satellites Synchronization (2E-CVRP-SS). In this problem, time constraints on the arrival and the departure of the vehicles at the satellites are considered. In fact, the k-1 stage vehicles arriving in a satellite unload their freight, which must be immediately loaded into a k-stage vehicle. These constraints can be of two types: hard and soft. In general, a small time interval, called synchronization margin T_s, is defined. In hard SS, every time a k-1 stage vehicle unloads its freight, k-stage vehicles must be ready to deliver it. This is represented as follows: k-1 stage vehicles cannot wait more than T_s, and this is expressed by a very restrictive pseudo-TW, which does not have a fixed EAT but, when a k-stage vehicle arrives at a k-stage satellite at a time t, the corresponding complementary k-1 stage vehicles must arrive at most at time $t' = t + T_s$, and vice versa. In soft SS, when k-1 stage vehicles arrive, if k-stage vehicles are not available, the demand is lost and a penalty is paid.

A more complex version which derives from Multi-depot 2-VRP but consider feature services which are different from time constraints is Multi-depot multi-request NE-VRP (MD-MR NE-VRP). This problem is only considered if freight can be merged at satellites. In this case, given a k-stage satellite, the freight coming from k-1 stage routes assigned to different depots can be merged or reorganized to put on the same k-stage vehicle freight with different origin depot and having to be delivered to the same customer. The main difficulty of this variant arises in the fact of selecting the k-stage satellites to merge the freight which allow to minimize the overall costs.

Another service feature policy represents services with Pickup and Deliveries (2-CVRP-PD). Pickup and deliveries, are not presented here, detailed surveys can be found in literature (Berbeglia et al. 2007; Parragh et al. 2008) but we can define three types of operations: in VRP with Backhauls vehicles first make all deliveries then they make a second route starting from the last customer and ending on the depot to make pickups; in VRP with Mixed PD a vehicle can, at a customer, even deliver, even pickup or both, but can also first deliver a customer, continue its route and return to customer for picking-up freight; in VRP with Simultaneous PD, vehicles must deliver then pick-up freight at each customer, without the possibility to return, so the vehicle must have enough capacity when visiting a customer to pick-up the corresponding freight after delivering it. In this case we can consider the satellites as intermediate depots to store both the freight that has been picked-up from or must be delivered to the customers. PD constraints are applied only to customers, satellites being organised as in basic versions (1st-stage vehicles deliver freight to satellites then 2nd-echelon vehicles pick up the corresponding goods from them), so the VRP-PD approach is applied only for the second stage.

A particular case of 2-VRP is obtained when considering a transportation system where taxi services are considered (2-VRP-TS). In this variant, direct shipping from the depot or a k-stage satellite to customers is allowed if it helps to decrease the cost, or to satisfy time and/or synchronization constraints, without passing through the rest of the stages.

3.2 Exact Methods

Exact methods seek to find the exact optimum of the entire system, i.e. to prove that the best solution found is optimal. The main limits of such approaches are of two types: first is a strong simplification of the mathematical models, that assume one depot and all satellites and vehicle fleets (for each stage) having the same capacity; second is that the instance solved by such methods are very small (up to 5 satellites and 50 customers, according to Baldacci et al. 2013). The first model of this type is found in Gonzalez-Feliu et al. (2007) and a small set of works propose methods to solve this problem. Branch-and-Cut (Jepsen et al., 2013) and Branch-and Price (Santos et al. 2013) allow to solve instances up to two satellites and 32 customers, although Jepsen et al.'s (2012) method obtains better results than the others. However, a recently proposed Branch-and-Bound method (Baldacci et al. 2013) is able to solve almost all instances up to 5 satellites and 50 customers. Such instances, introduced in Gonzalez-Feliu et al. (2007) and Mancini (2011) are available in the OR-library of Beasley (1990).

3.3 Systemic Heuristic Approaches

According to Gonzalez-Feliu (2013b), two types of heuristics are proposed to solve such problems. The first is that of systemic approaches that see the multi-stage transport problem as a whole system and the second includes methods that separate the problem into a set of sub-problems, one per stage, that are solved separately. Concerning systemic approaches, they need to deal with simplified problems, in a similar way than exact methods, in order to be deployed but allow finding near-optimal solutions for bigger instances, some of them being near to real size problems. According to Mancini (2013b) we can group those heuristics in different categories. We adapt this classification to city logistics problems.

First is that of construction heuristics, which aim to find initial solutions. In other words, such algorithms find a sub-optimal solution to the problem and stop once the first feasible solution is found. Although they are far from theoretical optima (10–25 % in average for medium size instances), they have the interest to be easy to understand and implement and be applied to very large instances (Jacobsen and Madsen 1980). The most used algorithms are the savings algorithm of Clarke and Wright (1964), often combined with allocation algorithms (Madsen 1983), cluster-first route second algorithms, mainly using greedy or semi-greedy algorithms (Gonzalez-Feliu et al. 2010; Gonzalez-Feliu and Salanova 2012). In the two last cases, multi-depot multi-stakeholder problems were solved, the first with homogeneous fleets per stakeholder, the second involving heterogeneous fleets.

Local Search (LS) algorithms are procedures that, starting from an initial solution (mainly found using a construction heuristic method), iteratively analyze a neighborhood surrounding S' in the solution search space (Aarts and Lenstra 1997). The neighborhood's exploration can be exhaustively carried out then the best solution in the neighborhood is taken as current best and the algorithm is restarted (Best Improvement) or the exploration can be interrupted immediately after an improving solution is found and immediately restarted from the new current best (First Improvement). Although LS is not directly used in many works, it is broadly and usefully applied as an intensification tool into a metaheuristic framework as Multi Start heuristics (Crainic et al. 2011) or combined with Evolutionary Algorithms in hybrid or mimetic heuristics (Xu et al. 2013).

The Greedy Randomized Adaptive Search Procedure (GRASP) is a multistart two-phase metaheuristic algorithm based on adapted greedy procedures (Resende and Ribeiro 2010). In a first phase, an initial solution is obtained using a greedy randomized procedure, whose randomness allows solutions in different areas of the solution space to be obtained. The second phase is a local search phase that improves these solutions. This algorithm is often hybridated with path-relinking post-optimization (Nguyen et al. 2012; Crainic et al. 2013).

Alternate Large Neighborhood Search (ALNS) is an iterative post-optimization algorithm (i.e. that needs an initial solution as input) that at every iteration, a number customers are removed by a destroy operator, put in a customer pool and then re-inserted by a repair operator (Hemmelmayr et al. 2012). Several local search operators are used, selected by a roulette wheel mechanism based on their past success. ALNS was first developed by Ropke and Pisinger (2006) for the pickup and delivery problem and adapted to two-stage transport systems by Hemmelmayr et al. (2012).

Last but not least, classical metaheuristic methods, like tabu search (Boccia et al. 2010) or simulated annealing (Zegordi and Nikbakhsh 2009; Wang et al. 2011) or variable neighborhood search (Schwengerer et al. 2012) are also used. For a more in-depth description of such methods applied to two-stage systems, see Mancini (2013b).

3.4 Decomposition Heuristic Approaches

An alternative to systemic approaches is that of decomposition methods that are based on a logical separation of the overall system into a set of connected sub-systems (in general, by assigning transport demands to satellites, then constructing 2nd stage routes to finally obtain the 1st stage routes). It is not very easy to identify all such works, since some of them do not show directly then multi-stage nature of transport systems, but a general separation method can be found in Crainic (2008) and Crainic et al. (2009). The main advantage of such methods is that they can deal with more specific aspects of urban distribution such ad dynamic travel times, access time windows or multi-trip systems, among others.

4 Socio-Economic and Practical Implications of Two-Tier Schemes

As shown above, two-tier city logistics systems can be an interesting approach to reduce transport cost. However gains on transport cost are not alone in ensuring the success of these schemes (Gonzalez-Feliu 2012b). Indeed, the socio-economic context has to be taken into account because the feasibility of multi-stage transport systems depends also on other factors (Gonzalez-Feliu 2013a). According to Gonzalez-Feliu and Morana (2011), three types of factors can be defined. The motivators are the factors that contribute to the development of a transportation system with cross-docking. According to Gonzalez-Feliu (2012b), four groups of motivators can be defined:

- *Performance motivators*, on an economic, environmental and value viewpoints. They are related to economic efficiency, the prestige of the partners, and image. Sustainable performance is an important element to be included in this category (Gonzalez-Feliu and Morana 2011).
- *Legislation and jurisprudence issues*, mainly related to collaboration but also to transactions and formal or informal sub-contracting.
- *Financial motivators*, related to funding mechanisms of such systems (Gonzalez-Feliu et al. 2013a). Those factors are still few studied but they can constitute key success factors if well identified and analysed, as shown in Gonzalez-Feliu and Morana (2011).
- *Relation motivators*, closely related to habits and inter-personal relations. When stakeholders have already been involved together in collaborative or cooperative schemes resulting on positive impacts on their logistics performance, collaborative transportation is more naturally taken into account than in cases where such conditions are not met. Moreover, non-competing and complementary companies are more concerned with these types of approaches in the absence of legislative or financial motivators.

The facilitators are the conditions and situations that have a positive impact on the daily operations of a multi-echelon transportation scheme. They are similar to those of collaboration and logistics partnerships (Lambert 2008). These factors are not only related to logistics organization but also to the evolution of the strategic planning relationships between partners. The boundary between motivators and facilitators is not always clear but, according to Gonzalez-Feliu (2012b), these two categories can be distinguished by the fact that motivators appear in strategic planning and facilitators at tactical and operational levels. Closely related to the facilitators are the limitations and obstacles that can impede the successful development of strategies concerning multi-stage transport systems (Gonzalez-Feliu and Morana 2011). Both facilitators and limitations can be couples and summarized as follows:

- *Commercial strategies*. Each enterprise has its own commercial interests, which are not the same for loaders and for transport operators. Although they are not a major source of conflict among producers, retailers and logistics operators, they can become an major handicap for transport operators. In fact, aggressive strategies and disregard for transport plans to help "friends" or customers have been identified by many transport operators as a brake on the development of collaborative multi-echelon networks.
- *Ownership and savings management issues*. Although at a strategic level the investment costs can be easily shared by partners, the benefits resulting from the tactical and operational management of the system are less easy to share if no solid contracts and agreements have been signed. Moreover, the ownership of the system of some of its parts (facilities, vehicles, crews) can be a factor of success or a main brake to the system's deployment.
- *Logistics strategies of each stakeholder*. More precisely, the potential or real changes that an organization based on a multi-stage system may introduce are a source of obstacles to its development, but can also be a catalyser in case of good adaptation of crews. A special attention has to be given to the *acceptability of organizational changes*, because it can lead to malfunctions, delays or employees' strikes and complaints liable to harm the image and reputation of the multi-echelon system.
- *Physical and organizational conditions for freight compatibility*. Some characteristics and conditions related to commodity like dimensions, freight, type of packaging, loading unit and the main characteristics of loading operations are important. These are not only related to legislation but also to organizational issues, equipment and habit.
- *Acceptability of organizational changes*, which also has to be taken into account when defining the main characteristics of a multi-echelon system. This can lead to malfunctions, delays or employees' strikes and complaints liable to harm the image and reputation of the multi-echelon system.
- *Responsibility and confidentiality*. The main transactions in freight transportation are regulated by several commercial contracts. Moreover, confidentiality can become an obstacle to multi-stage systems. Indeed, since information is the

base of good collaboration, if one or more partners manage confidential information that they do not want to share for competitive reasons, the efficiency of the system can be considerably reduced.

Furthermore, other factors have to be considered, like for example transport cost optimization is seen by loaders as a competence of the transport operator. Finally, it is important to note that multi-stage transport systems entail the participation of several operators, so that coordinated optimization is not easy to organize but can be the key of success is well-managed.

5 Conclusion

Urban freight data serves a wide range of uses and is extremely important in helping public and private sector decision-makers to ensure that urban freight transport takes place in as efficient and sustainable a manner as possible. Without such freight data, it is extremely difficult for national, regional and urban authorities to make decisions on issues including road space allocation and congestion, freight transport's role in energy consumption and air quality, safety and security issues associated with freight transport, modal shift, and land use planning.

The extent of urban freight data collection varies significantly between the European countries surveyed. In addition, even in countries with the greatest quantity of urban freight data, most of this is derived from the disaggregation of data collections that take place at a greater geographical scale than the urban area. Freight data is currently collected by a large number of different organizations including: national, regional and urban governments, other public sector bodies and agencies on behalf of these governments, as part of one-off studies and projects, and by private sector organizations including industrial, retail, service and transport companies, trade associations and market research companies. These urban freight data collection efforts are not currently co-ordinated, and this results in many different data sources and data sets that vary widely in quality and methodology, making comparisons and combinations of them difficult or impossible. Even in the countries in which the greatest quantity of urban freight data is collected, when all of this urban freight data is brought together, it still does not provide a comprehensive picture of the urban freight transport system. Instead, the picture provided is patchy and unreliable.

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Time Constraints: The Cost of Sustainability

Jesus Muñuzuri and J. H. R. van Duin

Abstract Time constraints imposed on the accessibility of delivery vehicles to the inner city centre are a commonplace policy in European cities, linked to sustainable mobility strategies and seeking to reduce congestion, parking problems and pollution in the most sensible area of the city. However, these time constraints also impose an extra cost on carriers, who are often forced to modify their routes or use more vehicles, thus reducing the efficiency of the system. We present and apply a VRP-based methodology to estimate these costs, which should be brought into the overall cost-benefit analysis of urban time constraint policies.

1 Access Time Restriction

1.1 Description of the Policy

City logistics policies are not very often the result of detailed analyses and evaluations. This is reflected in similar types of regulations repeated through the different cities regardless their characteristics, the same type of accessibility and load/unload policies, and the failure to recognize different types of urban distribution which require different types of regulations. Apart from copying regulation frameworks, however, cities do not share information, knowledge or cooperation,

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and the lack of national or regional bodies dealing with city logistics, as there exist for urban passenger traffic, is significant.

Still, the distribution of goods in urban environments is an everlasting problem for most municipalities (Dablanc 2007), and many different tools or solutions are available for them to improve the efficiency of the system (Muñuzuri et al. 2005). The use of these solutions to deal with urban logistics issues does not necessarily mean bigger benefits for logistic companies, but rather and attempt to better regulate and manage freight deliveries in urban areas. The ultimate objective is the reduction of the clash between the interests of logistic companies and those of other stakeholder groups (residents, workers, retailers, etc.) involved in urban mobility. And the usual outcome of this scenario in municipal regulations is a series of restrictions imposed on delivery vehicles, in order to reduce their effect on the overall urban congestion levels and parking problems.

In order to reduce urban freight traffic movements in towns, municipalities have a powerful policy measure in accessibility regulations, which establish when and how delivery vehicles may access the innermost areas of the city, which are usually the most congested ones but also the ones concentrating (at least in Europe) higher levels of commercial and business activities, and thus requiring higher amounts of goods and higher numbers of deliveries. For many years, access time window regulations have been seen as the most popular answer to avoid urban freight transport traffic inside the city centre.

Access time windows as a policy measure implies that a specific group of urban road users is only allowed to enter the city center, a specific area or a given street during a specified time interval. Outside that access time window, entering the specified area is not allowed.

These access time windows represent only additional accessibility regulations, and do not require any infrastructure or technology provision. Therefore, they constitute a very simple and cheap measure to implement. The objective of the time windows is assumed to be the avoidance of the collision of interests between different groups of stakeholders, namely freight carriers and the owners of cars who drive them to work or go shopping in the restricted areas. However, there are usually some negative side effects which are often not assessed previously to implementing this solution. The fact is that very often, due to access time windows, freight delivery vehicles are forced to enter congested areas during peak hours, thus worsening congestion and pollution problems. Therefore, when attempting to implement this solution, careful analyses and evaluation processes are required beforehand, to ensure that the negative effects do not outweigh the positive ones.

1.2 Different Policy Configurations

In Europe many municipalities have established the beginning o their access time windows to the city center at 6 o'clock in the morning, and its ending (and thus the

Fig. 1 A representative example of percentage of Dutch cities that allow access to their downtown areas at each time of the day (PSD 2002)

re-opening of accessibility) at 11 o'clock is more and more prevalent. Some cities have time windows associated to the use of load zones. In cities with access time windows, these limitations are also shown on load zone signals, but in some other cities the time windows in load zones are used instead of having access time windows to the city centre. Figure 1 shows graphically an example of a representative distribution of time window regulations among Dutch cities.

On the other hand, in most South European cities, deliveries are also allowed until 11 o'clock, although it is very common for shops to open around 10 o'clock (see Table 1). A change in the time windows is a long-time request of carriers, but no modifications have been introduced for years. The result is that carriers often have to disregard time window restrictions, caught between the need to make the delivery and the risk of getting a ticket. This is especially being the case in the afternoon, when access time windows usually remain closed until 5 o'clock, the time when shops normally open. Time windows are not habitual in small towns, but they are one of the most widespread policy measures in medium and large cities.

The importance assigned to the subject of urban freight distribution varies widely between municipalities. Basically they can be roughly divided into three categories:

- Municipalities with active policy attitude in the field of urban freight distribution, understanding that a well organized system of urban freight distribution can be a solution to other specific problems (e.g. accessibility, environmental zoning, descending town visits).

Table 1 Typical opening hours for different types of activity sectors

Sector	Southern Europe		Northern Europe
	Morning opening hours	Afternoon opening hours	Opening hours
Private companies	09.00 to 14.00	16.00 to 19.00	08.00 to 18.00
Banks and public administrations	08.00 to 15.00		08.00 to 16.00
Bars and cafés	08.00 to 23.00		10.00 to 02.00
Restaurants	13.00 to 17.00	20.30 to 23.00	12.00 to 23.00
Retailer shops	10.00 to 14.00	17.00 to 20.30	09.00 to 18.00
Supermarkets	9.00 to 15.00	17.00 to 21.00	17.00 to 22.00
Fresh food markets	8.30 to 15.00	–	08.00 to 15.00
Malls	10.00 to 22.00		08.00 to 18.00

- Municipalities that issue urban freight distribution on the agenda, but without urgency, because this type of problems is not viewed as urgent or relevant.
- Municipalities where urban freight distribution is not an issue because the present situation in the town does not imply significant problems.

Especially those municipalities with an active policy attitude have indicated that a town needs to have selective access restrictions to achieve a sustainable level of mobility, and thus make use of access time windows. However, there is a common paradoxical awareness that on the one hand standardization and objectification of the time-window regulations are needed to provide a clear answer to all logistics service providers involved. However, on the other hand there is general understanding that traditional time window policies should upgrade to a more differentiated access policy in order to gain more efficiencies in transport.

Some cities (their number has been slightly expanding) are experimenting with stretching the access time windows and therefore avoiding the artificial 'peak' in the urban freight deliveries at the same time. As an example of maximum stretching the time windows currently there are cities that use the 'silent' trucks developed in the PEAK-program (Logistiek.nl). The application of these trucks allows carriers to perform loading and unloading activities before the time windows close since the residents will not be confronted by noise. Customers of these systems can even receive evening and night deliveries. This means better distribution of supplies during the day and less congestion may occur. Shops must nevertheless have staff available to ensure that the goods can be unloaded, and municipalities must establish separate window times for silent trucks during the early morning and evening.

Regional approaches to coordinate urban distribution policy measures (as for example the GOVERA program in the Netherlands) have the intention to improve urban freight distribution at regional level in such a way that the sector will become more efficient and will lead to improvements for the municipalities by means of more efficient, safer and cleaner trucks. In close consultation with municipalities and logistics service providers, the possibilities for better matching the access time windows are investigated. The idea is to analyze, together with municipalities, the main urban corridors or freight, and possible deconsolidation options on the outskirts of large cities. This deconsolidation can occur from large trucks to smaller (electric) vehicles at specific outskirt cross-docking locations or urban distribution centers. Also, the identification of the main logistical corridors in cities can facilitate the movement of freight, and make distribution centers and supermarkets more accessible and flexible in their reception of goods. This way, companies become less dependent on access time windows.

In general, access time windows represent strong attempts to induce significant modifications in the city logistics system and in urban traffic in general, but they are likely to result in severe opposition from stakeholders whose interests have been damaged. Beyond their isolated consideration, access time window regulations should be well integrated with a well designed loading and unloading plan considering aspects such as accessibility, safety (shopping) environment, noise, and efficient use of space.

1.3 The Impacts of Access Time Windows Regulations

The introduction of access time window restrictions by local authorities responds to sustainability criteria, seeking to eliminate congestion and pollution from the central areas of cities during the most sensible time of the day. However, the analyses related to the introduction of these policies have failed to take into account an amount of relevant inputs (Seasons 2003). For instance, the extra costs imposed on freight transport companies, forcing them to use an increasing number of extra vehicles and to cover longer distances depending on the size of the restricted area and on the duration of the time window. Research has shown that a non-alignment and the frequent introduction of tight access time windows have a devastating effect on the logistics operations, cost and sustainability (van Rooijen et al. 2007). Indeed, the sustainability concept is usually a combination of social, environmental and economic sustainability (Richardson 2005), but while the social side of sustainability is guaranteed by these access time window policies, this is not the case of the other two sides, at least with respect to urban freight deliveries. Good policy practice in urban freight transport asks for a serious attention to the logistics supply at an early stage in the planning process. In this stage of the planning process ex-ante analyses of policy measures based on detailed cost-benefits-analyses (van Duin et al. 2008, 2010) can provide a good evaluation of the effects. However, we need to estimate the additional costs imposed on carriers by access time windows, so that they can be taken into account in the corresponding cost-benefit analyses.

Several studies (Groothedde et al. 2003; van Rooijen et al. 2007; Quak 2008) have focused on the effects of implementing access time window regulations. All these studies followed almost identically the methodology for cost distribution mapping described by Groothedde et al. (2003), consisting of four steps. The first step consists in identifying the (demand) market. The second step identifies the time windows and vehicle restrictions that retailers and shopkeepers have to deal with. The third step contains the optimization of the routes by means of Operations Research techniques and calculates the fleet-seize and the individual truck performances. The last step is calculating the total cost referred back to the individual load units.

Thus, Groothedde et al. (2003) calculated that the delivery of a roll cage for a (large) supermarket in an inner urban area with restrictions (i.e. access time windows and weight or length restrictions) on average costs 7.50 Euros, while such a provision in a village costs on average 5.40 Euros. Based on these calculations, the additional logistical costs for the Dutch supermarket sector as a result of access time windows and vehicle restrictions matched exactly 100 million Euros. Also additional costs were estimated for the entire Dutch retail trade, which amounted for 425 million Euros. All the data used in the analysis was obtained from 5000 stores representative in 9 different branches of the Dutch retail sector.

van Rooijen et al. (2007) examined the Dutch cities and simulate specific time windows to complement the previous study a number of policy options. Five practical policy options were investigated:

- abolition of time windows in towns with less than 50,000 inhabitants;
- regional coordination of time windows;
- a uniform window from 7:00 to 9:00 h in all municipalities;
- a uniform window of 7:00 to 1:00 p.m. h;
- a uniform window of 7:00 to 7:00 p.m. h.

The effect of these access time window regulations were calculated for various retail chains in 4 sectors: supermarkets, department stores, drug stores and electronics shops. In the reference run the time window lasted on average 4.7 h a day for a municipality. The results showed that a uniform extension of time windows gives the best results. An average extension of the time windows of about 1 h in all municipalities gave more than 2 % reduction in vehicle kilometers and 6 % fleet reduction. These savings were roughly the same as if the time windows in the smaller municipalities would disappear. In case all municipalities had no time window regulations the savings in vehicle kilometers went up to 4 %, while the savings on fleet-seize grew to a substantial level of 23 %. The benefits of night distribution were also examined and showed a saving of almost 17 % of the total fleet. Surprisingly the savings on the number of vehicle kilometers by night delivery remained zero. The conclusion was that a uniform extension of time windows gave the best results (van Rooijen et al. 2007).

Finally, Quak (2008) examined in detail the effectiveness of broadening time windows. He compared the scenario of current access time windows in the Netherlands, fees and other access restrictions, with a softer regulation scenario with longer access time windows, between 7 and 11 h. The analysis concluded that the current scenario leads to a cost increase between 12 % and 38 %, whereas the modified situation, applying time windows from 7:00 to 11:00 a.m., lead to a total cost increase of 8 %. Also, the initial situation led to 4 % more CO_2 emissions, with the softer access time window scenario only caused a 2.5 % increase with respect to the no-restriction case.

2 The Vehicle Routing Problem with Access Time Window

2.1 Problem Formulation

Operations Research techniques have been increasingly applied over the last years to deal with planning problems related to urban freight deliveries (Crainic et al. 2004). More specifically, the optimization of vehicle routing in cities, due to its specific characteristics, has usually been associated with the time-dependent vehicle routing problem (Malandraki and Daskin 1992; Donati et al. 2008), real-time dynamic vehicle routing (Gendreau et al. 1999; Fleischmann 2004) or a combination of both (Chen et al. 2006). Also using a case-study analysis, Figliozzi (2010) assessed the influence of urban congestion on the cost of freight vehicle tours. Finally, the aforementioned works by Groothedde et al. (2003), van Rooijen et al. (2007), Quak (2008) and Deflorio et al. (2012) applied VRPTW techniques to assess the influence of access time windows, often considering a multi-town environment.

However, when considering a single town with many customers, a specific development is required. We will show that the characteristics of the routing problem that delivery companies have to face when operating in a city with access time windows does not correspond purely to a classical VRPTW formulation, and the cost estimations calculated through the application of VRPTW techniques are approximations to the exact evaluation provided by the Vehicle Routing Problem with Access Time Windows (VRPATW).

When formulating the VRPATW, we consider our vehicle routing problem defined on a graph: $[N, L]$, where N is the set of nodes and L is the set of links communicating them. The set of nodes N contains one node d with a positive level of supply (depot), a subset C of nodes with a positive level of demand (customers), and another subset $\overline{C}$ of nodes with zero levels of supply and demand, so that $N = \left(C \cup \overline{C}\right) \cup d$. A number V of vehicles (where V is a variable) will travel through the graph visiting all the different customers, only one vehicle per customer. We do not consider capacity restrictions on vehicles, which is a realistic assumption in the case of less-than-truckload urban freight deliveries, where vehicles are rarely full.

The problem is defined inside a predefined time horizon, corresponding to the day's working hours, and the objective is to minimize the number of vehicles that need to be used and the cost (in time units) of transporting goods from the depot d to the nodes of C, crossing along the way the necessary nodes of the subset $\overline{C}$.

We also define a set T of time costs associated to the different links in the graph. These costs depend only on the transit of vehicles through links, and not on the amount of freight carried by those vehicles. In general, we will incur in cost t_{ij} when travelling from node i to node j. We will also compute the unloading time at each customer as a time cost h, incurred every time a vehicle visits one of the customer nodes contained in C.

Within the set of nodes N, we also consider a subset RZ of nodes that correspond to the restricted zone, and which cannot be crossed or visited during a pre-specified closed time window period (CWT), which period will obviously be smaller than the overall time horizon. We asume that $C \cap RZ \neq \emptyset$ and that $\bar{C} \cap RZ \neq \emptyset$.

A schematic description of the problem is shown in Fig. 2.

Before describing the different situations that have to be considered in the routing process, we define here the concepts and terminology involved. For example, with respect to the time window:

t_{VC} = Window closing time, that is, the instant when the time window restriction starts operating.

t_{VA} = Window opening time, that is, the instant when the time window restriction ends.

With respect to the time horizon, linked to a full day or rather the business hours of a given day, we define:

t_o = Starting time for the day.

t_f = End-of-day time, when the business hours end.

All these instants are represented in the timeline shown in Fig. 3.

The cost h models the fact that the vehicle, when visiting a customer, needs to spend a given amount of time unloading the goods and making the final delivery. This is why we distinguish a time of arrival and a time of departure for all the nodes in subset C for the analysis and interpretation of the problem. The terminology used is as follows:

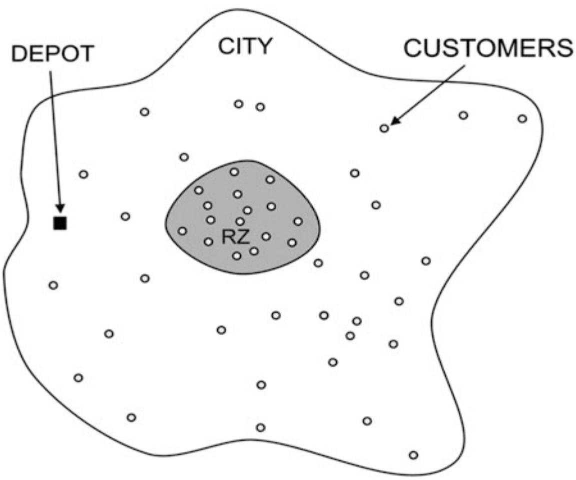
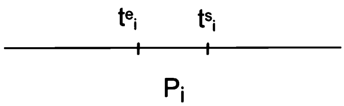


Fig. 2 Schematic representation of a city where a VRPATW applies

Fig. 3 Timeline showing the start and end of the time horizon, and the start and end of the time window access restriction

Fig. 4 Representation of the times of arrival and departure at customer i in a vehicle's route



t_i^e = Arrival time to customer i for the vehicle visiting that customer.

t_i^s = Departure time from customer i towards customer $i+1$, with $t_i^s = t_i^e + h$.

Going back to the timeline in Fig. 4, we have represented these two times, with Pi representing customer or stop i in the route of a vehicle.

2.2 General Case Analysis of the VRPATW

After defining the problem, the time window, the restricted zone and the related terminology, we now proceed to analyze the different cases that may arise when calculating vehicle routes. Starting with the general scenario of a vehicle moving from one customer to the next one until the end of its route, we will describe those cases, their interaction with the time window and the restricted zone, and what should be the reaction of the algorithm in each one of them.

2.2.1 Case Description

If a vehicle has to visit a determined sequence of customers, the default situation establishes that it starts its route at the depot at the starting time of the day t_o. Then, at every customer that is visited, we calculate the corresponding arrival and departure time, but we also need to take into account whether the customer in inside the restricted zone and, if so, whether the time window is open or closed. If no restrictions affect the displacement, the process continues with the following customer in the sequence, until all the customers have been visited and the end of the day is reached for the vehicle. The process is the same for all the different vehicles introduced in the routing planning.

However, if any restriction related to the time window could affect the visit to a given customer in the route, additional considerations must be introduced. These

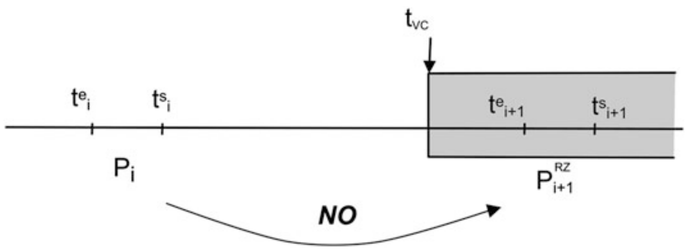


Fig. 5 Representation of the entry to the restricted zone when the time window is closed

considerations, and the procedure followed in each case, are described in the following sections.

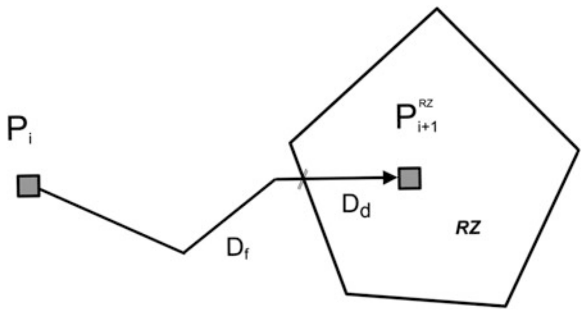
2.2.2 Entering the Restricted Zone

This is the case of traveling from customer i, located outside of the restricted zone *RZ*, to customer $i + 1$, located inside. Several different situations can appear in this case, depending on whether the time window is open or closed. If the time window is open at the time of arrival at customer $i + 1$, t^e_{i+1}, the procedure is identical to the general case, since the time window does not affect the displacement.

However, if the time window is closed at t^e_{i+1}, the displacement is unfeasible (see Fig. 5), and the distance (in time units) covered between both customers' needs to be divided (see Fig. 6) into D_f (distance covered outside of the restricted zone) and D_d (distance covered inside the restricted zone).

In this case, the vehicle needs to wait at the previous customer until the time window opens again and it can access the restricted zone. If that previous customer is not located inside the restricted zone, the instant of arriving at customer $i + 1$ is moved forward, making t^e_{i+1} equal to $t_{VA} + D_d$ (see Fig. 7). This synchronizes the instant of entering the restricted zone with the instant when the time window is open again, thus guaranteeing that the vehicle is never inside the restricted zone while the time window is closed.

Fig. 6 Distances covered inside and outside the restricted zone when travelling between customers i and $i + 1$



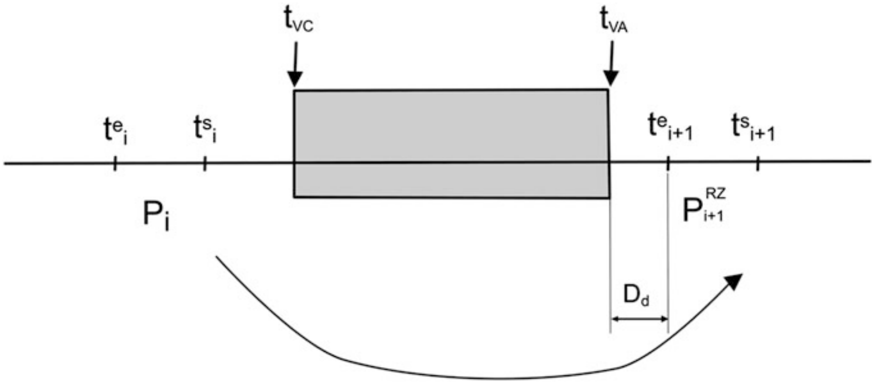


Fig. 7 Readjustment of the arrival time to customer $i + 1$ in order to ensure that the vehicle is not inside the restricted zone while the time window is closed

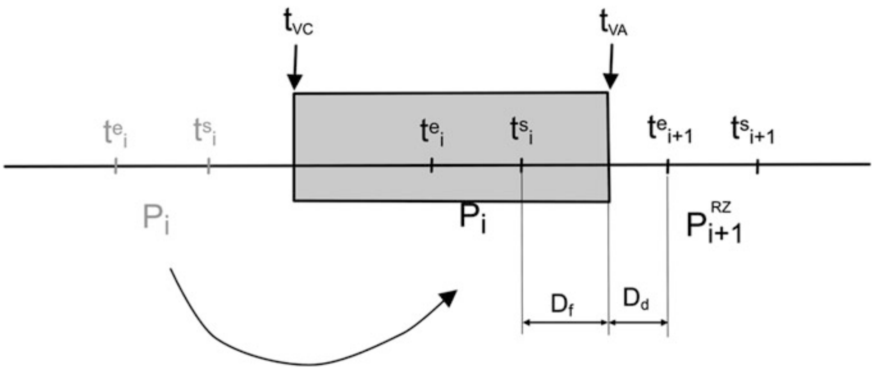


Fig. 8 Readjustment of the arrival time to customer i as close as possible to the new arrival time to customer $i + 1$

Next, and seeking to reduce the overall route duration, the arrival time to the previous customer i also needs to be revised, moving it forward as close as possible to the new arrival time to customer $i + 1$. This mechanism is represented in Fig. 8.

This readjustment can in turn result in different scenarios in case the customers visited before customer $i + 1$ are also located inside the restricted zone. In that case, the route planning procedure needs to do the following:

Revise backwards until the first customer located outside the restricted zone. This is the reference customer (P_{ref}), where the vehicle is able to wait until the time window is open again.

Move back the group of customers located inside the restricted zone (P^{RZ}), to visit them after the time window opens (see Fig. 9).

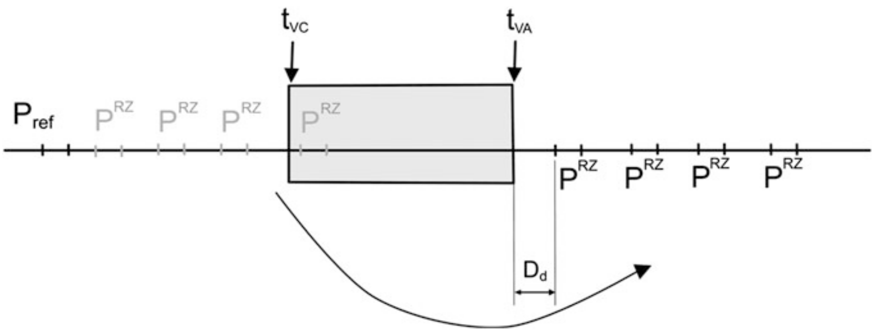


Fig. 9 Readjustment of a group of customers located inside the restricted zone (PRZ) to visit them after the time window is open again

This operation, depending on the number of customers rearranged, might cause the last ones of them (up to customer $i + 1$) to be assigned arrival times after the end of the day *tf*. In that case, the route will be completed only with the customers that can be visited inside the time horizon, leaving the rest of them to be incorporated in the next vehicle's route.

The visit to the reference customer will also have to be moved back, together with the customers visited before it, in order to reduce the overall route time. In this process, if the customer visited before the reference one is located inside the restricted zone (see Fig. 10), the visit time to all the customers, including also the depot, must be moved back until $t^e_{P_{ref}} - D_f = t_{VC}$. On the other hand, if before the reference customer the vehicle has to visit other customers located outside the restricted zone, they can all be moved back as far as possible, keeping outside the closed time window period only those located inside the restricted zone (see Fig. 11).

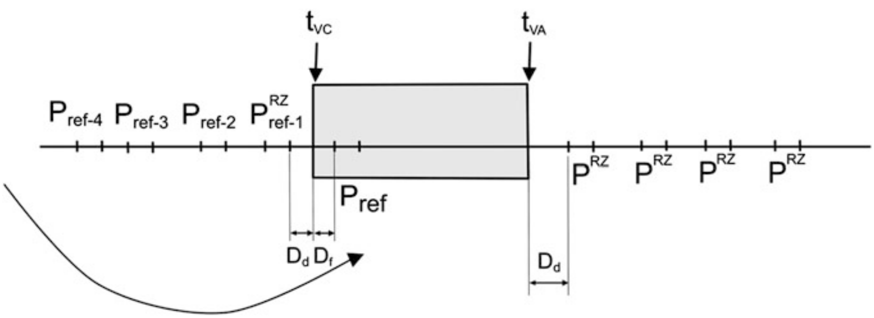


Fig. 10 Readjustment of the reference customer when it is preceded by another customer located inside the restricted zone

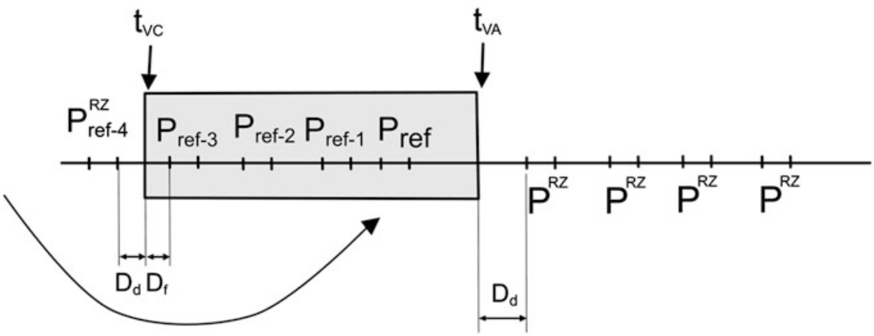


Fig. 11 Readjustment of the reference customer and the previous customers until reaching a customer that is located inside the restricted zone

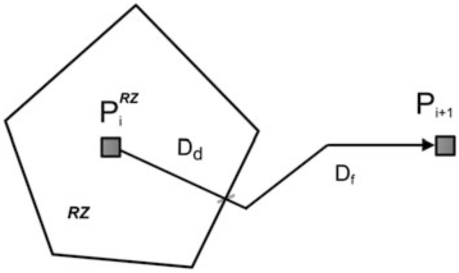


Fig. 12 Illustration of the displacement between a customer located inside the restricted zone to another one located outside

2.2.3 Leaving the Restricted Zone

If the vehicle is now traveling from customer *i*, located inside the restricted zone, to customer $i + 1$, located outside, we can again distinguish between two parts of the trajectory, one inside the restricted zone (D_d) and the other one outside (D_f), as shown in Fig. 12.

The possible cases to contemplate now, depending on the time window, are very similar to the previous scenario. For instance, if the time window is open when reaching customer i + 1, the displacement follows the general case procedure, as shown in Fig. 13.

However, the time window may close on the vehicle during the displacement, which happens when the vehicle leaves the restricted zone after t_{vc}. For instance, the displacement depicted in Fig. 14 is valid, and is treated like the general case, whereas the one in Fig. 15 is not.

In this unfeasible case, the procedure needs to readjust the arrival time to customer *i*, moving it back until the time window is open again (see Fig. 16). Then, like in the previous scenarios, all the customers visited before I and which are not located inside the restricted zone would also be moved back in order to visit them while the time window is closed and thus save time in the overall route.

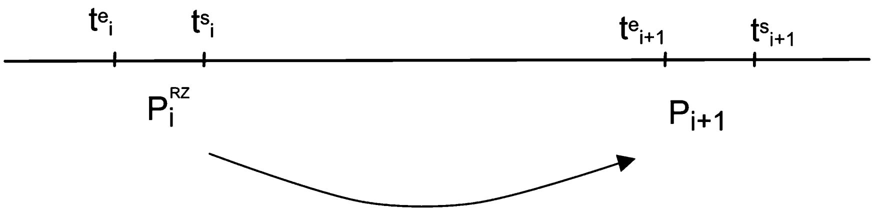


Fig. 13 Exiting the restricted zone while the time window is open

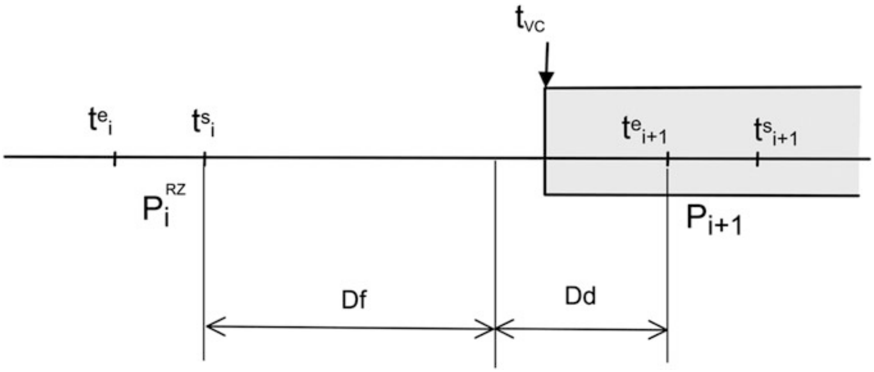


Fig. 14 Feasible displacement, since the vehicle leaves the restricted zone before the time window closes

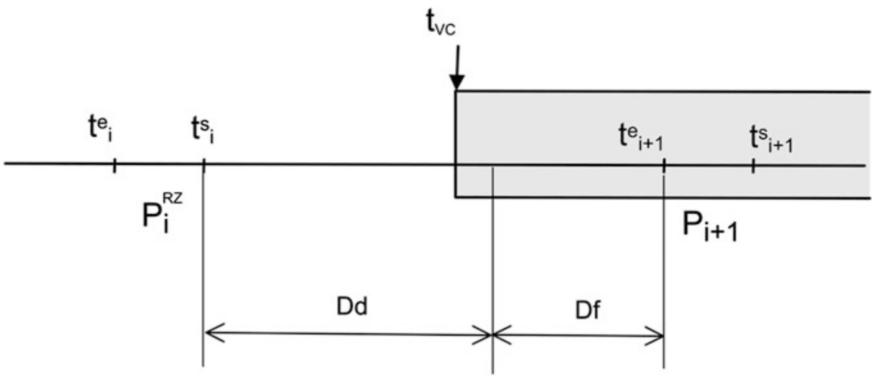


Fig. 15 Unfeasible displacement, since the vehicle would leave the restricted zone after the time window closes

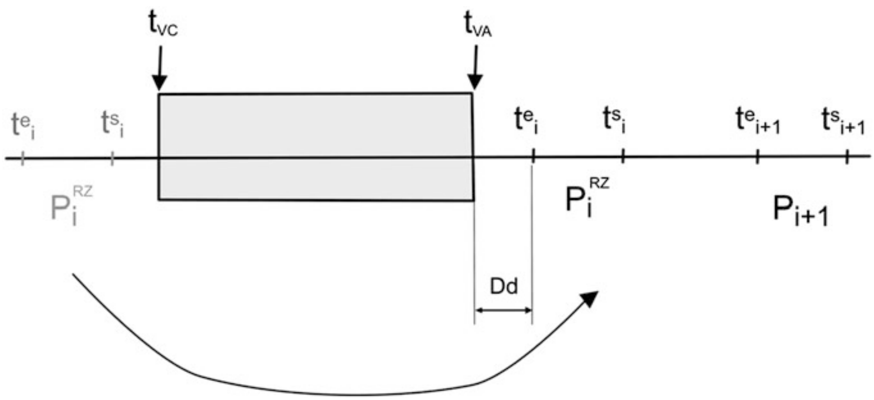


Fig. 16 Readjustment of the arrival time to customer *i* as close as possible to the re-opening of the time window

2.3 Genetic Algorithm Solution Procedure

We developed and implemented an algorithm to solve the VRPATW, based on the sequence of stops provided by a basic Genetic Algorithm, built according to the design shown in Fig. 17. The operators of this GA can be briefly described as follows:

Crossover: built according to the evaluative procedure proposed by Uchimura and Sakaguchi (2002).
Mutation: random selection and exchange of two stops in the sequence.
Probabilistic selection: assigning a probability of survival linearly distributed between 0 and 1 depending on the fitness of the individual (which depends on the total number of vehicles used and the total duration of the routes).
Population restart: when the best fitness value is less than 5 % below the average fitness value, keeping only the three best individuals of the population.

The stopping criterion is only associated to the number of iterations.

The rest of this section describes the procedure to calculate the fitness of a given individual (a sequence of customers to visit), which is based on the discussion of the different routing situations in the previous section. The flowchart of this fitness function is shown in Fig. 18.

The fitness calculation starts with the sequence of customers provided by the GA and an empty route associated to the first vehicle. For each customer *i*, the procedure is as follows:

If customer *i* is not located inside the restricted zone, the procedure enters block N. This block explores the previous customer $i-1$ in the route and, in case it was located inside the restricted zone, determines whether the time window closes in the process of traveling from $i-1$ to *i*. Should this happen, the procedure modifies

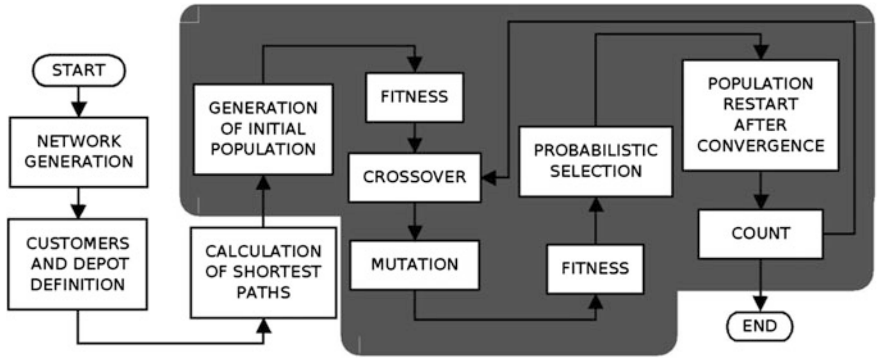


Fig. 17 General structure of the genetic algorithm used

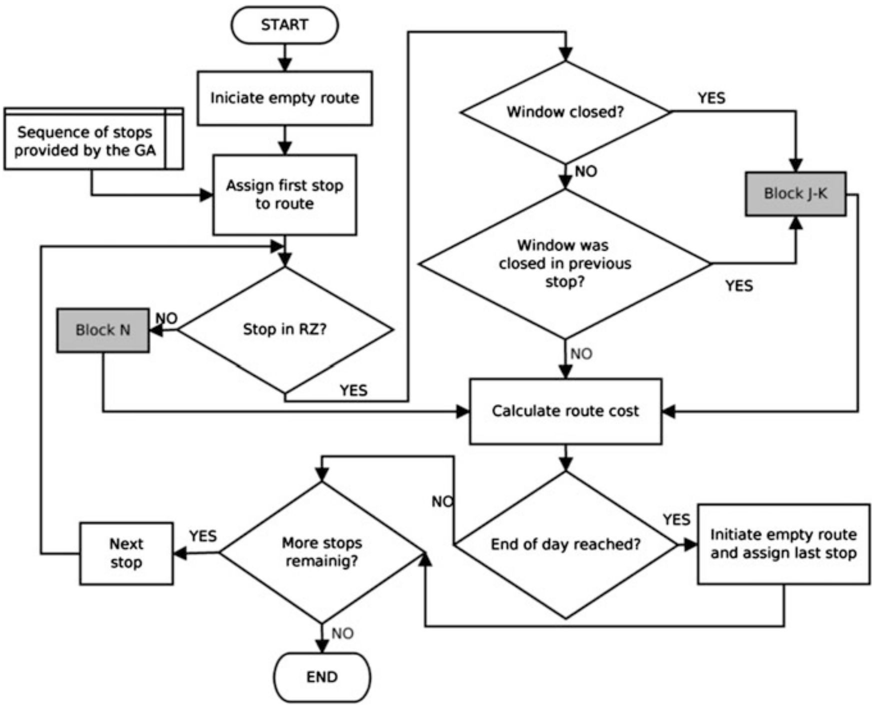


Fig. 18 Procedure implemented to calculate the fitness of an individual provided by the genetic algorithm

the arrival time at the customers visited before i, as shown in Sect. 3. The overall route cost is then incremented accordingly after the introduction of customer i.

However, if customer i is located inside the restricted zone, the next question is whether the time window is closed when the vehicle entered the restricted zone.

If so, the procedure enters block J-K. This block explores the previous customers in search for those also located inside the restricted zone. It then readjusts those customers in the restricted zone to be visited after the time window opens again, and the ones that are not inside the restricted zone to be visited during the closed window period, as described in Sect. 3. If, on the other hand, the time window is open during the displacement, the procedure simply updates the overall route cost after the introduction of customer *i*.

The last calculation determines whether the time horizon has been covered with the last customer's introduction or because of the readjustment of arrival times due to their interaction with the time window. If it has, the procedure starts a new route with a new vehicle, and assigns its first stop to the first customer that could not be incorporated into the previous route. Otherwise, the procedure moves on to the next customer, as long as there are customers remaining in the sequence waiting to be assigned to routes.

Once all the routes have been determined, the fitness value is equal to the sum of all the route durations plus the sum of the fixed costs associated to the number of vehicles used.

3 Case Study Application

After calibrating the Genetic Algorithm using a series of specifically designed test problems, we applied it to a case study analyzing the deliveries of a transport company operating in the Spanish city of Seville, transporting less-than truckload deliveries to between 50 and 150 customers daily. Many of these customers are located inside or near the city center, and the company's operations are greatly affected by the access time window restriction imposed by the local authorities. In order to prevent high pollution levels and to avoid their interaction with passenger flows and with tourists visiting the monuments located there, accessing, or remaining in, the centre is forbidden for delivery vehicles between 12.00 and 16.00 every day. And, within an intense campaign of pedestrianisation and promotion of clean transport systems like bicycles, the local authorities are considering to extend these forbidden hours, and even to extend the restricted area on which the access time window is applied. But no actions have been taken towards evaluating the effect of these policies on the costs of transport operators in the city.

Figure 19 shows the distribution of the nodes composing the metropolitan area of Seville, and which conform the VRPATW graph. When solving the problem, we assumed that the company could count on a number of vehicles sufficient to make all the deliveries, and also that the capacity of these vehicles did not impose any restriction whatsoever on the solutions, corresponding to the real case, where the company is permanently striving to increase its load factors. We also assumed a 20 km/h speed for the vehicles, a 20 min unloading time at each customer, and a time horizon of 10 h, representing the daily operation hours of the company's fleet. The company's depot is located in one of the industrial areas in the outskirts of the

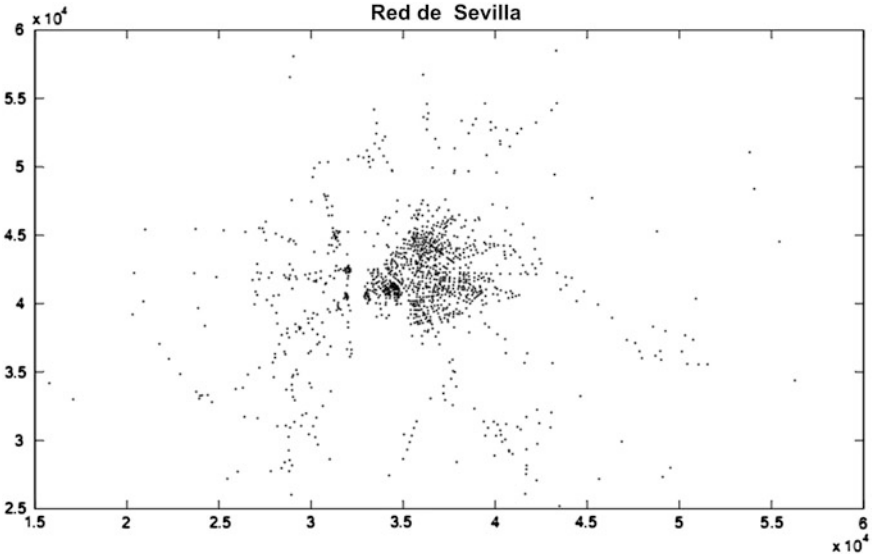


Fig. 19 Nodes in the network of the Seville metropolitan area

city, and all the delivery vehicles start their routes there and have to return before the end of the day. The fixed cost applied from the second vehicle onward was assumed to be equal to 8,000 min.

We designed and solved 30 problems with different values of the number of customers (40, 100 and 150), the size of the restricted zone (considering no restricted zone or ZN equal to 2—the current scenario—5 and 9) and the length of the time window restriction (TW = 2, 4 and 6). For each number of customers, their location is always the same, varying only the size of the restricted zone and the length of the time window.

Table 2 shows the results for the different problems. Each problem was solved twice, with the A and B parameters of the GA equal to 2 and 6 respectively, but using two different values (0.1 and 0.5) for the probability of mutation. For each problem, we have represented the best value of the fitness, the total number of hours in the delivery routes and the number of vehicles used. Represented in bold are the best values obtained in each case.

This case study provides several interesting findings:

- The scenarios with the current size of the restricted zone (RZ = 2) show small cost increments with respect to the base (no-window) scenario, but these increments grow larger as the length of the time window (TW) increases.
- The scenarios with RZ = 5, corresponding to the size of the restricted zone that is currently being considered in Seville, do show significant differences with respect to the base scenario. As expected, these differences increase with the length of the time window.

Table 2 Results of the experiments solved for the case study in the city of Seville

	N° Stop	RZ	TW	Exp. 1			Exp. 2		
A				2			2		
B				6			6		
TM				0.1			0.5		
				Fitness	Hours	Vehicles	Fitness	Hours	Vehicles
P1	40	0	0	**964.06**	**60.78**	**7**			
P2	40	2	2	**858.60**	**54.13**	**6**	878.21	55.37	7
P3	40	2	4	**919.79**	**57.99**	**7**	927.35	58.47	7
P4	40	2	6	**957.15**	**60.35**	**7**	972.87	61.34	7
P5	40	5	2	**1136.34**	**71.64**	**8**	1137.70	71.73	8
P6	40	5	4	1042.66	65.74	7	**1034.77**	**65.24**	**7**
P7	40	5	6	1113.20	70.19	8	**1109.03**	**69.92**	**8**
P8	40	9	2	**1240.00**	**78.18**	**9**	1244.59	78.47	9
P9	40	9	4	1142.52	72.03	8	**1141.02**	**71.94**	**8**
P10	40	9	6	1114.21	70.25	8	**1107.29**	**69.81**	**8**
P11	100	0	0	1148.96	72.44	8	**1148.58**	**72.42**	**8**
P12	100	2	2	1194.10	75.29	9	**1057.12**	**66.65**	**8**
P13	100	2	4	1043.97	65.82	8	**1040.43**	**65.60**	**8**
P14	100	2	6	**1120.56**	**70.65**	**8**	1075.73	67.82	9
P15	100	5	2	**1109.25**	**69.94**	**9**	1141.66	71.98	10
P16	100	5	4	1190.84	75.08	12	**1188.22**	**74.91**	**12**
P17	100	5	6	2249.41	141.82	25	**2017.52**	**127.20**	**24**
P18	100	9	2	1497.19	94.39	11	**1479.29**	**93.27**	**11**
P19	100	9	4	**2329.89**	**146.90**	**18**	2358.94	148.73	18
P20	100	9	6	**4196.02**	**264.55**	**30**	4488.67	283.00	33
P21	150	0	0	1815.24	114.45	13	**1787.68**	**112.71**	**13**
P22	150	2	2	1745.11	110.03	13	**1626.33**	**102.54**	**12**
P23	150	2	4	1751.48	110.43	14	**1702.51**	**107.34**	**13**
P24	150	2	6	**1825.09**	**115.07**	**15**	1863.49	117.49	15
P25	150	5	2	1824.10	115.01	15	**1767.30**	**111.42**	**14**
P26	150	5	4	1955.58	123.30	18	**1953.94**	**123.19**	**18**
P27	150	5	6	3101.77	195.56	34	**3081.31**	**194.27**	**33**
P28	150	9	2	2013.62	126.95	17	**1974.27**	**124.47**	**17**
P29	150	9	4	**2708.25**	**170.75**	**25**	2828.70	178.34	25
P30	150	9	6	5947.08	374.95	46	**6170.43**	**389.03**	**45**

Bold values correspond to the best known solution for each instance (either Exp. 1 or Exp. 2)

- The influence of the RZ and TW parameters are larger when the number of customers is larger, despite the possibility of having more options to configure near-optimal routes, entering and leaving the restricted zone, when the number of customers increases.
- The scenarios with RZ = 9 show a large increase in the number of vehicles required in the fleet, which represents overall cost increments of up to 400 %.

- The scenario with RZ = 9 and TW = 2 shows better results than the scenario with RZ = 5 and TW = 6. This indicates that the influence of the length of the time window increases as the size of restricted zone grows.

Based on the results provided by the 30 scenarios analyzed in the case study, we can conclude that the VRPATW algorithm constitutes a sound technique to assess the introduction of access time window policies from the point of view of the extra costs imposed on carriers. We have shown the influence of the three parameters considered (number of customers to visit, size of the restricted zone and length of the time window) and the fact that a small increase in one of them does not significantly affect the results, but bigger increases in at least two of them causes relevant extra costs.

These conclusions cannot be considered obvious when these extra direct costs are neglected by local authorities when implementing access time window policies, while considering externalities like pollution, congestion or visual intrusion. The contribution of Operations Research techniques provides a powerful tool to evaluate these extra costs and incorporate them to the analysis.

4 Conclusions

Access time windows constitute a commonplace policy for local authorities to restrict the movements of delivery vehicles in central urban areas. They are easy and cheap to implement and to enforce, with the objective of avoiding the overlapping of peak hours for delivery vehicles and private cars. Thus, the social benefits of this type of policy are clear, reducing congestion, parking problems and noise peaks. However, there exist also a series of additional costs, which are imposed on carriers and which are often not brought into the picture. These costs are related to the need to use a larger number of trucks in the fleet and to make those trucks drive longer distances. The consequence is that a policy destined to reduce pollution and congestion might in the end be causing higher levels of pollution and congestion.

Therefore, a procedure to estimate those costs and distances is needed in order to incorporate the corresponding negative effects to the overall cost-benefit analysis. Previous estimation efforts have used the classical VRPTW approach, which enables the analyst to employ standard solution techniques and software packages. However, the vehicle routing problem with access time windows (VRPATW) is not so easily transformed into a VRPTW. In the latter, time windows are assigned to specific nodes (customers), while in the former it is a whole area of the network that is subject to those time restrictions, with the subsequent effect on routing and waiting practices. This is why our VRPATW development proves useful in the analysis of access time window policies, allowing city planners and transportation companies to determine the extent of the extra costs and distances imposed on carriers by those access restrictions.

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Urban Consolidation and Logistics Pooling

Planning, Management and Scenario Assessment Issues

Joëlle Morana, Jesus Gonzalez-Feliu and Frédéric Semet

Abstract In logistics and freight transport, collaboration and pooling are popular strategies, in practice, that remain less explored in research. In recent years, collaborative transportation and pooling have become urban logistics alternatives to classical urban consolidation centres, but remain in a developmental stage. This chapter proposes a framework for urban logistics pooling, strategic planning and ex-ante evaluation. First, the main concepts of logistics pooling and their applications to urban delivery services are presented. Then, an information systems-based framework for planning and evaluation is described, from which a set of indicators are identified. To illustrate this framework, a case study from a French urban logistics pooling system is proposed.

Keywords Urban logistics pooling · Freight transport · Supply chain management · Sustainability · Collaboration

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1 Introduction

The freight transport sector is a major source of employment and often plays an important role in the economic development of regions and the country. However, freight transport is also a disturbance-generating activity, due to congestion and environmental pollution, particularly in urban areas (Crainic 2008). In urban contexts, city logistics have been developed for more than fifteen years, providing solutions and methods to support public authorities as well as other stakeholders in urban freight transport planning and management (Taniguchi et al. 2001). One of the most popular solutions related to city logistics is that of urban consolidation centres (UCC). Because they are located near city centres, UCCs usually have significant costs related to real estate expenditure. Similarly, urban distribution systems based on consolidation also require extra support to ensure their economic continuity (Ville et al. 2012). For these reasons, UCCs in Europe are currently represented by only a few operationally cost-effective cases, most of them in Southern Europe (France and Italy).

Another solution is that of logistics pooling, analogous to car-pooling with the common use of logistics resources, whether material (vehicles, platforms), human (drivers, land operators) or conceptual (software tools, information). We have observed several projects dealing with urban logistics resource sharing in the last years, and most of them are still in the developmental phase (Gonzalez-Feliu and Morana 2011). Most of these projects aim at forming a semi-closed group of collaborators who share vehicles and platforms to reduce their logistics costs and the environmental hazards related to last-mile distribution in dense urban zones. Although several urban logistics pooling projects have been started in Europe, they remain at the conceptual level, and no experimentation or evaluation has yet been performed. The evaluation of a logistics system is important since the performance of the system will be assessed "ex ante" and will motivate public authorities to implement a pilot phase or deployment of these systems.

This chapter proposes a global study of urban logistics pooling, illustrating the different stages of planning, assessment and evaluation. First we present the main concepts of logistics sharing, focusing on urban freight consolidation, followed by a conceptual model for urban logistics sharing. Finally, the organizational model is validated via a case study.

2 Urban Consolidation and Logistics Pooling

Traditionally, urban freight transportation planning is carried out by the operating companies. In recent years, public authorities have started to get involved in the development of solutions to deal with the major problems of freight transportation in city centres: congestion, air pollution, noise and other environmental nuisances. Some of the most common measures taken by the authorities in different countries are restrictive policies, mainly regulation relating to parking and street access. In several countries, surveys and data collection activities have been performed, and some studies give elements of freight transportation analysis and organization for urban areas. These efforts are aimed at better understanding and quantifying these phenomena, and represent a first step in the development of a new discipline, called City Logistics or Urban Logistics by several authors. The main goals of City Logistics measures and projects are related to reducing congestion and air pollution rates, without penalizing business activities in city centres.

Several city logistics actions are organized around the concept of the urban consolidation centre (UCC), defined by Allen et al. (2007) as *a logistics facility situated in relatively close proximity to the geographic area that it serves (be that a city centre, an entire town or a specific site such as a shopping centre), to which many logistics companies deliver goods destined for the area, from which consolidated deliveries are carried out within that area, in which a range of other value-added logistics and retail services can be provided*. The first UCCs were private or semi-private initiatives in pursuit of economic and optimization interests. Later, environmental and social issues incited public administrations to develop such systems for urban goods distribution (Gonzalez-Feliu 2008).

In order to produce a European overview of UCCs we have selected the main experiments reported in the literature. In Table 1 we present a synthesis of the relevant experiments.

We can observe that only a few experiments are still operating (about 40 % of the total), and in many cases they need an important contribution from public authorities, in terms of both funding and organizational support.

Italy is the country with the largest number of planned and operational UCCs. Including Sienna's UCC in the latest developments of Cityporto's network of cities with UCCs, more than 15 UCCs have been planned in all. Most of them derive from public decisions and have an important contribution from public authorities regarding both regulation and funding. The main UCCs in Italy are linked to medium-sized cities, i.e. cities between 100 000 and 500 000 inhabitants, like Bologna, Genova, Ferrara, Padova, Parma, Sienna, Venezia-Mestre and Vicenza,. In the last 5 years, other small cities (from 10,000 to 50,000 inhabitants),

Table 1 Synthesis of the main European experiments

Country	Total number of UCCs	UCCs operational in 2010
Italy	16	10
France–Monaco	15	7
United Kingdom	15	3
Germany	13	5
The Netherlands	6	2
Sweden	4	2
Spain–Portugal	3	1
Switzerland	2	0
Greece	1	0
Total	75	30

like Frosinone and Aosta have started to develop such systems. The only cases of really big cities include Milan, where the public transport operator ATM used their bus depots and other facilities to propose an urban freight delivery system, and Naples, which set up a pilot project for an urban-regional rail distribution system. The city of Rome considered the idea of developing a UCC network (Crainic et al. 2004), although the project was stopped after the preliminary study. We note most of these experiments are financed by regional, national or European funds (mainly related to research and development programs). Most Italian UCCs benefit from strong support from public authorities. This support can take the form of financing for operational management (Venezia-Mestre, Ferrara, Genova) or regulations to increase the attractiveness of UCCs (Bologna, Modena, Parma, Vicenza). However, we found two particular cases where the contribution from public authorities was limited to general regulation not directly benefiting the UCC distribution system, but rather promoting green transport in city centres: that of Cityporto, a network of UCCs inspired by the successful experience of Padua (presented below) and the case of ATM in the city of Milan. The effort of the UCC in Cityporto Padova is considered one of the most remarkable Italian successes and will be presented in the next section. Concerning the UCC system in Milan (ATM developed a network of three urban platforms in Milan with a dedicated fleet of environmentally friendly vehicles), the system was operational between 2005 and 2008. It stopped because a major change in urban regulation forbade ATM to use the bus corridors for freight distribution.

The French UCCs have been developed on similar lines (we include the UCC of Monaco in this category for reasons of cultural and geographical proximity to France). Note that in this country, a National Committee for Urban Goods Transport was created in 1995 and is still operational,[1] facilitating the exchange and promotion of good practices. Three main development periods relating to UCCs can be defined:

- before 1995, several private experiments, like those of Paris or Aix-en–Provence (near Marseilles) were carried out, but stopped for reasons of cost-effectiveness or changes of strategy by the instigating companies;
- from 1995 to 2003, experiments were promoted by public authorities, mainly with funding similar to that provided in Italy and from the angle of "public freight service";
- after 2003, private and semi-private companies proposed last-mile distribution services to transport operators based on UCC or similar platforms, like La Petite Reine or Natoora, or big companies like Chronopost and Monoprix, which have developed distribution schemes using private UCCs.

In France, we can observe three types of UCC: city-based UCCs, which are related to an entire city or its historical centre (La Rochelle and Monaco are the two that still remain operational); area-based UCCs, more related to a

[1] For more information, see http://www.transports-marchandises-en-ville.org/.

neighbourhood and used by several companies without providing a public service (Bordeaux, Paris, Rouen) and private UCCs, like those of Chronopost and Samada-Monoprix (Paris), Colizen and La Petite Reine (several cities in France).

Germany has also developed several UCCs, but the existing experiments represent less than 40 % of the total number projected. This can be explained by the fact that German UCCs have generally been developed by consortiums of private companies, without public funding to support their construction and operational cost balancing, although research and development funds and regulatory support have been provided by the authorities in some cases. Indeed, German UCCs are an example of the absence of direct intervention by public authorities. This makes the number of successful UCCs lower than those in France or Italy, but with a stronger connection to the market and the business development of the transport operators concerned.

The German UCC success rate, lower than in France and Italy, remains however, higher than in countries like the United Kingdom or The Netherlands, for which support from public authorities did not suffice for operational logistics schemes, resulting in only a very small number of UCCs still functioning (about 20–30 % of the total number of projects). Other countries have also set up UCCs to a lesser degree, but the results are not encouraging, with only a 30 % success rate for all the UCCs initiated. It is noteworthy than in both cases, the UCC systems were supported by the public authorities, mainly in the form of strong regulation policies, but with less financial support than in France and Italy.

Other interesting cases have been observed in Sweden and Switzerland, with schemes similar to British and Dutch UCCs. The success rate is still low, but several lessons can be learnt from them. Finally, the remaining Southwest European countries (Greece, Portugal and Spain) are only starting to consider the question and follow the French and Italian initiatives. However, the problem of financial support to ensure UCC continuity is still an important obstacle to their development and assessment.

As most of these experiments show, a UCC needs major initial investment in terms of infrastructure, facilities and human and technical resources (including delivery vehicles), which are often supplemented by public financial support. This support is not always enough, as operational costs are not always covered by the overall income of the UCC. Moreover, transport operators still remain reticent about using UCCs under some conditions, because the schemes related to these logistics platforms suppose at least one additional transhipment. The main limits to using UCC systems are grouped in the following categories (Ville et al. 2012):

- *Legislation*. Although it can be seen as a factor favouring UCC development in many cases (restrictions on access to some areas of the city for non-UCC vehicles can help the development of UCCs), legislation can also be a limitation when related to freight compatibility, i.e. the norms and laws that forbid the loading of a vehicle with products of different sorts (for example dangerous goods, fresh food, waste, raw materials, etc.) or when dealing with competition laws that can limit the development of sharing approaches.

- *Organisation*. The physical and organizational conditions for freight compatibility can limit the development of a UCC. For example, the dimensions, type of packaging, stock unit and the need for specific equipment for loading and unloading operations will necessarily limit the cohabitation of two shipments on the same vehicle or consolidation platform. Another organizational factor related to the acceptability of transport carriers arises from the possible changes they will make in their distribution schemes.
- *Cost*. If a transhipment implies organizational change, it also supposes cost increases. Although some UCCs have found optimization schemes to reduce these costs and impute similar costs to the transport operators, the question is still controversial when planning and developing these platforms.
- *Responsibility*. The factors related to the transport operator's responsibility are strictly set out in the contract established between the different actors. If the collaboration between the partners and customers of UCC distribution systems abides by a contract or a charter where the questions of responsibility are well defined, it will not interfere with sharing. On the other hand, if these questions are not clearly specified in a contractual document, disputes related to ill-defined responsibility can lead to legal conflict.

The main issue for UCCs is to reach a cost-effective threshold that ensures the economic balance of the logistics facility. Imposing a unique UCC operator does not seem to be the most efficient solution, as shown by Gonzalez-Feliu et al. (2013), and other strategies have to be found. Collaboration is one of the most promising areas of study in supply chain management and has started to be applied to freight transport management. This collaboration can take place at different stages as shown below (Gonzalez-Feliu and Morana 2011):

- *Transactional collaboration*: the first stage of collaboration consists of the common coordination and standardization of administrative practices and exchange techniques, requiring information and communication systems.
- *Informational collaboration*: the second stage concerns the mutual exchange of information such as sales forecasts, stock levels and delivery dates. At this level, confidentiality and competition have to be taken into account in the sharing of information.
- *Decisional collaboration*: This category concerns different planning and management decisions (Crainic and Laporte 1997), and is divided into three stages:
  - *Operational planning*, related to daily operations.
  - *Tactical planning*, or middle-term horizon,involving decisions like sales forecasts, route configurations, inventory management and quality control.
  - *Strategic planning*, related to long term planning decisions such as network design, logistics platform location, finance and commercial strategies.

Logistics sharing and logistics pooling are specific forms of resource sharing (Gonzalez-Feliu et al. 2010). Although in a narrow sense the word "sharing" refers to the joint or alternate use of inherently finite resources, both material and immaterial, it can also refer to the process of dividing and distributing

(Gonzalez-Feliu and Morana 2011). According to Gonzalez-Feliu and Morana (2011), operational decisions are in general made individually. Tactical and strategic decisions can be made by different actors or groups, with different modalities:

- In *non-collaborative sharing*, the shared resources are managed independently by their users, without any direct interaction between them. The actors involved share infrastructures or vehicles, but each of them uses them for his own purposes, without simultaneous sharing.
- *Collaborative sharing with hierarchical decision-making* is a further step in collaboration where shared resources are commonly managed by their users. In order to manage and guide the collaboration, a hierarchy is established, through which the main decisions are taken by a manager or a small group of stakeholders, with the others expressing their opinion but not taking part in planning and management issues.
- *Collaborative sharing with non-hierarchical decision-making* is a more co-operative approach where all the users take part in the decision processes. Indeed, management can be sub-contracted or given to a third person, but all the stakeholders are directly and equally involved in strategic and tactical decisions.

In the first and the second types of sharing, strategic decisions are taken by a single decision maker. In the third type, these decisions are made by the members of a collaborative group of actors, under a partnership contract or some other type of agreement.

Sharing resources in freight transport is related to three main issues: vehicle sharing, infrastructure sharing and route sharing. Concerning vehicle sharing, the logistics organization is similar to that of car-sharing or bike-sharing systems for the transport of persons (SUGAR project 2010). Indeed, a freight vehicle-sharing system proposes a fleet of shared vehicles, and each user of the system can book and use a vehicle for their own purposes. In these systems, each user continues to follow an individual organization scheme in which vehicles are shared, but each user continues with his own transport schemes without merging them with those of other users. The second approach is that of platform sharing (Rakotonarivo et al. 2011), without necessarily requiring collaboration between users. These two issues have recently been studied in the literature (Simonot and Roure 2007; Gonzalez-Feliu and Morana 2011). The third, least studied system, is that of logistics pooling.

We can introduce freight transport pooling as the mutual and contemporary use of a vehicle by two or more actors, all of them being well informed and having direct influence on decisions concerning the relevant transport organizational aspects. Note that the use of a freight forwarder or integrated logistics provider (4PL, LLP) is usual in freight transport, but the responsibility and the decision making are relayed to a third party, who assumes the consequences. Indeed, in such transport and logistics schemes, the sender (or the receiver) hires a company that organizes all the transport- and distribution-related operations, involving other actors like transport operators and logistics providers. This company takes decisions and organizes all the distribution processes, the sender (or the receiver) being only a customer paying for a standard or personalized service. In logistics-pooling approaches, the decisions are not taken by one stakeholder alone, but by the group participating in the pooling operations. As with car-pooling, freight transport pooling involves deliveries with a common trip chain in their overall itinerary and follows the same principles of multi-echelon transport with cross-docking.

3 Planning and Management Issues in Urban Logistics Pooling: A Conceptual Model

As logistics pooling follows similar schemes, such as integrated supply chains, we can envisage adapting methods from supply-chain evaluation to estimate the effects of this form of collaboration from a sustainable development viewpoint. However, as several stakeholders are involved, current studies do not represent the specificities of pooling strategies in logistics planning and optimization. In the next section we propose a methodology from the current literature on supply-chain sustainable performance evaluation and review the recent literature on the subject. Then, we will illustrate our choice using a realistic test case applied to small retail grocery distribution.

Collaborative services with the common use of resources take place at the second stage of collaboration at the latest (see Fig. 1). For this reason, service-sharing management and planning have to be backed up by a good information system. Laudon and Laudon (2007) define the conceptual bases of such systems summarized as follows in the chart below:

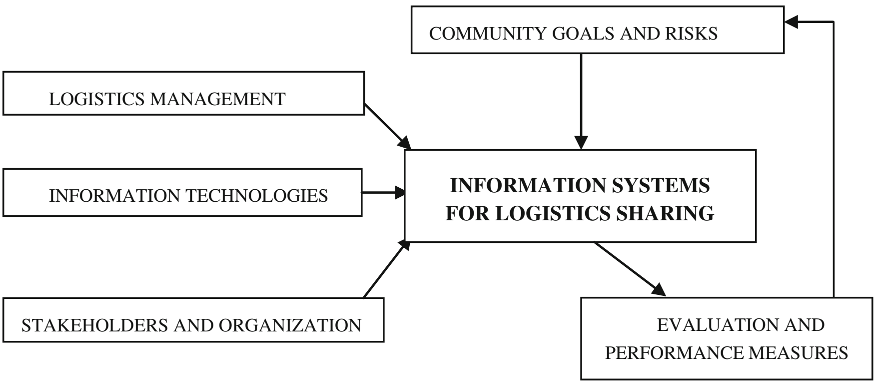

Fig. 1 Basic elements for the concep, design and management of an information system for logistics sharing (Gonzalez-Feliu and Morana, 2011, adapted from Laudon and Laudon 2007)

This conceptual model comprises five modules. The management-sharing module contains all the elements for the management of sharing services and collaboration. The information technology module contains all the ICT used in the proposed sharing solution. The organization module lists all the actors involved in the sharing solution, in both internal and external contexts. These three modules are related to tactical and operational decisions. The other two (i.e. the enterprise's challenges and solutions) belong to strategic planning.

3.1 The Goals and Risks of the Community

One of the first actions in project management is to define the main goals, expectations and risks studied in that project's preliminary development (Clerland and Ireland 2002). Considering the technologies and tools as well as the contexts for their use, several choices must be made in order to set up the optimal logistics-sharing services. It is therefore important to formulate questions related to the goals and risks of the project, and to find the most appropriate solutions .

Individual targets for a given group of stakeholders, as well as each specific context, must be taken into account in order to determine the goals to be attained. Consequently, the project's general objectives will serve to re-define individual goals and establish the principal targets at operational, tactical, commercial and strategic levels.

However, the main targets of logistics sharing and collaboration are related to the following incentives:

- Economic gains that can be obtained either by reducing costs or increasing efficiency (Crainic and Laporte 1997)
- Company quality, which is increased by better respecting lead-times and service quality standards in order to reach new markets and potential customers (Gonzalez-Feliu 2012a).
- Improved environmental performance, which will bring both new customers and the right of access to restricted zones or allow the continuation of certain practices respectful of environmental laws (Dablanc 2008)

After that comes the indispensable in-depth analysis of the possible risks that the project may encounter. The main types of risk to be considered in a logistics and transportation project (Seiersen 2006) are as follows:

- Risks related to the project accounting itself, more precisely to the different types of resource that can be affected to the project, in financial, economical, technical, technological or human terms.
- Risks related to the organization of the project and its continuity. It is important to note that the reorganization of a project can be considered only when it is already operative and stable.

- Technological risks. In general, the technological problems are chiefly related to functionality, robustness and compatibility. It is important to examine these questions before making any technological decision or choice.
- Risks related to policies, processes and current practices. The development and use of new logistics solutions may require an important change in the way people think and act to make them operative. Continuous social analysis during all the design and development phases seems crucial to the stability and success of very innovative solutions.
- Risks related to the impact of the systems in current and future operations, at both human and technical levels.
- Dependency risks. In an information system based on several technologies, the dysfunction of any one technology can impair the efficiency of the whole system or even bring it to a halt. These risks have to be studied in the preliminary phase of a project.

3.2 Project Targets, Evaluation Methods and Performance Measurement

This module includes the main objectives of the project and the evaluation of its performance (Laudon and Laudon 2007). Although at the end of the 20th century the notion of performance was basically related to economic indicators, the notion of sustainability is nowadays a central element in transportation and logistics planning and management. Sustainable development is at the conjunction of three spheres: the first deals with the economic aspects, the second contains the social and societal elements, and the third is related to the environmental challenges. In this context, a list of indicators has been defined. They are derived from an in-depth bibliographical analysis (Morana and Gonzalez-Feliu 2012). We report here the main indicators that should be considered when evaluating the performance of urban logistics systems. For the method and discussion of the retained indicators, see Morana and Gonzalez-Feliu (2012) (Table 2).

3.3 Stakeholders and their Involvement in Logistics Sharing

Several stakeholders interact along a supply chain in order to complete all the tasks necessary to first produce, and then distribute a given product to a given retailer. In this section, we will present the main categories of actors in logistics and their potential domains of sharing, focusing on the logistics of urban distribution. We will also list the main categories of actors in the freight transportation field that can be directly concerned by logistics sharing. Since a detailed description of urban logistics stakeholders are presented in the first chapter of this book, we propose a synthetic overview below.

Table 2 Main indicators for urban logistics sustainability

Economic indicators	
• Travelled distance	• Investment costs
• Vehicle load factor	• Operational costs
• Warehouse load factor	• Return on investment
• Vehicle load path	• Total travel time
• Number of parcels at warehouses	• Service rates
• Number of delivery points	• Delay respect rates
• Number of collection points	• Customer satisfaction rates
Environmental indicators	
• Greenhouse gases emission rates	• Noise rates
• Polluting gases emission rates (NOx, SOx)	• Road occupancy rates
• Solid particles emission rates (PM 10)	• Reverse flows rates
Social/societal indicators	
• Absenteism rates	• Employment creation rates
• Stress management rates	• Employment conversion rates
• Users acceptability	• Formation rates
• Inhabitant's satisfaction rates	• City's image estimation

First of all, we describe the "loaders" (Routhier et al. 2011), which are the actors that send or receive the freight. The producers of the different raw materials and components as well as the final product manufacturers, the logistics providers, the distribution and gross commerce enterprises, and then the retailers all fall into this category. These actors can be considered as "senders", if they act at the origin of the transportation process, or "receivers" if they are at its destination. Another important category concerns the "transporters". These transporters may be the "loaders" that perform self-transport operations, or the third-party transportation companies (Ambrosini and Routhier 2004). These companies may be artisans that have only one vehicle, small and medium enterprises or big companies and multinational groups, as well as postal and courier operators, and not forgetting integrated logistics solutions providers like TNT, DHL, FedEx and UPS, among others. A third category concerns the logistics real estate actors, that are the "owners and management companies" of warehouses, cross-docks, intermodal platforms and other logistics infrastructures. Finally, in this classification certain other actors are not taken into account, like public administrations, highway companies and customs operators, because as logistics sharing partners they are far less involved and much less important when compared to the three main categories.

3.4 Logistics Pooling in Supply Chain Management

In supply chain management, we observe sharing approaches in different processes, involving both production and distribution sub-chains. More precisely, when focusing on distribution, we can distinguish two main domains of application: the activities complementary to transportation, for example, warehousing or supplying, and the transportation itself. We will briefly describe the main organizational models of sharing in both fields. Since the Anglo-Saxon definition of vertical and horizontal structures of supply chains (Lambert et al. 1998) differs from the French vision (Becker 2003) and does not define the same terms, we will use the terms of longitudinal and transversal collaboration.[2] Longitudinal collaboration is defined by Becker (2003) as the *common process management in a supply chain by sharing complementary knowledge and resources in order to efficiently use synergies for planning, deployment, operation follow-up and control*. In longitudinal collaboration, three main schemes can be found:

Efficient Consumer Response (ECR) can be defined as a cooperative approach whose goal is the total satisfaction of the consumer by an improvement of the economic performance of the different actors within the supply chain. The ECR optimizes the retailer's supply service and improves both promotional actions and freight availability (Gonzalez-Feliu and Morana 2011). In its first phase (Best Practices Efficient Replenishment), the ECR allows automating the supply chain links and consequently the reduces costs related to manual ordering and invoicing, and in a second phase (Efficient Replenishment), the integration of all processes in a unique furnishing-distribution supply chain for optimized sales forecasting and common transport management (La Londe and Pohlen 1996).

The Vendor Management Inventory (VMI) can be considered as the next step relating to the ECR (Roy et al. 2006). In this collaborative approach, the supplier is jointly responsible for warehouse replenishment by using the sales forecasts, which involves collaborative actions. This approach implies a commitment of the distribution company to give real-time information to the producer, who will be able to make a re-supply proposal and then make their demand forecasts in order to adapt their production phases and their resources for these phases (Waller et al. 1999). Often considered as the continuity of VMI (Evrard Samuel and Spalanzani 2009), Collaborative Planning, Forecasting and Replenishment (CPFR) emerged at the end of the 1990s. Verity (1996) reports the initiative of Wal-Mart Stores Inc. and Warner-Lambert Co., which obtained significant stock management improvements through this practice. Since 198,[3] this approach has been extended to many fields, becoming one of the main pillars of the supplier-distributer-retailer relationship.

A new form of VMI, which can be called "shared VMI", has been developed in the UK and France, and involves several producers which agree to work with the same distribution company and share information (Simonot and Roure 2007).

[2] Becker (2003), Gonzalez-Feliu et al. (2010) and other French authors refer to it as vertical and horizontal collaboration, according to the French notation which is different from the USA definitions of vertical and horizontal structure of Supply Chains (Lambert, 2008). For this reason, we prefer to unify both notations using the longitudinal and transversal notions.

[3] In 1998, the Voluntary Inter-Industry Commerce Standards committee® (VICS) published the VICS CPFR Guidelines, available online at: http://www.vics.org/committees/cpfr/.

A shared VMI can then be defined as a VMI developed and managed by a consortium of supply chain stakeholders sharing a common destination, i.e. retailers and/or facility areas. A new concept is that of shared CPFR, extending the collaborative approach to a consortium of producers and/or distribution stakeholders grouped around a co-ordinator that pools their sales and logistics information to optimize their common resources (Gonzalez-Feliu et al. 2010). However, all these approaches suppose the externalization of transport, and, regrettably, the transport carriers are seldom invited to meetings and strategic planning, but considered only as subcontractors providing a specific service.

Transversal collaboration can be added to longitudinal collaboration (Rakotonarivo et al. 2011), defined as the collaboration between a group of stakeholders (two or more) of different supply chains acting at the same levels and having analogous functions. Transversal collaboration often takes place among transport carriers, which are mainly small and medium-size companies (Patier 2004; Simonot and Roure 2007), between distribution companies (Gonzalez-Feliu and Morana 2011) or retailers. To our knowledge, this type of collaboration is not explicitly defined in the literature, although indirectly cited. We propose three categories for transversal collaboration, which can be articulated with those of longitudinal collaboration.

Bilateral collaboration can be defined as the collaboration between two pairs of distribution logistics. Several types of bilateral collaboration can be observed. Producers can be associated for supply sharing, in order to make bigger commands and reduce supply costs or develop co-production strategies. Distribution companies can have supply-sharing agreements, or common infrastructures, like collaborative warehouses or shared cross-docking facilities (Rakotonarivo et al. 2011; Gonzalez-Feliu et al. 2010). Finally, retailers can carry out small actions, more related to supply grouping than to logistics management (Patier 2004). Finally, periodic collaboration between freight forwarders and their loyal subcontractors is a good example of bilateral collaboration.

Another form of collaboration is that of logistics networks (Simonot and Roure 2007; Gonzalez-Feliu et al. 2010). Most of these networks involve companies of the same type, and are frequent among small transport operators. Moreover neighbourhood, local and regional networks of retailers are common in some countries. A network is presented as an association, although some of them assume the form of a cooperative company (Simonot and Roure 2007). The main functions of these networks are related to supply co-ordination or logistics organization, and can be the organized extension of bilateral collaboration to three or more stakeholders. Most of these networks subcontract their management to an external consultant or deploy a specific figure dependent on the network and not only on one of its members.

The last form of collaboration is that of open e-marketplace platforms. This approach is based on an electronic information exchange system, where potential customers for logistics services meet potential providers. Specific logistics services, like transport, storage, consolidation, or packaging, are offered by various providers. On the other hand, producers or distribution companies ask the platform for logistics services. Two types of platform are observed, related to their type of management: platforms where potential customers meet potential suppliers in person, analogous to online bidding websites, and platforms with a coordinator that confidentially matches offers and demands and proposes a solution to each customer, like a freight forwarder.

In both longitudinal and transversal collaboration, freight may be consolidated and pass through one or more warehouses and/or transhipment platforms (Gonzalez-Feliu and Morana 2012). Moreover, several stakeholders, like transport operators, warehouse keepers, logistics providers, producers, retailers, distribution companies and other logistics practitioners may be involved in collaborative logistics and transport.

3.5 Information Technologies and Transport/Logistics Management Tools

Information is the key to sharing. Without information sharing, the other levels of sharing cannot take place. In transport management, the role of Information and Communication Technologies (ICT) has been recently overviewed (Fabbe-Costes 2007). Two types of information technology have been identified by the author: transportation management modules, related to transportation planning, and information exchange tools, that allow transportation to be integrated into the supply chain.

In logistics planning, decisions on the transportation network settings not only have a direct impact on the quality of the service but also on its cost (Gonzalez-Feliu and Morana 2010). It is therefore important to adapt the transportation network to economic, geographical, organizational and quality constraints (Crainic and Laporte 1997; Wieberneit 2008). More precisely, the main questions in freight-distribution tactical and operational planning are related to supply and inventory policies (warehousing), vehicle routing and scheduling (transportation management), vehicle assignment to a route and crew assignment to each operation. The two last points depend on the first two and take place subsequently. Inventory and vehicle routing and scheduling problems are very popular subjects in research, and several algorithms have been proposed in recent surveys (Toth and Vigo 2002; Leung 2004; Dullaert et al. 2007; Golden et al. 2008). Moreover, a periodic survey on operative software for vehicle routing management is available (for the last version of the survey, see Hall and Partyka 2008).

In transportation planning and management, ICTs play an important role, and are usually combined with optimization modules in order to improve the performance of the different operations. Special attention has to be paid to the main technologies which allow the freight transport operations to be included in the global supply chain of a product. Fabbe-Costes (2007) details three categories of IS, i.e. document exchange systems, communication systems and traceability

Table 3 Information systems and technologies for logistics pooling

Aim	Technologies and tools
Document exchange	Fax; electronic data exchange tools (web-based or intranet-based); internet; smartphone applications
Communication	Onboard radio; onboard/portable terminals; fixed phone; mobile phone; internet; multifunction portable terminals
Tracking	Identification/codification; electronic reading; barcodes; RFID; bidimensional codes; waymarks; GPS tracking systems; vocal systems; recorders; memory systems

systems. The document exchange systems assure communication between the actors and record several transactions after which the communication systems ensure enterprise flow guidance. Finally, the traceability systems are developed to locate and monitor freight movement Table 3.

3.6 Synthesis and Organizational Model

After presenting the model of various modules, we can define an organizational model from the Information Systems Theory (Laudon and Laudon 2007) as shown in Fig. 2.

4 Model Validation Via a Case Study: The LUMD Project

Finally, we present the main results of research on a case study (Eisenhardt 1989; Yin 1994) for a logistics sharing project conducted by the biggest press distribution company in France, which involved 12 different partners, each with a different competence. This is a qualitative study. In a recent study (Gonzalez-Feliu and Morana 2011), the main aspects of sharing for a single operator were presented, whereas in this work, we will focus on the collaborative aspects of logistics sharing, more precisely related to the virtual logistics-sharing platform developed within the context of the LUMD (Logistique Urbaine Mutualisée Durable, or Sustainable Urban Logistics Sharing) project.

4.1 Press Distribution in France: General Context

The case study deals with the Presstalis group, an action-based delivery company handling 80 % of traditional press distribution in France. The main activities of the company deal with logistics planning and organization for all the distribution and

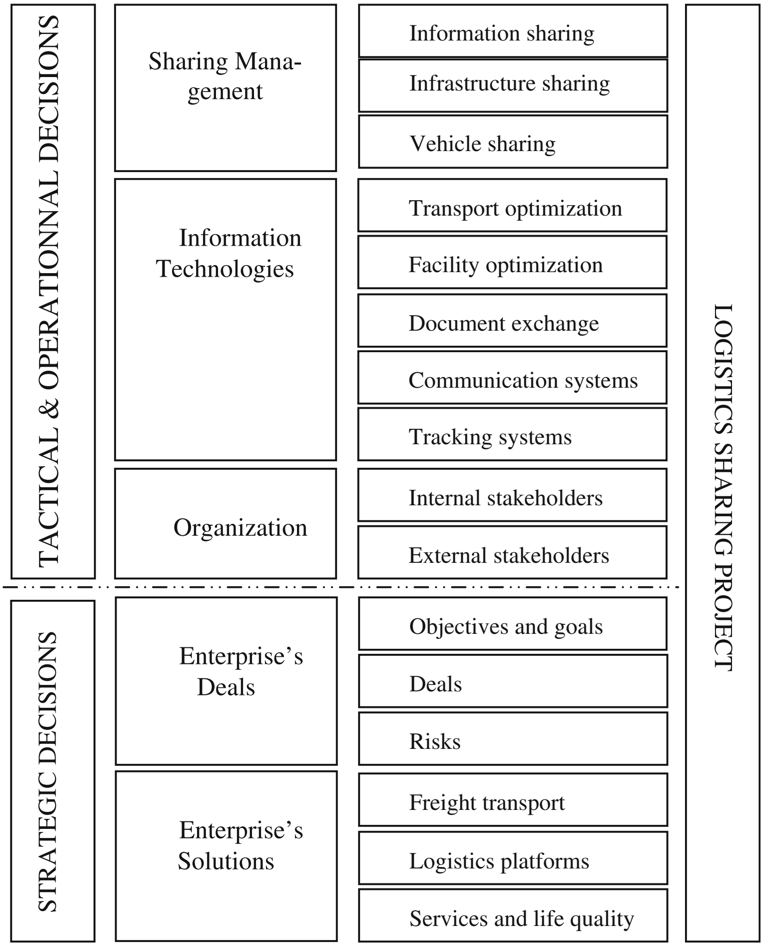

Fig. 2 Summarized organizational model (Gonzalez-Feliu and Morana 2011)

reverse supply chains of the written press, excluding the distribution of the free press whose supply chains differ from those of the traditional written press. The company's key information is summarized in Table 4.

In 1994, because of the constant decline of the traditional press in France, Presstalis started to envisage a set of strategies, with a ten-year horizon, to modernize their company and increase the efficiency of its distribution system. From this perspective, Presstalis invested in a new project for collaborative transportation sharing based on a mixed group including logistics operators, software developing companies, research centres and consultants, with a twofold aim: (1) to optimize their 'land logistics' (press depots and warehouses) and (2) to find new products to distribute in a transportation sharing perspective. The case study presents the concerns of the R&D project up to the present day.

Table 4 Presstalis' key information at the beginning of the project

Key information
2008 Turnover 2,560 M €
2007 Turnover 2,677 M €
3,000 employees in 2008
2.5 million customers per day
Presstalis distributed product sales (end 2008)
Global sales: 1,235 million units (2,560 million euros)
Unsold rate/(49.9 % value)
Sales in overseas France = 1.1 % of the global sales
Export sales (100 countries) = 8.9 % of the global sales

4.2 Presentation of the LUMD Project

The LUMD project (Logistique Urbaine Mutualisée Durable, or Sustainable Urban Logistics Sharing) is a collaborative project financed by the Unique Investment Fund of the French Government. This project started in November 2008 and finished in October 2011. Moreover, a post-project evaluation was performed between December 2011 and March 2012). The objective of the project was twofold:

- To propose a collaborative solution as an alternative to the City Distribution Centre, with a unique operator, by providing an Information System-based virtual platform for warehouse and transportation sharing.
- To standardize urban logistics concepts in order to transfer the LUMD solution (virtual platform) to different cities in Europe.

The project instigated by Presstalis involved several partners, including one logistics consulting agency, two software development companies, one geographical information service company, four research units of different natures and three other logistics providers. The main phases of the project were related to the development of a technological solution. In this work, we will explore the organizational aspects related to the implementation and deployment of this solution.

4.3 Organizational Analysis

We will present the most significant results of the qualitative analysis performed on the basis of a regular follow-up of the project, since the authors of this paper participated directly in different phases of the project, mainly in the initial phases and the evaluation of logistics sharing (that took place last year). Moreover, eight interviews and two site visits, as well as regular exchanges with the different stakeholders of the project were carried out to keep the follow-up process well updated.

The logistics chain of Presstalis (sharing management module) is similar to that of the other French press distribution groups, and can be divided into two macro-echelons: inbound distribution (from the publishers' printing platforms to the press depots), and outbound distribution (from the depots to the retailing activities selling the distributed products). In 2009, Presstalis had about 172 press depots and 30,000 sales points. The inbound distribution presents a more flexible transportation demand than the outbound distribution; inbound flows are contracted every day and well optimized, because consolidation and rationalization are possible. However, this is not possible for the outbound flows, because of the retailers' constraints and Presstalis' quality control rules.

One of the goals of the shared platform is to reduce the number of storage and consolidation platforms, which will in turn reduce the number of echelons in each category of distribution flow by including other categories of products in the outbound distribution. Currently, Presstalis, the main stakeholder in the project, has bilateral partnerships with providers and two transport companies and, during the project, a consortium of five logistics operators was initiated. The form of the platform can be open (everybody has access), semi-open (the right to enter can be requested by meeting several conditions and/or paying a fee, without the need of being accepted by current members) or closed (the entrance of a new member needs the consensual agreement of current members). After consensus, the second formula was chosen for the LUMD platform: a good environmental profile is necessary to enter the group and have the right to share resources; moreover, sharing resources implies a commercial transaction, so a price for the logistics service is demanded from the company that subcontracts the logistics operation. A crucial question remains: Who will be the platform manager? If one of the stakeholders involved (logistics operators, including Presstalis) takes this role, a conflict of interests may occur (LUMD 2012). To avoid such conflict, a third-party company, created only for this purpose seems the best solution. Since a commercial transaction is performed each time resources are shared, part of that payment is used to finance platform management as it is important to ensure the economic continuity of the platform by defining a solid business model for the service performed.

The system is based on an e-marketplace information system. An online website allows the different stakeholders involved to access important information and manage their logistics requests and supply capacity. To become part of the LUMD network, a logistics supplier (i.e. a company offering its surplus logistics capacity to others) needs to meet several conditions, particularly related to efficiency and environmental practice. However, a logistics customer (i.e. a loader asking for a logistics service, like transport, storage or consolidation) does not need to satisfy those conditions. The information system is composed of several modules:

- A request-allocation module, which optimizes the transport and consolidation operations. A detailed description of the operations' research methods used to build this module is found in Huart and Semet (2011).

- A vehicle-load verification module, which checks that the vehicle has been efficiently loaded, taking into account the packages' dimensions and the vehicle's characteristics.
- A warehouse-load allocation module, which optimizes the storage operations.
- A yield-management and multi-agent method for price setting, which is used when allocating requests to suppliers in order to maximize the LUMD network's benefits.
- A vehicle re-allocation module, which is used to find an alternative to a means of transport when unexpected events like traffic incidents or vehicle breakdowns take place.

The organization module defines the different actors in the LUMD community. We observe two types of stakeholder: internal and external actors. The internal ones are those related to the echelons of both distribution systems and their subcontractors, i.e. their contracted transporters, the logistics platform managers and employees, the press depot operators, Presstalis' partners, and the current LUMD logistics suppliers. These operators are environmentally-friendly, last-mile transporters who handle products potentially compatible with Presstalis' distribution system. Since their goals are similar, agreements can be negotiated,but not all the freight will be shared. In the partner-research phase, the legal and regulation aspects of sharing are also studied. The external stakeholders are the partners' customers and sub-contractors, real estate companies and public administrations. Public stakeholders also appear to be an important party because the legal requirements depend on these entities, and their involvement can have a non-negligible impact on the acceptability of potential members of the LUMD community to enter the decision-making community. Finally, the potential customers, i.e. the recruiting of "loaders" and logistics operators that can contribute to the community by bringing in transportation demands, once the basic version of i virtual platform sharing has been tested.

After that, we focus on the goals and risks that the LUMD system needs to take into account. Logistics sharing is considered a good solution because of the system's reliability during the press distribution period, and the possibility of delivering other products after the last sales point has been visited. The risks of this approach have to be considered, and the proposed sharing distribution system has yet to be developed. To do this, the main tactical decisions have to be spelled out, and subsequently,, the main strategic decisions can be defined by using the analytical model. The main problems or risks identified during the project concern the following:

- Project accounting, mainly related to the delicate situation of the enterprise. Indeed, the press distribution sector is being restructured in France, and Presstalis has lost a part of the market. This has led the shareholders to reduce R&D funds. However, the logistics sharing solution is a priority, and the main funds for developing the information system and the business model were attributed before the reorganization of the press distribution sector, so the tool has been operational since March 2012. Moreover, public funding is being sought to finance a demonstration of the system. Two cities (Nantes and Strasbourg) are interested and negotiations were carried out in mid-2012.

- There were notable problems related to the organizational risks of the project and its continuity, mainly due to the different visions of the project partners. Consensus and negotiation have proved essential to overcome the tensions and allow the project to advance.
- The technological problems were related to delays in the development of the information system and incompatibility of data transmission. The pace of the project was slowed down because of computer programming and algorithmic calibration, and consequently the partners in charge of the evaluation were allowed a deadline extension of four months.
- The risks related to policies, processes and current practices did not give rise to any problems due to the strong technological aspects of the projects. The demonstration phase and the discussion with public authorities and private companies will be essential to identify and control them.
- The risks related to the impact of the systems in the current and future operations are now well-estimated and will be taken into account in the demonstration phase.

The risks of dependence are difficult to estimate for the time being, as they can only be identified during the demonstration phase. After the R&D phase has been completed, the main aspects of an operational logistics sharing system can be defined. We summarize them below:

- The press distribution sector is being restructured in France, and Presstalis' share fell from 80 % of demand in 2009 to about 65 % in 2011. Moreover, new competitors are expected to enter the market, so the press sector will not be as profitable as before. A logistics sharing system will help Presstalis to better manage their resources and give the company a strategic position as an urban delivery specialist,on a par with postal companies.
- The operational system needs a group of companies, or a form of consortium. This community would represent an important lobby, with a good environmental profile (the main goal of the system is to reduce costs, congestion and pollution).
- By taking a stand for collaboration, Presstalis seeks the opportunity to surpass the Urban Consolidation Centre concept (Ville et al. 2012). With the decline of this idea (only 15 of more than 100 projects are currently operational in Europe, and less than 10 have attained real financial equilibrium), the logistics sharing solution can be an example for other applications in urban and long-distance logistics and freight transport.

Finally, concerning the Enterprise Solutions module, a dashboard has been designed. Several stakeholders have participated in its design and divided it into three spheres and five categories. The spheres are: economic indicators, quality

Table 5 The proposed sustainability dashboard

Sphere	Category	Indicator
Economic	Logistics performance	Vehicle loading rate
		Warehouse loading rate
	Finance balance	Yearly cost benefit analysis
Quality	Service	Service rate
Environmental and social	Environmental effects	GHG emission reduction
		Traffic congestion reduction
	Social effects	Percentage of jobs to create/reconvert

measurements and environmental/social indicators. Seven indicators have been defined, and are presented in Table 5. Note that an operational dashboard has to be understood by different readers, so it is recommended to have between five and eight indicators for overall workability.

5 Conclusions, Stakes and Future Development

Logistics sharing is becoming a popular approach to reduce the distribution costs of a product. However, the subject has not been extensively studied in the literature. In this chapter, we presented the main concepts of logistics sharing in the freight distribution sector, focusing on collaboration for transportation-based sharing approaches. We presented both an organizational model for the development of a sharing-based information system and an analytical model for its strategic decisions, defining the categories of factors that can impact them.

A collaborative sharing approach must have an efficient information sharing system. In this perspective, several aspects have to be considered in the different planning horizons. Tactical decisions deal with technological and planning tools, management sharing between the potential actors of the sharing-based supply chain, both at internal and external levels. The strategic decisions are based on the possible tactical choices to define the main objectives and the sharing solutions to be developed, also taking into consideration the risks inherent to these choices. Several organizational issues are at stake and can be deduced from the models and examples of logistics sharing approaches presented above. The first is to consider transportation explicitly as part of supply chain management methods, providing multidisciplinary research that includes systems engineering, information science, economy, management, sociology and other scientific approaches to decision-making, to mention the most important ones. In this sense, group-decision theory becomes a field of investigation that can produce interesting results for logistics sharing management-decision support. The second issue, concerns any logistics strategic decision-maker who must make a preliminary analysis of the factors affecting the key decisions, in order to choose the best approach to meet their goals. Thirdly, for company managers, the challenge is to correctly identify the external factors facilitating and limiting the logistics sharing solution, in order to improve their professional performance. Finally, the public deciders have to take into account the legislation that can have a positive or negative impact on the development of collaborative service-sharing for freight distribution concerning the market and competition rules applicable in the current macroeconomic context.

However, this is a new field of research, and this work remains exploratory for the time being, aiming at establishing standards and schemes to support logistics sharing decision-making. New variables will very likely appear with the development of shared management and planning. Moreover, a measurement scale could be implemented to facilitate evaluation techniques and strategic decision support. An extrapolation of the proposed models from (and to) other fields has to be considered in order to generalize and enrich them with respect to other applications for sharing and collaboration.

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Direct Effects of City Logistics Measures and Urban Freight Demand Models

Agostino Nuzzolo and Antonio Comi

Abstract This chapter proposes a general integrated demand modeling system developed within a simulation system to forecast both internal (transportation cost variations) and external (variations of pollution, noise and road accidents) direct effects of city logistics measures. In the first part, the paper considers the shopping and restocking components of urban freight mobility and the relative actor's choices that can be influenced by city logistics measures. The road simulation system is then considered with its various components, and the demand models are analyzed with particular attention to shopping demand models.

1 Introduction

Urban freight transport (UFT) is a fundamental component of city life. Every day, people consume and use goods (e.g. food, clothes, furniture, books, cars and computers) produced throughout the world. Furthermore, freight transport maintains a set of core relationships within urban areas since a city is an entity where production, distribution and consumption activities are located and use limited land. Therefore, UFT plays an essential role in meeting the needs of citizens but, at the same time, contributes significantly to unsustainable effects on the environment, economy and society. Hence a planning process to improve urban attractiveness and quality of life cannot overlook the role of freight transport, unlike what happens today where most resources are focused on people transport.

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Several city logistics measures can be implemented with a view to reducing the negative effects of freight transport. As freight flows are generated by restocking and shopping trips (see the first part of the paper), both these two types of components are to be considered.

Furthermore, since the characteristics of urban areas can differ substantially, city logistics measures have to be specifically designed and assessed in order to implement the most effective. The choice of a set of city logistics measures (i.e. a new city logistics scenario) should be based on assessment methodology consisting of several stages able to highlight different types of effects.

The effects can be classified as *internal* (i.e. cost variations incurred by the users of the system, such as retailers, wholesalers, distributors, and carriers) or *external* (i.e. incurred by members of the public not directly involved in using the system; e.g. variations in pollutant emissions, noise, road accidents). Further, within each of these two classes there may be:

- *direct* effects, i.e. variations in transportation system costs;
- *indirect* or *second-order* effects, mainly variations induced by transport cost modifications in land use or in the economic system and in the social sphere.

This paper focuses on *internal/external direct* effects resulting from variations in network transportation and environmental costs, which are those considered, for example, in traditional cost-benefit analysis.

In forecasting direct effects, a key role is played by road network simulation models and a general framework of these models is analyzed in the second part of the paper. The subsequent section focuses on freight demand models used to estimate the Origin–Destination (O-D) matrices of freight vehicles, which are used in road network simulation models, and a review of current models is given, using a proposed general advanced framework. Further, some upgrading in shopping demand models is presented. Finally, some conclusions and considerations are given.

2 Urban Freight Mobility Components

Analyses of urban freight transport traditionally focus only on *restocking* flows, i.e. freight vehicle flows from warehouse/distribution centers to trade or service establishments (e.g. shops, food-and-drink outlets, service activities), and usually neglect *shopping* flows. However, some surveys show that purchasing activities account for about twice or three times the veh-km of deliveries and pick-up activities. For example, surveys carried out in some European cities on urban freight mobility (Schoemaker et al. 2006; Gonzalez-Feliu et al. 2012) revealed that about 69 % of urban distances (veh-km) covered each day by motorized vehicles related to freight transport consists of shopping trips, 24 % of restocking trips and the remaining 7 % results from urban management (e.g. building sites, waste

Table 1 Urban freight transport: actors and relative choices

Actors	Strategic level	Tactical level	Operational level
End consumer	Residence locations		Where and in what type of retail outlet to buy What transport mode to use
Retailer	Shop/store location	What transport service type to use (i.e. on own account or by carrier)	
	Shop/store size	What shipment size	
Wholesaler	Warehouse location	What transport service to use (i.e. on own account or by carrier)	What time to start tours What type of vehicle to use Which delivery tour to follow
Carrier			What time to start tours What type of vehicle to use Which delivery tour to follow

collection, network maintenance). In this context, a city logistics set of measures should seek to reduce the impacts of both freight transport components.

Urban freight mobility is the result of several choices undertaken by different actors at operational (i.e. short-term), tactical (i.e. medium-term) and strategic (i.e. long-term) level (Table 1):

- end consumers (e.g. residents, visitors) choose where and at what type of retail outlet to make purchases (i.e. small, medium and large retail outlet) and transport mode;
- retailers (including large-scale outlets) choose the type of transport to use (e.g. own account, third party) and shipment size; in the long term, their choices concern shop and store location;
- wholesalers and distributors choose what type of transport to use for restocking their customers (e.g. own account, third party) and, in the event of own account, choose time and type of vehicle to use for restocking and the relative delivery tour; in the long term, their choices concern locations of warehouses and distribution centers;
- carriers; their choices are mainly related to departure time, type of vehicle to use for restocking, as well as the delivery tour to follow.

The results of these choices can change as a response to measures that seek to reduce the negative effects of UFT. For example, shopping location choices of end-consumers depend on the location of commercial supply with respect to their residence and behavior, which in turn depends on characteristics such as age, income, family size and lifestyle. Further, end-consumer choices of retail type can also depend on the accessibility of shopping areas. Thus if accessibility changes (for example, due to shopping demand travel management), type of shop and/or transport mode can also change. If there is a change in the characteristics of end consumers, residential and commercial land-use distribution, and/or accessibility to the commercial area, then the freight restocking characteristics may also change. Similarly, some city logistics measures can reduce the restocking accessibility of an area and induce re-allocation of retail businesses.

Thus, the analysis of urban freight transport, design of new city logistics scenarios and relative assessment methodology should consider all these components and actors. Although several methods and models have been proposed (Comi et al. 2012), they sometimes fail to point out the relationships among restocking and shopping mobility and to predict changes in actors' behaviors. The integrated modeling framework, reported below, tries to overcome these limits.

3 Freight Transport Simulation System

As stated in the introduction, in this paper the short-term direct effects of city logistics measures will be considered and the forecasting models of these effects will be analyzed. The transport simulation system that can be used is reported in Fig. 1 and consists of different sub-systems: road network, demand, path choice/assignment, and road performance (impacts).

The *Road Network Sub-system* comprises the graph of the main road network and relative link cost functions specific to both passenger and freight vehicles. The *Demand Sub-system* simulates the relevant aspects of travel demand as a function of the activity system and road travel costs. It includes the demand models that give the O-D matrices which are the input for the subsequent assignment sub-system.

The *Assignment Sub-system* includes path choice models and network loading models for both passenger and freight vehicles. Truck-driver path choice within an urban network is constrained by vehicle size but there are other factors that tend to influence the behaviors of truck drivers including driver preferences, vehicle and route performances (e.g. travel time, vehicle operating costs, gateway tolls; Taniguchi et al. 2001; Russo et al. 2010). The network loading model simulates how O-D vehicle flows load the paths and the links of the road network, and estimates the link flows, i.e. the number of cars and freight vehicles loading each link. For more details on assignment models refer to Cascetta (2009) and references quoted therein.

The link flows (output of the assignment module) are used to estimate the various scenario variables (*performance and impact sub-system)* that are, in turn, used to compute the new scenario effects:

- network transportation costs, using time–flow functions, like BPR (BPR 1964) or Davidson function (Davidson 1966);

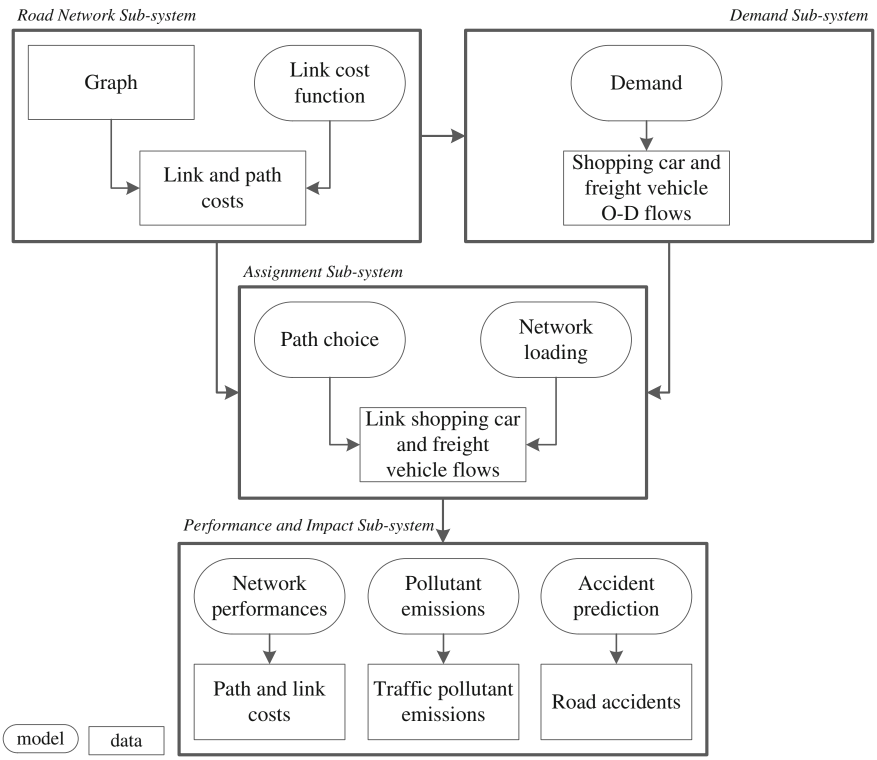

Fig. 1 Simulation system of direct scenario effects

- traffic pollutant emissions, using average emission functions (Gokhale and Khare 2004) that allow pollutant emissions to be estimated in relation to average link kinematic variables (e.g. vehicle speed and acceleration); for example as implemented within COPERT (COmputer Programme to calculate Emissions from Road Transport; Eggleston et al. 2000) and used in Filippi et al. (2010) to estimate pollutant emissions in inner Rome;
- road accidents involving both passenger and freight vehicles, using accident prediction models (APM); the probability of accidents are evaluated in relation to vehicle flows and road characteristics, location and characteristics of infrastructures (e.g. junction), control system (e.g. traffic lights, crosswalks), and other standardization variables (e.g. reference period, environmental conditions); examples may be found in Poul Greibe (2003) and Dietze et al. (2005).

The simulation system of direct scenario effects provides to analyze both passenger and freight vehicle flows because both of them can be influenced by city logistics measure implementation. Few studies have been developed on integrated shopping and restocking, even if the demand models are the core of the simulation system because they allow the impact of any measures on actors' behaviors to be captured. Thus an advanced integrated modeling system is proposed below for internal/external direct effect forecasting.

4 Urban Freight Demand Models

The need to find solutions to support the definition of new city logistics scenarios which allow for both external costs and internal direct costs incurred by several actors of freight restocking and shopping mobility has led to the investigation and development of new demand models. Traditionally, these two demand segments have been handled independently.

Shopping may be considered a major trip purpose as it forms part of the lifestyle of the population. Nevertheless, most of the current transport literature focuses on studying the characteristics of worker trips, with little emphasis being placed on studying non-worker travel patterns, such as shopping trips (Mokhtarian 2004; Cao et al. 2010). Furthermore, shopping mobility has been studied as a component of passenger demand through the relationships among travel behavior, the built environment (e.g. land use allocated for different business activities) and socio-economic characteristics (Nuzzolo and Coppola 2005; Ewing and Cervero 2010). In general, the focus of passenger transportation research is mainly on trip generation, distribution and mode steps within the well-known four-step models. Although researchers have increasingly argued the high incidence of multi-stop trips in empirically observed behavior (e.g. Dellaert et al. 1998; Popkowski Leszczyc et al. 2004), the commonly used modeling structure refers to round trips.

Various freight demand models have been proposed for simulating the freight flows destined to commercial urban activities (i.e. restocking process), many of which are multi-stage models (Taniguchi et al. 2001; Comi et al. 2012; de Jong et al. 2012). The mechanism underlying the generation of freight transport demand requires that *quantity* be used as the reference unit. Besides, the methods and models used for direct effect forecasting require the use of vehicle units (Fig. 1). Indeed, as stated above, *vehicle O/D* flows, interacting within the assignment model, allow us to obtain link flows and then to estimate performances and impacts of a given city logistics scenario. The translation of quantity into vehicle flows has to investigate the process of restocking; therefore a reference unit closer to those used by transport and logistics operators should be used, namely delivery and tours. *Delivery* (Nuzzolo et al. 2006; Muñuzuri et al. 2012) allows us to focus on transport service type used for restocking (e.g. on own account or by third party), and on shipment size, while *tours* should be used to investigate delivery tours in relation to departure time, vehicle type, number and sequence of stops (Nuzzolo et al. 2011; Nuzzolo and Comi 2013a).

Few studies (Russo and Comi 2010; Gonzalez-Feliu et al. 2012) have analyzed shopping mobility as a component of freight mobility and have considered that actions impacting on purchasing behaviors of end consumers (e.g. location of retail outlet, transport mode to use for shopping) can also affect restocking mobility.

Indeed, end-consumer choices in relation to type (e.g. small, medium or large) and location of retail outlet undoubtedly impact on freight distribution flows: the characteristics of the restocking process are strictly related to the type of retail activities to be restocked in terms of delivery size, delivery frequency, freight vehicle type and so on. For example, delivery size and freight vehicle size tend to increase with the size of retail activities, while delivery frequency tends to decrease, with considerable effect on the total distance travelled by freight vehicles. Therefore, end-consumer choices among small, medium and large retail outlets affect restocking characteristics and the total freight vehicle distance travelled.

In this context, a new city logistics scenario, implemented to improve urban sustainability and reduce the negative impacts of these two freight transport components, can affect one of the two components with effects on the other, too. Therefore, a study of urban freight transport and the relative methodology to assess a city logistics scenario should consider both components jointly and that freight transport is mainly generated by the requirement of end consumers to satisfy their needs for goods and services. Therefore, a joint modeling framework that considers both shopping and restocking flows (in terms of quantity, delivery, tour and vehicle) is desirable. The complete framework of such a modeling system developed by the authors in the course of multi-year research is reported below.

4.1 The Integrated Modeling Framework

The integrated modeling framework consists of various steps (Fig. 2):

- *shopping* trip models; these allow us to simulate the end consumer's shopping behavior and estimate the freight flows attracted by each traffic zone; this step allows us to point out the effects of implementing long-term action (e.g. urban land-use governance) on the location of retail establishments and place of residence; at the tactical or operational level such models can assess the effects on the choices of type and location of shops for purchasing goods and the transport mode used;

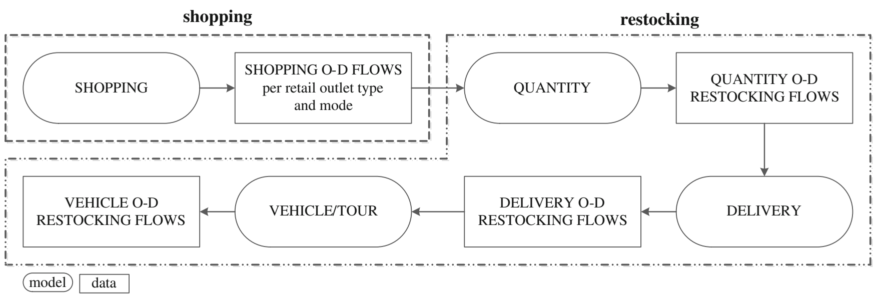

Fig. 2 Urban freight modeling structure

- *restocking* trip models,
  - *quantity* model sub-system; it allows us to estimate the quantity origin–destination (O-D) matrices characterized by freight types; this step highlights the effects due to implementation of strategic actions (e.g. urban land-use governance) on the locations of logistic facilities (e.g. warehouses and distribution centers) and retail activities (e.g. local shops or shopping centers);
  - *delivery* model sub-system; it allows us to convert quantities into delivery O-D flows; the delivery flows are also split in terms of transport services used (e.g. retailer on own account, wholesaler on own account and carrier); this step serves specifically to study the definition of restocking journeys in terms of transport service and shipment size (i.e. tactical level);
  - *vehicle* model sub-system; it allows us to obtain the vehicle O-D flows satisfying the given delivery O-D matrices, and investigate the *tours* undertaken to restock the study area; in particular, the tours are characterized by departure time, number of stops, vehicle used, and sequence of delivery locations.

4.2 Shopping Trip Models

Following Nuzzolo and Comi (2013b) and assuming that the decision-maker (i.e. end consumer) is in zone o, the choice dimensions involved are: the number of trips (x) for shopping, the destination (d) and type of shop (k; e.g. small, medium and large), the transport mode (or sequence of modes; m). The global demand function can be decomposed into the product of sub-models, each of which relates to one or more choice dimensions. The sequence most often used is the following:

$$D^i_{od}[skm] = D^i_{o.}[s] \cdot p^i[k/so] \cdot p^i[d/kso] \cdot p^i[m/dkso] \tag{1}$$

where

- D^i_{od} *[skm]* is the average number of trips with origin in zone o undertaken by end consumers of category i for purchasing freight of type s in retail outlet k located in zone d by using transport mode m;
- $D^i_{o.}$ *[s]* is the mean number of “relevant” trips undertaken by end-consumers belonging to category i for shopping freight of type s with origin in zone o obtained by a *trip generation model*;
- $p^i[k/so]$ is the probability that users, undertaking a trip from o, travel for purchasing at shop type k, obtained by a *shop type choice model*;
- $p^i[d/kso]$ is the probability that users, undertaking a trip from o, travel to destination zone d for purchasing at shop type k, obtained by a *location shop model*;
- $p^i[m/dkso]$ is the probability that users, traveling between o and d for purchasing in shop type k, use transport mode m obtained by a *modal choice* or *split model*.

Finally, the quantities required by each zone to satisfy end-consumer needs can be obtained by introducing the *quantity purchase model* (Russo and Comi 2012).

This model gives us the probability that the end consumer, arriving in a given zone, purchases something of a certain dimension (*dim*). Therefore, the quantity of freight type *s* sold by retail outlets *k* in zone *d*, $Q_{.d}[sk]$, can be calculated as:

$$Q_{.d}[sk] = \sum_{i} Q^{i}_{.d}[sk] = \sum_{i} \sum_{o,m,\dim} D^{i}_{od}[skm] \cdot p^{i}[dim/mks] \cdot dim \qquad (2)$$

where

- $Q^{i}_{.d}[sk]$ is the goods quantity bought/sold in retail outlet *k* in zone *d* given by the demand of end consumers belonging to category *i* living/working in a zone *within* the study area;
- *dim* is the dimension of purchases, expressed in kg;
- $p^{i}[dim/mks]$ is the probability that a trip concludes with a purchase of dimension *dim* conditional upon undertaking a trip to retail outlet *k* for a purchase of goods type *s* using transport mode *m*.

Trip generation is mainly affected by socio-economic characteristics and land-use patterns (or the physical characteristics of the area; Cubukcu 2001; Cao et al. 2010). The current models propose to estimate the number of trips undertaken by the individual category *i* departing from a zone *o* for shopping by two main categories of models: behavioral (or more properly, random utility models; Russo and Comi 2012) and statistic-descriptive models (Gonzalez-Feliu et al. 2010; Comi and Conte 2011).

As stated above, few models have been proposed to investigate the *choice of shop type* and hence some models of this type are proposed according to different freight types and socio-economic characteristics of end consumers.

There are several methods to model *trip distribution* (Ortuzar and Willumsen 1990; Cascetta 2009) with multinomial logit structures. Amongst others, Jang (2005) used joint disaggregated models to describe the generation and distribution of shopping trips. Veenstra et al. (2010) proposed an aggregated gravity model to simulate trip distribution for the shopping purpose. Comi and Conte (2011) developed gravity models according two different freight types, i.e. durable and non-durable goods. Finally, Gonzalez-Feliu et al. (2012), assuming that the choice of purchasing location occurs simultaneously with modal choice, obtained O-D shopping trips by first using regressive models to simulate the attracted trips for purchasing; secondly, the origin of trips is simulated by a gravity model. They refer only to the car mode.

Mode choice is a typical example of a travel choice that can be modified for different journeys in which performance or level-of-service attributes have considerable influence. Some examples on the investigation of shoppers' attitudes toward the various transport modes for shopping purposes are in Williams (1978) and Cervero (1996). Finally, some researchers also propose to model destination and mode choices jointly (Richards and Ben-Akiva 1974; Vrtic et al. 2007), or mode and departure choices (Bhat 1998).

4.3 Restocking Trip Models

Referring to the general modeling framework proposed by Nuzzolo and Comi (2013c), the following sections describe a model sub-system that allow us to estimate quantity, delivery and freight vehicle O-D flows with characteristics of restocking tours. Although they can refer to different freight types *s*, for simplicity of notation, the class index *s* will be understood.

Let $Q_{od}[k]$ be the average quantity of restocking flows moved from zone *o* (e.g. warehouse location zone) to the retail outlets of type *k* of zone *d*; it can be estimated as follows:

$$Q_{od}[k] = Q_{.d}[k] \cdot p[o/dk] \quad (3)$$

where

- $Q_{.d}[k]$ is the average freight quantity attracted by (i.e. to be delivered in) zone *d* and retail outlet *k*, obtained by the *shopping trip models* (see Eq. 2);
- $p[o/dk]$ is the probability that freight attracted by zone *d* and retail outlet *k* comes from zone *o*; it represents the acquisition share obtained by an *acquisition model*.

Having obtained the O-D flows in terms of quantities, O-D freight vehicle flows are required for the forecasting of performances and impacts (Fig. 1). Different types of methods and models have been proposed, starting directly from O-D quantity flows (Raothanachonkun et al. 2007; Wang and Holguin-Veras 2008) or introducing further steps in order to characterize the quantity flows in terms of deliveries (Routhier and Toilier 2007; Nuzzolo and Comi 2013a). This stage is required if we want to investigate the effects related to implementation measures impacting on the type of service (own account or using third party vehicle) and shipment size.

After estimating O-D flows in terms of deliveries, the next step is to convert them into tours and hence into O-D freight vehicles (Fig. 2). The vehicle level aims to do precisely that. The translation from deliveries to vehicles is not direct, particularly in urban areas where freight vehicles undertake complex routing patterns involving trip chains (tours). Indeed, each restocker jointly chooses the number and location of deliveries for each tour and hence defines his/her tours, trying to reduce the related costs (e.g. using a routing algorithm). The freight vehicle O-D matrices are then obtained from the delivery O-D matrices using a two-step procedure as proposed by Nuzzolo and Comi (2013a): definition of delivery tours from delivery O-D matrices, definition of freight vehicle O-D matrices from delivery tours. For more details on the above model calibration and validation, refer to Nuzzolo and Comi (2013a and c).

4.4 A New Shop Type Choice Model

This model gives us the probability (*p[k/so]*) of purchasing freight type *s* in a outlet of type *k* (i.e. small, medium and large) departing from zone *o*. As there are few examples of shop type choice models (Gonzalez-Benito 2004), below we present some models for the simulation of this choice. Besides, although they can refer to different categories of end-consumer *i*, for simplicity of notation, the class index *i* will be understood unless otherwise stated.

The results are based on surveys carried out in Rome where more than 300 households were interviewed, considering both home-based and non-home-based shopping trips.

From survey data analysis, it emerged that the choice of retail outlet mainly depends on freight types. Different multinomial logit models for the choice of retail outlet types were then calibrated according to the four main identified freight types: foodstuffs, hygiene and household products, clothing and shoes, other products.

In the following four tables, the multinomial logit models calibrated for the four freight types are reported. Our analysis reveals that foodstuffs and hygiene/household products are bought at all three different types of retail outlets, while clothing and other products are purchased at small or large retail outlets. Hence, for the latter freight types, only two alternatives are considered. All parameters are correct in sign and are statistically significant as shown by t-*st* and *p*-values, while values of ρ^2 are similar to those present in the literature for models of this type (i.e. discrete choice models).

From the calibration reported in Table 2 for foodstuffs, it emerges that the probability of making a purchase in small retail outlets increases if the purchase is made in the early morning (i.e. before 11 am), on Saturday and the customer is a woman. Increasing the money spent, the number of goods types to buy and the size of the group, the probability of customers buying in larger retail outlets increases. The probability of buying in a large retail outlet increases if the customer is younger than 29, while it decreases if the trip starts from home. The results confirm that many people travel to shop together or to buy many items and that large retail outlets are preferred if time for shopping is available.

As regards hygiene and household products (Table 3), the probability of purchasing in a small retail outlet increases if the customer is housewife, while the probability of shopping in large retail outlets increases if the trip is made to buy many products, if the customer is young, has much time available and/or travels with other people. As the time allocated to purchasing increases, the probability of choosing a medium retail outlet decreases. This result shows the inclination of customers to choose this type of outlet for rapid shopping for already-chosen products, such as washing-up liquid or soap powder. The results also confirm that younger customers travel to larger retail outlets (e.g. to find special discounts and because they have more free time).

Table 2 Shop type choice model: parameter estimation for foodstuffs

Parameter	Unit	Alternative	Value	t-st value	p value
Early morning	0/1	Small outlet	1.22	4.28	0.00
Woman	0/1	Small outlet	0.63	2.01	0.04
Saturday	0/1	Small outlet	0.70	2.30	0.00
ASA	0/1	Small outlet	8.40	2.89	0.00
Size of group		Medium outlet	−0.37	−2.33	0.02
Number of goods types		Medium outlet	1.00	4.43	0.00
Money spent	Euro	Medium outlet	0.04	4.19	0.00
ASA	0/1	Medium outlet	8.17	12.00	0.00
Young	0/1	Large outlet	1.12	1.80	0.07
Departure from home	0/1	Large outlet	−0.57	−2.52	0.01
Money spent	Euro	Large outlet	0.10	10.01	0.00
Time spent on purchases	Minutes	Large outlet	0.02	3.14	0.00
Number of goods types		Large outlet	2.18	6.67	0.00
ρ^2	0.32				

From the data and as we might expect, the purchases of clothing and other products (unlike the previous ones) are generally made at shops (small retail outlets) or shopping centers (large retail outlets). Table 4 reports the calibration for clothing. The probability of choosing a shop increases if the customer is female, travels early afternoon (i.e. before 4 pm) and on Sunday, and considerable time for shopping is available. This result shows that customers prefer to go to large retail outlets on Sunday and in the early afternoon because they have more time to spend on shopping (including leisure).

Table 3 Shop type choice model: parameter estimation for hygiene and household products

Parameter	Unit	Alternative	Value	t-st value	p-value
Departure from home	0/1	Small outlet	−0.79	−1.97	0.05
Housewife	0/1	Small outlet	1.07	2.21	0.03
ASA	0/1	Small outlet	3.26	3.32	0.00
Number of goods types		Medium outlet	1.89	5.60	0.00
Time spent for purchases	Minutes	Medium outlet	−0.01	−1.28	0.20
Money spent	Euro	Medium outlet	0.01	1.52	0.13
Size of group		Medium outlet	−0.66	−2.81	0.00
ASA	0/1	Medium outlet	1.00	1.15	0.25
Number of goods types		Large outlet	0.92	2.48	0.01
Time spent for purchases	Minutes	Small outlet	0.01	2.46	0.01
Young	0/1	Large outlet	0.77	1.60	0.11
Monday–Friday	0/1	Large outlet	−0.53	−1.25	0.21
Money spent	Euro	Large outlet	0.01	1.50	0.13
Early morning	0/1	Large outlet	−0.61	−1.41	0.16
ρ^2	0.29				

Table 4 Shop type choice model: parameter estimation for clothing

Parameter	Unit	Alternative	Value	t-st value	p-value
Woman	0/1	Small outlet	0.44	1.80	0.07
ASA	0/1	Small outlet	0.43	1.63	0.10
Early afternoon	0/1	Large outlet	0.17	1.91	0.07
Time spent on purchases	Minutes	Large outlet	0.01	2.46	0.01
Sunday	0/1	Large outlet	1.03	2.22	0.03
ρ^2	0.15				

Table 5 shows the results for other types of goods. The results confirm the tendency of women to buy in a shop, and of large groups to travel to large retail outlets on workdays (i.e. from Monday to Friday) and if considerable time for shopping is available. Furthermore, this result shows the inclination of many people to travel to large retail outlets for shopping together or for recreation.

4.5 Study Cases

The above modeling system was implemented by the authors to study the effects of strategies for urban freight activity location upon transport costs in the medium-size urban area of Padua in northern Italy (Nuzzolo et al. 2013). The strategy of clustering warehouses, distribution centers and large retail outlets in the first ring can have impacts in terms of reducing both freight distribution and shopping travel distances. Indeed, with respect to the other land-use scenario, this solution entails a reduction in freight distribution vehicle—km and a small increment in the number of car shopping trips which is offset by a considerable reduction in car shopping trip vehicle—km.

Table 5 Shop type choice model: parameter estimation for other products

Parameter	Unit	Alternative	Value	t-st value	p-value
Woman	0/1	Small outlet	1.18	2.66	0.00
ASA	0/1	Small outlet	1.74	4.30	0.00
Size of group		Large outlet	0.24	1.41	0.15
Monday/Friday	0/1	Large outlet	1.19	1.32	0.18
Housewife	0/1	Large outlet	1.48	1.41	0.15
Time spent on purchases	Minutes	Large outlet	0.03	5.02	0.00
ρ^2	0.23				

5 Conclusions

When dealing with the impact of urban freight transport, shopping and restocking are two sides of the same coin and both have to be considered by city logistics measures implemented for improving city sustainability. This interaction is especially relevant in the urban context where congestion is an effect shared and generated by both markets, and public decision-makers have to take such effects into consideration before making a planning decision. Furthermore, in the movement of goods from producers to end-consumers there may be a variety of decision-makers whose choices affect how the freight has to move. Implementation of freight transport measures must consider such different interests and find an optimal compromise between all interests of the actors involved. Furthermore, the choice of a new city logistics scenario should be based on an assessment method consisting of several stages able to highlight different types of effects. The paper described a simulation system for direct internal/external effect forecasting and hence focused on demand models that are the core of the simulation, because they allow the effects of city logistics measures on actors' behaviors to be captured. The integrated modeling system presented is a general framework that jointly simulates shopping and restocking flows. This framework could be considered an open architecture where various models developed in the literature can be used. However, as few examples can be found on the simulation of shop type choice, which is one of the main contact points between shopping and restocking mobility, suitable models for doing precisely this were proposed. Through logit models they simulate choices among small, medium and large retail outlets in relation to freight types and socio-characteristics of end consumers. Some tests were performed in a real study case and initial results confirm the goodness of the proposed framework and models.

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Behavioral Modeling of Urban Freight Transport

Testing Non-Linear Policy Effects for Retailers

Edoardo Marcucci and Valerio Gatta

Abstract Decision makers in urban goods movement (UGM) typically need to assess the impact new policy interventions might have on freight distribution. The effects of policy changes are inextricably related with the extant regulatory framework that also influences the relationships among the various actors interacting along the supply chain. The operators commonly considered important, given the crucial role they play in UGM, are: retailers, transport providers, and own-account. Notwithstanding the admittedly important role that a detailed knowledge of these three agent categories has for a correct policy implementation there is a limited knowledge concerning the specific preferences and behavior of each agent-type. It is de facto assumed that retailers, own-account and transport providers have homogenous preferences and can be seamlessly treated. The upsurge of behavioral models and the acquisition of data necessary to predict goods and vehicle flows both under the current and, more importantly, under altered policy/regulatory conditions explains the progressive importance that is attributed to an agent-based perspective. This research reports the result of a stated ranking exercise conducted in the Limited Traffic Zone in 2009 in the city center of Rome focusing on retailers which demand freight transport services and play an important role in extended supply chains. This paper proposes a comparison between two different Multinomial Logit model specifications where non-linear effects for the variations of the levels of the attributes considered are studied and detected. A meaningful comparison between willingness to pay measures derived by the two model specifications is proposed so to avoid known scale problems. The results obtained are very interesting and meaningful from a policy perspective since they show potentially differentiated effects of the policy implemented in deep contrast with the, often assumed, homogenous effect hypothesis.

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1 Introduction

Cities have historically, but more so for modern cities, manifested a strong dependence on freight transport systems to efficiently guarantee the net inflow of goods and ensure the availability of the necessary resources to fuel economic and urban growth. Local policy makers have intervened on the articulated contractual relationships among agents so to achieve the desired policy objectives. The most important agent-types in urban goods movement (UGM) are: retailers, transport providers and own-account. Few are the studies that have explicitly investigated the specific preferences and behavior of each of these agent-types (Stathopoulos et al. 2012; Stathopoulos et al. 2011) notwithstanding the a priori relevance that is ascribed to them (Ogden 1992). At the base of this research gap in this field one can safely put the lack of appropriate data that is, in turn, linked to elicitation costs and the low interest agent-types usually show when asked to participate in applied research projects in this field. The capability policy interventions have in producing the desired results is inextricably intertwined with the detailed knowledge policy makers need to have concerning the most likely response the intervention will produce given the extant regulatory, contractual and consuetudinal relationships that characterize this sector in the given city where the policy is to be implemented. In other words, we believe that one-size-fit-all policies, implying policy transferability, are not easy to define nor to implement in accordance to what has already been underlined by recent research (Stathopoulos et al. 2012).

The results reported and discussed are based on a data set derived from a research conducted for a Volvo Research Foundation project (2009) that focused on ex-ante policy mix evaluation for freight transport policies. The study concentrated on the freight Limited Traffic Zone (LTZ) in the city center of Rome. The analysis takes advantage of the data set collected that explicitly differentiates among three agent-types. The data include a wide range of information including both specific respondent's and his/her company's characteristics as well as the results of a Stated Ranking Exercise (SRE) where interviewees were asked to rank alternative policy scenarios. The paper reports the results of two Multinomial Logit model (MNL) specifications aimed at investigating the non-linear effects of policy intervention on retailers' utility functions in a similar vein to Rotaris et al. (2012).[1] A comparison is performed, via willingness to pay (WTP), between the potentially distorted scenario evaluations deriving from the assumption of linear

[1] Non-linear effects on utility function can be also tested via self-stated attribute cutoff. Please refers to Marcucci and Gatta (2011) for a detailed description and application.

policy effects. Our results allow us to comment on the distorted policy forecasts that would be produced by simpler and rougher treatment of the information acquired. On the base of recent evidence (Stathopoulos et al. 2011) we assume that the relevant policy attributes for retailers are: (1) number of loading and unloading bays (LUB); (2) probability of finding loading and unloading bays free (PLUBF); (3) entrance fee (EF) charged to enter the LTZ.

The paper contributes to UGM literature by bridging a specific gap via in depth investigation of retailers' preferences. Recent papers have investigated the role of heterogeneity for both transport providers (Gatta and Marcucci 2013) and own-account (Marcucci and Gatta 2013) agents with respect to policy intervention whereas this paper focuses the attention on the presence and magnitude of non-linear effects given the different levels of the attributes considered. Policy makers usually intervene and evaluate policies assuming that attribute variations have linear effects thus hypothesizing there is no dependence on the status quo (SQ) level of the policy variable and, furthermore, that both increases and decreases have symmetric effects on agent's utilities. The results reported show that one cannot assume linear effects and consequently both the direction of the variation as well as its magnitude should explicitly be considered when assessing a given policy change. Having estimated the coefficients for the various attributes and levels we calculate, via WTP measures, the biases that a linear assumption concerning the effects implies.

The paper is structured as follows. Section 2 reports a short literature review concerning agent-type analysis for UGM. Section 3 describes the survey instrument developed and the data acquired while Sect. 4 reports and discusses the econometric results and policy implications. Section 5 concludes and illustrates future research endeavors.

2 Literature Review

Freight modeling is usually performed via aggregate models thus limiting the attention dedicated to agent-level considerations that represent the appropriate level of analysis to investigate if a behavioral approach to the phenomenon is adopted.[2] This section succinctly summarizes recent literature that testifies the increasing attention paid to behavioral issues in UGM.[3]

Hensher and Figliozzi (2007) underline the weaknesses of the standard approaches to UGM modelling. In fact, the modified four-step approach (M4SA)

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[2] UMG literature analysis also reveals a substantial heterogeneity in the approaches adopted relates to the public or private perspective considered. The former mainly focuses on the definition of policies for reducing the negative external effects on cities, while the latter essentially aims at enhancing the efficiency of business operations (Corò and Marcucci 2001; Marcucci and D'Agostino 2003).

[3] For a definition of UGM see for example Ambrosini and Routhier (2004).

when used to simulate UGM does not adequately consider the complexity characterizing freight movements at different geographical scales. At the same time, however, it is appropriate to note that not all researchers in the field univocally share this view. For different positions one could refer to Sonntag (1985); Ogden (1992); Ambrosini et al. (2008) and the article by Gonzalez-Feliu et al. (2013) in this book.

This explanatory deficit is particularly relevant since the M4SA is structurally not capable of explaining potentially relevant preferences for current scenarios and, even more important, the possible reactions to policy changes. On the contrary, models adopting a behavioral approach (BA) to UGM modeling, representing only part of the larger disaggregate models set, explicitly consider stakeholders' utility maximization.[4] BA to UGM presume the researcher is capable of univocally and correctly identifying key decision makers so to develop an agent-based micro-simulation approach modeling framework that both describes and forecasts the behavior of the actors considered (Liedtke and Schepperle 2004). UGM is, according to a copious and qualified group of eminent researchers (Gray 1982; Wisetjindawat et al. 2006; de Jong and Ben-Akiva 2007; Russo and Comi 2011; Filippi et al. 2010; Comi et al. 2012; Sammi et al. 2009; Chow et al. 2010; Roorda et al. 2010) an appropriate field of research where the development of micro agent-based models is most likely going to produce policy relevant results. In fact, since freight is not moved for its own sake and the underlying motivations can always be traced back to the profit maximization intent of a given agent, participating in the process, it appears appropriate to analyze the choices made according to a well-known and robust theoretical framework that has successfully been applied in many other fields (also outside transportation) whenever economic agents' modeling is deemed appropriate.

Different UGM options are influenced, given the derived nature of freight transport demand, in their relative convenience for each agent-type considered, by changes in fuel prices, land use patterns and pricing strategies in the markets that demand freight transport services. It has been suggested (Puckett and Greaves 2009) that in order to understand the impacts, measured in terms of the market outcomes that a policy might produce, one should conjointly consider all the instruments policy makers could use and the relevant attributes capable of affecting agents' freight choices.

Policy makers are intrinsically and structurally interested in knowing, before implementing a given policy, what the most likely reactions will be in terms of achievement of the desired objectives. As it will be apparent when discussing the econometric results (Sect. 4) the research proposed can quantify the WTP for the possible policies implemented with respect to the reference scenario before the policy is actually put into action in a real-life context. This paper focuses on

[4] In fact, the success or failure of UGM initiatives mainly depends on the reaction of stakeholders to the implementation characteristics' of policies (see, for instance, Marcucci and Danielis 2008; Paglione and Gatta 2007; Danielis and Marcucci 2007; Marcucci et al. 2007).

the role and preference of retailers that, in the context studied, play a relevant role (Quack and de Koster 2009).

3 Survey Instrument and Data Description

This paper is based on data acquired in Rome's LTZ between March and December 2009 thanks to a project carried out for Volvo Research Foundation (2009). The LTZ in the city center of Rome was first implemented in the late 80s over a 5 km^2 area originally banned to non-resident vehicles only. Only Euro 1 and more fuel-efficient vehicles are allowed to enter the LTZ with free access granted to residents while others (e.g. retailers and freight carriers) pay an access fee. Cameras and optical character recognition software are used to enforce the system which operates diurnally with a yearly entrance fee of 565€ per number plate.

Notwithstanding the extensive list of impediments applying generically to all agents a wide ranging of ad hoc exemptions applies to third party freight operators. The regulation, after a careful reading of all the exemptions conceded, seems mostly targeted to discouraging own-account operators.

As it is for the questionnaire development it is important to first define, select, develop and customize the attributes to be included in the questionnaire which, in our case, was a SRE since it was considered most appropriate to use a ranking exercise given the final aim was to unveil agents' preferences concerning UGM policies which are not de facto "chosen". The project involved different phases among which the most important are: (1) advancement from stakeholder consultation to final attribute selection criteria; (2) attribute definition; (3) levels and ranges selection; (4) progressive design differentiation by agent-type (Stathopoulos et al. 2011).

The SRE alternatives are characterized by a set of attributes, which can take several levels. The attributes considered were selected thanks to: (1) literature survey; (2) previous UGM studies performed in Rome; (3) focus groups with experts. An in depth review of the literature adopting an agent-based perspective allowed the identification of a set of eligible attributes that represented potentially conflicting policy instruments.[5]

Previous UGM studies in Rome (STA 2001; Filippi and Campagna 2008) together with expert and stakeholder focus groups were very useful in guiding the attribute selection process[6] that were characterized by high and shared support of

[5] Nighttime deliveries, for instance, were considered efficiency enhancing by carriers but considered a mere increase in costs by retailers and were consequently excluded.

[6] An important phase of the expert surveys focused on defining the policies considered most appropriate to mitigate the identified UGM problems (Stathopoulos et al. 2011). Volvo Report (2010) provides a detailed overview of the link between the stakeholder survey results and the attributes used in the SRE.

Table 1 Attribute levels and ranges used in the SRE

Attribute	Number of levels	Level and range of attribute (*Status Quo* underscored)
Loading/unloading bays (LUB):	3	*400*, 800, 1200
Probability of free l/u bays (PLUBF):	3	*10 %*, 20 %, 30 %
Entrance fee (EF):	5	200€, 400€, *600€*, 800€, 1000€

the stakeholders contacted (Stathopoulos et al. 2011). The attributes were also validated via a pilot test with real operators. The final list included: LUB, PLUBF, and EF. All attributes are considered as possible levers of intervention by local decision-makers and perceived as appropriate measures for possible policy mixes by stakeholders (Marcucci et al. 2012). Attributes, number of levels, and ranges are reported in Table 1. Attributes are all characterized by, at least, three levels thus allowing the test of non-linear effects that represent the core of this paper and play a special role in the evaluation of policy reactions to policy changes where different effects can be originated by varying specific levels. Joint stakeholder as well as local policy-makers meetings were an important source of information concerning the attribute distribution and range. Based on the ranges provided by the stakeholders and the comments from local planning changes the minimum and maximum points of the attribute ranges were defined to achieve realism and properly mirror plausible policy changes. For LUB and PLUBF the minimum coincides with the current situation, implying that the policy scenarios only proposed an increase in the levels. EF was defined having a wide range of variation in both directions with respect to the status quo level since past policy changes have been quite abrupt.

A SRE is adopted to test currently unavailable options. The alternatives presented to respondents, who had to rank them, include two policy options plus the SQ alternative. Table 2 reports an example of a SRE task.

In total, 252 interviews were finalized and 229 used after removing pilot interviews that were utilized to preliminary test the design. The sample of retailers used for estimation consists of 90 units whose distribution is scattered in nine main macro-freight sectors, namely: (1) *food* (fresh, canned, drinks, tobacco, bars, hotels and restaurants); (2) *personal and house hygiene* (detergents, pharmaceuticals, cosmetics, perfumes, watches, barbers, etc.); (3) *stationery* (e.g. paper, newspapers, toys, books, CDs etc.); (4) *house accessories* (e.g. dish washers, computers, telephones, metal products etc.); (5) *car accessories* (e.g. vehicle components,

Table 2 Example of a ranking task

	Policy 1	Policy 2	Status Quo
Loading/unloading bays (LUB):	400	800	400
Probability of free l/u bays (PLUBF):	20 %	10 %	10 %
Entrance fee (EF):	1000€	200€	600€
Policy ranking	☐	☐	☐

vehicles, gasoline, etc.); (6) *services* (e.g. laundry, flowers, live animals, accessories and animal food, etc.); (7) *clothing* (cloth, leather, etc.); (8) *construction* (e.g. cement, scaffold, chemical products, etc.); (9) *other* (all those not included in previous categories). We follow the same classification proposed in Filippi and Campagna (2008) for comparison purpose, since it represents still today the most reliable investigation of urban freight data in Rome.

4 Econometric Results and Policy Implications

This section reports the results of the models[7] estimated for retailers based on the data obtained via the SRE described in the previous section.

The methodological framework is based on random utility theory, where utility is modeled as a random variable consisting of both deterministic and stochastic part. The former is a function, linear in its parameters, of the fundamental attributes, while the latter is the random term. Different assumptions about the distribution of the random term imply different discrete choice models that can be used to analyze the gathered choice data with the purpose of estimating the parameters associated with the attributes. In the early 1970s Mc Fadden (1974) developed MNL which is derived from the assumption that the error terms of the utility functions are independent and identically Gumbel distributed. MNL has many interesting and much appreciated advantages (closed form, ease of interpretation, etc.) is also characterized by relevant drawbacks linked to preference homogeneity assumption across respondents. Even if confounded for the scale, the estimated parameter represents the marginal utility of each attribute variation and implies an equal taste for all agents for the given attribute.[8]

The first model (M1), employing a MNL specification,[9] utilizes all attributes as linear and normalized while the second (M2) adopts an effects coding for the variables in order to investigate potential non-linear effects of the different levels of the explanatory variables.

M1, reported in Table 3, employing just normalized variables, provides interesting results and also shows a good fit of the model (adj. $Rho^2 = 0.142$; 5 Coeff.). All the coefficients are statistically significant and with the expected sign with the exception of the two alternative specific constants (ASCs) for which there was no strong a priori concerning the sign. In particular LUB and PLUBF have a positive coefficient since an increase in either the number of loading and unloading bays or

[7] The models are estimated using NLOGIT 4.0.

[8] For a detailed discussion of the methodological framework and possible applications of discrete choice models see, for example, Marcucci (2005); Gatta (2006).

[9] We just recall that a MNL specification of the model implies an implicit assumption concerning the independence from irrelevant alternatives. In other words, it is assumed the unobserved effects homogeneously impact all the alternatives in the same way that is equivalent to hypothesizing that the error component is identically and independently distributed.

Table 3 Econometric results based on M1

Variable	Coefficient	St.Err.	T-Stat	Expected Sign
LUB	0.253	0.048	5.24	+
PLUBF	0.347	0.053	6.51	+
EF	−0.699	0.042	−16.44	
ASC_Alt1	0.824	0.154	5.32	*
ASC_Alt2	0.657	0.136	4.82	*

in the probability of finding them free has a positive impact on retailers' utility. On the contrary, an increase in EF has a negative impact on retailers' utility. M1 also includes two ASCs for the unlabeled hypothetical cases (ASC_Alt1, ASC_Alt2) whose coefficients represent the overall alternative impact on retailers' utility when all the coefficients of the other attributes have a zero value. In our case, results show that, there is an a priori evaluation against the SQ (ASC_Alt3 has a negative sign) and, after conducting a Wald test for ASC_Alt1 and ASC_Alt2, we cannot reject the null that the difference between the two coefficients is different from zero. In summary, one can affirm that ASC_Alt1 and ASC_Alt2 have a positive, but undistinguished between them, effect on utility. Furthermore, it is also interesting to note that the ASC inclusion in the model not only substantially increased the model fit but also provided more realistic interpretation of the parameters.

The normalization adopted for the explanatory variables allows us to compare the estimated coefficients of the attributes considered. One can notice that tariff plays the lion part in explaining retailers' preferences. In fact the EF's coefficient is more than double the sum of LUB and PUBF coefficients. This result is further reinforced by looking at the t-stat of each of the variables considered that testify EF's coefficient is, almost for sure (t-stat 16.44), different from zero even if LUB and PLUBF coefficients are highly significant too (respectively t-stat 5.24 and 6.51).

M2, reported in Table 4, differs from M1 in the treatment of the variables which, in this case, are effects coded.[10] The different coding aims at detecting possible non-linearities in the explanatory variables' effects. In fact, the estimation of a single parameter for a given attribute will give rise to a linear estimate (i.e. slope) and we generically refer to these estimates as linear estimates (M1). An attribute's impact can be estimated with two dummy (or effects) parameters, which are usually referred to as a quadratic estimate or higher degree dummy (or effects) parameters which are also referred to as polynomial of degree L-1 estimates (with L denoting the number of dummy or effects parameters). In more detail, one can affirm that the more complex the part-worth utility function, the more advisable is to move to more articulated coding structures capable of recovering the necessary data to estimate the more complex non-linear relationships.

[10] For a clear description of effects coding the explanatory variable please refer to Hensher et al. (2005), pp 119–121.

Table 4 Econometric results based on M2

Variable	Coefficient	St.Err.	T-Stat
LUB3	0.215	0.046	4.68
PLUBF2	0.246	0.059	4.15
PLUBF3	0.262	0.068	3.86
EF1	1.113	0.104	10.65
EF2	0.937	0.087	10.67
EF4	−0.761	0.099	−7.68
EF5	−1.589	0.126	−12.54
ASC_Alt1	1.085	0.166	6.51
ASC_Alt2	0.814	0.143	5.66

M2, thanks to the effects coding of the variables, provides more detailed information and is characterized by a statistically significant better fit[11] with respect to M1 (adj. $Rho^2 = 0.154$; 9 Coeff.). All reported coefficients are statistically significant. In fact, the LUB2 (e.g. the second level of the variable LUB, i.e. 800) coefficient, not reported in the table, was not statistically significant thus suggesting agents' utility is not influenced by a variation of only 400 LUB from the SQ situation (i.e. 400).[12]

As it is for the PLUBF one can notice that there is an evidently non-linear effect of the variable. In fact, going from a 10 Probability Base Points (PBP) for PLUBF (i.e. SQ level) to 20 PBP we have a much greater impact on retailers' utility [BetaPLUBF2-1 = BetaPLUBF2 (0.246)—BetaPLUBF1 (−0.509) = 0.756] than going from 20 PBP to 30 PBP [BetaPLUBF3-2 = BetaPLUBF3 (0.262)—BetaPLUBF2 (0.246) = 0.016]. EF is the variable that benefited the most from the adoption of effects coding in detecting non-linearities. This is both due to the presence of five levels compared to the three levels for the other variables as well as to their symmetricity with respect to the SQ (i.e. 600€). The analysis of ASCs leads us to the same conclusions reported for M1.

With reference to Fig. 1, and in line with prospect theory (Kahneman and Tversky 1979), one can observe that reductions in EF produce positive effects on utility compared to negative effects induced by opposite variations of similar amount. Initial variations, in both directions, from the SQ (EF3 = 600€) have bigger effects [$Beta_{EF3\text{–}4} = Beta_{EF3}$ (0.300)−$Beta_{EF4}$ (−0.762) = 1.062 and $Beta_{EF2\text{–}3} = Beta_{EF2}$ (0.937)–$Beta_{EF3}$ (0.300) = 0.637] with respect to subsequent ones [$Beta_{EF4\text{–}5} = Beta_{EF4}$ (−0.762)–$Beta_{EF5}$ (−1.589) = 0.828 and $Beta_{EF1\text{–}2} = Beta_{EF1}$ (1.114)–$Beta_{EF2}$ (0.937) = 0.176]. In fact, for positive variations (EF increases; EF4 = 800€ and EF5 = 1.000€) we have $Beta_{EF3\text{–}4} = 1.062 >$ -$Beta_{EF4\text{–}5} = 0.828$ and for negative variations (EF reductions, EF2 = 400€ and EF1 = 200€) we have $Beta_{EF2\text{–}3} = 0.637 > Beta_{EF1\text{–}2} = 0.176$. Furthermore, still

[11] We checked this by performing a log-likelihood ratio test.

[12] Therefore, we recoded this variable so that LUB3 = 1 when LUB = 1,200 and −1 otherwise (according to the effects coding of the variables).

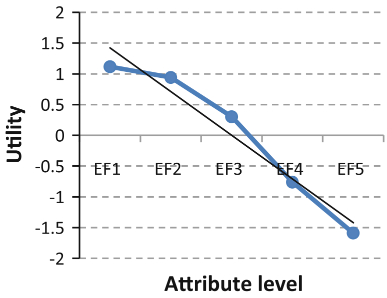


Fig. 1 Part-worth utilities for EF

in line with prospect theory we find that positive variations of equal amount are valued less than negative variations and, in our case, this is testified by both inner variations [$\text{Beta}_{\text{EF3–2}}$ (0.637) < $\text{Beta}_{\text{EF3–4}}$ (1.062)] as well as by outer variations [$\text{Beta}_{\text{EF1–2}}$ (0.176) < $\text{Beta}_{\text{EF4–5}}$ (0.828)]. Similar considerations also apply to PLUBF (see Fig. 2).

In order to analyze the impact of different estimation methods, define and measure the potential biases for policy implementation one can use WTP/WTA to avoid scale problems that would, otherwise, fraud the comparison.

As it is well documented in the literature (Daly et al. 2010) there are different methods that can be used to test the statistical significance of the ratio of coefficients between the desired attribute and the monetary one representing the base of any WTP/WTA measures.

Testing the statistical significance of the ratios is not only important per se, since it allows the researcher to infer reliability of the results obtained especially when using them for simulation purposes, but also because it is reasonable to assume some heterogeneity in the sample selected. Especially in connection with this last point and for policy evaluation purposes it is interesting to estimate monetary confidence intervals rather than using single point estimates.

Among the methods that one can use to construct confidence intervals for these ratios the most popular are: (1) Krinsky and Robb (Krinsky and Robb 1986, 1990); (2) Bootstrap (Efron 1979; Mooney and Duval 1993; Efron and Tibshirani 1993); (3) Delta Method (see e.g. Greene 2003). In our case we opted for this last method. WTP are assumed normally distributed and, thus, symmetrical around the mean. Delta Method's estimates of the variance of a non-linear function of two random variables is obtained by taking a first-order Taylor expansion around the mean value of the variables and calculating the variance for this expression (Hole 2007).

Our choice is motivated by two main considerations: (1) Delta Method is an exact method compared to both Krinsky-Robb and Bootstrap where a simulated distribution for the variable of interest is generated; (2) Shanmugalingham (1982) has empirically shown that the normality assumption underlying the Delta Method is, in general, less tenable when the standard deviation of the denominator variable

Fig. 2 Part-worth utilities for PLUBF

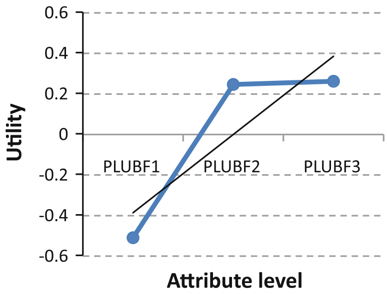


Table 5 WTP estimates with delta-method (based on M1)

Variable	Coefficient	St.Err.	T-Stat
LUB/EF	0.362	0.064	5.64
PLUBF/EF	0.496	0.066	7.47

is large relative to its mean and this is not the case for our results given that the cost coefficient is strongly significant and no skewness risks are incurred.[13]

Table 5 and 6 report the WTP estimates respectively for M1 and M2. In both cases all the reported estimates are statistically significant and, with reference to M2, non-linear effects are clearly evident.

To interpret the meaning of coefficients' estimates one has to recall that for estimation purposes and in order to avoid measurement unit effects (e.g. LUB absolute numbers –400, 800, 1.200–; PLUBF PBP –10, 20, 30–; EF Euros –200€, 400€, 600€, 800€, 1,200€–), it is advisable to normalize all the variables so to sterilize the unit of measurement effect.

Notwithstanding the considerations above we deem useful to explain in detail how the monetary WTP were calculated so to facilitate interpretation. For instance (with reference to M1), as it is for LUB, departing from a normalized WTP of 0.362 and wanting to know the amount of money the interviewees are willing to pay for an additional LUB one has to perform the following calculations: 0.362 * (200€/400LUB) = 0.18€/LUB whereas for PLUBF we have 0.496 * (200€/10PBP) = 9.93€/PBP.

At this point from a policy perspective it is interesting to compare two different policies that guarantee, in alternative ways, equal results. In more detail, one can compare how much people are willing to pay to have an extra LUB free either via additional LUB construction or via increased probability of finding a LUB free. In order to perform the comparison one has to recall that, taking the SQ as a

[13] Notwithstanding the above made considerations we think it would be interesting to test under which conditions each of the three methods provides the best results. We are presently working on a paper specifically addressing this issue using both simulated as well as real data.

Table 6 WTP estimates with delta-method (based on M2)

Variable	Coefficient	St.Err.	T-Stat
LUB3/EF1	−0.1938	0.0377	−5.13
LUB3/EF2	−0.2302	0.0511	−4.49
LUB3/EF4	0.2834	0.0621	4.56
LUB3/EF5	0.1358	0.0279	4.86
PLUBF2/EF1	−0.2213	0.0597	−3.7
PLUBF2/EF2	−0.2629	0.0679	−3.86
PLUBF2/EF4	0.3236	0.0911	3.55
PLUBF2/EF5	0.1550	0.0400	3.87
PLUBF3/EF1	−0.2358	0.0569	−4.13
PLUBF3/EF2	−0.2802	0.0716	−3.91
PLUBF3/EF4	0.3448	0.0828	4.16
PLUBF3/EF5	0.1652	0.0408	4.04

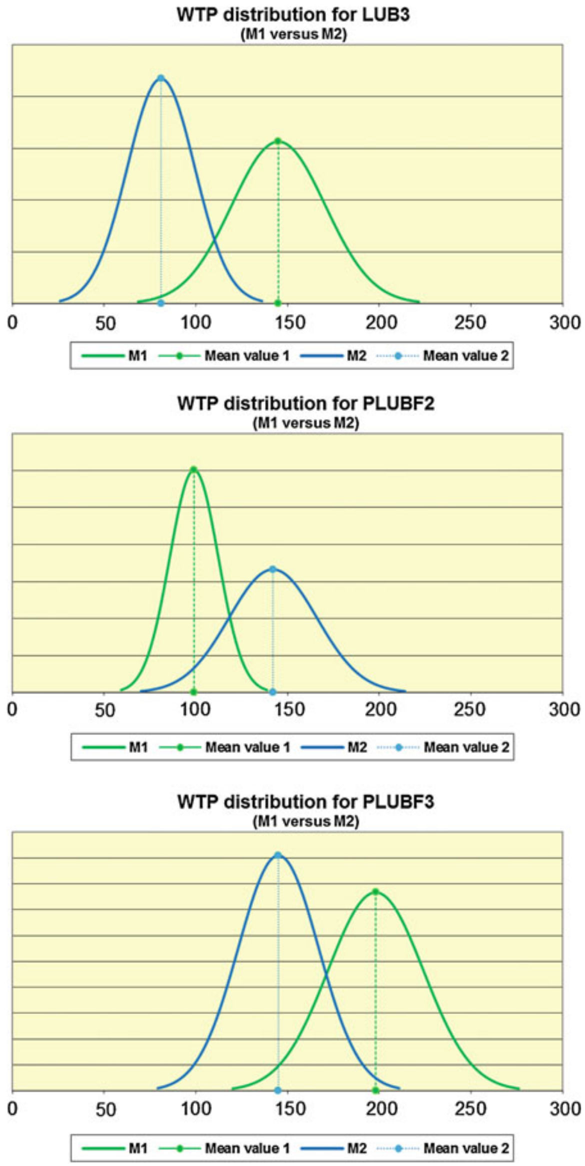
Table 7 WTP comparison between M1 and M2

Variable	M1	M2
	WTP (discrete variation)	
LUB	+800	
	145€ (95€- 195€)	81€ (45€- 117€)
PLUBF	+10	
	99€ (73€- 125€)	142€ (95€- 189€)
	+20	
	198€ (147€- 251€)	145€ (102€- 188€)

reference, we need to construct 10 extra LUB to ensure one additional free LUB. On the other hand, one could obtain the same result by an increase of 0.25 PBPs.

One extra free LUB is evaluated 1.80€ if obtained by construction of additional LUBs whereas the same result would be evaluated 2.48€ if achieved by increasing PBPs of finding a LUB free. The apparently contradictory result could be interpreted, on one side, as a lack of trust the interviewees have in the announced extra LUBs construction policy which has for long been on the local administration agenda and never materialized and, on the other, as an explicit preference for a short-term, no-financial-outlay policy that can be simply pursued by an increased surveillance and repression of illegal parking. The policy implications derivable from this interpretation are clear and suggest the adoption of light intervention policy based more on regulation rather than LUB construction with a limited impact on the public purse.

Fig. 3 WTP distributions. A comparison between M1 and M2



Similar considerations apply to M2 (see Table 6) where we also calculate different WTP measures since we test and discover non-linear effects for the EF. It is important to clarify that since we have only ameliorative variations, with respect to the SQ level, for both LUB and PLUBF in the case of reductions of EF levels, in order to interpret the meaning of the coefficients one has to imagine that the values derived represent (in order to have a trade off of some sort) the amount of money the agent would be willing to receive for not having potentially gained from the increase in the level of the beneficial attribute under consideration.

Notwithstanding the interesting analysis just discussed one has to scrutinize the policy implications derived by using either M1 or M2. An informative comparison between the WTP estimates (and their respective confidence intervals) of the two models is reported in Table 7.

We underline that all the results reported use $Beta_{EF3-4}$ as a base since this represents the part-worth utility variation from the SQ (600€) to the next step up (800€). Moreover, for M2, having effects coded the variables, one has to be careful in interpreting results especially when it comes to WTP measures. In fact, one should recall that the WTP to move from the basic level of an attribute to a different one represents the difference in the corresponding valuations (Collins et al. 2012). In our case, for LUB3 we have 113€ representing the amount of money interviewees are willing to pay to obtain 800 additional LUB.

The results reported in Table 7 show the strong policy impacts that adopting either a linear or non-linear assumption might have. In fact, comparing the results of M1 and M2, one observes substantial differences for both LUB and PLUBF. In particular, Fig. 3 shows that M1 tends to overestimate WTPs associated with the greatest attribute levels and, in these cases, the distributions are much flatter than those related to M2 (i.e. LUB3 and PLUBF3). On the contrary, M1 underestimates WTP linked to intermediate level and the distribution is characterized by a little dispersion around the mean value (i.e. PLUBF2).

From a purely statistical point one should suggest policy maker to have more faith in M2 results giving its higher explanatory power given its capability to fit the data.

5 Concluding Remarks

This paper reports the results from an empirical research on UGM policy intervention in the Roman freight LTZ. The research specifically focuses on retailers' preference analysis for hypothetical policy scenarios. The paper innovates in terms of questionnaire development and in terms of ex-ante policy-mix evaluation. The results obtained are relevant both from a theoretical point of view as well as from a more practical and policy-oriented perspective. It is noticeable that notwithstanding the often called for agent-level analysis, the literature on UGM policies has rarely investigated this issue at this specific level. Therefore, the paper represents a first attempt at bridging the gap between theory, applied research and data needs.

In more detail, from a methodological stance the results reported show that not only it is important and interesting to adopt an agent-based point of view but also to consider potentially non-linear effects of the policy instruments adopted. Data reveals, in fact, that both with respect to all attributes considered the policy potentially implemented might have a different effect depending on the attribute level the policy is trying to influence. The results have been analyzed in terms of WTP so to facilitate interpretation and, under this respect, the robust estimation conducted on the coefficients' ratios allowed us to produce monetary confidence intervals for each of the policy attribute considered. The comparison between M1 (linear effects) and M2 (non-linear effects) shows that potentially relevant biases could characterize the results obtained if non-linearities in the effects are duly accounted for. The limited amount of observations available do not suggest extrapolating the results to a real-life context, however we trust the reader will appreciate the methodology exposed as useful in providing local policy-makers with relevant information. Future research will pursue two different but concurrent objectives. On one side we will perform similar investigations on two other relevant UGM agent-types, namely transport providers and own account, while, on the other, from a methodological perspective, we will also investigate other potentially relevant issues such as for instance: (1) various forms of heterogeneity in preferences (e.g. investigating deterministic, stochastic, as well as both deterministic and stochastic, see Marcucci and Gatta 2012); (2) develop interactive choice models along the methodological lines proposed by Hensher and colleagues at ITSL Sydney (Hensher and Puckett 2007; Puckett et al. 2007); (3) adopt Bayesian estimation methods since they are particularly useful when researchers are faced with a limited number of observations.

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Financing Urban Logistics Projects

From Public Utility to Public–Private Partnerships

Jesus Gonzalez-Feliu, Eichi Taniguchi and Bruno Faivre d'Arcier

Abstract Urban goods movement and urban logistics started to be defined as a scientific discipline 20 years ago, where several actions in research, development, policy and deployment were started to be coordinated. However, most of the innovations and projects presented in that field are stopped or reduced because of a common constraint that becomes its worst enemy: the financing mechanisms. Although many studies deal with urban logistics, only a few of them show the difficulties at financing, but without entering in detail on the financing mechanisms. This chapter aims to present the main financing issues in urban logistics. First, the main categories of funding strategies that can be applied to urban logistics are presented, focusing on public–private interactions and collaborations. After that, a scenario assessment using a cost benefit analysis framework shows the different interests and issues of each category of stakeholders, and the main advantages and limits of each category of investment and financing strategies. Then, the fields of urban logistics that seem the most adapted to public–private collaboration in terms of financing are identified and commented. As a conclusion, guidelines for researchers and practitioners to take into account financing issues in urban logistics decision support are proposed.

Keywords Cost-benefit analysis · Finance · Public–private partnerships · Urban logistics

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1 Introduction

Planning and management issues in terms of urban goods are not something new. The first documented proof of the interest of public authorities on regulating the traffic flows for urban supply is found in the Ancient Rome (Quak 2008). Indeed, the oldest known urban freight transport restriction dates from the first century BC: pickups and deliveries were banned from the ancient city of Rome during the day by an edict attributed to Julius Caesar (i.e. the ‘Lex Iulia Municipalis’), based on references in conserved letters of Cicero to a comprehensive law of Caesar that deals with municipal affairs (Smith 1875). However, it is not the only ancient example of urban logistics interest by public authorities: several researches in history and archaeology show the importance of urban goods management to feed big cities like London or Paris (Britnell 1995). Also the Islamic medieval cities accorded a particular importance to urban goods distribution (Boone et al. 1990). Moreover, the economic context in the late medieval period had a direct impact on the urban consumption, then on the flows of goods in urban zones, having an indirect impact on employment. This lack of planning concerning the supply of cities is one of the consequences of what is called the “medieval decline” (Bailey 1996).

Focusing on recent and contemporaneous event, the integration and development of urban goods strategies passes through different stages. After the 2nd World war (1944–1960), Europe and Japan are on a reconstruction period. Although delivering primary materials is an important, it is seen as an emergency case by public authorities that make big economic efforts on rebuilding cities and primary infrastructures. With the development of the industry during the Cold War (mainly in the U.S.A., Europe and Japan) and the popularization of private cars, the period between 1960–1980 is characterised by two related phenomena: City expansion and need of understanding personal mobility. The aims of local authorities and even several countries’ governmental offices are focused on expanding urban areas and creating core infrastructures to incite internal mobility (of both people and goods). However, local economies remain important and cities start to be populated resulting on a constant increase of cities’ supply flows.

It is why between 1980 and 1990 the first congestion problems start to be observed. Urban goods trips co-habit with personal trips, and the first conflicts are in general solved by punctual interventions or market regulations (Gonzalez-Feliu 2008). It is during the 1990–2005 period that the main concepts of urban logistics will be developed. The notion of Urban Goods Movement is introduced by Ogden (1992) and extended by Ambrosini and Routhier (2004). Several coordinated actions take place in different countries during those years (mainly in Germany, France, Japan, The Netherlands), supported by the research community (Taniguchi and Thompson 1999, 2001, 2004, 2006, 2008, 2010, 2012; Maccharis and Melo 2010). Public authorities being the most active during that period, the private stakeholders start to strongly being implicated in urban logistics projects since 2004, mainly in France, Germany and the Netherlands.

However, we observe that after almost 20 years of coordinated urban logistics researches and studies, most innovations and projects are stopped or reduced because of a common constraint that becomes its worst enemy: the financing mechanisms. Although many studies deal with urban logistics, most of them are related to regulation, optimization and management issues, and only a little set show the difficulties at financing, without entering in detail on the financing mechanisms.

For this reason, and to support this field in urban logistics research, this chapter proposes to present the main financing issues in urban logistics. First, the three categories of funding strategies common to infrastructure investment are presented and applied to urban logistics, focusing on public–private interactions and collaborations. Moreover, several examples are presented to illustrate those concepts. Then, an example is presented to show the different interests and issues of each category of stakeholders, and show the main advantages and limits of each category of investment and financing strategies. To do this, an example of deployment of delivery space booking systems is proposed, as well as a cost benefit analysis taking into account three modes of financing: an “all private”, an “all public” and a “public–private partnership”. After that, the fields of urban logistics that seem the most adapted to financing-based public–private collaboration are identified and commented. As a conclusion, guidelines for researchers and practitioners to take into account financing issues in urban logistics decision support are proposed.

2 Urban Logistics Funding Strategies

In urban logistics several funding strategies can be identified. Since the variety of stakeholders is high and their interactions frequent, the financing actions can take different forms.

The first is public funding, as happens in several city’s infrastructures like delivery bays or reserved lines.

For private initiatives, private funding is the most common strategy. However, public intervention is possible. We find three main forms of public intervention:

- Delegation: public authorities cover a part of the investments (or not) and give a private company the structures to make a service. Sometimes (like in public transport) they cover a part of operational costs, in other cases (like Vicenza’s UCC) they cover only the investments and give free usage of the structures, but the operational costs have to be covered by the private company.
- Subsidies: subsidies are economic helps that must not be refunded back.
- Public loans: this is the case of low interest credits to help the development of urban logistics systems. Those economic helps must be refunded back to the public authority.

In South-West Europe, the concept of delegation is one of the most popular when referred to the deployment of urban logistics solutions. Indeed, many operational systems derive from trials and demonstrations financed by local authorities (with the contribution of regional, national or European subsidies). The most significant cases are the UCCs of La Rochelle (France), Monte Carlo (Monaco), Ferrara, Parma, Venice Mestre and Vicenza (Italy). In all those cases, the logistics terminals and the vehicles have been funded by the public authorities (who remain the owners). Also failed projects have followed this funding strategy, like Strasbourg (France), Genova and Bologna (Italy), Regarding logistics facilities, such projects use mainly on de-used public publics like gross marketplaces, warehouses or industrial pavilions, reconverted into urban crossdocking terminals (and sometimes, like in Parma, warehouses). The vehicles are in general built in association with the public transport operator, but remain property of the city council. Once the investments are funded (in general without a real return of investment), a carrier is contracted to operate the system. This can be a consortium of existing operators (Bologna), a municipal service (Monte-Carlo, Parma, Venice Mestre), a specific society created with public funds (Vicenza), a mixed-capital company (Genova) or a public transport operator (La Rochelle).

Subsidies are in general applied in many cases. From R&D projects (like those promoted by the European Union) to public actions like those of the Emilia Romagna region in Italy, we find in several countries cases of subsidies. They cover in general the following application fields:

- Subsidies to local authorities by national or international entities to cover a part of structural and infrastructural investments (Emilia Romagna Region subsidies, European Commission projects).
- Financial support of local, regional and national governments to carries for equipping them with green vehicles.
- Technological subsidies, when dealing to the deployment of vehicle and driver support technologies.
- In some cases, social subsidies can be used to recruit fragile populations and to prepare them to urban logistics. Although some French stakeholders like La Petite Reine or Alud have promoted those practices, this field remains less developed than the others.

The case of public loans is less common. However, the French politics in terms of environment have promoted several actions where funds are not given to private carriers as subsidies but as loans that have to be refunded back. Although most actions concern industry and long haul carriers, we can find also applications regarding urban logistics, mainly related to intermodal transport in urban areas o to technological innovation to support urban goods transport.

3 Public Economics Re-funding Strategies

Traditionally, two main families of re-funding approaches have been applied by public authorities, mainly for infrastructure investments: that of collective utility and that of users' refunding. Those two families have been seen as opposite so being in direct conflict. However, a third family of approaches that mix both precedent families have been observed in the last years, mainly in transport infrastructures (Bonnafous et al. 2006) but also in urban logistics projects (Browne et al. 2004). This family includes all mixed approaches where a part of the investments are covered (or refunded) by public authorities on the basis of collective utility and the rest must be obtained by the economic benefits of the systems, paid by its direct users or their customers. In this section we will examine all three families of approaches, illustrating them by representative examples in urban logistics.

3.1 Collective Utility

By collective utility we intend the socio-economic interest that a project can bring to a society. In collective utility viewpoints, the initial investments and operational costs are paid by public authorities. The funds come from the public taxes, either local or national, and in general no refunding is allowed. In some cases, it can be asked to a private partner to invest a part (in case of PPPs) with a total refunding by public funds, although this case is less common. Collective utility is motivating the construction of free infrastructures, like national and regional public roads, public parking (with no fees) or, regarding urban logistics, delivery bays or electronic accesses to limited traffic areas. To justify public utility, a system must be proven socio-economically viable. In other works, it must prove to bring a quantifiable socio-economic benefit to the collectives of the city or country it is deployed.

The decision to invest is then conditioned to a quantifiable analysis of the balance between the used (and sometimes destroyed) resources and the created richnesses, which are advantages of different nature (economic, environmental, cultural, social, societal, etc.) directly or indirectly lead by the project (Bonnafous et al. 2006). To do this analysis, a socio-economic assessment via Cost Benefit Analysis is a valid alternative, as seen in infrastructure investment (Hayashi and Morisugi 2000).

To make a first example related to urban logistics, we will cite the deployment of delivery bays and other free parking infrastructures for trucks in urban centres, common to several European cities.[1] Indeed, delivery bays in city centres are in general located next to fee-based parking spaces (so no free parking zones) and their deployment imply two types of resource usage: one is that of real costs, both for its construction (signalling, painting and sometimes small civil works) or for enforcement controls (sometimes assimilated to car parking controls); the second is the lack of savings that suppose blocking private car parking economic benefits to make a delivery free parking space. To justify that resource usage, it is

[1] The following statements are made after a quantitative and a qualitative analyses of two delivery bay and road parking behaviour surveys (one in Bilbao, Spain and one in Lyon, France) made between 2011 and 2012 in the context of the FREILOT project. For a detailed description of the surveys and their main results, see Blanco et al. (2012).

important to quantify the socio-economic benefits: impacts on congestion, social benefits (mainly to delivery workers and private car drivers related to the decrease of double line parking) and economic benefits for carriers (mainly related to global time savings). Because the socio-economic benefits are higher than the destroyed resources, the development of delivery bays is justified.

Another case of collective utility is that of Bologna (Italy), where the city centre has rigorous restrictions but presents also parking facilities to "clean freight transport vehicles" (Trentini et al. 2012). In that case, vehicles have to be identified (mainly by RFID) and automatic control devices are installed at the "gates" of the limited traffic zone. Those investments are not refunded back, because they are of collective utility (the decongestion of the city centre due to such controls, on both private cars and business/goods vehicles led to significant socio-economic savings). However, they have been financed by different public bodies: the city, a regional contribution and a national subsidy.

3.2 User's Refunding

The user's refunding strategy is that of making the user (in this case the transport carriers, the retailers or the freight senders) for using the service, i.e. to pay a fee for using an urban logistics service. This strategy is mainly motivated for economic reasons and the systems in this category need to be economically viable. This is the case of German UCCs, most of them stopped when carriers found less costly delivery schemes. Indeed, in Germany, consolidation has followed an economic logic, and carriers adopting such schemes have done only because they allowed economic savings. The main example is the Postdamer Platz distribution centre of Berlin, which is still operational. Another example is that of Dresde's cargo-tram, developed for private interests of a Volkswagen manufacturing plant. The system, which was an example of user's refunding, stopped in 2010 because considered as less rentable that a classical truck-based delivery system due to the global economic situation.

An alternative is to use refunding mechanism applied to a larger set of individuals (urban tolls, negotiable permits, etc.) to make the less virtuous pay for the virtuous delivery system. This alternative, although envisaged for delivery space booking services, has not been adopted by the city of Bilbao (Spain) because of both cultural and legal issues.

3.3 Mixed Approaches

In urban logistics, the main re-funding approaches are mixed because of a common factor of most projects: investment costs are difficult to be entirely refunded. For that reason, public authorities accept to partially finance them, then to make them operational and economically viable (for operational costs and a part of the investments). However, mixed approaches are various in nature and structure and it is not always easy to properly identify all of them. We however propose a categorisation of mixed approaches:

The most common strategy is that of a partial contribution of authorities as a subsidy. In other words, when developing urban logistics solutions, some investment costs are covered by a public subsidy. In general, those costs cover feasibility studies, part of the investments (mainly related to civil works and technological issues, including clean vehicles) and a demonstration period. In many cases, they are not refunded back (like in Genova and in several cities from the Emilia Romagna Region in Italy). In other cases, a part is refunded back but not the entire subsidy.

Another strategy is that of giving concession (with or without asking for retribution) of infrastructures and/or vehicles. Indeed, since platforms and vehicles constitute the main investment costs, public authorities can give concession of them to the service operator. In Vicenza (Italy), a specific carrier was created to operate the UCC, freely having the right to use the logistics facilities and the vehicles given by the city's authorities. The management, maintenance and other management costs are covered by the fees the system asks the transport carriers to deliver the city centre. Being compulsory to a large number of fields to use the UCC (Ville et al. 2012), the economic benefits are enough to make the operator continue managing the system, and ensures its continuity.

Also indirect subsidies are found in practice. In Paris, Chronopost developed an urban logistics space in a central part of the city (Place de la Concorde). Since the facility prices are high, the city of Paris gave a subsidy to one of the main real estate stakeholders to make reduce the price asked to Chronopost to the values seen in near periphery areas, and allow the operator have an economically viable system. The platform is still working but the indirect subsidy needs to be maintained because of the economic situation.

Concerning Private–Public Partnerships (PPPs), the most common action related to financing transport systems is that of making a mixed investment, where public funds are used to cover a part of the global costs and the rest must be funded by the private company, or vice versa. That strategy starts to be popular in urban people transport but remains quite unusual in urban logistics.

Finally we find approaches combining various strategies, like in Padova's UCC, where the facility was already owned by the operator. In that case, costs for feasibility analysis and demonstration were not refunded (as paid directly by public authorities), but vehicles were bought on the name of the public transport operator, and given free to the operator. The system is operational and economically viable (for only operational costs) since its second year. For new vehicles, subsidies have been given, but original vehicles are step by step re-bought to the public transport company in order to refund a part of the initial investments. New investments, like the increase of storage surface and the development of fresh products logistics, are funded by the operator (which is a main logistics real estate stakeholder in the area).

4 A comparison of Funding Strategies

In this section, we present a comparison among four funding strategies. To do this, we will follow a classic cost-benefit analysis (CBA) method after defining each scenario. All the scenarios are defined on the same basis, i.e. a deployment project arising on implementing and making operational a network of delivery space booking (DSB) systems.

4.1 A Note on Cost Benefit Analysis

Generally, a CBA method consists on listing on one side all investment and operational costs, year after year, for a given time horizon (in general 10 years for infrastructure projects, i.e. DG REGIO 2008). Then benefits are also listed in the same time horizon. After that, for each year, benefits are confronted to costs and their difference is updated using an update rate in order to take into account the money updating year after year. Finally, an Investment Return Rate (IRR) after the project's time horizon is calculated. In order to take into account the pluri-annual time horizon, it is important to define an updating rate "a" which allows comparing two quantities of money at two different periods. Taking the value of a quantity of money V_t at time t, and V_n the value of this quantity at horizon n, they are related by the following equation: $V_t = Vn/(1 + a)n$.

Then, year by year, benefits are confronted to costs and their difference is updated using an update rate of 4 %. Finally, an Investment Return Rate (IRR) is calculated, in a 10-year horizon.

To simulate the scenarios, we need to have a unique basis on which only parameters related to who invests would change. We assume a hypothetic city, making abstraction of the country. All simulations are then made on the same city, a virtual 2.000.000 inhabitant urban area created from real data (the details on how the virtual city is constructed and how the freight demand is forecast, see MODUM 2011). Using the tools of evaluation in this context, i.e. generalising local effects to a city point of view, we estimate the costs and the benefits for the two main stakeholders: the city (or the collective community) and the transport carriers (or individuals).

We assume a VAT of 20 % and, for each system personnel fees equal to those of employees working during the pilot implementation, operation and evaluation phases (in case of pilots in different cities, the retained costs will be précised in the corresponding section). Another important assumption concerns the time period where investments are made. Oppositely to public transport infrastructures (tramways, subways, urban-suburban trains), investments are not made in the first two years, but the systems are introduced gradually. This assumption enforces that of money availability.

The CBA will be made on a 10-year horizon, which is enough long to ensure a return of investment and enough short to not need a strong technology change or replacement during the operation period. We also assume the level of operating costs and revenues as constant over this period. The discount rate is assumed to be the French public one, i.e. 4 %. This rate varies from one country to another, and can be updated (as well as personnel costs and VAT) when adapting the scenario assessment to cities of one precise country. Moreover, we define a target internal return rate (IRR) of 15 % for the private company and 4 % for the public entity. Last but not least, we assume that invested money is available by each investor, so no hypotheses on how the money is obtained are made.

4.2 Context, Scenario Characteristics and Assumptions

When assessing a scenario, for a CBA or other forecasting analyses, it is important to explain well the context and the input variables by defining all the parameters and setting the various assumptions that allow building the scenario. In this section we present the main characteristics of the scenario that will simulate the deployment of a DSB service in the virtual city as well as the assumptions that have been made.

First, we aim to make a quick synthesis of how a DSB system works. Such system is installed into a surface parking machine which is located next to the delivery space that can be booked. The user that aims to book has to be registered and have an identification card that needs to be introduced in the machine each time the vehicle is stopped on the delivery space. Two booking alternatives are proposed: either by internet (both punctual and periodical reservations are allowed) or directly on the machine is the delivery space is free. When a vehicle is stopped on the delivery bay, lights on the floor indicate if it is reserved (red) or not (green). In any case, the vehicle needs to be identified. If the delivery space was free, the vehicle automatically books the place. If not, if the introduced card corresponds to that of the reservation, the lights change colour (to green). If an unauthorised vehicle is stopped on a reserved delivery space, lights indicate it and a message is sent to the police station to inform about the irregular situation.

To build a deployment scenario under realistic commercial, tactical and operational conditions, we suppose that the solution tested in Bilbao has been further developed and can be applied to existing parking machines in order to allow the possibility to make private car parking payment (for private parking places around the DSB) and booking operations for the DSB systems on the same machine. In that way, existing machines can be used for both private parking and DSB services. We suppose that all delivery bays with the DSB technology are deployed in a central area (about 3.5 km^2). A total number of 100 DSB will be operational in 5 years, and we assume a total number of users (per year) of 1200 vehicles. We assume that one user corresponds to one vehicle and then one vehicle uses only one card. Because the cards can be lost, broken or stolen, we estimate that 15 % of

Table 1 Deployment trends for the chosen scenario

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6 and after
Number of installed DSBs during the year	16	40	60	80	100	100	100
Number of vehicles using the system	0	150	450	850	1150	1250	1250
Percentage of replaced cars	15 %	15 %	15 %	15 %	15 %	15 %	15 %

Table 2 Cost structure (in k€)

Investment costs						
Cost type	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Technologic investments	27.00	0.00	0.00	0.00	0.00	0.00
Infrastructure and civil works	40.25	60.37	50.31	50.31	50.31	0.00
Other investment costs	10.00	10.48	16.00	11.00	10.50	10.46
Total investment costs	77.25	70.85	66.31	61.31	60.81	10.46
DSB—operational costs						
Cost type	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Functional costs	0.00	40.00	40.00	40.00	40.00	40.00
Maintenance	0.00	57.90	80.56	99.44	118.32	137.20
Other operational costs	0.00	0.11	0.34	0.64	0.86	0.94
Total operational costs	0.00	98.02	120.90	140.08	159.19	178.14

the users will need to replace their cards each year. The deployment trends of the system and the number of vehicles consequently using it are reported on Table 1.

In all scenarios, we make the assumption that operational costs will not change. The details of those costs are found in Gonzalez-Feliu et al. (2013). The cost structure can be summarized in Table 2.

To finance the system and also to make it more efficient, it is necessary to ask a fee to the users, in order to both contribute to its development and be more involved in using it as well as in defending its good usage. The following CBA (one for each scenario) will be made to find the better fee to ensure a viable system and then continuous in time.

4.3 Transport Carrier Benefits

Before making a CBA for each scenario, it is important to define the benefits of transport carriers to estimate the values that fees to ask to carriers can take. This value corresponds to the maximum fee transport carriers would accept to pay. To obtain this value, we need first to estimate the benefits of a DSB for a transport company. In this case, we can identify four direct benefits for a carrier:

- Fuel savings, directly translated into economic gains (money savings related to fuel consumption).
- Time savings, also directly translated into economic gains (money savings related to timetabling and working hours).
- Distance savings, indirectly translated into economic gains (money savings related to vehicle usage).
- CO_2 savings, which can be related to economic gains if a Carbon Tax is assumed.

We assume that the DSB areas will be created in order to consent the loading and unloading operations for carriers that are not DSB customers, i.e., to be developed in a non-congested situation. We extrapolate the results of Bilbao's DSB evaluation with a small calibration concerning small vehicles, the category the less concerned by the system (their characteristics and delivery behaviour show the need of stopping even no place is available and the possibility to make double lines without significantly perturbing the traffic and the environment). In this context, we assume a unitary fuel and CO_2 savings per vehicle per DSB stop as shown in Table 3.

We make the following assumptions:

- The deployment of the DSB allow an average usage of the system, per vehicle, as follows:
  - First year (16 DSB): 5 stops/route at DSB.
  - Second year (40 DSB): 8 stops/route at DSB.
  - Third year and more: 11 stops/route at DSB.
- Savings related to double line avoiding are negligible for drivers in terms of fuel consumption and CO_2 emissions. However, a speed gain related to congestion decreasing can be assumed. This gain is estimated to be about 2 km/h in average in the considered area, i.e. an average gain in route of 20 min., corresponding to a time savings of 6 % with respect to total travel time.
- Fuel savings are estimated in gram, then converted into liter using an average volumetric mass for fuel of 750 g/l. Moreover, a fuel cost of 1.3€/l is assumed (this is the current value in France, according to CNR (2012), it can be updated to the current value for each country).
- Concerning CO_2, we assume a carbon tax for each transport carrier. Although the current value is 17€/ton, we aim to set it to 100€/ton, according to the last European Considerations (French Ministery of Land Use and Transport 2005). In this configuration, a carrier having a standard route (see Pluvinet et al. 2012, for more information about routes using DSB in Bilbao) would pay about

Table 3 Fuel and CO_2 savings for DSB in a deployment situation

Vehicle type	Fuel savings (ml)	CO_2 savings (g)
Van	0	0
Small truck	32	82
Big truck	40	101

Table 4 Benefit monetary conversion, for each savings category

Type of gain	Stakeholder	Economic gain per vehicle (€/year)
Vehicle usage	Transport operator	0
Time savings	Transport operator	350
Fuel savings	Transport operator	85
CO_2 reduction	Transport operator	15
Total savings	Transport operator	450

1175€/truck each year (for trucks making urban distribution as those of DSB pilot). On the another hand, the direct benefits are small since the gain of CO_2 and the current carbon prices give an average gain of 16€/truck each year.

The benefit table for the transport carrier is reported in Table 4.

With these assumptions, after year 5 and that each transport carrier would have an average benefit of 450€/vehicle each year, mainly due to the congestion reduction (which is traduced into time savings). However, it is important to take into account margins. Since the main impacts are related to time savings because of congestion reduction and traffic estimations have in general errors of 20–30 %, a 25 % margin seems reasonable. We set then the maximum fee that can be asked to transport carriers to 360€ per vehicle and year, including VAT.

4.4 Collective Benefits

After defining individual benefits for transport carriers, it is important to define the collective benefits in order to estimate the interest of municipal authorities on investing on such systems. Some of those benefits derive from those of transport carriers but others have to be estimated by taking into account global traffic on the DSB influence areas. The main benefits that have been identified are:

- Time savings of drivers (both for personal or commercial trips), which can be translated into economic gains (money savings related to timetabling and working hours). However, since it is difficult to make this estimation, we assume an average cost of time according to World Bank (2005) for monetary value estimation of travel time.
- Distance savings, indirectly translated into economic gains (money savings related to vehicle usage) are as for transport carriers savings, negligible.
- CO_2 savings, which can be related to economic gains if a Carbon Tax is assumed. The estimation method is similar to that of heavy vehicles, using an estimation of the current distribution of vehicle types on the considered city and translating it to the traffic in the parts of the city where we supposed to have DSB systems operationally working.

Table 5 Collective benefit monetary conversion, for each savings category

Type of gain	Stakeholder	Overall economic gain (€/year)
Time savings	Transport operator	150,000
CO_2 reduction	Transport operator	50,000
Total savings	Transport operator	200,000

The collective benefits table is the following: (Table 5).

The overall benefits by year are estimated to be comparable to those of investments, so that will justify a collective utility vision.

4.5 Scenario Simulation

We propose a scenario simulation on the basis of 5 scenarios of public and/or private funding of the DSB system. The scenarios are:

- S1: Investment and management costs covered by the public authority on the basis of a public utility. No fee is asked for carriers and public authority assumes all costs by using the public funding mechanisms (local tax derivation or national funds). For this reason, only socio-economic CBA is regarded for this scenario.
- S2: Investment and management costs covered by the public authority on the basis user's refunding. Public funds are only loaned for a part of investment costs then refunded back on the basis of the public funding interest rates (about 4 %). For this reason, an IRR of 4 % is necessary to justify a balance.
- S3: Investment and management costs covered by a private company, on the basis of public delegation of service. No financing is made by public funds, and the company needs to ensure a minimum benefit that can be translated on an IRR of at least 14 %.
- S4: Investment and management costs covered by a private company, on the basis of public delegation of service, with a public subsidy that covers all investment costs for years 0 to 5. That amount is funded by a public mechanism and no IRR is asked. The company needs to ensure however an IRR of at least 10 %.
- S5: Public–Private Partnership. Public authorities cover 60 % of the costs (on an IRR of at least 4 %) and private carrier the 40 % remaining (on an IRR of at least 15 %). In this case, both stakeholders get an economic return but it allows a better management (by a private carrier) and a contained fee for the transport carriers.

We observe from Table 6 the main differences in terms of cost assumed by each stakeholder, in terms of internal rate of return (IRR), socio-economic rate (i.e., the theoretical economic benefit that should be obtained if all benefits considered in

Table 6 Scenario simulation synthesis

Scenario	Stakeholder	Total costs (€)	Economic IRR	Socio-economic rate	Yearly fee[a] (per vehicle) (€)
S1	Public	1,853,428.91	n.a.	5.7 %	0
S2	Public	1,853,428.91	4.6 %	90.9 %	250
S3	Private	1,853,428.91	16,2 %	n.a.	280
S4	Public	346,974.33	n.a.	5.7 %	0
	Private	1,506,454.57	14.3 %	n.a.	220
S5	Public	1,112,057.34	4.6 %	62.0 %	260
	Private	741,371.56	17.6 %	n.a.	

[a] Fees include a Value Added Tax (VAT) of 20%, which is a reallistic value for European countries (Gonzalez-Feliu et al. 2013)

the study would be monetized) and the yearly fee that has to be asked to transport carriers (per vehicle) to reach the expected IRR. Scenario S1 defines the socio-economic issues and shows the global benefits in case of a total funding by public authorities. In the current economic context, this scenario is not viable, since at least a part of the costs (most operational costs and if possible a part of investment costs) should be refunded by the user. In that context (Scenarios 2 to 5), different possibilities are shown. The lowest fee is obtained by a system managed and financed by a private carrier with a public subsidy which cover the investment costs, representing about 18 % of the total costs of the system in a 10 years operational configuration (S4). Then, a system totally financed by public funds but with a user's refunding strategy (S2) results on a similar but lightly higher fee (220€ for S4 and 250 for S2). An only privately financed system (S3) needs a fee of 280€, almost 30 % more expensive that the best case. However, in S4, public authorities need to finance almost 350,000€ without any economic return of investment, whereas in S2 and S5 the invested capital can be refunded. The difference is that in S2, the total amount (more than 1.8 million €) needs to be invested, and in S5, the amount to invest is about 60 % of the total (about 1.1 million €). Moreover, having a private partner guarantees a constant need of ensuring the system's efficiency and reaching in the best way the expected IRR.

5 Which Urban Logistics Fields Seem the Most Adapted to Public–Private Partnerships?

From the example, we observe that PPPs can be a valid alternative to classical funding strategies. Moreover, other forms of public–private collaboration seem interesting for different types of urban logistics solutions, whereas for commercial applications or private actions they are few recommended. Furthermore, also in the case of public utility cases (mainly related to infrastructural or policy actions) the collective utility thinking dominates the other strategies. In this section we present several fields of urban logistics where public–private collaboration for funding seems a good alternative to consolidate their deployment and operability. We distinguish three categories of fields:

- Urban logistics facilities.
- Urban logistics systems based on ITS and ICT.
- Resource sharing-based logistics schemes.

5.1 Urban Logistics Facilities

5.1.1 Urban Consolidation Centres

Urban consolidation centres (UCC) have been considered as the main example of urban logistics (Allen et al. 2007). However, most of the planned facilities are nowadays not operational (Gonzalez-Feliu et al. 2013). This lack of operability is in general related to the difficulty to maintain the system due to a sub-usage of the platform. However, we observe different cases where the systems are working.

The first category of systems is that of UCCs with a strong public intervention. Either in totally public funding cases, like Vicenza (Ville et al. 2012) or Monaco (ref.) or on private management with public subsidies, like La Rochelle (Trentini and Malhéné 2010), the UCC remains operational or continuous because of an explicit implication of public authorities. In the first two cases, the public authorities ban the access of all freight transport vehicles (allowing however some exceptions) using public ordinances, which is at the limit of free competition (Ville et al. 2012) but has been allowed by National Juridic instances. In the second case, the support to the UCC is not only policy-based but also economic. Indeed, La Rochelle municipality has grouped three service (two for personal transport and the UCC delivery system) into a lot, and given to a private company. The deficit of the UCC is compensated by the benefits of the other two services (Trentini and Malhéné 2010), and in the first years of the contract a yearly public subsidy was given to the management operator to make the system operational. A similar case is that of Milan, where the public transport operator used the public transport infrastructures and their service facilities and vehicles to deploy an urban delivery system. The system was stopped after the municipality retired its support, not allowing the delivery vehicles of the system going on the bus lanes (Trentini et al. 2012).

In the second category we find private-managed initiatives with public subsidy where municipalities have not been supporting the UCC outside the initial subsidy for investment and release costs. This is the case of Padova (Gonzalez-Feliu and Morana 2010), However, this strategy is less used than the others, but when public authorities do not interfere it appears to be efficient and sustainable.

In the third category a number of UCC have been operated by private sector without any subsidies by public authority. We can find these cases in Motomachi, Yokohama, Japan and Shinjuku, Tokyo, Japan (PIARC report 2012). The Motomachi joint delivery system using UCC started in 2004. The Motomachi Shopping Street Association (MSSA) carried out management of the system asking a nutral freight carrier to operate UCC and collect/deliver goods to about 1,300 retail shops and 500 homes in place of 20 freight carriers. The success factors were that about 95 % of retails shops in the area have participated in the joint delivery systems and MSSA effectively coordinated stakeholders involved in the system. Shinjuku UCC was another successful joint delivery system using UCC which started in 1992. The system mainly collect/deliver goods to offices and retail shops in high rise buildings in Shinjuku are of Tokyo. It is very hard and costly for freight carriers to collect/deliver goods to individual office in high rise buildings with about 50–60 stories in very busy area. In addition to the congestion on streets, the bottleneck of delivering goods in such situation is the shortage of loading/unloading space and elevators dedicated for goods delivery in the buildings. They established an association named Shinjuku Matenro stuff for operating UCC near Shinjuku station. In both cases of Japan UCC has been successfully operated without any subsidies by public authority, because private associations had good business models with the excellent leadership of management as well as enough amount of goods to be delivered by UCC.

Urban consolidation terminals can be useful if the demand is well identified (Danielis et al. Danielis et al. 2005) and a good business model is found. However, to reach operability, such systems often need public help. Instead of forcing the usage, the best approach is that of partially funding the system at its investment phase (for example providing help to by vehicles) and make an access restriction policy that helps the establishment of an UCC without forbidding the rest of operators (instead of a limiting policy, an incentive action). However, it is important to ask the UCC operator to ensure a robust business model and a good operational management follow-up in order to ensure the balance of operational costs by the service benefits.

5.1.2 Urban Multimodal Terminals

Close to UCC we find the case of urban multimodal terminals. Despite the failures of Cargo trams (Amsterdam and Dresde), the subject starts to be popular and the cities of Lyon and Paris aim to develop freight systems with trams to access the city centres (not for final deliveries but for city access from important peri-urban logistics zones). Moreover, a case of urban combined transport is that of Samada Monoprix. In all three cases, a specialised operator (of public or private origin) is needed to run the system, but since terminals have to be constructed in the city centre, a help of public authorities is needed. However, in the case of Dresde tram and Monoprix train service, the initiative was private and related to the main customer of the system (respectively an automotive manufacturer and a grocery distribution group), and follows the competition rules. The public intervention is more related to indirect subsidies to make the real estate costs decrease.

A similar case is that of soft mode transport, like Chronopost (postal chariots and small electric vehicles) and La Petite Reine (electric-supported cargo cycles). In both cases, a private initiative started the system, with the goal of an operational system. To do this, a help of public authorities in terms of real estate advantages is needed. Outside of those indirect subventions, no other advantages, neither political nor financial, are given to operators.

In all those cases, the collaboration seems to take place in the form of private initiatives with the need of public subsidy strategies.

5.1.3 Proximity Delivery Points

Another interesting facility, mode related to e-commerce and proximity delivery services is that of proximity delivery points (Augereau and Dablanc 2008; Durand and Gonzalez-Feliu 2012). Nowadays, two types of reception points are seen: small shops acting as reception points for food and non-food parcel deliveries, which are in general private networks without public funding, and automatic delivery machines for non-food parcels, mainly located in passage points of cities (terminal public transport stations, commercial areas, etc.), which need in general a help of the land owner's to be developed. Although some public–private partnerships can be made in the first category (to use postal offices as delivery reception points, for example), the most interesting collaboration is found in the second category, where public–private partnerships can increase the competitiveness of its business models and provide benefits to both public and private stakeholders.

In Japan we have a large number of small convenience stores in urban areas which are used as proximity delivery points using e-commerce. The individual delivery of products to home with designated time windows can generate a burden for e-commerce company. A freight carrier very often has to visit customer more than one time, since no body is at home. To avoid such inefficient delivery, customers can obtain their products at a convenience store near their home, which is generally open for 24 h. These systems are operated without any subsidies by public sector. As e-commerce and home delivery is increasing in aging society, proximity delivery points play an important role to reduce costs of home delivery.

5.2 Introduction of ITS and ICT for Urban Logistics

The example is a clear example that illustrates it. In addition to delivery space booking, truck-based intersection control systems, like those of Helmond, the Netherlands (Pluvinet et al. 2012) can be deployed. Both systems need the implication of cities since there is a communication between he vehicle (a login card or an on-board unit) and the infrastructure (respectively parking machines and delivery bays with a reservation system), so public authorities need to invest on it and users should also pay for the service. When a public interest is found, cities can invest higher amounts of money. For example, intersection control increases security for fire brigade, police and ambulance vehicles that need to cross lights even when they are red, decreasing the number of red light crossings. For that reason, the city of Helmond promoted the installation of almost 40 systems in key crossroads of the city. Since such technologies need to evolve and be maintained, a management company which is also a technological actor is needed. The public–private collaboration is trivial in that case.

5.3 Logistics Sharing Systems

Last but not least, the collaborative systems among transport carriers seem to be a valid alternative to UCCs (Gonzalez-Feliu and Salanova 2012) that can derive on an overall cost decrease, having important economic, environmental and social benefits (see Morana et al. (2013) of the present book). This is also the case of e-commerce distribution sharing systems (Gonzalez-Feliu et al. 2012; Wygonik and Goodchild 2012), where synergies can be found among operators to strongly decrease overall costs of physical distribution. However, stakeholders are reticent to share (Gonzalez-Feliu and Morana 2011), mainly for competition and confidentiality reasons. To deal with that issue, logistics networks seem a good compromise, but to develop them, a neutral partner is needed.

It is then necessary to constitute a consortium with the different operators, a neutral management company and a public authority that ensures the neutrality of the management operator and the collective utility of the system. The most suitable way to make the system work is then to involve the different partner (public and private stakeholders) at financing levels, in order to make them participate to the development (but also to the benefit sharing) of the system, ensuring a good operational management and tactical and strategic development of the logistics sharing approach.

6 Conclusion

In this chapter we have overviewed the main financing strategies in the context of urban logistics, translating the main public economics concepts from transport infrastructure planning to urban logistics deployment. After that, we have simulated several scenarios for financing a delivery space booking system that illustrate the main concepts and show, through a cost-benefit analysis, the main economic returns for both public and private stakeholders. We observe that public–private collaboration can be a good option if both parts share the risks and are disposed to share the benefits. Opposing to transport infrastructure planning (Bonnafous and Faivre d'Arcier 2013), in urban logistics both parties can see immediate benefits of adopting a system, and PPPs can be a good alternative to share costs and risks.

However, this does not apply to all urban logistics solutions. The most suitable application fields seem to be related to infrastructures, but not to linear ones (i.e. road or railway lines) but to nodal facilities: urban consolidation centres, proximity delivery and reception points and delivery bay related systems. Furthermore, collaborative transport systems have an important potential but need a good partnership between public and private stakeholders to be efficiently deployed and ensure then their continuity.

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