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Procedia - Social and Behavioral Sciences 39 (2012) 101 – 115

Procedia
Social and Behavioral Sciences

The Seventh International Conference on City Logistics

City logistics modeling efforts: Trends and gaps - A review

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Abstract

In this paper, we present a review of city logistics modeling efforts reported in the literature for urban freight analysis. The review framework takes into account the diversity and complexity found in the present-day city logistics practice. Next, it covers the different aspects in the modeling selection process that includes (1) the stakeholders' involvement (2) the objective of modeling (3) the defining criteria i.e. the descriptor for modeling purpose and (4) the viewpoint for achieving objective i.e. the perceptive. This review argues that these factors are evidently demonstrating forces behind urban freight transportation and thus are more determinative for carrying out urban freight modeling. The review analyzes the trends of city logistics modeling research in terms of its relevance to city logistics problems and attempts to identify gaps in modeling urban freight domain.

Keywords: City Logistics; urban freight modeling; stakeholder involvement

1. Introduction

With the increase in urban population, demand for goods and services is increasing manifold. This demand transforms into goods delivery commercial vehicle trips which result into more congestion, pollution and reduction of accessibility and safety. With the increasing significance of the freight deliveries in city areas, freight related decisions are becoming more important. With multitude of stakeholders with conflicting objectives consequences of poor decision making become more severe. In addition, several logistical developments such as JIT, Lean manufacturing etc. further complicate decision making in the urban goods movement domain. As a simple example, a shopkeeper orders goods from

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1877-0428 © 2012 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of 7th International Conference on City Logistics
doi:10.1016/j.sbspro.2012.03.094

supplier (shipper) who often hires a carrier to supply the goods. This ordering of goods triggers goods movement which ultimately results in truck trip to the city and finally contributes to city logistics related problems. Thus, understanding about interactions among different stakeholders for fulfilling (supply) goods and services demand provides insights in urban goods movement causes. This explanation strongly urges for a more systematic and analytical approach to understand decision making among different stakeholders in order to understand urban freight transportation movements.

Reviews found in urban freight literature employ different frameworks. For example, Ambrosini et al., (2004) provides a review of urban freight modeling efforts based on country. They classify urban freight models in two families 1) Operational models those are primarily directed towards the improvement of flow management and 2) Systemic models, those are meant for evaluating the impact of urban logistics modifications on the flows generated. Woudsma (2001) reviews a number of planning studies that have been carried out for major Canadian cities covering the period 1974–96. The author classifies these studies according to objectives and methods of the models developed and suggest that city size and form play a role in influencing the characteristics of urban goods movement (UGM). A review by Regan et al., (2001) on freight demand and shipper behavior states that urban freight modeling is less focused domain where few researches carried out to understand vehicle flows. The authors show concern that there should be more research on commodity flow as it is the cause, while vehicle flow is the effect. Similarly, Holguín-Veras (2000) also argues that commodity flow represents actual demand where as vehicle flow represents urban freight traffic. Thus both should be analyzed simultaneously. He recommends that an urban goods movement model should include elements from commodity based as well as vehicle-trip based types of model. Other informative reviews about urban freight research include Anderson et al., (2005; Browne et al., (2007; Paglione (2007; Behrends et al., (2008; Samimi et al., (2009; Russo et al., (2010).

The frameworks discussed in different urban freight reviews do not consider clear cut factors involved in urban goods delivery process. They rather concentrate on the country of origin, methods of modeling or status of the model (i.e. state-of-the-art/state-of-practice). We argue that factors such as stakeholder involvement, objective in urban goods movement, the means available for achieving objectives, are evidently demonstrating forces behind urban freight transportation and thus are far more determinative for carrying out urban freight modeling. The remainder of the paper is organized as follows. In next section we present a prescriptive framework for classifying the available urban goods movement models. Then, we review the existing literature and discuss the relevance of decision methods and techniques practiced in urban freight analysis. In the section following it, we examine the results obtained from review and discuss trends of modeling research for urban freight analysis. Finally, we draw conclusions and give suggestions for future research.

2. Review framework

Urban goods movement is a means in itself and not an end. It facilitates the goods movement to the final consumer. On one hand goods movement is affected by different parameters (i.e. infrastructure conditions, industry structure) and on the other hand, it affects different parameters (i.e. congestion, accessibility, pollution etc.). The cause and effect of the goods movement is also interdependent. i.e., more congestion leads to less efficient goods movements and *vice versa*.

In general terms, urban goods movement concentrates on city road networks. However, for firms goods transportation is part of their broad concept of "logistics management". After the production of goods, until it reaches the consumer entire distribution process (including warehousing, transport etc.) comes under logistics management. Thus, uban freight movement is primarily constrained to urban areas but its roots are expanded to the regional, national and international level. With multiple firms transporting goods to the city area urban freight domain consists of multiple commodity flow, multiple supply chains and multiple transportation activities. On this line of reasoning, in order to understand the relevance of urban freight modeling it is wise to start asking who the different stakeholders are involved in the urban freight domain. Boerkamps et al., (2000) classify urban the freight domain in five components of freight movement and their four interacting markets. According to different segments of market, the four main stakeholders which affect urban freight domains primarily are 1) Shippers 2) Carriers 3) Customers 4) Administrators (See Fig. 1).

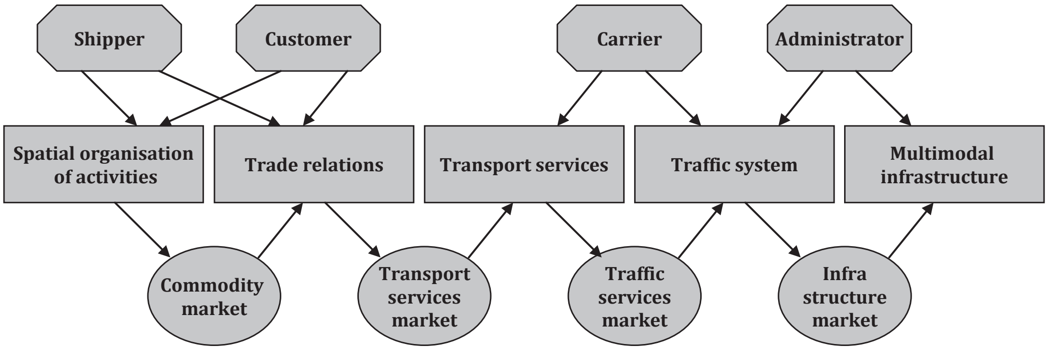


Fig. 1. Urban freight domain (Source: derived from Boerkamps et al., 2000)

These stakeholders belong to different parts of the city logistics domain and are closely connected to atleast onecomponent (see Fig. 1) but loosely connected to whole domain. Although action by one stakeholder affects the whole domain, a stakeholder can influence only that part to which it is closely connected. For example, a carrier can use a different strategy for routing and avoid congestion, but it cannot influence traffic flow in the city. Similarly, an administrator (i.e. municipality) can impose route restrictions but cannot directly impose a specific route choice. The objective for analyzing urban freight domain varies and depends on who is interested in the analysis. The framework we present for reviewing the urban freight modeling efforts differs from other review approaches. It accommodates the diversity of situations in terms of complexity and importance found in the present-day city logistics practice. Next, it covers the different phases in the modeling selection process, ranging from (1) Finding out exactly which stakeholders are involved in the model (2) what is the objective behind the modeling (3) what are the defining criteria i.e. the descriptor for modeling purpose and (4) tool used for achieving objective with the help of descriptor, i.e. the perceptive.

3. Review of existing literature

3.1. Search methodology

We have used scientific refereed journals, textbooks, doctoral dissertations and refereed conference proceedings as sources for city logistics related modelling literatures. Following list of keywords (and their combination) are used for search : “city logistics”, “urban goods movement”, “urban freight transport”, “urban distribution”, “urban logistics”, “city distribution”, “sustainable freight transport”, and “sustainable transport development”. Only English language literature is included. Computerized databases (Proquest, Emerald, Business Source Premier, Science Direct, Scopus, Web of Science, Google Scholar) are used for searching urban freight modeling related articles. Referred conference proceedings from City Logistics conferences, Transportation research board conference and World Conference on

Transport Research (WCTR) are used to find relevant articles for this review. Finally, project database available at BESTUFS (Best Urban Freight Solutions, see www.bestufs.net), is also used to include articles that report on a method or technique that specifically models one or more part of urban freight domain.

3.2. Stakeholder involvement

Urban freight traffic is an outcome of interactions among different stakeholders mainly from commodity, transport and infrastructure sectors. The review framework assumes that stakeholder involvement in modeling attempt should be considered when his/her attributes and behaviors are accounted in the model. Stakeholders in the urban freight domain can be roughly divided in two categories: 1) Public sector stakeholders that include traffic authorities, infrastructure authorities, municipalities, railway terminal/port authorities etc. These all stakeholders can be termed as "administrator". Note that road users and residents are not directly involved in urban freight process but their objectives align with those of administrator. 2) Private sector stakeholders that include producers, suppliers, shippers, freight forwarders, trucking firms, truck drivers, shopkeeper, receivers etc. This long list of private stakeholders can be stratified to shipper, carrier and receiver according to leg of transportation activities.

Although all stakeholders share common objective of *transporting goods in urban area*, their other individual interests often conflict. For stakeholders that belong to the private sector (i.e. shipper, carrier and receiver) the cost related with transportation is the "lost cost". Transportation becomes inevitable in case the production and consumption locations are different. For private sector stakeholders "total logistics cost" is of highest interest and not "specific transportation cost". So they may not wish to minimize their own transportation costs, because they have a broader internal objective and can trade those costs off against other internal costs Ogden (1992). Under the banner of "Supply chain management" these firms optimize their total logistics cost, of which city freight distribution is only a small segment. On the other hand, administrator is responsible equally for livelihood of city and economic development of city area. For a sound and efficient city logistics domain, interests of all stakeholders must be taken into account. While administrator is not the central decision making authority for the city logistics domain it can affect stakeholders' decision making by applying policy measures. Thus, in contrast to private stakeholders, administrator is interested in achieving the overall objective, i.e. reducing the total social cost Ogden (1992), (see also Taniguchi et al., (2005; Macário et al., (2008). This clarifies why most urban freight modeling efforts are directed from administrative point of view and (mostly) without considering behavior or attributes of other stakeholders (i.e. shipper, carrier, receiver). For example, a planning model by Southworth (1982) examines the implications of alternative freight terminal zone location patterns considering trip generation and distribution. This model does not include behavioral patterns of attributes of stakeholders. A model by Visser et al., (1997) evaluates effectiveness of different measures solely from administrator's point of view to solve environmental and accessibility problems in urban areas.

Positively, recent modeling efforts understand the importance of including other stakeholders. A model by Holguín-Veras (2000) proposes a framework for "integrative freight market simulation" that considers producer, carrier, customer and government for urban freight analysis. Planning models by Crainic et al., (2004) consider the carriers and its attributes to efficiently organize its activities. The framework introduced by Hensher et al., (2005) investigates the effectiveness of the interaction between a shipper and a carrier in order to reduce cost of city freight distribution. Tokyo Model Wisetjindawat et al., (2003), developed on the base of GoodTrip Boerkamps et al., (2000) model, tries to evaluate how a shipper chooses a carrier for its transportation activities and how a carrier select its fleet etc. A model developed by Russo et al., (2010) considered 1) Family/Individual 2) Business/Shopkeeper.

3.3. Objective

The institute of city logistics defines 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." Negative effects and inefficient activities related to the urban freight domain are the main reasons to carry out urban freight analysis. How to create more efficient urban freight operations and how to reduce its negative externalities are the main questions. City logistics focuses on the improving the efficiency of urban freight transportation, while reducing traffic congestion and lessening environmental impacts. According to Ogden (1992) city logistics has overall objective to reduce the total social cost of urban goods movement. He further divides this overall objective in six specific objectives: 1) Economic 2) Efficiency 3) Road-safety 4) Environment 5) Infrastructure & management 6) Urban structure (for detail see Ogden (1992)). Intuitively, these objectives are intermingled and therefore modeling urban freight to achieve one objective invariably involves one or more other objectives.

Efficiency of urban goods delivery operation is one of the most considered issues in modeling efforts. For example, Holguín-Veras (2000) proposed a framework for integrative freight market simulation to create *efficient* urban freight system. Xu et al., (2003) describes Dynamic Freight Traffic Simulation model DyFTS, for studying the effects of highly developed information technologies and logistic strategies to improve efficiency of the goods delivery operations. Crainic et al., (2004) presents a model to plan efficient distribution of urban freight and reducing its impact on environment. Model by Visser et al., (1997; Kanaroglou et al., (2008; Muñuzuri et al., (2010) emphasis on reducing environmental externalities caused by urban freight transportation. A model by Young et al., (1983) focuses on efficient planning of infrastructure for to efficiently divide traffic between rail and road. Similarly, Crainic et al., (2004) discusses location problem for city distribution centers. Interestingly, most of these objectives as well as most negative effects of city logistics are very well reflected in urban freight traffic market. Thus, for natural reason, many urban freight modeling efforts are concentrated on reproducing urban freight traffic and consider *overall objective* instead of any specific objective listed in Table 2. This trend is justified as evidently an administrator is the one who is interested in overall objective and most of such efforts are carried out from administrator's point of view. Consequently, such model serves as a laboratory for urban freight transport analysis to understand the factors affecting urban goods movement. Knowledge gained from analysis is then used to improve the city logistics related activities. Examples of such modeling efforts are found in Russo et al., (2002; Holguin-Veras et al., (2004; Figliozzi (2007; Hunt et al., (2007; Wang et al., (2008; Russo et al., (2010).

3.4. Descriptors

Clustering of activities and interactions among stakeholders in different markers defines descriptors. Combined effects of all these descriptors shape the urban goods movement domain. Table 1 lists the different descriptors associated with different market. In reality, these descriptors are typical indicators that are observed, measured and analyzed while analyzing urban goods movement.

Table 1. Urban freight descriptors (Source: adapted from Ogden, 1992)

Market	Descriptor	Market	Descriptor
Commodity	Freight generation Commodity flow Industry structure	Traffic service	Traffic design Traffic flow Pollution level
Transport service	Vehicle loading Vehicle design Trip generation Cost	Infrastructure	Land use Location Building & site design Modal transfer

Analyzing the effects of different descriptors provide insight about how the system or a part of the system works and how to mould or modify the system to achieve the objective. It is to be noted here that many modeling approaches use different names for descriptors, i.e. Boerkamps et al., (2000) - GoodTrip and Wisetjindawat et al., (2007) - Tokyo model consider supply chain structure which is mentioned here as an industry structure. Moreover, depending on the stakeholder and specific objective of modeling, the descriptor can be very specific. For example, model to understand effect on environment can consider level of pollutant as descriptor. At the same time, number of trucks can also be considered to measure level of pollution. Therefore, to cover all specific descriptors is out of scope of this paper. Review of literature reveals that many modeling approaches consider Traffic flow and Commodity flow descriptor due to widespread use of “four step approach”. Examples of modeling efforts considering one or both of Traffic flow and Commodity flow are Visser et al., (1997; Crainic et al., (2004; Hensher et al., (2005; Muñuzuri et al., (2005; Figliozzi (2007; Hunt et al., (2007; Gentile et al., (2009; Russo et al., (2010). Land use and location are also important descriptors as better freight facilities bolster development and generate more freight related traffic. Southworth (1982; Crainic et al., (2004; Yannis et al., (2006) considered these descriptors for urban freight analysis. A GoodTrip model Boerkamps et al., (2000) that introduces supply chain concept in urban freight modeling and Tokyo Model Wisetjindawat et al., (2003) consider supply chain industry structure along with trip generation, vehicle loading and traffic flow.

3.5. Perspective for urban freight modeling

A modeling perspective is a meticulous way to represent pre-selected aspects of a system. A perspective has a different focus, conceptualization, dedication and visualization of what the model is representing. Urban freight system can be viewed from the different perspectives, depending on the user, the objective(s) for modeling and the means available to achieve objective(s). In this line of reasoning we argue that a perspective is the strategic viewpoint towards a specific objective to be achieved. Urban goods movement can be analyzed from different perspectives for the same objective. Therefore, it is important to understand what different strategic viewpoints are available and how effective they are to achieve the objective at hand. For example, freight traffic flow can be analyzed modeling carrier behavior but also typically modeling truck trips in the urban freight domain. Similarly, reduction in traffic can be achieved introducing policy measures (i.e. vehicle restriction based on weight, size and time) or providing technological measures (i.e. ITS, ITC etc.). We found four widely used perspective in urban freight modeling, i.e. planner, technology, behavior and policy. Some of the recent research efforts consider the fifth novel perspective called multiple actors' perspective. Below we explain and review urban freight modeling efforts according to perspective adopted.

3.5.1. Planner's perspective

In urban area, where space is limited and infrastructure expansion can be enormously expensive, importance of proper planning become essential. Planner's perspective deals with organizing vehicle flow by efficient use of current and proposed infrastructure and services. For a planner, a facility catering to efficient urban freight operations flow is a system characterized by a set of parameters which the planner can control. More specifically, the planner is interested in knowing, for a given range of the various planning strategies, what combination will serve best. There are considerable efforts found in literature from planner's perspective. Most of the earlier attempts of urban freight modeling are from planner's perspective. In such efforts the administrator analyzes the urban freight system for planning (traffic, infrastructure, port, terminal etc.) to enhance the urban freight related processes. A *planning* model by Southworth (1982) examines the implications of alternative freight terminal zone *location patterns.* Hunt et al., (2007) developed a tour-based micro-simulation model of urban commercial movements for city of Calgary in Canada for better freight transportation *planning*. The model permits to test wide variety of responses to network changes possible scenarios related to traffic, policy and employment and its effect on commercial vehicle traffic. A modeling approach presented by Muñuzuri et al., (2009) appears to be useful for better planning of urban freight activities. The model can be applied to analyze urban freight traffic, identify traffic corridors, plan new infrastructure, analyze logistics policies and impact on environment. Models with similar perspective are Figliozzi (2007; Kanaroglou et al., (2008; Wang et al., (2008; Crainic et al., (2009; Muñuzuri et al., (2010).

3.5.2. Technology perspective

The 21st century is marked with technological innovation in all spectrums of human life and transportation is not an exception. GIS based dynamic information systems allow users to choose the least congested path and save travel time. ITS, ITC, etc. are other technological innovations which are making their way to the transportation market. Freight vehicles can also benefit from this technological innovation in order to increase the efficiency of goods delivery operations. Technological changes have transformed transportation-logistics decision making. Hill et al., (2002) show how electronic data interchange (EDI), an important class of IT used for inter-organizational information transfers between supplier and customer. In urban freight context, Xu et al., (2003) describes Dynamic Freight Traffic Simulation model DyFTS, for studying the effects of highly developed information technologies and logistic strategies on characteristics of vehicle trip for urban freight transportation. Taniguchi et al., (2004) presents a dynamic vehicle routing and scheduling model that incorporates advanced information systems or intelligent transport systems (ITS) in urban areas. The model by Figliozzi (2006) investigates impact of technological changes on urban commercial trips by commercial activity routing. The author describes how information and communication technology can create impact on the truck traffic flows over the public infrastructure. Other articles explaining use of technology in transportation are Kia et al., (2000; Yu et al., (2001; Golob et al., (2002). Such initiatives can be modeled and accessed for urban freight transportation as well.

3.5.3. Behavioral perspective

Behavior analysis attempts to understand, describe and predict the behavior under different situations. Behavioral models consider complexities of attribute and decision making ability of various stakeholders which cannot be captured in traditional four-step approach with the aggregate nature of the data. Urban freight transportation modeling lacks appropriate behavioural approach towards modeling related processes Regan et al., (2001). Planning or policy assessed under such circumstances does not guarantee anticipated results. Similar view is expressed by Tavasszy et al., (1998; Liedtke et al., (2004; de Jong et al., (2007; Roorda et al., (2009; Samimi et al., (2009). In city logistics modelling, behavioral aspect of shipper is considered by Young et al., (1983) in Elimination-by-Aspects mode choice model for regional freight mode choice. The GoodTrip model by Boerkamps et al., (2000) includes behavioral aspects of administrator, supplier, carrier and receiver to analyze urban freight system. This model aims to help decision maker to assess new distribution systems and the impacts of changes in the freight distribution environment on infrastructure needs and usage, logistical performance, emissions, and energy use for planning and evaluation of freight distribution. The Tokyo model by Wisetjindawat et al., (2003) follows similar framework. Other models rich in behavioral context are Holguin-Veras et al., (2004; Taniguchi et al., (2005; Russo et al., (2010).

3.5.4. Policy perspective

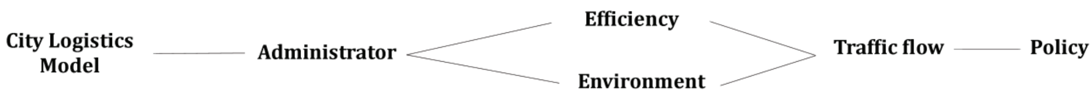
Urban freight movement can be improved to make it more sustainable in various ways. Van Duin (2006) distinguishes two different groups who are capable of changing the urban freight system. One is company-driven change where companies implement measures that will reduce the impact of their freight activities operating in a more environmentally or socially efficient manner. Second, changes implemented by governing bodies—i.e. the introduction of policies and measures that force companies to change their actions and thereby become more environmentally or socially efficient (e.g. changing the way in which they undertake certain activities Ogden (1992)). Policy perspective differs from planning as former concerns with planning new infrastructure (i.e. road, terminal, parking facilities etc.) or traffic planning to enhance urban goods movement and reduce externalities whereas latter (largely) concerns with introducing policy measures as rules, regulation or initiatives mainly to reduce negative externalities related to urban goods movement. Most common policy measures related to urban freight transportation is vehicle restriction based on weight, size and time for delivery vehicle. Many times policy measures are implemented considering visible possible counter measures to the city logistics problems without any data evaluated or method used. Conclusively, urban freight policy mostly follows "Learning by doing" approach Visser et al., (1999) that is not effective many times. For example, Quak et al., (2006) shows that the use of time access restrictions does not result in a decrease of pollutant CO_2 emissions, in contrary in many cases it results in an increase of these emissions. In other modelling efforts considering policy perspective Taniguchi et al., (2005) simulates test road network by implemented policy measures such as truck ban and tolling of urban expressway. Figliozzi (2007) analyzes effect of variations in circuitry factor, delivery time, vehicle speed and payload. A model by Holguín-Veras (2008) considers three policy combination of road pricing and financial incentive to estimate its impact on stakeholders' profit and consequently to get insight on their reaction. Other models that model urban freight transportation and state its possible use for policy analysis are Hensher et al., (2005; Gentile et al., (2009; Muñuzuri et al., (2010)

3.5.5. Multi-actors perspective

Urban freight system is characterized by multiple stakeholders with conflicting objectives. In absence of central authority all stakeholders act autonomously that makes urban freight a distributed decision making system. This non-cooperative decision making leads to inefficient system performance Friesz et al., (2005). The complexity of city logistics domain is also considerably due to its emergence phenomenon which appears when number of stakeholders operates and forms a complex behavior as collective Puckett et al., (2007). The number of interactions between components of a system increases combinatorially with the number of stakeholders, thus potentially allowing for many new and subtle types of behavior to emerge which can be described as 'aggregate complexity'. Multiple actors' perspective refers to analyzing interactions of autonomous stakeholders with a view to assessing their effects on the system as a whole. At an abstract level this perspective is a representation of the various stakeholders and relationship among them. Modeling urban fright domain from multiple actors' perspective can reveal complex inter-related behavior pattern and can provide valuable information about system mechanics and its activities. Example of this perspective is found framework set out by Hensher et al., (2005) to investigate how stakeholders in retail supply chain might interact more effectively to reduce the costs of urban freight distribution. The authors call this as "economic-behavior-based freight model" and believe that the system is capable of identifying initiatives that will increase the likelihood of cooperative outcomes in a supply chain, designed in particular, to reduce the level of traffic congestion in cities. In another example, van Duin et al., (2007) describes a model where different carrier-agents negotiate in auction for logistic contract. The model attempts to get insight on the interaction dynamics of bidding behavior among carriers and shippers through distributed intelligence.

4. Results

The review of literature illustrates that various types of modeling efforts exist for city logistics analysis. With the variety of concepts of urban freight, the method and tool used for research also varies widely. Table 2 shows detail review according to the discussed framework. The results of review is transformed into interesting pattern of urban freight modelling efforts. Fig. 2 depicts this mapping of city logistics modelling efforts according to stakeholder, objective, descriptor and perspective. Thus, for example, according the review framework if model has following details.



Then we map these detail drawing a line for each detail. So, in figure 2, thicker line implies that more instances of that detail considered, i.e. in reviewed models, administrator is included 21 times. We emphasize that this list is not exhaustive; nevertheless, we believe this review gives a fair picture trends and gaps in modelling efforts for urban freight domain.

As stated, city logistics is a process of creating efficient urban goods movement and therefore models to enhance the efficiency of system are repeatedly found in literature. The review suggests that planning is the widely used perspective for this objective. Administrators are concerned with planning and infrastructure management and therefore, objective of efficiency and infrastructure is quite often addressed by planner's perspective. In some cases, behavioral attributes are also integrated in modeling; however, stakeholder involvement depends on which market is targeted for efficiency enhancement. In transportation market carrier is primary stakeholder while in traffic market it is the administrator. Technological perspective is equally helpful for creating efficient routing of delivery vehicles as well as reducing vehicle kilometer travelled (VKT) thereby reducing congestion and pollution. Objective to reduce environmental externalities is generally tackled by administrator who is responsible for habitable urban areas. Policy perspective is used to test measures such as congestion charging and vehicle restrictions.

Table 2. Review of city logistics models

Author	Stakeholder	Objective	Descriptor	Perspective
Southworth 1982	A	Infrastructure	Land use, Location	Planner
Young et al., 1983	A, C, S	Efficiency, Infrastructure	Modal transfer	Behaviour
Visser et al., 1997	A	Environment, Accessibility	Commodity flow, Traffic flow	Policy
Harris et al., 1998	A	Economic	Freight Generation	Planner
Holguín-Veras 2000	A, C, S, R	Efficiency	Commodity flow, Traffic flow, tours	Technology
Taniguchi et al., 2000	A, C, S	Efficiency, Environment	Co2 level, Load factor	Policy, Technology
Boerkamps et al., 2000	A, C, S, R	Efficiency, Environment	Industry structure Trip generation, Vehicle loading, Traffic flow	Behaviour, Policy
Russo et al., 2002	A	Overall	Freight Generation	Planner, Behaviour
Xu et al., 2003	S, R	Efficiency	Freight generation Commodity flow, Cost	Technology
Wisetjindawat et al., 2003	A, S, C	Efficiency, Environment	Commodity flow, Traffic flow	Behaviour, Policy
Xu et al., 2003	S, R	Efficiency	Freight generation, Cost	Technology
Crainic et al., 2004	A, C	Efficiency, Infrastructure	Location, traffic design	Planner
Holguin-Veras et al., 2004	S, C, R	Overall	Trip generation, Vehicle loading	Behaviour
Taniguchi et al., 2005	A, C, S	Efficiency	Traffic flow, Pollution level	Policy, Behaviour
Hensher et al., 2005	S, C, A, R	Efficiency	Traffic flow	Behaviour, Multi-actor, Policy
Friesz et al., 2005	C	Efficiency	Cost	Planning, Multi-actor
Figliozzi 2006	C	Efficiency	Traffic flow	Technology, Behaviour
Yannis et al., 2006	A	Environment	Traffic flow, Pollution, level	Planning, Policy
Van Duin et al., 2007	S, C	Efficiency	Cost	Multi-actor
Figliozzi 2007	A	Efficiency	Trip generation, Traffic flow	Policy
Hunt et al., 2007	A	Overall	Traffic flow	Planner
Wang et al., 2008	A	Overall	Trip generation	Planning
Kanaroglou et al., 2008	A	Environment	Trip generation, Pollution level	Planner
Holguín-Veras 2008	C, R	Road-safety, Environment	Cost	Policy, Multi-actor
Friesz et al., 2008	S, C, R	Efficiency	Cost	Multi-actor
Muñuzuri et al., 2009	A	Overall	Freight Generation	Planner
Crainic et al., 2009	A, C	Efficiency	Traffic flow	Planner
Gentile et al., 2009	A	Infrastructure	Traffic flow, Commodity flow	Planner, Policy
Russo et al., 2010	R	Efficiency	Commodity flow, Traffic flow	Behaviour
Muñuzuri et al., 2010	A, C	Environment	Traffic flow	Planning, Policy

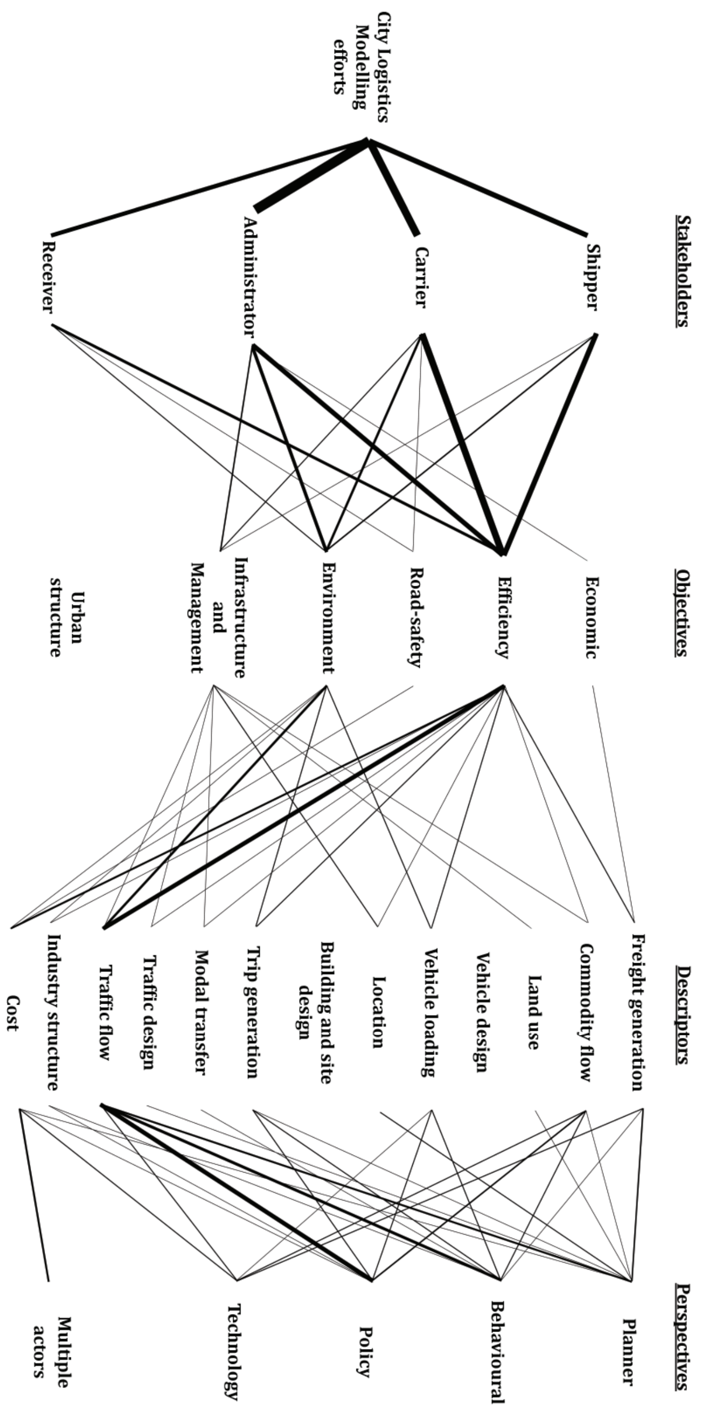


Fig. 2. City logistics modelling efforts – Trends and gaps

There is a wide variety of approaches found for the same objectives that include implementing routing, dynamic traffic information system, building city distribution centers, analyzing behavior of different stakeholders involved, and executing policy measures. There are also models available discussing modeling methods or framework for mapping urban freight movement. These models focus on gaining insight into urban goods activities for achieving overall objective instead of directing towards any specific objective. Models for analyzing economic impact of freight at national and regional level are available in literature but such practice is not common in urban freight context. An exception is a model by Harris et al., (1998) for input–output modeling of the urban and regional economy that provides reasonable accuracy in terms of estimates of input-output multipliers that can be helpful for planning and policy at the local level. In many cases, movement of commercial vehicles is considered using traditional four step approach. Similarly, there is a considerable use of operational modeling tools based on traffic observations, but these models rely on incomplete information since they do not take into consideration thorough knowledge of the behaviors of the different actors involved.

Earlier modeling attempts were carried out from solely from administrator’s point of view without considering attributes of other stakeholder. However, recent city logistics modeling consider behavior and attributes of other stakeholder for modeling urban freight activities. Additionally there are some researches go step further and considers multi-actor perspective. Modeling under this perspective considers interaction among different stakeholder to capture dynamics of city logistics processes. Also, unlike in past when policies were implemented to counter measures negative externalities of urban freight transportation, modeler started considering effect and reactions of stakeholder. However, such attempts are limited and in juvenile stage. Wide range of descriptors is considered in evaluating urban freight modeling. Freight and Trip generation, traffic and commodity flow, loading rate, pollution level and transportation cost are most widely used descriptors. When modeling is carried out from administrator’s point of view descriptors of traffic and infrastructure market are considered. On the contrary, in case of private sector stakeholder’s point of view the descriptors are service and cost related, such as transportation cost, trip length distribution (TLD), VKT, loading rate etc. derived from transportation market.

5. Conclusion

Apart from covering the state of the art decision models available at present, this paper attempt to analyze urban freight modeling from its stakeholders’ point of view describing their objective, descriptor choice and perspective towards the objective. Thus, we not only consider the final objective related to the urban freight modeling effort, but also recognize criteria for its approach. Moreover, in the prescriptive framework we attempt to analyze what tool is used in combination with descriptor to achieve the stated objective. From our analysis of the efforts currently being reported for urban freight modeling and the potential still left unused we draw the following conclusions.

Most attention has so far been paid to the urban traffic market in urban freight modeling. Since most negative effects related to urban freight transportation is visible at traffic market, other markets (i.e. transport, trade, etc) have received far less attention from researchers in city logistics research. However, the generation of urban freight traffic is largely dependent on the supply demand activities from trade and transport markets. Therefore, in order to understand problems at traffic level, the understanding of related logistics processes is inevitable and for that multi level, multi dimensional and multi disciplinary approach is required Van Duin et al., (2007).

Considerable numbers of the modeling efforts are carried out from the point of view of an administrator as a sole stakeholder of city logistics domain. Most of the literature on urban freight modeling sum up as to how an administrator can create efficient urban freight transportation without considering inputs from other active stakeholders. There are only a few models available in which all stakeholders and their influence in urban freight domain are included. It would be worthwhile to investigate and incorporate the specifics of using decision methods in urban freight modeling by other stakeholders as well (i.e. shipper, carrier, receiver etc.)

Research on the suitability of descriptors for different stakeholders is also needed to justify policy making based on urban freight analysis. The framework for classifying descriptors for various stakeholders from different markets is developed in this paper. The suitability of descriptors for stakeholder depends upon the specific objective he/she is seeking, which depends on the specific industry or product or service under consideration. The difference between various sectors and products and services included urban freight modeling ultimately result into different intrinsic meanings of selection criteria and different relevant importance of weights but these differences in itself does not affect the suitability of a certain decision method.

Finally, the assignments of perspectives in our framework to urban freight modeling efforts show that not all perspectives are equally useful to deal with different objectives. However, the reviewed articles on urban freight analysis do not sufficiently address this contextual issue. Often they assume, explicitly or implicitly, that their method deals with all city logistics problem. At most, a reference is made to a particular problem in which a method has been empirically tested or the need to change the criteria considered when applying the method to another type of problem. However, neither the specific problem nor the particular descriptor criteria at hand determine the usefulness of certain method. Our framework shows that more generic factors such as the objective, stakeholders' involvement, descriptor of their activities and means available for achieving objectives are more determinative for carrying out urban freight modeling. In future research therefore, more attention should be paid to positioning new contributions in such a framework.

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