

# **DESIGNING FOR SUSTAINABLE LOGISTICS IN URBAN AREAS – WHAT DO WE KNOW?**

**Catrin Lammgård**, School of Business, Economics and Law at Gothenburg University, Sweden, [catrin.lammgard@handels.gu.se](mailto:catrin.lammgard@handels.gu.se)

**Johan Hagberg**, School of Business, Economics and Law at Gothenburg University, Sweden, [johan.hagberg@handels.gu.se](mailto:johan.hagberg@handels.gu.se)

## **ABSTRACT**

The purpose of this paper is account for the state of the art of sustainability initiatives in urban logistics by reviewing the current literature in the field. Previous research studies (76 articles) have been classified along three dimensions: the sustainability challenges addressed the theme and topic under study and the methods employed. The paper identifies the various aspects that have been explored in depth but also some areas that warrant more extensive studies. It is suggested that more studies should address the social aspects of sustainability, analyse the situation for specific business actors and that more collaborative methods should be introduced.

*Keywords: urban logistics, sustainable transport, freight transportation, environmental aspects, literature review*

## **INTRODUCTION**

The increased urbanization around the globe continues. The world population is projected to surpass 9 billion people by 2050, compared to about 7 billion today, according to the United Nations population estimates and projections and 70% of the world's population (6 billion) will live in cities by year 2050 (Stigson 2011). This can be compared to 2010 when half of the population was urban. With this development new challenges concerning sustainable development emerge. One of these areas where a number of challenges arise is in the flow of goods in cities. Many cities are struggling with meeting sustainability objectives in urban logistics. Different projects have been run where measures have been implemented, e.g. weight restrictions, congestion charging, low emission zones, and time restrictions.

Researchers worldwide study these different initiatives and actions. As there are many similar challenges in many urban areas around the world, there is also a need to regularly review what is done in the field and what can be learned from what others are doing. Reviews may be oriented towards the various initiatives that are performed in different parts of the world or specific aspects of city logistics (e.g. Ambrosini & Routhier 2004; Benjelloun et al 2009; Danielis et al 2010; Goldman & Gorham 2006; Russo & Comi 2010) or to the

research performed in the field (see e.g. Behrends et al 2008; Howgego & Roe 1998; Perego et al 2011; Sachan & Datta 2005).

## **Logistics in urban areas**

Logistics may encompass many business activities such as transports and warehousing but in this paper we will focus on freight movements. Our point of departure is that there are two main freight movements, as proposed by Russo and Comi (2010):

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

As there are various ways of moving freight from producers to end-consumers, several functional relations and trade schemes may be identified. Freight may reach end-consumers in different ways from a company (Russo & Comi 2006), which of course have different implications for logistics and transport planning. Other transport flows that can affect logistics in a city area are reverse logistics flows (for a conceptual framework for managing retail reverse logistics operations see Bernon et al 2011).

City logistics has been defined as involving “delivery to retail shops, home delivery, on-demand delivery in combination with storage services, reverse logistics, on demand collection at a retail shop or a central storage location, on demand delivery at home and on demand delivery at a pick-up location” (Awasthi & Proth 2006: 7-8). The transport of goods in urban areas is variously termed urban logistics, urban freight transportation or city logistics etc. The term ‘city logistics’ can be considered more narrowly than ‘urban logistics’, as urban areas may be addressed with similar problems as a city but having a smaller size than what is defined as a city. For the purposes here we will consider them synonymous, but will mainly use ‘urban logistics’ and/or ‘urban freight distribution’ in this paper.

## **Sustainability**

The concept of “*sustainable development*” is well-known and the most widely-known definition is that of the Brundtland report from the UN that encompasses: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (The World Commission on environment and development, 1987). In this report, the urban challenge was identified as one of the common future challenges stating that almost half the world will live in urban areas by the turn of the century. Today, this projection of the urban population of the world is a reality.

In order for a society, company or an organisation to be sustainable, there must be a balance between economic, environmental and social goals. In a company setting, it may be named

the Triple bottom line (Elkington 1998) or included in the Corporate Social Responsibility-practice (e.g. Carter & Jennings 2002). This balance is also a main challenge for an urban area where transport and distribution of goods have a large impact, especially producing negative environmental externalities (congestion, pollution, CO<sub>2</sub>, traffic safety etc). This put pressure on and influence actors or stakeholders involved, and collaboration is needed in urban freight transport. According to Taniguchi et al. (2010) there are four key stakeholders in city logistics which interact with each other: shippers (manufacturers, wholesalers, retailers), residents (consumers), freight carriers (transporters, warehouse companies) and administrators (national, state and, city level).

It is needed to map out what challenges in an urban context have been addressed in previous studies. Ambrosini and Routhier (2004) made a literature review in city logistics in which an international comparison of the objectives, methods and results in previous studies in the field. They found that a variety of approaches were employed and had different geographical scopes. The studies were mostly concerned with local effects, rather than more long-term global issues. This paper will account for the state of the art in research of sustainable freight transportation in urban areas.

The objective of this paper is to scrutinize and categorize research in sustainable logistics in urban areas, leading to insight on themes in literature and directions for future research and challenges for the future. This paper account for sustainable logistic initiatives in urban areas and is based on a literature review on sustainable urban freight transportation. The research papers are scrutinized and categorized based on the following three dimensions: (1) the challenges of sustainable urban freight, (2) the addressed topics/themes in research and (3) the methods used in the conducted studies.

The outline of the paper is as follows: we start by describing the methodology followed in this review. Then, based on the selected paper's content, we show the resulting sustainability challenges, the themes or topics addressed and finally the research methods applied in prior research. Finally, we close the paper with a concluding discussion of the themes presented, and themes missing, that lead to implications for research and policy including need for future research.

## **METHODOLOGY**

The paper is based on a literature review on sustainable urban freight transportation. The research papers in this field are scrutinized based on the following: the sustainability challenges of urban freight; the addressed topics/themes in research and the methods used in the conducted studies. The structure of the classification is similar to the one proposed by Meixell and Norbis (2008) in their review of transportation mode choice and carrier selection, divided in methodology, topics and challenges. This review will provide us with knowledge of what research has been conducted and also to identify gaps in research. This is a good basis for directions of future research where the ultimate goal may be to further explore how future logistics operations can be designed in urban areas and at the same time be sustainable.

We have limited this review to publications that we could find in two databases of academic journals. This method has a number of limitations. First, city logistics initiatives may have been introduced but have so far not received academic attention. Second, there may be

some initiatives that are well researched due to their closeness to where academic interest is situated. Third, what the specific article focuses on may be different from aspects that another would have focused on and thus a comparison is not made on the same basis. For instance a researcher may aim to develop a specific method, but what really distinguish the project under study may be the specific challenges and motives of the same project.

The databases Scopus and Business Source Premier have been used for the literature review in October 2012. We have used the keywords city logistics, urban distribution and urban freight transport. These keywords resulted in hundreds of hits. Articles were then chosen based on two criteria: 1) its relevance for the research area of urban freight/distribution; and 2) whether it was accessible in full text. Our list of articles then resulted in 110 articles. However, a second round made us exclude further 34 articles because the area of urban freight/distribution was not strong enough focused on in the articles. This left us with a total of 76 articles as our final sample.

In this review, there were no specific time span given in the searches but the resulting articles are predominantly published year 2000 or later. Only six articles are published earlier, where the oldest is dating back to 1937 (Cassels & Bacon 1937), one each in the 1970s (McDermott 1970) and the 1980s (Ogunsanya 1982), and three articles in the 1990s (Browne & Allen 1998; Howgego & Roe 1998; Nemoto 1997). One reason for having very few articles before year 2000 may have to do with the criteria of full text format in the databases in order to be included in the review. In reality city logistics research was an active field in the 1970s but not during the 1980s and 1990s (McKinnon 2012) but the results were probably not resulting in academic articles.

## **SUSTAINABILITY CHALLENGES**

The paper gives an overview of sustainable freight and transportation in urban areas. The concept 'sustainable' is broken down into the three dimensions: economic, environmental and social. Classification of different sustainability aspects have been proposed along these lines e.g. based on stakeholders conflicting interest (Anand et al 2012), different forms of impacts (Andersson et al 2005) and criteria for evaluation (Awasthi & Chauhanb 2012).

### **Economic sustainability**

Economic sustainability is the sustainability challenge that is most commonly addressed in the papers. This dominance can almost exclusively be explained by the focus on congestion (e.g. Browne & Allen 1998). However, it is important to note that while most of the literature considers congestion an economic sustainability aspect (e.g. Andersson et al 2005), there are also other classifications proposed that consider it more related to the environmental dimension (e.g. Awastih & Chauhanb 2012). Congestion may also be considered a social dimension of sustainability. Among the studies addressing economic sustainability there are also other aspects covered explicitly related to costs (e.g. Bräysy et al 2009), resource efficiencies (e.g. Marcucci & Danielis 2008), road protection (e.g. Sathaye et al 2010), profitability (e.g. Anand et al 2012), local prosperity (e.g. Anand et al 2012) and revenues (e.g. Weltevreden 2008).

## Environmental sustainability

A great number of studies address different aspects of environmental sustainability. Among these, emissions are the most common topic of the papers (e.g. Alessandrini et al 2012) followed by pollution (e.g. Nemoto 1997). Other aspects related to environmental sustainability found in these studies are fossil fuel consumption (e.g. Benjelloun et al 2009), waste products (e.g. Behrends et al 2008), valuable area protection (e.g. Anand et al 2012) and wildlife habitats (e.g. Andersson et al 2005).

## Social sustainability

Social sustainability is the least studied dimension. In comparison with the economic and environmental dimensions, there are not one or a few aspects that dominate. On the contrary, there is an almost equal share among the different aspects addressed. Among these aspects are noise (e.g. Dablanc et al 2011), accessibility (e.g. Binsbergen et al 2000), land use/ freeing of public space (e.g. Muñuzuri et al 2005), safety (e.g. Regan & Golob 2005), mobility (e.g. Basbas & Bouhouri 2012), health (e.g. Browne & Gomez 2011), visual intrusion (e.g. Quak & De Koster 2007), liveability (e.g. Anand et al 2012), equality/justice (e.g. Schweitzer & Stephenson Jr 2007), accidents (Awasthi & Chauhanb 2012), difficulty of journey (Andersson et al 2005), and other quality of life (e.g. Crainic et al 2009a). As proposed by Behrends et al (2008) social sustainability aspects may be related to or a result of economic and environmental aspects. However, social aspects may also to a greater extent introduce conflicting objectives and interests in the sustainability challenges, as there may be great difference on what different stakeholders consider important.

A summary of articles focusing on the different sustainability challenges is seen in Table 1 below.

Table 1 Articles addressing the sustainability challenges (economic, environmental and social) and the subgroups

Challenges		References
<b>Economic</b>	Congestion	Anand et al 2012; Andersson et al 2005; Awasthi & Chauhanb 2012; Awasthi & Proth 2006; Benjelloun et al 2009; Boussier et al 2011; Browne & Allen 1998; Browne & Gomez 2011; Crainic et al 2004; Crainic et al 2009a; Danielis et al 2010; Ehmke et al 2012a; Ehmke et al 2012b; Figliozzi 2007; Flamini et al 2011; Grakovski et al 2008; Hensher & Puckett 2005; Holguín-Veras 2012; Ljungberg & Gebresenbet 2004; Mcdermott 1970; Muñuzuri et al 2010; Nemoto 1997; Qureshi et al 2012; Regan & Golob 2005; Russo & Comi 2010; Russo & Comi 2011.
	Costs	Behrends et al 2008; Bräysy et al 2009; Danielis et al 2010; Deflorio et al 2012; Hensher & Puckett 2005; Holguín-Veras 2012; Kim & Sohn 2009; Lau 2009; Ljungberg & Gebresenbet 2004; Marcucci & Danielis 2008; Mcdermott 1970; Merrick & Bookbinder 2010; Muñuzuri et al 2012b; Perego et al 2011; Quak & De Koster 2007; Qureshi et al 2009; Qureshi et al 2012; Russo & Comi 2010; Sheu 2006; Taniguchi et al 2000.

	Resource efficiencies	Andersson et al 2005; Behrends et al 2008; Bräysy et al 2009; Marcucci & Danielis 2008; Sheu 2006; Warnaby 2009; Zeimpekis & Giaglis 2006.
	Road protection	Anand et al 2012; Sathaye et al 2010.
	Profitability	Anand et al 2012.
	Local prosperity	Anand et al 2012.
	Revenues	Weltevreden 2008.
<b>Environmental</b>	Emissions	Alessandrini et al 2012; Anand et al 2012; Awasthi & Chauhanb 2012; Awasthi & Proth 2006; Behrends et al 2008; Boussier et al 2011; Browne & Gomez 2011; Crainic et al 2009a; Dablanc et al 2011; Escuín et al 2012; Merrick & Bookbinder 2010; Quak & De Koster 2009; Quak & De Koster 2007; Qureshi et al 2012; Saide et al 2009; Sathaye et al 2010; Taniguchi et al 2000.
	Pollution	Alessandrini et al 2012; Andersson et al 2005; Awasthi & Proth 2006; Boussier et al 2011; Browne & Gomez 2011; Crainic et al 2009a; Dablanc et al 2011; Holguín-Veras 2012; Marcucci & Danielis 2008; Mcdermott 1970; Nemoto 1997; Regan & Golob 2005; Russo & Comi 2010.
	Fossil fuel consumption	Alessandrini et al 2012; Anand et al 2012; Andersson et al 2005; Awasthi & Chauhanb 2012; Benjelloun et al 2009; Nemoto 1997.
	Waste products	Andersson et al 2005; Behrends et al 2008.
	Valuable area protection	Anand et al 2012.
	Wildlife habitats	Andersson et al 2005.
<b>Social</b>	Noise	Anand et al 2012; Andersson et al 2005; Awasthi & Chauhanb 2012; Behrends et al 2008; Browne & Gomez 2011; Crainic et al 2009a; Dablanc et al 2011; Quak & De Koster 2009; Quak & De Koster 2007; Russo & Comi 2010.
	Accessibility	Awasthi & Chauhanb 2012; Behrends et al 2008; Binsbergen et al 2000; Lindholm & Behrends 2012; Marcucci & Danielis 2008; Quak & De Koster 2009; Quak & De Koster 2007; Zhou & Rana 2012.
	Land use/ freeing of public space	Awasthi & Chauhanb 2012; Behrends et al 2008; Lindholm & Behrends 2012; Muñuzuri et al 2012a; Muñuzuri et al 2005; Ogunsanya 1982; Schweitzer & Stephenson Jr 2007; Zhou & Rana 2012.
	Safety	Anand et al 2012; Andersson et al 2005; Awasthi & Chauhanb 2012; Behrends et al 2008; Browne & Gomez 2011; Regan & Golob 2005.
	Mobility	Awasthi & Chauhanb 2012; Basbas & Bouhoura 2012; Crainic et al 2009a; Stathopoulos et al 2012; Weltevreden 2008.

Health	Anand et al 2012; Andersson et al 2005; Behrends et al 2008; Browne & Gomez 2011.
Visual intrusion	Andersson et al 2005; Quak & De Koster 2007; Quak & De Koster 2009.
Liveability	Anand et al 2012; Crainic et al 2009a.
Equality/ justice	Behrends et al 2008; Schweitzer & Stephenson Jr 2007.
Accidents	Awasthi & Chauhanb 2012.
Difficulty of journey	Andersson et al 2005.
Other quality of life	Andersson et al 2005; Crainic et al 2009a.

## **THEMES AND TOPICS ADRESSED**

The topics addressed in the papers have been divided in five broader themes: 1) public policy measures, 2) single business actors or supply chains, 3) infrastructure, 4) stakeholder collaboration, and 5) methodological development. In each of these broader themes we find different topics addressed.

### **Public policy measures**

The most common theme of the studies is related to public policy measures. Among these the topic that is most addressed is planning for freight flows (e.g. Browne & Allen 1998) followed by urban distribution centres (e.g. Alessandrini et al 2012) and vehicle access time restrictions (e.g. Stathopoulos et al 2012). Other topics studied include vehicle weight or size restrictions (e.g. Sathaye et al 2010), parking, loading and unloading zones (e.g. Boussier et al 2011), congestion charging schemes (e.g. Hensher & Puckett 2005) and low emission zones (e.g. Muñuzuri et al 2005). There have also been a few studies on tax policies (e.g. Danielis et al 2010), drop off points (Goldman & Gorham 2006), off hour deliveries (Holguín-Veras 2012) and automated underground transportation (Binsbergen et al 2000).

### **Single business actors or supply chains**

In this theme we have grouped a variety of topic that address private business actors that may be either single companies (such as retailers) or whole supply chains. The most common topic is various forms of routing and Intelligent Transportation Systems (e.g. Bräysy et al 2009). Another topic addressed in many studies is various forms of efficiency in freight distribution (e.g. Taniguchi et al 2000). The topics of time windows and time based frameworks have also been extensively covered (e.g. Ehmke & Mattfeld 2010), as well as there are a number of studies with a cost focus (e.g. Deflorio et al 2012). Other topics included in this theme specifically address retailers (e.g. Holguín-Veras 2012), fuel efficiency

(Merrick & Bookbinder 2010), business logistics strategies (Yang et al 2005) and revenues (Weltevreden 2008).

## Infrastructure

A number of studies address the theme of infrastructure. These studies can be divided into two topics. The first topic is investments such as automate underground transportation (Binsbergen et al 2000), pipelines (Howgego & Roe 1998), RFID logistics system (Kim & Sohn 2009) or systems of minihubs (Muñuzuri et al 2012b). The other topic is large multimodal terminals, which has been addressed in a number of studies (Dinwoodie 2006; Hesse 2004; Muñuzuri et al 2005).

## Stakeholder collaboration

A common theme in the studies is related to stakeholders and collaboration. Among the studies addressing themes of stakeholder collaboration there is for example focus on different stakeholder interest (Anand et al 2012), sustainability evaluations with stakeholders (Awasthi & Chauhanb 2012), definitions of sustainability (Behrends et al 2008), stakeholder involvement (Dablanc et al 2011), conflicting objectives (Danielis et al 2010), cooperation and interaction (Hensher & Puckett 2005)

## Methodological development

A final theme addressed in a number of papers, concern methodological development. These can be divided in two types of topics. First, there are many studies that develop mathematical models. The second topic is different forms of theory development oriented towards concepts and frameworks.

The following Table 2 provides an overview of what sustainability challenges are addressed and within which topics. It should be noted that one article may fall into many categories, both sustainability challenges as well as topics addressed in the articles.

Table 2 The number of articles addressing the sustainability challenges and within which themes and topics

<b>Sustainability Challenge</b>	Public policy measures	Business / private actors / supply chain	Infrastruc- ture	Collabora- tion	Methodo- logical Develop- ment	<b>TOTAL</b>
Economic	26	25	4	12	14	<b>50</b>
Environmental	25	11	5	11	11	<b>40</b>
Social	18	3	3	11	9	<b>25</b>
<b>TOTAL</b>	<b>41</b>	<b>34</b>	<b>8</b>	<b>19</b>	<b>22</b>	
<i>All 3 adressed</i>	<i>10</i>	<i>1</i>	<i>1</i>	<i>7</i>	<i>5</i>	



The three sustainability challenges are all important for a sustainable development. It is clear that the *economic challenge* is most frequently addressed (in 50 articles), not only within the topic of business/private actors/supply chain but also regarding public policy measures. It is also the most commonly addressed challenge in the articles aiming at methodological development. The *environmental challenge* is also addressed frequently (in 40 articles) but as expected, mainly within the topic of public policy measures (25 articles). The *social challenge* is less addressed in research than the other two. All three sustainability challenges are mostly addressed in the papers dealing with public policy measures (10 articles) and cooperation (7 articles), but is almost absent when focusing on business and private actors (1 article). To sum up the themes and topics addressed, an overview of the articles focusing on the five themes and their subtopics are seen in Table 3 below.

Table 3 The articles addressing the five different themes and their subtopics

Theme	Topic	References
<b>Public policy measures</b>	Planning for freight flows	Andersson et al 2005; Binsbergen et al 2000; Browne & Allen 1998; Crainic et al 2004; Crainic et al 2009b; Dablanc 2007; Dablanc et al 2011; Hesse 2004; Howgego & Roe 1998; Lindholm & Behrends 2012; Ljungberg & Gebresenbet 2004; Marcucci & Danielis 2008; Mcdermott 1970; Merrick & Bookbinder 2010; Muñuzuri et al 2012a; Muñuzuri et al 2012b; Nuzzolo et al 2012; Ogunsanya 1982; Russo & Comi 2011.
	Urban distribution centres	Alessandrini et al 2012; Awasthi & Chauhanb 2012; Awasthi et al 2011 Danielis et al 2010; Dinwoodie 2006; Escuín et al 2012; Goldman & Gorham 2006; Hemmelmayr et al 2012; Marcucci & Danielis 2008; Mcdermott 1970; Nemoto 1997; Regan & Golob 2005.
	Vehicle access time restrictions	Andersson et al 2005; Awasthi & Chauhanb 2012; Danielis et al 2010; Muñuzuri et al 2012a; Muñuzuri et al 2012b; Muñuzuri et al 2010; Muñuzuri et al 2005; Nemoto 1997; Quak & De Koster 2009; Quak & De Koster 2007; Stathopoulos et al 2012.
	Vehicle weight or size restrictions	Andersson et al 2005; Awasthi & Chauhanb 2012; Danielis et al 2010; Muñuzuri et al 2012a; Muñuzuri et al 2005; Quak & De Koster 2009; Sathaye et al 2010.
	Parking, loading and unloading zones	Boussier et al 2011; Browne & Gomez 2011; Danielis et al 2010; Muñuzuri et al 2012a; Muñuzuri et al 2012b; Muñuzuri et al 2005; Nemoto 1997.
	Congestion charging schemes	Andersson et al 2005; Awasthi & Chauhanb 2012; Browne & Gomez 2011; Goldman & Gorham 2006; Hensher & Puckett 2005.
	Low emission zones	Andersson et al 2005; Browne & Gomez 2011; Goldman &

		Gorham 2006; Muñuzuri et al 2005.
	Tax policies	Danielis et al 2010; Holguín-Veras 2012.
	Drop off points	Goldman & Gorham 2006.
	Off hour deliveries	Holguín-Veras 2012.
	Automated underground transportation	Binsbergen et al 2000.
<b>Single business actors or supply chains</b>	Routing and Intelligent Transportation Systems	Bräysy et al 2009; Crainic et al 2009a; Ehmke & Mattfeld 2010; Ehmke et al 2012a; Ehmke et al 2012b; Escuín et al 2012; Figliozzi 2007; Flamini et al 2011; Giaglis et al 2004; Goldman & Gorham 2006; Grakovski et al 2008; Hemmelmayr et al 2012; Kim & Sohn 2009; Lau 2009; Perego et al 2011; Polimeni et al 2010; Qureshi et al 2009; Qureshi et al 2012; Regan & Golob 2005; Taniguchi et al 2000; Zeimpekis & Giaglis 2006.
	Efficiency in freight distribution	Browne & Gomez 2011; Cassels & Bacon 1937; Hesse 2004; Holguín-Veras 2012; Ljungberg & Gebresenbet 2004; Merrick & Bookbinder 2010; Qureshi et al 2009; Sheu 2006; Stathopoulos et al 2012; Taniguchi et al 2000; Zeimpekis & Giaglis 2006.
	Time windows and time based frameworks	Browne & Gomez 2011; Deflorio et al 2012; Ehmke & Mattfeld 2010; Ehmke et al 2012a; Ehmke et al 2012b; Escuín et al 2012; Flamini et al 2011; Polimeni et al 2010; Qureshi et al 2009.
	Cost focus	Cassels & Bacon 1937; Deflorio et al 2012; Hensher & Puckett 2005; Holguín-Veras 2012; Lau 2009; Quak & De Koster 2007; Sheu 2006.
	Retailers	Holguín-Veras 2012; Quak & De Koster 2007; Weltevreden 2008.
	Fuel efficiency	Merrick & Bookbinder 2010.
	Business logistics strategies	Yang et al 2005.
	Revenues	Weltevreden 2008.
	<b>Infra-structure</b>	Investments
Large multimodal terminals		Dinwoodie 2006; Hesse 2004; Muñuzuri et al 2005.
<b>Stakeholders</b>	Stakeholders and collaboration	Anand et al 2012; Awasthi & Chauhanb 2012; Behrends et al 2008; Benjelloun et al 2009; Dablanc 2007; Dablanc et al 2011; Danielis et al 2010; Lindholm & Behrends 2012; Hensher & Puckett 2005; Marcucci & Danielis 2008; Mcdermott 1970; Muñuzuri et al 2012a; Petersen 2006; Regan & Golob 2005; Russo & Comi 2010; Stathopoulos et al 2012; Weber 2003; Zhou & Rana 2012.

<b>Methodological development</b>	Mathematical models	Anand et al 2012; Andersson et al 2005; Awasthi & Chauhanb 2012; Hemmelmayr et al 2012; Hensher & Puckett 2005; Lau 2009; Muñuzuri et al 2010; Polimeni et al 2010; Qureshi et al 2009; Qureshi et al 2012; Saide et al 2009; Taniguchi et al 2000.
	Theory development, concepts and frameworks	Benjelloun et al 2009; Behrends et al 2008; Kim & Sohn 2009; Muñuzuri et al 2005; Ogunsanya 1982; Petersen 2006; Russo & Comi 2010; Zhou & Rana 2012.

## METHODS APPLIED

We have grouped the methods employed in these studies in four broader categories: 1) Simulation, optimization and scenarios, 2) Modelling, 3) Reviews, and 4) Case studies. A great number of studies also combine different methods concerning the overall study design as well as methods for collecting data. Therefore, an article can fall into various categories in the classification below.

### Simulation, optimization and scenarios

This is the most common group of methods used and applied in 27 studies. These quantitative methods are applied on themes/topics in mainly public policy measures (e.g. Muñuzuri et al 2012) and business actors (e.g. Quak & de Koster 2007). Few studies aiming at infrastructure (e.g. Kim & Sohn 2009), collaboration (e.g. Marcucci & Danielis 2008) and methodological development (e.g. Taniguchi et al 2000) used these methods.

### Modelling

Modelling as a method is applied mainly in studies about public policy measures (e.g. Russo & Comi 2011) and around business actors (e.g. Qureshi et al 2012). In addition, the aim of many papers is theory development in modelling (e.g. Saide et al 2009). This is the case in modelling more often than in the group of methods of simulation, optimization and scenarios.

### Reviews

The review is a method used in 22 of the articles. The method is applied in two ways. The first is a review of literature/prior research and the second is as a review of reality, a reality check. The articles are quite evenly split between the two (12 and 10 respectively). The 12 literature review articles deal mainly with collaboration (e.g. Russo & Comi 2010) and methodological development (e.g. Schweitzer & Stephenson Jr. 2007.) in five articles each. The review of reality is mainly (in 9 out of 10 articles) about public policy measures. The articles using review as a method are mainly dealing with public policy measures (e.g. Russo & Comi 2010) and collaboration (e.g. Behrends et al 2008), and to a lesser extent dealing

with business actors (only 6 out of a total of 34 articles on this theme/topic) while it is more common around collaboration (10 out of a total of 19 articles on this theme/topic).

## Case studies

This is the most commonly applied method of the four methods analysed and the total amount of articles based on a case study is 45. However, these case studies are different in nature and can be analysed in subgroups. First, it is common to do a case study of city/cities as a “reality check” (e.g. Dablanc et al 2011) which was applied in 30 articles. The most common topic is about public policy measures (18 articles) but even so, these articles may also involve business/private actors/supply chain (13 articles). Secondly, there are articles that use only a business or company as a case (e.g. Giaglis et al 2004) which was applied in four articles. Thirdly, there are other types of case studies not falling into the first two subgroups (11 articles).

## Summary

Summing up, Table 4 provides an overview of the number of articles using different methods and within which themes. As seen, there is a dominance of quantitative methods (simulation, optimization, scenarios and modelling) applied when studying urban freight. The case studies can be both qualitative and quantitative in nature and so can review but is mainly qualitative methods.

Table 4 The number of articles using different methods and within which themes / topics

Theme/topic	Simulation Optimization Scenarios	Modelling	Review	Case study
Public policy measures	14	13	12	27
Business	13	11	6	21
Infrastructure	3	2	3	6
Collaboration	3	4	10	9
Methodological development	5	11	7	12
<b>TOTAL</b>	<b>27</b>	<b>22</b>	<b>22</b>	<b>45</b>

Table 5 The articles applying the four main methods, however, “review” is split up on “literature reviews” and “review of practice”

Method	References
Simulation, optimization and scenarios	Awasthi et al 2011; Awasthi & Proth 2006; Boussier et al 2011; Browne & Allen 1998; Browne & Gomez 2011; Crainic et al 2004; Crainic et al 2009b; Deflorio et al 2012; Ehmke & Mattfeld 2010; Ehmke et al 2012a; Ehmke et al 2012b; Flamini et al 2011; Kim & Sohn 2009; Marcucci & Danielis 2008; Mcdermott 1970; Merrick & Bookbinder 2010; Muñuzuri et al 2012b; Muñuzuri et al 2010; Nuzzolo et al 2012; Quak & De Koster 2009; Quak & De Koster 2007; Qureshi et al 2009; Saide et al 2009; Sathaye et al 2010; Sheu 2006; Taniguchi et al 2000.

Modelling	Anand et al 2012; Andersson et al 2005; Awasthi & Chauhanb 2012; Browne & Allen 1998; Browne & Gomez 2011; Crainic et al 2009b; Escuín et al 2012; Figliozzi 2007; Hemmelmayr et al 2012; Hensher & Puckett 2005; Holguín-Veras 2012; Kim & Sohn 2009; Lau 2009; Muñuzuri et al 2012b; Muñuzuri et al 2010; Nemoto 1997; Qureshi et al 2009; Qureshi et al 2012; Regan & Golob 2005; Russo & Comi 2011; Saide et al 2009; Sheu 2006.
Literature Reviews	Ambrosini & Routhier 2004; Behrends et al 2008; Howgego & Roe 1998; Muñuzuri et al 2012a; Muñuzuri et al 2005; Perego et al 2011; Russo & Comi 2010; Schweitzer & Stephenson Jr 2007; Warnaby 2009; Weber 2003; Yang et al 2005; Zhou & Rana 2012.
Review of practice	Alessandrini et al 2012; Andersson et al 2005; Benjelloun et al 2009; Crainic et al 2009a; Dablanc 2007; Dablanc et al 2011; Danielis et al 2010; Giaglis et al 2004; Goldman & Gorham 2006; Muñuzuri et al 2012a.
Case studies	Alessandrini et al 2012; Andersson et al 2005; Basbas & Bouhoura 2012; Benjelloun et al 2009; Boussier et al 2011; Browne & Allen 1998; Browne & Gomez 2011; Bräysy et al 2009; Cassels & Bacon 1937; Dablanc et al 2011; Danielis et al 2010; Deflorio et al 2012; Dinwoodie 2006; Ehmke et al 2012a; Escuín et al 2012; Flamini et al 2011; Grakovski et al 2008; Hesse 2004; Kim & Sohn 2009; Lau 2009; Lindholm & Behrends 2012; Marcucci & Danielis 2008; Muñuzuri et al 2012b; Muñuzuri et al 2010; Nemoto 1997; Nuzzolo et al 2012; Ogunsanya 1982; Petersen 2006; Polimeni et al 2010; Quak & De Koster 2009; Quak & De Koster 2007; Qureshi et al 2009; Russo & Comi 2011; Sheu 2006; Weber 2003.

## CONCLUDING DISCUSSION

Our review shows that research in sustainable freight transports is extensive. Various sustainability issues have been addressed in a broad spectrum, such as social (e.g. noise, accessibility, land use), environmental (e.g. emissions and pollution) and economic dimensions (e.g. congestion and costs). The themes and topics that dominate the literature in the field concern public policy measures (e.g. planning for freight flows, urban distribution centers and vehicle access time restrictions), business aspects of single actors or supply chains (e.g. routing or Intelligent Transport Systems, efficient freight distribution and time windows), various forms of stakeholder collaborations involving both public and private actors, and methodological development. The methods used in the studies include case studies of efforts in specific cities and various forms of simulation, optimization and scenarios.

In the literature review, three areas are identified in which we believe that more research is needed. *First*, there is an emphasis on environmental and economic sustainability dimensions in the reviewed studies. The social dimension has not been as thoroughly studied. In particular we find it important to pay more attention to aspects such as livability, mobility and accessibility. It would relate city logistics more directly to practices of city inhabitants, such as living, entertainment and shopping. These are also areas in which the city logistics initiatives may make great impact and become more “visible” for a larger public. *Second*, we found that relatively few studies address the problems for specific business

actors. In particular there are few studies that involve retailers and specific supply chains. We think that there is great potential in relating city logistics to the concrete and specific challenges for business actors as their activities and orientations have great impact on how city logistics is performed. Also the articles focusing on business actors hardly ever incorporate the social dimensions of sustainability (in most cases mainly the economic dimensions and to some extent the environmental dimensions). *Third* and finally, we see a potential for more development of collaborative methods. The studies suggest that there are many different motives and that these motives may differ between different actors. These methods should have the potential to involve collaboration between many actors, but also be able to combine description and prescription. Thus this review provides knowledge of what research has been conducted and also to identify gaps in research. This is a good basis for directions of future research where the ultimate goal may be to further explore how future logistics operations can be sustainably designed in urban areas.

## **IMPLICATIONS FOR RESEARCH/POLICY**

The results show that more studies are needed that integrate all three sustainability challenges, especially in the studies concerning business/private actors/supply chains. The social dimensions are hardly ever addressed. One example where this would be relevant is the theme of off-hours deliveries as the costs of delivering for companies for example at night may conflict with noise for inhabitants which should be addressed in research. Social and environmental challenges are relevant for business actors today as they are judged on their sustainability performance and proactive companies normally have a CSR strategy. Research may have a role in connecting knowledge in urban logistics with business strategies in for example CSR.

The complexity of urban logistics is mainly due to the various groups of stakeholders and their interests. Therefore the collaboration between actors, but also how these are studied in research, needs to be developed. Integrating the interests of public actors with private actors is a challenge in urban logistics.

A majority of the articles published use mainly quantitative methods such as modeling and optimization. These are important especially with respect to external effects such as environmental challenges. However, more studies in how collaboration between actors is developed are needed in order to also find for example business models that work. Also studies combining methods would be enriching.

This review contributes to map the current status of research in urban logistics in connection to sustainability. This knowledge may be used before forming policies and actions around urban logistics operations in order to make the cities even more attractive for inhabitants, retailers, consumers, policy makers and other stakeholders. It will provide an overview of the experiences of the sustainable logistics initiatives implemented and may also be used to improve the current situations in urban areas,

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