Final Report

Indicators and data collection methods on urban freight distribution

Technical report

Non-binding guidance documents on urban logistics

N° 6/6

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Executive Summary

Policymakers need data about urban logistics to set up their policies concerning this topic. By collecting data on a regular basis, policymakers can make informed decisions about urban logistics [1]. Often, the problem setting is that no comprehensive database is available. Moreover, data are necessary for research and urban logistics modelling [2]. Therefore, the aim of this report is to give an overview of the urban logistics data needed to collect data in a focused way and to determine different urban logistics profiles. More specifically, this report answers the following two research questions:

1) What are the common indicators needed within an urban freight context?
2) What are the common data collection methods used to obtain the data?

The method used is based on a three-stage analysis: (1) overview and analysis of literature, (2) application of literature on a framework for urban freight profiles, (3) a case study of Flanders. These three steps lead to answers to the two research questions. The literature review is accomplished concerning the issue of data availability, urban logistics indicators and data collection methods. Moreover, examples of data collection initiatives are indicated for different countries. Finally, the theory is tested for a few case studies.

The findings of the literature analysis confirm a lack of publicly available urban logistics data in some European countries [1]–[5]. Moreover, this lack is indicated in the BESTUFS-project of 2006 and at the CIVITAS [6] and BESTFACT [7] conferences. Furthermore, the literature analysis displays four observations. The first observation is linked with the neglect of freight transport in many surveys and models. A second observation is that where freight data are collected, this is in most cases done for freight transport in general and not specifically at urban level. Thirdly, it can be observed that the methodologies used to collect data are not systematic and therefore, different data cannot be compared to each other. Fourthly, where data are available, they are often not analysed due to the fact that this is an expensive and complex process. In some cases, the existence of the data is unknown or the data are not made public. Some authors ([8]–[11]) have also listed the main gaps in urban logistics data.

The first problem statement examines logistics indicators. There are different ways of clustering these. Firstly, common indicators used for data collection in urban logistics are defined within an urban freight context. Data collection methods are also presented for each indicator, as well as some case studies. A second way of grouping indicators is based on Allen & Browne [2]. They distinguish ten different aspects of urban logistics, and define indicators and data collection methods for all ten categories. A third way of presenting indicators is proposed in the BESTUFS-project by Patier & Routhier [10]. They group indicators according to the purpose of the data collection, and indicate data collection methods as well as measuring units.

With regard to the second problem statement, it is important to start with determining the specific context, the purpose of the data, the purpose of the model in which the data will be used, technical and financial limitations, etc. [8]. The collection method can subsequently be determined. Based on Holguin-Veras & Jaller [8] different methods are distinguished and clustered in categories, these being establishment-based, vehicle-based, trip intercept-based and tour-based. For each of these methods, a more specific collection method is described, as well as indicators, case studies and the advantages and disadvantages of the methods. Furthermore, some case studies of data collection initiatives in West-European countries are presented. In different countries, different surveys are conducted, resulting in different indicators measured in different units. Finally, some examples of data models are shown. Important models for urban logistics are for example WIVER and FRETURB. These models are used to estimate urban logistics data based on past data collection activities.

The first case study shows how certain urban freight data can be collected. Data are collected for the city of Antwerp, Belgium, by means of traffic counts. The case study is a first step, illustrating how data can be collected. The main observation is that only certain data can be collected with traffic counts, and to obtain other information, different data collection methods are necessary.

The analysis has two main findings. Firstly, it shows that only a limited amount of data on urban logistics is available for public use. When specific urban logistics data are needed, they often still have to be collected first. In order to achieve this, several data collection methods exist. Every method has its own advantages and disadvantages and is therefore suitable for certain specific situations. Therefore, it is important to determine the objective and specific circumstances of the data collection.

Secondly, the analysis also shows that there are large differences between countries and even cities in terms of data collection efforts and methods. This implies that comparisons between data collection initiatives are very difficult to make. Therefore, there may be a role for policymakers in making a general framework for urban logistics data collection, resulting in more transparent, focused data that are publicly available and can be used as foundations for policy measures and for research purposes.

Chapter 1 Introduction

1.1 Study context

Policymakers need data about urban freight distribution to set up their related policy. Moreover, data are necessary for research, supported by, for instance, urban freight distribution modelling [2], [12]. By collecting data on a regular basis, policymakers can make informed decisions about urban freight distribution [1], [12]. When only a limited amount of data is available, authorities have too little insight into urban freight operations to develop strategies and take policy measures. More information contributes to a better design and usage of the infrastructure, a better estimation of potential costs and benefits of new projects, and better monitoring of freight transport performance [3], [11], [13]. Moreover, possessing relevant and accurate data is important for communication purposes in the sense that politicians can better understand reality on the basis of specific data and thus, strive for good governance. The Urban Freight research roadmap [14] states that data collection is a crucial step for a relevant urban logistics research agenda.

The European policy making process and the role of data collection are discussed in the Sustainable Urban Mobility Plans (SUMP). 11 steps are identified in the SUMP, of which four address data collection [15]:

- Step 3: analyse the mobility situation and develop scenarios (preparation)
- Step 5: set priorities and measurable targets (goal setting)
- Step 8: build monitoring and assessment into the plan (elaboration)
- Step 11: learn the lessons (implementation)

Urban freight distribution data collection has gained increased attention in recent literature. Binnenbruck [16] shows examples of collection methods used and indicators measured in specific data collection efforts in Germany. Routhier & Patier [17], Browne et al. [11] and Patier & Routhier [18] describe general collection methods and indicators. McCabe et al. [5] provide indicators for driver surveys and GNSS-based data collections. Ambrosini et al. [4] indicate collection methods and indicators specifically for establishment-driver surveys. Ban et al. [9] and Holguin-Veras & Jaller [8] define a data collection framework in which collection methods are discussed. In both frameworks, a broad description of the data to be collected is given, but this does not comprise specific indicators. Gonzalez-Feliu et al. [19] show collection methods and a typology of indicators, related to shipment, pickup or delivery operation, vehicles and external elements. Routhier [20] provides categories of collection methods, without describing indicators. Allen et al. [12] make a comparison of urban freight data collected between countries. However, in all these works, no direct link is made between the urban freight indicators and the collection methods.

Few authors have made the link between urban freight collection methods and indicators. Patier & Routhier [10] propose some indicators depending on the objective of the data collection, and mention the appropriate collection method. Allen et al. [21] offer some survey techniques and 11 basic indicators. Pluvinet et al. [22] match 13 indicators and five collection methods. However, in these papers only a few broad indicators are given and no examples of data collection efforts measuring these indicators are provided. Moreover, Allen et al. [12] state that stakeholders often do not know whether the indicators they commonly use are potentially useful indicators.

Therefore, this report gives an overview of the urban freight distribution data needed for collecting data in a focused way and determining different urban freight distribution profiles. More specifically, the objectives of this paper are twofold. The first objective is to determine the common indicators needed in an urban freight context. The overview of indicators allows the identification of different profiles, so that data can be collected in a more focused way. The second objective of this report is to discuss the common data collection methods used to obtain these indicators. In addition, examples of case studies measuring specific indicators and using certain collection methods are included in order to provide an overview of interesting sources for each indicator and method.

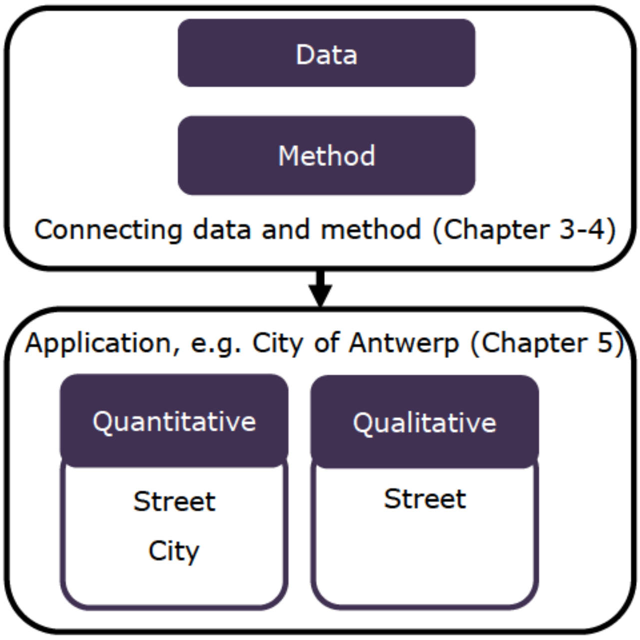
1.2 Approach

The method used is based on a three-stage analysis. Firstly, an overview and analysis of literature on data availability is given. Subsequently, the literature is applied to a framework for urban freight profiles. Finally, a few case studies illustrate the theory.

1.3 Structure

The structure of this report is as follows. Firstly, the need for data collection is highlighted in Chapter 2. Subsequently, this report is developed around two main blocks (Figure 1). Chapter 3 gives an overview of data collected in European countries for certain research programs. In Chapter 4, the methods to collect data for urban freight distribution are discussed. Chapter 5 offers a number of applications of some data collection methods. More specifically, traffic counts are elaborated on for the City of Antwerp (Belgium), both at quantitative and qualitative level. With respect to the quantitative counts, the streets as well as the city level are studied. Finally, Chapter 6 provides some conclusions and recommendations.

Figure 1 Relationship Chapters 3-5



Source: Own composition

Chapter 2 Lack of available data

This Chapter discusses the lack of available data on the basis of an extensive literature study. Firstly, some of the general observations of the literature are commented on. Secondly, some case studies of Western-European countries are briefly discussed. This Chapter concludes with the main shortcomings in data on urban freight distribution. Urban freight distribution in this report is referred to as "a segment of freight transport which takes place in an urban environment. … [It] is the transport of goods by or for commercial entities […] taking place in an urban area and serving this area" [1].

2.1 General observations

The first author who published an extensive book on urban freight was Ogden [23]. Since the 21st century, the data availability of urban freight distribution has been the same, or has even slightly improved. The improvements are the result of new national freight surveys in some countries, or data collection efforts at local urban level. One of the most important data collection initiatives in Europe took place in France, in around 1997. This initiative was executed with the help of government financing [11]. In 2011-2012, a new survey round was set up for the city of Paris [24]. Four main observations are derived from existing data collection efforts.

Firstly, Dablanc [1] points out that urban **freight transport** is **neglected** in many surveys and models. More specifically, Ambrosini et al. [4] observe that parameters such as type of goods, packaging, delivery frequency, type of vehicle, which are needed to reflect the urban freight reality, are not available in common statistics.

Secondly, Newton [25], Vleugel [26], Schoemaker et al. [27], Patier & Routhier [18] and Arndt & Gies [28] indicate the **lack of data at urban level**. Moreover, Ambrosini & Routhier [29] and Crainic et al. [30] highlight the lack of sufficient representative surveys on urban freight distribution and the difficulty involved in estimating the importance of urban freight transport. McCabe et al. [5] state that most cities around the world do not have enough data at their disposal to analyse urban freight distribution in a proper way. Allen & Browne [2] and Allen et al. [12] note that national surveys are accomplished in many countries, but they often fail to contribute to an extended knowledge of urban freight distribution, for different reasons. A sample in an urban area is small, and thus statistically not representative. Furthermore, it is difficult to extract data from a general dataset when data in national surveys do not deliver the detailed information needed for the analysis of urban freight distribution. Giuliano et al. [31] point out the limited availability of urban freight data specifically for rail freight flows. In general, Cherrett et al. [3] and Allen et al. [12] notice the lack of public data collection with respect to urban freight distribution.

Thirdly, it is observed that the data collection methodologies are not systematic; therefore, different **data cannot be compared** to each other [12], [30], [32]–[34]. Data on urban freight transport are often incompatible with data on freight transport between cities [29]. Other reasons for the incompatibility of data are the collection by diverse institutions or authorities [11], [12], [25] and the fact that different countries employ different definitions for 'urban goods movement' [29], [32]. Taniguchi et al. [34], Browne et al. [11], Dablanc [1], Browne & Goodchild [32] and Allen et al. [12] confirm these findings and add that cities and countries do not collect data on a regular basis.

Fourthly, where urban freight distribution data are available, they are often **not analysed** due to the fact that this is expensive and complex [25]. In addition, Newton [25] states that the existence of the available data is often unknown. The reasons for this are that data are not all preserved at the same location and that they frequently belong to reports formulated in national languages, or that the existing data are not made publicly available [2], [21], [27], [32], [34], [35].

In brief, it is observed that data collection initiatives are not carried out in a systematic way. Therefore, the following chapters provide an overview of indicators that characterise urban freight distribution, as well as common methodologies used to collect these indicators. (Local) authorities play an important role here in turning the indicators and collection methods into a generic framework that is used by the main stakeholders. Hence, the results of the framework can be translated to a policy based on systematic data collection.

2.2 Case studies

In 2006, the BESTUFS project was executed. This project had as an objective to identify and to spread case studies concerning urban freight distribution. Within the context of this project, several reports on urban freight data collection were published. For every participating country[1] for example, an overview was provided of past transport policies and data collection initiatives.

One of the conclusions for **Belgium** is that no urban freight indicators are collected and the knowledge of urban freight distribution is limited. Most indicators collected are general indicators, such as the average transport distance of Belgian freight vehicles, the total number of accidents of freight vehicles on motorways, etc. Most freight data are collected at national level, leading to less attention at the urban level. In terms of small freight vehicles in particular, only limited data are available, and there is also little knowledge regarding the organisation of urban freight transport.

The main data gaps in **France** are summed up by Routhier & Patier [17] and include the following. Firstly, there is not enough knowledge on traffic flows generated by urban freight distribution. Secondly, only limited data on the costs resulting from urban freight distribution are available. Thirdly, the available data are often outdated. Fourthly, many local surveys exist, however the results are not synchronized. Consequently, no best practices come from different experiments and too little data exists on commuting traffic, waste and reverse logistics, network management and flows generated by urban public management.

In **Germany**, a lack of data is particularly notable concerning the following: the use of small utility vehicles of a maximum weight below 3.5 tonnes, freight transport by foreign vehicles, transport flows within and between agglomerations, the use of roads by commercial transport, reasons for accidents involving utility vehicles in a city, data on parking fees, parking spaces for freight vehicles, road taxes, city taxes, etc. as well as the use of energy, and CO_2 emissions by utility vehicles. Data collection on urban freight distribution is the own responsibility of cities and regions. The government does not coordinate data collection centrally, but offers financial incentives. In general, little data are available. Where data are available, they are frequently in the hands of private companies, such as logistics service providers and couriers, thus often not publicly accessible [16]. More specifically, Table 1 shows the data requests in Germany.

[1] The countries for which this information is available, are Belgium, France, Germany, Hungary, Italy, The Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom [98].

Table 1 Main data requests in Germany

Category	Mode	Data requests
Infrastructure	Road	Regularly and permanently updating of data concerning the municipal road network, bridges, parking facilities
	Rail	Closed and new railways, list of main rail works, especially side tracks used by the industry
	IWW	Storage capacity of inland ports
	Combined transport	Capacity and facilities of terminals, inland ports
Vehicles	IWW	Size and structure of container ships on inland waterways
Companies	Rail	Structure of railway companies, infrastructure managers
Supply	Rail	Performance of freight transport by rail and by combined transport
Demand	Rail	Freight transport by rail of foreign companies in Germany
	IWW	Incoming and outgoing traffic of inland ports, modal structures
	Air	Transport performance of air cargo
	Road, rail, IWW	Freight transport, freight flows, vehicle movements (O/D relationships) at local level and depending on the mode
Accidents	Road	Accidents with water polluting substances

Source: Own composition based on [16]

In **The Netherlands**, it is concluded that no reliable public data with respect to urban freight distribution are available. Problems when collecting data are, amongst others, the lack of financial resources and small size of the samples often used in surveys. The main shortcomings are that (1) urban freight is not well represented in existing statistics, (2) national O/D data are limited if disaggregated for certain urban areas, (3) only limited information on trip frequency, time, vehicle type, etc. exists, and (4) no information on rail and inland waterways is available within the context of urban freight distribution. Subsequently, only a limited part of the data is published at urban level. However, these data do not provide information on how the goods are transported. Finally, traffic counts do exist, but freight transport is often not a separate category in these counts[36].

Moreover, the lack of available data is highlighted at conferences and by specific institutions and case studies. At the CIVITAS-conference in September 2012 for example, it was stated that data collection has to improve in the future, since better management would be possible through better data collection [6]. This message was repeated at the BESTFACT workshop in December 2012. It was stressed that comparable data between cities are necessary, but currently still unavailable [7]. Lindholm & Behrends [37] found in their research that in new Member States of the EU[2], only limited data concerning freight transport are available, whereas the incumbent Member States investigated in the research[3] feature urban freight distribution data. However, the objective of the data is just the optimisation of the traffic and not the use of the data at strategic level. In general, the conclusion of this research too is that there is a lack of data on urban freight transport.

[2] In this research these were more specifically the cities Gdynia (Poland) and Kaunas (Lithuania).

[3] The cities Bremen (Germany) and Örebro (Sweden) are the subject of research in the work of Lindholm & Behrends [37].

The CITILAB project has been running since 2015. The objective of this project is to gain knowledge on urban last-mile deliveries, large freight attractors and public administrations, urban waste and reverse logistics, and logistics facilities and warehouses. Cities acting as living labs include Amsterdam, Brussels, London, Oslo, Paris, Rome and Southampton [38].

The NOVELOG project has been running since 2015 and will conclude in 2018. This project helps the involved cities increase their awareness of urban freight distribution. Several cities in countries across Europe are participating in the project[4] [39].

Another project that started in 2015 is the SUCCESS project. This initiative investigates solutions for construction sites urban freight transport. Cases are elaborated on in four cities: Luxembourg (LUX), Paris (F), Valencia (ES) and Verona (IT) [40]. Finally, there is the URBACT network, in which cities are enabled to cooperate in order to develop sustainable best practices and to share them. 29 countries and 550 cities are involved in the network [41].

2.3 Main shortcomings in data

Browne et al. [11], Patier & Routhier [10], Ban et al. [9], Holguin-Veras & Jaller [8] and Allen et al. [12] list the main gaps in available data. With regard to urban freight distribution, these main gaps are data concerning empty flows, activities of lorries with a maximum weight below 3.5 tonnes, speed and (geographic) route data, loading and unloading operations, choice of transport mode and data on transport modes other than road transport. Browne & Goodchild [32] add to this list data on trip distances and patterns, including which freight types use which infrastructure elements, while Giuliano & Dablanc [33] replenish it with information on impacts and externalities. An overview is given in Table 2.

Table 2 Main data gaps

Data category		Availability
Freight generation data	Production	No data
	Consumption	
Delivery tours	Sequence	Only GNSS data from private suppliers
	Location	Limited level of detail
	O/D[5] flows	No full information
	Empty flows	No data
	Activity of trucks <3,5t	No data
	Speed and (geographic) route data	No data
	Loading and unloading operations	No data
Economic characteristics of participating agents	Shippers	Few sources, but no complete image; data do not have added value compared to other data categories
	Carriers	
	Receivers	
Spatial distribution/ location of participating agents	Shippers	
	Carriers	
	Receivers	
Network	Travel times and costs	Limited level of detail

[4] Test cases are executed in Athens (EL), Barcelona (ES), Copenhagen (DK), Emilia-Romagna Region (IT), Gothenburg (SE), Graz (AT), London BDD (UK), Mechelen (BE), Pisa (IT), Rome (IT), Turin (IT), Venice (IT).
[5] O/D is the abbreviation of Origin/Destination.

characteristics	Use restrictions	
	Capacity	
	Traffic volumes	
	Complete supply chain	No data
Special choice processes	Mode choice	No data
	Other modes than road	No data
	Delivery time	Limited level of detail
	Mode attributes	Reasonable level of detail
Other economic data	Production functions	No data
	Demand functions	
	Input-output technical coefficients	Strong level of detail, e.g. Regional Economic Information System (US) and the Benchmark Input-Output Accounts (US)
	Shopping trips of customers	No data
	Methodology, data collection, reliability and representability of data	Limited information

Source: Own composition based on [11], [10], [9], [8]

This chapter makes it clear that currently, a lack of representative data on urban freight transport exists, particularly in the urban context. Therefore, the next chapter examines in more detail the type of data that should be collected, as well as the methods of collection. In addition to the theory, examples from abroad are given, which show how different countries deal with data collection.

Chapter 3 Urban logistics indicators

In the second stage of the analysis, literature is applied to an urban freight profiles framework. Wolpert & Reuter [42] state that indicators exclusive to the urban freight context are needed. Therefore, this chapter describes in more detail the type of data needed to understand urban freight distribution.

Urban freight distribution can be classified by producing clusters of urban freight distribution data. Schoemaker et al. [27] split urban freight distribution into six impact factors, these being: freight volumes and commodities in urban areas, urban freight transport fleet, urban deliveries, contribution to the economy, the environment and safety. Another classification, used by the Flemish cities and municipalities, is provided by the following six sub-categories: shop profile, delivery profile, transport profile, analysis of logistics rules, stakeholder analysis and other data[6]. This line of thought was used in previous research [43] and is also followed here. Janjevic et al. [44] state that logistics profiles are characterised by a collection of indicators. Therefore, the aim is to give, for each of the six sub-categories, an overview of indicators that are commonly used to describe that category. General transport indicators that are used for long distances, such as tonnage, tonne-kilometres, etc. are to a lesser extent relevant at an urban level [4]. Therefore, the indicators in this Chapter result from a review of literature on urban freight distribution.

Table 3 gives an overview of the urban indicators that are mentioned in literature[7]. For each indicator, a proposed data collection method is mentioned, as well as an application of the data collection in a specific country and the scientific source providing information on the indicator.

[6] The shop profile comprises the location of different shops; the delivery profile incorporates the timing, frequency, location, parcel size, shipper, etc. of the deliveries; the transport profile defines the type of transport operator, the sector, the type of load, type of vehicle, load factor and bundling; the analysis of logistics rules includes time windows, pedestrian zones, loading and unloading zones, etc.; the stakeholder analysis equals the different stakeholders involved, as well as the analysis of their requests and bottlenecks; the other data collection tackles other types of datasets [43].

[7] This overview is non-exhaustive, but comprises the main sources on urban freight data collection in literature. The indicators are ranked alphabetically per profile, and only cells for which the information was found, are filled in.

Table 3 Overview of urban freight indicators by sub-category

Indicator	Method	Example	Source
Analysis logistics rules			
Environmental zones	Carrier survey, freight associations survey, local-decision maker survey	London (2015), Berlin (2015)	[15], [16], [17]
Loading/unloading zones	Carrier survey, driver survey, in-depth focus groups	Rome (2010), New York (2014)	[15], [18], [19], [20], [21]
Noise emissions			[15]
Off-peak deliveries	Carrier survey, delivery space observation, driver survey, establishment survey, GNSS data collection, in-depth focus groups	New York (2014), Brussels (2016), Stockholm (2015)	[22], [23], [24]
Possibility to find a free loading/unloading zone	Delivery space observation, driver survey	New York (2014)	[18], [25]
Road pricing	Carrier survey, delivery space observation, driver survey, establishment survey, GNSS data collection, in-depth focus groups	Rome (2010), New York (2010)	[18], [26], [22]
Size limitations (length, height)	Local-decision maker survey, shipper survey		[15], [27]
Time windows	In-depth focus groups, carrier survey, driver survey	Rome (2010)	[15], [18], [27], [28]
Urban consolidation initiatives	Carrier survey, in-depth focus groups, shipper survey, supplier survey	Brussels (2012), The Hague (2010)	[29], [30], [31], [32]
Weight limitations (total or per axle)	Carrier survey, shipper survey, road sensors		[15], [33]
Delivery profile			
Delivery frequency	Carrier survey, driver survey, establishment survey, receiver survey, vehicle observation	Bordeaux, Dijon, Marseille (1997), Budapest (1999), Milan (2002), Medan (2006)	[12], [15], [34], [35]
Loading/unloading share for own account	Urban goods movement survey	Bordeaux, Dijon, Marseille (1997), Breda (2008)	[34], [36]
Load value	Driver survey		[34]

Indicator	Method	Example	Source
Location of stops	Carrier survey, delivery space observation, driver survey, establishment survey, GNSS data collection, license plate matching, roadside interview, roadside postcard survey, supplier survey, urban goods movement survey, vehicle diary	Antwerp (1995), Bordeaux, Dijon, Marseille (1997), Liège (2004), Toronto (2006-2007), Breda (2008), New York (2014), Antwerp (2016), Lisbon (2015)	[9], [12], [22], [34], [37]–[45]
Location of consolidation points	Carrier survey, in-depth focus groups, shipper survey, supplier survey	Paris (2012)	[46]
Number of deliveries	Carrier survey, delivery space observation, driver survey, establishment survey, receiver survey, supplier survey	Antwerp (1995), Antwerp (2016), Bordeaux, Dijon, Marseille (1997), Liège (2004), Breda (2008)	[12], [17], [35], [36], [38], [40], [41], [47],[48]
Number of loading/unloading operations per week/employee/activity	Driver survey, shipper survey, supplier survey, urban goods movement survey, vehicle observation	Amsterdam, Utrecht (2002), Rotterdam (2003)	[9], [34], [35], [37], [38], [48], [49]
Number of pieces per drop	GNSS data collection, traffic counts	Rome (2005-2006), Milan (2010)	[50], [51]
Parking infractions	Delivery space observation, driver survey, establishment survey, parking survey, vehicle diary	Liège (2004)	[40], [43], [49], [52]
Parking location (e.g. walking distance)	Driver survey, establishment survey, GNSS data collection, parking survey, traffic counts, service provider survey, vehicle observation	Amsterdam & Utrecht (2002), Rotterdam (2003), Breda (2008), New York (2016)	[12], [18], [25], [34], [36], [38], [43], [49]
Ratio loading/unloading	Carrier survey, establishment survey, urban goods movement survey	Bordeaux, Dijon, Marseille (1997), Breda (2008)	[8], [9], [34], [36]
Reverse and waste flows	Carrier survey, driver survey, receiver survey, supplier survey	Breda (2008)	[12], [36], [38]
Size of the shipment	Driver survey, establishment survey, shipper survey, urban goods movement survey, vehicle observation	Bordeaux, Dijon, Marseille (1997), Liège (2004), Breda (2008), Antwerp (2016)	[14], [36], [38], [40], [44], [48], [53]

Indicator	Method	Example	Source
Service time	Delivery space observation, driver survey, establishment survey, GNSS data collection, parking survey, traffic counts, urban goods movement survey, vehicle diary, vehicle observation	Rome (2005-2006), Milan (2010) Livorno (2003), Liège (2004), Rome (2005-2006), Barcelona (2010), Milan (2010)	[9], [12], [37], [38], [40], [42]–[44], [48], [50], [51], [53]–[55]
Storage space/(re)building plans	Carrier survey, driver survey, establishment survey, receiver survey, supplier survey	Breda (2008)	[36]
Type of transport equipment (e.g. pallets, foldable boxes)	Delivery space observation, driver survey, establishment survey, traffic counts, vehicle diary	Breda (2008), Milan (2010)	[36], [43], [50]
Unloading equipment (e.g. fork-lift truck, pallet transporter)	Carrier survey, delivery space observation, driver survey, establishment survey, urban goods movement survey, vehicle diary, vehicle observation	Liège (2004)	[38], [40], [43], [53]
Use of lorry equipment (e.g. loading bridge)	Delivery space observation, driver survey, establishment survey, traffic counts, vehicle diary, vehicle observation	Breda (2008), Milan (2010)	[36], [38], [43], [50]
Variation of deliveries by hour/ day/ during year	Establishment survey, traffic counts	Bordeaux (1995), Amsterdam, Utrecht (2002), Rotterdam (2003), Dublin (2004), London (2004), Bologna (2004), New York (2014), Lisbon (2015)	[12], [22], [35], [38]
Vehicle trip purpose (e.g. joint or separate delivery and collection)	Carrier survey, driver survey, establishment survey, roadside interview, service provider survey, supplier survey, vehicle diary	New York (2014), Lisbon (2015)	[9], [12], [34], [38], [42], [44], [53]
Shop (B2B) and receiver (B2C) profile			
Company and sector category	Establishment survey, traffic counts, urban goods movement survey	Antwerp (1995), Amsterdam, Utrecht (2002), Rotterdam (2003), Barcelona (2010), Milan (2010), Lisbon (2015)	[9], [34], [35], [38], [41], [44], [47], [50], [54], [56], [57]

Indicator	Method	Example	Source
Location of the shop	Establishment survey, traffic counts	Milan (2010), Lisbon (2015)	[34], [44], [50], [57]
Name of the shop	Establishment survey, traffic counts	Milan (2010)	[50]
Number of employees	Establishment survey, government databases	Antwerp (1995), Medan (2006), Barcelona (2010)	[15], [38], [41], [44], [54], [56]
Number of inhabitants in area (density of demand)	Government databases		[14], [58]
Order lead times	Carrier survey, driver survey, establishment survey, roadside interview, service provider survey, supplier survey		[38]
Presence/signature of and/or control by staff required or not	Carrier survey, driver survey, establishment survey, roadside interview, service provider survey, supplier survey		[38], [22]
Inventory management and strategies	Establishment survey		[38]
Shop size	Establishment survey, government databases	Antwerp (1995), Breda (2008), Barcelona (2010)	[36], [38], [41], [54]
Stakeholder analysis			
Drivers	Roadside interview, roadside postcard survey		[15], [18]
Inhabitants	In-depth focus groups, urban freight forum		[15], [18], [36]
Large transport and logistics firms	In-depth focus groups, license plate matching, roadside interview, roadside postcard survey, urban freight forum		[15], [18], [38]
(Local) governments	In-depth focus groups, urban freight forum, sensors, license plate matching		[59]–[61]
Local shopkeepers (B2B)	In-depth focus groups, urban freight forum	Lisbon (2015), New York (2015)	[14], [15]
Receiver (B2C)	License plate matching, roadside interview, roadside postcard survey		[37]
Shipper	License plate matching, roadside interview, roadside postcard survey	Breda (2008)	[37]
Small operators	In-depth focus groups, license plate matching, roadside interview, roadside postcard survey, urban freight forum	Antwerp (2016)	[15], [38], [48], [50]

Indicator	Method	Example	Source
Transport profile			
Average speed per round trip	Driver survey, GNSS data collection, urban goods movement survey	Gauteng (2008)	[9], [37], [44], [45], [62], [63]
Carrier name	Establishment survey, traffic counts, license plate matching, roadside interview, roadside postcard survey	Bordeaux, Dijon, Marseille (1997), Milan (2010)	[15], [38], [43]
Choice of distribution channels (e.g. own account, logistics company, parcels carrier)	Establishment survey	Bologna (2002), Liège (2004), Antwerp (2016)	[12], [15], [17], [38], [40], [48]
Driver characteristics	Driver survey, service provider survey		[44]
Engine information (speed, rpm, load, acceleration, stops, fuel consumption, euro norm)	GNSS data collection	Toronto (2006-2007)	[34], [43]
Freight type (dangerous, volume, livestock)	Carrier survey, delivery space observation, driver survey, establishment survey, license plate matching, roadside interview, roadside postcard survey, supplier survey, urban goods movement survey, vehicle diary, vehicle observation	Antwerp (1995), Bordeaux, Dijon, Marseille (1997), Bologna (2004), Liège (2004), Toronto (2006-2007)	[12], [34], [38], [40], [41], [43], [44], [53], [64]
Fuel type & consumption	Driver survey	Amsterdam, Den Bosch, Groningen, Tilburg (1999)	[12], [43], [64]
Load factor	Establishment survey, roadside interview, Urban goods movement survey	Amsterdam, Groningen, Tilburg (1999), Budapest (1999), Copenhagen (2002-2004), London (2002), Medan (2006), Barcelona (2010)	[9], [12], [15], [37], [38], [44], [50], [54]
Location of (urban) distribution centres	Carrier survey, government databases, tracking of individual shipments, urban goods movement survey	Paris (2010)	[65]
Number of stops (per round/ per day)	Driver survey, GNSS data collection, urban goods movement survey, vehicle diary	Bordeaux, Dijon, Marseille (1997), Melbourne (2006)	[12], [38], [43], [56], [63]

Indicator	Method	Example	Source
Number of trips	Carrier survey, vehicle observation		[37], [43]
Number of vehicles	Driver survey, establishment survey, traffic counts	Antwerp (1995), London (2004), Bologna (2006), Milan (2010), Rome (2010), Brussels (2012)	[9], [12], [18], [19], [41], [50]
Operation type	Delivery space observation, driver survey, establishment survey, vehicle diary		[43]
Organisation of the transport chain	Carrier survey, tracking of individual shipments, urban goods movement survey		[11], [14], [38], [42], [43], [53]
Package type	Delivery space observation, driver survey, establishment survey, traffic counts, vehicle diary, vehicle observation	Bordeaux, Dijon, Marseille (1997), Liège (2004), Barcelona (2010), Milan (2010)	[14], [38], [40], [43], [53], [54]
Route duration	Driver survey, GNSS data collection, vehicle diary	Bordeaux, Dijon, Marseille (1997), Amsterdam, Den Bosch, Tilburg (1999)	[12], [14], [37], [38], [43]
Route length	Driver survey, establishment survey, GNSS data collection, urban goods movement survey, vehicle diary	Bologna (2002), London (2002), Melbourne (2006), Breda (2008)	[12], [36], [37], [43], [44], [55], [56], [63], [66]
Route type (single trip, round trip)	Carrier survey	Bordeaux, Dijon, Marseille (1997), Amsterdam, Den Bosch, Groningen, Tilburg (1999)	[12], [38], [44]
Routing	Carrier survey, classical survey, driver survey, GNSS data collection, license plate matching, receiver survey, roadside interview, roadside postcard survey, service provider survey, supplier survey, urban goods movement survey, vehicle diary	Bordeaux, Dijon, Marseille (1997), Toronto (2006-2007), Breda (2008), Gauteng (2008)	[14], [36], [38], [43], [44], [49], [50], [62], [63]
Share of loading/unloading with vehicles < 3.5 tons in vehicle movements	Urban goods movement survey	Bordeaux, Dijon, Marseille (1997)	[14], [56]

Indicator	Method	Example	Source
Share of small establishments (< 5 employees) in vehicle movements	Urban goods movement survey	Bordeaux, Dijon, Marseille (1997)	[14]
Stopping manoeuvres	Delivery space observation, driver survey, establishment survey		[43]
Time at different locations along the route	GNSS data collection	New York (2014)	[22], [26], [37]
Transport mode	Carrier survey, delivery space observation, driver survey, establishment survey	Bordeaux, Dijon, Marseille (1997), Toronto (2006-2007), Breda (2008)	[15], [36], [38], [43], [64]
Vehicle capacity (weight and volume)	Carrier survey, driver survey, observations		[12], [38], [43], [44]
Vehicle crew size	Carrier survey, driver survey, establishment survey, service provider survey, supplier survey	Lisbon (2015)	[38]
Vehicle length	Traffic counts		[38], [44]
Vehicle movements	Carrier survey, establishment survey, service provider survey, supplier survey, traffic counts	Toronto (2006-2007)	[12], [37], [38], [43], [56], [64]
Vehicle speed	GNSS data collection, traffic counts		[37], [38], [64]
Vehicle type	Carrier survey, delivery space observation, driver survey, establishment survey, license plate matching, parking survey, traffic counts, roadside interview, roadside postcard survey, traffic counts, urban goods movement survey, vehicle observation	Antwerp (1995), Bordeaux, Dijon, Marseille (1997), Amsterdam, Groningen, Tilburg (1999), Budapest (1999), Copenhagen (2002-2004), Liège (2004), London (2002 & 2004), Breda (2008), Barcelona (2010), Milan (2010)	[12], [35]–[37], [40]–[42], [44], [50], [53]–[56]
Weight of vehicle and freight	GNSS data collection, license plate matching, roadside postcard survey, urban goods movement survey	Bordeaux, Dijon, Marseille (1997), Rome (2005-2006)	[38], [44], [55], [66], [51]
Externalities			

Indicator	Method	Example	Source
Accidents	Government (police) databases		[12], [35], [67]
Air pollution	Carrier survey, sensors	Bordeaux (1995), Bordeaux, Dijon, Marseille (2000)	[9], [12], [35], [37]
Environmental impact	Establishment survey, GNSS data collection	Lyon (1999), Rome (2005-2006), Barcelona (2010)	[35], [37], [51], [54]
Nuisance to the environment	GNSS data collection, vehicle diary	Bordeaux, Marseille, Dijon (1995-1997), Florence (1998), Amsterdam, Utrecht (2002), Rotterdam (2003)	[12], [35], [43]

Source: Own composition based on [86]

Multiple indicators are developed through different studies. Allen & Browne [2] made in their research a sub-division of indicators on the basis of the specific aspects of urban freight distribution that have to be investigated. An overview is provided in Table 4.

Dablanc [1] discusses the Freight Urban Mobil Equipment (FUME) indicator, developed by Betanzo & Romero Navarrete [87], but on which no official research has been published. This indicator is a measure for the number of freight vehicles per 1,000 residents in a city. Research shows that FUME decreases when cities become larger. More detailed information on this indicator can be found in [88].

Table 4 Indicators according to the specific aspect of urban freight distribution

Aspect of urban freight transport	Indicator	Methods
Vehicle delivery/collection trips at establishments in the urban area	Type of establishment, size of establishment, employees at establishment, number of deliveries/collections, delivery/collection frequency, size/type of delivery/collection, number of waste collections, time of day, variation by day of week, variation during year, type/size of vehicle, whether vehicles deliver and collect jointly, type of vehicle operator (own account, logistic company, parcels carrier, etc.), whether vehicles based at establishment, vehicle types/sizes, deliveries/home deliveries made by vehicles at establishment	Establishment survey, vehicle observation
Goods flows to/from establishments in the urban area	Type of establishment, size of establishment, employees at establishment, type and quantity of goods delivered/collected, frequency of goods flow, time of day, variation by day of week, variation during year	Establishment survey, urban goods movement survey, supplier survey
Service trips to establishments in the urban area	Type and number of service trips received, time of day, variation by day of week, variation during year, type/size of vehicle, time taken to carry out service	Establishment survey, vehicle observation
Trip details and patterns of goods/service vehicles in the urban area	Type of operator, vehicle type, vehicle weight, type of goods carried and delivered/collected, type of establishments/land use served, type of vehicle round (singe/multi-drop; deliveries/collections), number of stops per round, number of rounds per day, distance between stops, journey time, vehicle speed, driving time: stationary time, journey length, vehicle crew size, vehicle load factor, empty running, vehicle time utilization, start and finish time, origin and destination/s, type and quantity of goods/equipment carried, fuel consumption	Shipper survey, driver survey, roadside interview, vehicle (trip) diary, GNSS data collection, supplier survey, service provider survey
Loading/unloading activity of goods vehicles in the urban area	Type of vehicle, time of day, parking location (on- & off-street etc.), time taken for service, dwell time of vehicle, number of servicing task by driver without moving vehicle, legal: illegal parking activities, type of contravention during parking	Establishment survey, shipper survey, driver survey, vehicle observation, parking survey, vehicle (trip) diary, GNSS data collection, supplier survey
Parking activity of service vehicles in the urban area	Type of vehicle, time of day, parking location (on-& off-street etc.), time taken for service, dwell time of vehicle, number of servicing task by driver without moving vehicle, legal: illegal	Vehicle observation, parking survey, vehicle (trip) diary, GNSS data collection,

	parking activities, type of contravention during parking	service provider survey
Movement of goods between vehicles and establishments in the urban area	Method of goods handling from vehicle to establishment, type of delivery packaging used, proximity of location to delivery/collection point, quantity of goods, end destination for delivery (shop floor, stock room, etc.), whether staff from establishment need to be present, whether signature is required, whether goods have to be checked by receiver	Establishment survey, shipper survey, driver survey, vehicle observation, vehicle (trip) diary, supplier survey
Origin location of goods flow/vehicle trip to establishments in the urban area	Origin of goods, origin of delivery journey, type/land use of establishment vehicle dispatched from	Establishment survey, shipper survey, driver survey, roadside interview, supplier survey
Ordering and stockholding arrangements at urban premises	Whether stock is held, size of stockholding space, order lead times, ordering system	Establishment survey
Supply chain management between establishments, their suppliers and freight transport operators	Type of supply chain, number of dispatch points to establishment, whether delivery/ collection is regular or ad hoc, who organizes delivery/ collection time, who resolves delivery/ collection issues	Establishment survey

Source: [2]

The BESTUFS project also lists a number of common indicators for urban freight distribution. These indicators are displayed in Table 5.

Table 5 Indicators urban freight distribution according to BESTUFS

Objectives	Urban freight indicators	Way of collect	Units in which the indicator is measured
To know the contribution of each industry sector. Make possible a fast appraisal of the generation of deliveries and pick-ups in a town without any survey.	Number of loading/unloading in each activity	Establishment survey	Number of deliveries and pick-ups per employee per time unit
To measure the importance of the goods flows in a zone	Loading/unloading density in a zone	Establishment survey	Number of deliveries and pick-ups per km²
To measure the contribution of each industry sector to the goods flows	Loading/unloading intensity per activity in a zone	Establishment survey	Number of deliveries and pick-ups
To measure the contribution of each industry sector to the road congestion by the on street double parking deliveries	Loading/unloading time in a zone, per vehicle, per activity	Establishment survey	Number of hours of on street double parking for delivery or pick-up
To measure the contribution of the running vehicles delivering each industry sector to the road congestion	Distance covered for loading/ unloading in a zone, per vehicle, per activity	Establishment + driver survey	Number of kilometres covered for one delivery or pick-up
To measure the impact of the location	Average length of	Carrier survey	Kilometres

of the platform delivering goods relating to its market radius	the first leg from platform to the delivery area		
To measure the contribution of one delivery/pick-up to the urban traffic (per type of involved vehicle)	Average distance travelled per pick-up/ delivery	Driver survey	Kilometres per pick-up or delivery
To measure the contribution of the total industry activity on the traffic	Total distance travelled on roads in urban areas transporting goods by HGV, rigid lorries and LGV (<3.5t) used	Establishment + driver survey	Total vehicle kilometres
To measure the time taken for delivering in a tour, on a street, for an industry activity, etc.	Average time taken per delivery (per activity type, per vehicle, own account, for hire, etc.)	Driver survey	Minutes per delivery
To measure the performance of the round for each way of organization, type of vehicle	Average speed per round (including and excluding stops to make deliveries)	Driver survey	Kilometre per hour
To measure the performance of the rounds for each way of organization, type of vehicle, etc.	Average payload per kilometre per tour, per activity, per type of vehicle	Driver survey	Ton-kilometre
To measure the road occupancy per hour	Number of vehicles involved in deliveries and pick-ups per hour per type per size	Establishment + driver survey	Number of vehicles per hour
To measure the impact of urban goods movement on the energy consumption, local and global nuisance and greenhouse gas	Greenhouse gas and pollution according to the zone, the vehicle, the activity, the management	Establishment + driver survey	Grams pollutant per kilometre, grams CO_2 per kilometre, litres of fuel per kilometre

Source: [10]

Dablanc [1] presents some general indicators that are representative for cities in developed countries. On average, cities generate 0.1 loading or unloading operations per person per day, 300-400 lorry trips per 1 000 people per day and 30-50 tons of freight per person per year. These indicators are estimated for some West-European capitals, ranked by increasing number of residents, in Table 6.

These estimations are only general estimations for the cities and do not comprise detailed information. However, they offer a first view on the estimated freight transport within the cities.

Table 6 Indicators illustrated for West-European capitals

City	Number of residents on 01/01/16	Number of loading/ unloading operations (per year)	Number of truck trips (per year)		Number of tons freight (per year)	
			Minimum	Maximum	Minimum	Maximum
Amsterdam	834713	30467025	91401074	121868098	25041390	33388520
Brussels	1187890	43357985	130073955	173431940	35636700	47515600
Berlin*	3520000	128480000	385440000	513920000	105600000	140800000
Paris	6968051	254333862	763001585	1017335446	209041530	278722040

Source : Own composition based on [1] and websites of the cities

After the identification of the main indicators and methods, the next Chapter treats the collection methods more in depth.

Chapter 4 Data collection methods

4.1 Overview of methods

Ogden [23] states that it is impossible to produce definitive statements on the data needed for urban freight distribution. This requirement depends on the specific situation, the current and future planning and policy framework, existing data collection methods and the availability of existing data. Browne et al. [11], Browne & Goodchild [32] and Allen et al. [12] add to this that the collection method depends upon the type of data to be collected and the reasons behind it. Consequently, the most suitable collection method depends on the specific situation. Before collecting data, the purpose of the data and of the model for which the data are input needs to be clear. Furthermore, any technical or financial limitations need to be determined. Furthermore, Patier & Routhier [18] suggest that the observation unit has to be defined before collecting the data.

Holguin-Veras & Jaller [8] confirm that the choice for a particular collection method follows on from these preceding steps, and whatever choice is made will incur a cost. . A trade-off must be made between the costs of collecting the data and of having non-representative data. Moreover, it is important to use the correct sample size for every single data collection effort. Holguin-Veras & Jaller [8] propose some sample sizes based on analyses of the New York Metropolitan Transportation Council.

Holguin-Veras & Jaller [8] developed a framework (see Table 7) for data collection, where both the indicators that need to be collected and the method used are related to the kind of data required, the objective and the intended population. Depending on these variables, a different output of data is expected.

Table 7 Framework of data collection

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 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. *	Computer aided telephone interviews.	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 to describe the geographic patterns of commodity flows, vehicle-trips, sequences of stops and pickup and delivery actions.	Private and common carriers in the study area.	Company characteristics; tonnage; commodity types; vehicle-trips; tours and delivery sequence; amounts delivered and picked up; and time of travel. *	Travel diaries complemented with Global Positioning System (GNSS) 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 an expanded sample of tonnage transported, tours, and vehicle trips, used to produce origin-destination matrices.
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. *	Large Establishments: CATI 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 behavioural models and to support the study of specific policy questions.	Depends on the specific choice process to be modelled.	Data required include company characteristics and stated preference (SP) and revealed preference (RP).	CATI based on random sampling of potential participants.	Dataset containing company characteristics and the SP/RP data needed for behavioural modelling.

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
Source: [8]

Allen et al. [12] indicate that some important aspects to compare data collection methods are the costs, the implementation and difficulties surrounding execution, the quantity and quality of the data collected and sampling considerations.

Allen et al. [21] make a distinction between four categories of collection methods: general surveys, stakeholder-specific surveys, vehicle-specific surveys and land use-specific surveys. Holguin-Veras & Jaller [8] distinguish among four main categories of data collection methods:

establishment-based, tour-based, trip-intercept and vehicle-based methods[8]. In the present paper, the typology of Holguin-Veras & Jaller [8] is followed.

Table 8 gives an overview of this classification and indicates for every method the specific tool that can be used, the indicators and profile that are measured by applying that method and case studies using the collection method.

[8] Establishment-based data collection means that the data collection takes place at the establishment; tour-based data collection includes collection of data by following a shipment along a route; trip-intercept is a method by which data are collected at a certain point of the trip; vehicle-based data collection is the gathering of data at the vehicle-level.

Table 8 Different data collection methods

Method	Specific method	Indicator	Profile	Example	Source
Establishment					
Carrier/ freight operator/ transport operator survey	Face-to-face, phone, self-completion	Company and sector category, delivery frequency, freight type, location of stops, number of deliveries, organisation of the transport chain, number of trips, ratio loading/unloading, reverse and waste flows, routing, storage space/ rebuilding plans, transport mode, unloading equipment, vehicle movements, vehicle trip purpose, vehicle type	Delivery, shop and receiver, and transport profile	Liège (2004), Medan (2006), Breda (2008), Rome (2010)	[1], [4], [10], [16], [21], [22], [47], [64]–[67], [89]
Delivery space observation		Freight type, location of stops, operation type, package type, parking infractions, start and end time of the stop, stopping manoeuvres, transport mode, type of transport equipment, unloading equipment, use of lorry equipment, vehicle type	Delivery, shop and receiver, and transport profile	Liège (2004)	[10], [22], [67]
Driver survey	Face-to-face, phone, self-completion	Activities at the stops, average speed per round trip, delivery frequency, freight type, fuel type & consumption, load value, location of stops, number of deliveries, number of loading/unloading operations per week/employee/ activity, number of stops, number of vehicles, operation type, organisation of the transport chain, package type, parking infractions, parking location, reverse and waste flows, route duration, route length, routing, size of the shipment, service time, stopping manoeuvres, storage space/ rebuilding plans, transport mode, type of transport equipment, unloading equipment, use of lorry equipment, vehicle capacity, vehicle trip purpose, vehicle type	Delivery, shop and receiver, and transport profile	Bordeaux, Dijon, Marseille (1997), Amsterdam, Utrecht (2002), Rotterdam (2003), Breda (2008), Toronto (2006-2007)	[2], [4], [5], [10], [13], [17], [19], [22], [26], [64], [66], [69], [76], [90], [91]
Establishment survey	CATI, face-to-face, phone, self-	Carrier name, choice of distribution channels, company and sector category, delivery frequency, environmental impact,	Delivery, shop and receiver, and transport profile	Antwerp (1995), Bordeaux,	[1], [2], [4], [10], [11], [13], [16],

Method	Specific method	Indicator	Profile	Example	Source
	completion	freight type, load factor, location of stops, location of the shop, market share, name of the shop, number of customers, number of deliveries, number of employees, number of vehicles, operation type, package type, parking infractions, parking location, purchase zones, ratio loading/unloading, route length, route type, shop size, size of the shipment, service time, stopping manoeuvres, storage space, total sales, transport mode, type of transport equipment, unloading equipment, use of lorry equipment, vehicle movements, vehicle trip purpose		Dijon, Marseille (1997), Amsterdam, Utrecht (2002), Rotterdam (2003), Liège (2004), Medan (2006), Breda (2008), Barcelona (2010)	[17], [19], [21], [22], [26], [46], [64], [66]–[69], [71], [76], [89]
Urban goods movement/ delivery survey	Establishment survey and driver & carrier survey; face-to-face, phone, self-completion	Average speed per round trip, company and sector category, empty running, freight type, location of stops, loading/unloading share for own account, number of loading/unloading operations per week/employee/ activity, number of (un)loading operations per km², number of stops (per round), organisation of the transport chain, package type, ratio loading/unloading, route length, routing, share of loading/unloading with vehicles < 3.5 tons in vehicle movements, share of small establishments (< 5 employees) in vehicle movements, size of the shipment, service time, unloading equipment, vehicle type, weight of vehicle and freight	Delivery, shop and receiver, and transport profile	Bordeaux, Dijon, Marseille (1997), Calgary (2000), Edmonton (2001), Ontario (2007)	[4], [11], [12], [17], [18], [22], [69]
Parking survey	Real-time/ later observation by means of video	Parking infractions, parking location, service time, vehicle type	Delivery, and transport profile		[2], [4], [11], [21], [22], [66]
Service provider	Face-to-face, phone, self-	Parking location, routing, vehicle movements, vehicle trip purpose	Delivery, and transport profile	Rome (2010)	[2], [4], [19], [21], [22],

Method	Specific method	Indicator	Profile	Example	Source
survey	completion				[47], [66], [91]
Supplier survey	Face-to-face, phone, self-completion	Freight type, location of stops, number of deliveries, number of loading/unloading operations per week/employee/ activity, reverse and waste flows, routing, storage space/ rebuilding plans, vehicle movements, vehicle trip purpose	Delivery, and transport profile	Breda (2008)	[2], [4], [21], [22], [64]
Receiver survey		Delivery frequency, number of deliveries, reverse and waste flows, routing, storage space/ rebuilding plans	Delivery profile	Breda (2008), Amsterdam, Utrecht (2002), Rotterdam (2003), Ghent & Liège (2004)	[11], [16], [26], [64], [89]
Shipper survey		Number of loading/unloading operations per week/employee/ activity, size of the shipment	Delivery profile	Toronto (2006-2007), Breda (2008), Liège (2004)	[4], [5], [11], [12], [16], [19], [22], [64], [66], [89]
Tour					
Accompanying of drivers			Delivery, and transport profile		[4], [11]
Tracking of individual shipments		Organisation of the transport chain	Transport profile		[8]
Trip-intercept					
License plate matching	License plate matching and survey that is sent around	Carrier name, freight type, large transport and logistics firms, location of stops, receiver, routing, shipper, small operators, vehicle type, weight of vehicle and freight	Delivery and transport profile, stakeholder analysis		[8], [11]
Roadside interview/ aerial photography	Face-to-face	Carrier name, driver, freight type, large transport and logistics firms, load factor, location of stops, receiver, routing, shipper, small operators, vehicle trip purpose, vehicle type	Delivery and transport profile, stakeholder analysis	Medan (2006), Ontario (2006-2007)	[1], [2], [4], [11], [18], [21], [22], [66]

Method	Specific method	Indicator	Profile	Example	Source
Roadside postcard survey		Carrier name, driver, freight type, large transport and logistics firms, location of stops, receiver, routing, shipper, small operators, vehicle type, weight of vehicle and freight	Delivery and transport profile, stakeholder analysis		[11]
(Vehicle) Traffic counts	Street Chapter monitoring, manual counting, automatic vehicle classifier, e.g. weigh-in-motion, magnetic loops	Carrier name, company and sector category, location of the shop, name of the shop, number of pieces per drop, number of vehicles, package type, parking location, service time, type of transport equipment, use of lorry equipment, variation of deliveries by hour/ day/ during year, vehicle length, vehicle movements, vehicle speed, vehicle type	Delivery, shop and receiver, and transport profile	London (2004), Bologna (2006), Barcelona (2010), Milan (2010), Brussels (2012)	[2], [4], [11], [12], [16]–[18], [21], [22], [27], [48], [71], [73], [76], [89], [92]
Vehicle					
GNSS data collection/ survey	GNSS, mobile phone	Average speed per round trip, engine information, environmental impact, location of stops, nuisance to the environment, number of pieces per drop , number of stops, parking location, route duration, route length, routing, service time, time at different locations along the route, vehicle speed, weight of vehicle and freight	Delivery and, transport profile, other data collect-ion	Rome (2005-2006), Melbourne (2006), Toronto (2006-2007), Gauteng (2008)	[2], [4], [5], [11], [12], [17], [19], [21], [22], [34], [35], [66], [74], [83]
Vehicle (trip) diary	Completion by the driver or another employee of the freight carrier	Freight type, location of stops, nuisance to the environment, number of stops, operation type, package type, parking infractions, route duration, route length, routing, service time, type of transport equipment, unloading equipment, use of lorry equipment	Delivery and, transport profile, other data collect-ion		[2], [4], [21], [22], [66].

Method	Specific method	Indicator	Profile	Example	Source
Vehicle observation	Real-time observation or later observation by means of video	Delivery frequency, freight type, number of loading/unloading operations per week/employee/ activity, number of trips, package type, parking location, size of the shipment, service time, unloading equipment, use of lorry equipment, vehicle trip purpose, vehicle type	Delivery profile, transport profile	Paris, Medan (2006)	[1], [2], [4], [11], [21], [22], [66]
Other					
In-depth focus groups		Residents, large transport and logistics firms, loading/unloading zones, local shopkeepers, road pricing, small operators, time windows	Stakeholder analysis	Rome (2010)	[1], [11], [47], [64]
Urban freight forum		Residents, large transport and logistics firms, local shopkeepers, small operators	Stakeholder analysis		[1], [47], [64]

Table 8 shows that a well-prepared driver and establishment survey[9] enables the collection of a large number of indicators. Otherwise, tracking of individual shipments provides mainly information about the organisation of the transport chain. The most discussed methods in literature are traffic counts and establishment, carrier and driver surveys. Delivery space observation, accompanying of drivers, tracking of individual shipments and roadside postcard survey are methods that were less the subject of research to date. To sum up, it is clear that a combination of different collection methods is necessary to get a full overview of urban freight distribution. This is in line with an observation of Gonzalez-Feliu et al. [19].

Classic surveys are often used to collect data. The disadvantage of this method is that surveys offer only limited data while being both time and cost intensive [22]. Globally, four different data collection categories are distinguished, as illustrated in the paragraphs below: concerning the establishment, the vehicle, the tour and the trip-intercept.

ESTABLISHMENT

An **establishment survey** is an often-used method of collecting data from total freight vehicle trips to/from certain establishments or from the type of freight being loaded/unloaded [2], [66]. Between 2000 and 2002, an establishment survey was executed in Canada in combination with a shipper and driver survey. The establishments were contacted three times. First, information was gathered via e-mail and telephone communication concerning employment, the nature of the goods/services and the willingness to participate to the survey. Next, a formal letter was sent by e-mail or fax, followed by a new telephone conversation. Finally, the data was gathered by the survey itself [4].

In 1997, an establishment survey was also executed in Bordeaux with 1,500 establishments, together with a driver and a freight operator survey. The combination of these three surveys was called an **urban goods movement survey**. A similar survey was conducted in Marseille (2,000 establishments) and Dijon (1,000 establishments). In all three cases, Computer Assisted Telephone Interviews (CATI) were partially used. The knowledge resulting from these surveys can be transferred without calibration to other cities within France and even Europe. This is bundled in the **FRETURB** model [4].

More recent examples which follow a similar approach are the establishment surveys conducted in Lisbon [78] and New York [93] in 2015, however, both surveys focus on more specific sub-markets and transport characteristics.

In light of the establishment survey, a questionnaire concerning the activity of the establishment, vehicle fleet, storage capacity, parking facility, etc. was completed based on interviews with the manager of the establishment. Further, the logistics manager also kept a logbook with information concerning loading/unloading operations such as location, vehicle type, delivery time, as well as the name of the freight operator, loading/unloading frequencies and product data. The latter includes product type, package type, weight, origin and destination [4].

A **carrier survey** can also be conducted. This type of survey provides information on the activity patterns of the vehicles of a company in an urban environment, which facilitates the collection of data from the entire fleet [2]. This method was, for example, applied in the research in Bordeaux in 1997 [4] using face-to-face interviews. The gathered data includes the activity of the company (express, (inter)national, fleet, amount of employment), the organisation of the transport chain, delivery frequency, vehicle fleet related to the urban

[9] An urban goods movement survey could be added to this list. However, since this is a combination of a driver survey and an establishment survey, it is not separately mentioned here.

deliveries, number of vehicle movements, number of loading/unloading operations, daily trips, terminal location, etc.

In a **supplier survey**, the focus of data collection lies with the goods the suppliers deliver to urban establishments, and the corresponding vehicle activity. This method is often conducted in combination with an establishment survey. If the supplier also takes care of the deliveries, this survey is similar to the carrier survey. The **service provider survey** is similar to the carrier survey as well. This method provides data on the pattern of service activities and vehicle activity in the urban area, facilitating the data collection of the entire fleet instead of a sole vehicle [2]. In Italy, a retail survey was conducted in the Calabria and Palermo region. The collected data included the choice of distribution channel, purchase zones, vehicle times, location and size of shop, most important type of vehicles, number of employees, average number of customers per day, storage capacity, etc. [94].

Driver surveys are used to gain understanding of the driving patterns of a truck, the loading/unloading operations, the time required to perform the task, the loading and parking locations, the manner in which the goods are taken out of the vehicle, the vehicle type, the vehicle capacity, the activity carried out at every stop, etc. [5], [22]. The driver survey in Bordeaux collected data on the amount of stops in the city, the vehicle type and weight, the type of treatment material, the driven distance and the type of establishment. 903 valid questionnaires were submitted by the drivers, which is a response rate of 17% [4].

Parking surveys are similar to vehicle observation, but are specifically used to collect data on the loading/unloading/parking activity of a vehicle. This method can be used to research the use of space originally assigned to freight or service vehicles but being used by other road users [2].

Further, **urban goods movements** surveys can be conducted. Examples are the surveys conducted in Canada between 2000 and 2007 in Edmonton, Calgary and Ontario (Peel-region). These surveys were successful, but an important side note is that the availability of a comprehensive and up-to-date establishment database was available. The cost of the data collection for this survey was on average $1 million per city [95].

VEHICLE

Using the **logbook** of a vehicle, detailed information concerning its activities over one or several days can be collected. More specifically, based on this information, the exact locations of the truck can be determined, as well as route details, arrival and departure times, the time required for loading/unloading and the type of goods [2], [22]. In France, the Service National de l'Observation et des Statistiques (SOeS) conducts an annual survey. The results can be used to estimate the performance of heavy vehicles, the amount and type of goods delivered and the number of vehicles. Periodic surveys are carried out for light vehicles [4].

Surveys are often complemented with traffic counts or **GNSS data collection** [22]. GNSS data collection is a method in which data is collected automatically. There are three possible objectives. The first is to use GNSS data collection to provide information on new technologies in vehicles or to follow vehicles and this way capture vehicle information. This can only be done where there are both a limited number of vehicles and a limited amount of data to be collected. Secondly, data can be collected in this way to test a model. The advantage here is that the number of vehicles can be reduced and the data is easy to analyse. The third objective uses this method to present the movement of urban goods [22]. This method reaches its maximum value when used to complement other methods [8].

The disadvantage of GNSS data collection is that it does not provide a general overview of the freight flows and operations [8], [22] and is not necessarily representative of the region [8].

Additionally, since there is a continuous data stream, it is difficult to indicate the end of a trip. Also at the beginning of the trip certain issues arise, since it takes a certain amount of time to locate satellites, and data is not captured during this period. Moreover, both carriers and drivers can perceive the use of GNSS as a breach of their privacy, and the technology still has to be developed further [22].

This method has not been used often for freight transport and therefore there are not many studies [22]. On the other hand, Holguin-Veras and Jaller [8] do indicate the increasing use of GNSS data, as more companies are using GNSS devices. In 2006, data was collected in Melbourne as part of an update of freight data in the Melbourne Region, using a GNSS in 30 commercial trucks delivering office supplies, paper, restaurant foods, quarry materials, and general freight [35]. In 2006-2007, data was collected from 600 shippers and drivers in Toronto. For this purpose, surveys were sent using e-mail, and GNSS data was used. The objective of this survey was to collect specific data concerning shipments, trips and to describe behavioural and economic processes related to commercial vehicles. The GNSS provided data of the driven routes, the location of stops, rest times, fuel consumption, etc. [5]. In 2010, data was collected in Bilbao and Lyon via smartphones in the framework of the European project Freilot. The smartphone collected the GNSS location of the vehicle every two seconds, for three different types of carriers: catering logistics, food distribution and express carriers. This project showed that the cost for this type of data collection was around €400 per truck per year [22]. In Vienna data was also collected using GNSS, where the GNSS devices of the drivers of companies delivering in the city were used [7]. It is important to mention here the existence of C-ITS (Cooperative Intelligent Transport Systems). Two freight-related projects within this field are CO-GISTICS[10] and COMPASS 4D[11].

Furthermore, vehicles can be observed in order to obtain data. This method involves estimators in the street close to establishments to collect data regarding the total number of freight trips to and from the establishment per moment of time. In addition, information can be collected concerning the vehicle type used, time to load/unload/offer services, methods to transport vehicles from the vehicle to the establishment, etc. If more than one entrance is used to load/unload, this method is harder to use. Deliveries/pickups outside normal working hours will also not be captured by the estimator as the estimator will not be present. Furthermore, it is not always easy to see which establishment is supplied if the driver does not move his vehicle between different deliveries. The advantage of this method is that it can deliver higher quality of information on the vehicle on street activity compared to an establishment survey [2].

TRIP-INTERCEPT

Interviews can also be conducted with drivers along the route. Here the drivers are asked questions concerning the starting point, destination, the reason for the trip, etc. The objective is to collect information about the number of stops, the location of the stops, their purpose, etc. The disadvantage of this method is that internal traffic within a certain area is not captured [4]. In Canada, a national survey was conducted in 1999-2000 in which drivers were interviewed along the road. Approximately 65,000 drivers were questioned at 238 different locations. This survey was updated in 2006-2007. The objective of this survey was to collect data on transport between cities [95]. In Belgium, this method has already been applied. In collaboration with students from higher education, drivers were questioned in the ports of Antwerp, Ghent and

[10] CO-GISTICS is a European project working on cooperative services of trucks and vans in several European logistics hubs, including Arad (RO), Bordeaux (F), Bilbao (ES), Frankfurt (DE), Thessaloniki (EL), Trieste (IT) and Vigo (ES) [110].

[11] COMPASS 4D is another European project that ended in December 2015 and was elaborated on in the cities of Bordeaux (F), Copenhagen (DK), Helmond (NL), Newcastle (UK), Thessaloniki (EL), Verona (IT) and Vigo (ES). The topic of this project was the implementation of roadside units on more than 600 vehicles in order to prove the advantage of cooperative systems for citizens [111].

Zeebruges. These projects showed that the method is not easy and that information between businesses could only be compared to a limited extent.

Traffic counts can be executed at street level, street level or at the level of an urban area [2]. They can be executed with Automated Vehicle Classifier techniques, such as, for example, Weigh-In-Motion[12], magnetic loops[13] or video cameras [8]. Different countries use magnetic loops, because traffic can be easily counted at a low cost. Moreover, heavy vehicles can be distinguished among from light vehicles. This method is particularly useful to monitor and predict traffic [4]. The disadvantage is that the loops should be built into the pavement. This implementation allows functioning in all weather conditions and use of the loops for long-term counts. Weigh-In-Motion techniques are expensive and can only be used on a limited number of locations [8]. The high price of traffic count techniques, such as sensors, is an important issue when collecting data. One sensor to collect data on the vehicle type costs around €150. In order to track vehicles at different locations, a large set of sensors (in fact APNR cameras) is needed. Altogether, this is a huge investment for which the costs of collecting the data and the benefits of having them have to be balanced.

Pneumatic counting loops[14] can also be used for traffic counts. The advantage of this method is that the counting loops are easy to move, and just need to be placed on the road to be able to count traffic. The disadvantage is the reduction in accuracy when multiple vehicles drive over the counting loop simultaneously. This is often the case on roads with high volumes and high capacity utilisation [8].

Another method is the manual counting of traffic. This requires trained staff who observe and count traffic. Video cameras can also be used. The advantage of the latter is that images can be paused and viewed again [8].

Depending on the objective of the data collection, traffic counts can provide insufficient information. This is because there is a lack of insight into [2]: the freight and service flows supporting the vehicle activity, the specific objective of the trip, the establishments generating the demand for the trip and their requirements, the decision made in the supply chain resulting in trips at specific moments with specific vehicles, the route chosen by the vehicles, the type of driving pattern, details about loading/unloading, parking activities, etc.

An example of a survey to create a profile of the supply for a city can be found in the research by [64]. Based on the counts, an overview was made of the supply of shops in the inner city. The main indicators here were the number of deliveries, the volume, the type of delivery vehicle, the type of transport, the time of goods received, the nature of loading/unloading, return and waste streams, storage/conversion plans and the routing [64]. Table 9 provides an overview of the specific measurements executed to measure these indicators.

Table 9 Indicators delivery profile Breda

Indicator	Specific measurements
Number of deliveries	Number of delivery days per week, amount of deliveries per week by third parties
Volume	Number of loading units (roll containers, pallets, loose boxes/crates/barrels, clothing racks, others)
Type of delivery	Number of deliveries per week per type of vehicle, delivery

[12] Weigh-in-Motion technique means that vehicle are weighed by passing a certain sensor in the road [112].

[13] Loop built in the pavement to collect data on the vehicles passing.

[14] Pneumatic counting loops are sensors that send air pressure along a rubber tube when a vehicle is passing. The air pressure produces an electrical signal, which is then transmitted to analysis software [113].

vehicle	method own transport, delivery method suppliers and carriers (trips per week)
Type of vehicle	Own delivery, delivery by third parties
Time of goods received	Average receipt time of delivery, rate of shops and HoReCa open to receive goods, system available to receive goods without the presence of staff
Loading/unloading	Share unloading area within pedestrian zone, loading/unloading locations, usual parking unloading vehicles
Return and waste streams	Distribution collection of collectors, share of companies returning cardboard and plastic to supplier
Storage/conversion plans	Is there enough storage space at the branch office, storage space in the retail and HoReCa, are there plans to carry out renovations within one year.
Routing	Route of the main road network to the inner city, route within city

Source: Own composition based on [64]

In addition to this delivery profile, shop owner and driver surveys were conducted to integrate the vision of these stakeholders into the study. Information was collected concerning their views on accessibility for the delivery traffic, strengths and weaknesses, and areas of improvement for delivery in the city [64].

TOUR

Alongside the above-mentioned methods, individual shipments can also be followed along the route, or data collectors can ride with the drivers.

To create an overview of the needs and desires of the key **stakeholders** and thus execute a stakeholders analysis, Dablanc [1] proposes the establishment of a permanent urban freight forum, bringing together target audiences on a regular basis. Here it is important to involve all key stakeholders. These meetings can be used to share information, and also to negotiate specific local policies. Alongside this, a freight portal serving as a communication channel between different stakeholders should be set up. In 2010, a freight forum was created in London, at which 120-150 decision makers with respect to receiving and delivering goods in London meet twice a year to discuss key topics [96]. In 2016, Transport for Greater Manchester also opened a freight forum, at which public and private stakeholders discuss logistics issues [97].

Stathopoulos, Valeri & Marcucci [47] collected data on bottlenecks in urban distribution using in-depth focus groups in the framework of their research of the limited traffic zone in Rome. In these focus groups, the stakeholders of three main categories were present: freight forwarders, local policy makers and retailers. They found that different stakeholders often have conflicting objectives. A carrier survey was conducted in addition to a consultation of the stakeholders. The objective was to evaluate reactions to the policy by using focus groups.

Browne et al. [11] provide a typology of data collection methods in their research, including very specific methods that are not included in Table 3. The main reason is that these categories are very specific and therefore can be classified under the broader categories of Table 3. Furthermore, the authors indicate in this study in which country data is collected per data category. They indicate if the data is collected at national, regional or urban level and whether this is collected by businesses or other commercial organisations.

It is important to remark here that privacy issues limit the opportunities of certain data collection methods. Some data collected by authorities cannot be shared with other stakeholders due to strict privacy regulations. Some data are even not allowed to be collected.

The latter is the case for tracking the individual trips of vehicles or persons in a number of countries. Furthermore, data are often collected by private companies, who do not want to share their collected data. It is therefore important to establish agreements or partnerships for data sharing. To achieve this, the mind set of different stakeholders has to change and a business model leading to a win-win situation has to be developed. As long as the private stakeholders collecting the data do not have anything to gain, they will not be willing to share their collected data.

4.2 Case studies in Western-European countries

As part of the BESTUFS project, an analysis was made of the data collection of urban distribution in countries participating in this project. These reports discuss the executed data collection activities by country. For Belgium, an elaborated summary of the different data collection initiatives can be found in Debauche & Decock [89], for Germany in Binnenbruck [16], for France in Routhier & Patier [17] and for The Netherlands in Vleugel [36]. The following Chapters briefly discuss Belgium and some of its neighbouring countries. This information for other countries of the BESTUFS project can be found on the website of BESTUFS [98].

BELGIUM

In Belgium, there are different case studies from the past with data collection specifically for urban distribution (see Table 10). The city of Ghent hosted a workshop in 2004 with different stakeholders to research the need and feasibility of a city distribution in Ghent. Retailers, carriers, transport organisations, etc. were invited for this workshop. An additional survey was conducted with 215 retailers. The main collected data were characteristics of the businesses and the freight flows to and from the shop [89].

In Liège, cargo surveys were conducted in 2004 in order to obtain an overview of the urban distribution. A total of 300 suppliers and 120 retailers were surveyed through a questionnaire, and 10 important political and economic stakeholders were interviewed. The obtained information was used to support policy decisions [89].

Table 10 Data collection actions in Belgium

	Institution	Method	Indicators
GENERAL			
Freight stream survey	NIS	125,000 surveys per year to carriers	Import and export of freight, amount of kilometres travelled, origin and destination of trucks for different categories of goods, hazard code of goods, packing systems, characteristics of vehicles such as axles, load capacity, etc., load factor
Traffic counts	FOD Mobility	Loops, video cameras	Traffic intensity per roadway per time unit, speed and type of vehicle per roadway and per time unit
Accidents on the road	BIVV	Analysis of policy report	Amount of accidents, amount of deaths, amount of deaths after 30 year, amount of heavy and light injured, amount of accidents with freight vehicles, amount of accidents per road type
Business data	Businesses in Brussels with > 200 employees	Database businesses	Amount of loading/unloading activities per business, amount of freight vehicles owned by the business, measures to improve mobility.
CASE STUDIES URBAN DISTRIBUTION			
Ghent, 2004	City of Ghent	Workshops and surveys conducted by IRIS consulting and DHV	Business sector, organizational structure of business, sales area, hours when loading/unloading is permitted, delivery frequencies, number of suppliers, typology of transported goods, lead time between delivery and order, time intervals and day of delivery of goods to the shop, experienced issues, used delivery zones, time need to deliver,
Liège, 2004	City of Liège	Freight survey conducted by BRRC and ISIS	Type of vehicle, delivery zone, parking facilities, (point of) time of deliveries, experienced issues, desired improvements, experience with delivery situation, amount of deliveries, type of goods and volume, origin of deliveries, transport organization (own or third parties), logistic supply chain, experienced limitations, (e.g. time windows), expectations local mobility plans, available possibilities to store goods, average time of a movement, time loading/unloading zone is occupied by vehicles without loading/unloading activities, time of loading/unloading zone used for deliveries, time of no activities happening
Freight plan Brussels	REFORM project	STRATEC, FEBETRA; surveys, interviews, traffic counts	Transport activities, type of operations in Brussels, identification of buildings, motives if certain circulation/parking measures have to be undertaken
INFACT	Federal	"Intercept	Socio-economic household characteristics,

	Science policy, Research centre for Road Construction, UA, FUNDP	and Follow" method, freight model	buying behaviour and related transport behaviour.

Source: Own composition based on [89]

Between 1996 and 1998, a freight plan was set up in Brussels. This was based on the existing passenger model IRIS. The objective of this freight model was to estimate the impact of freight on the general traffic in Brussels. Origin-Destination matrices were built for three different types of vehicles: private cars, light and heavy freight vehicles. Some traffic counts were conducted and license numbers were monitored to estimate the time that vehicles stayed within a given zone. Furthermore, different scenarios were used and several interviews were conducted with important stakeholders. Questionnaires were sent to 850 businesses, but the response rate was very low. Accordingly, the questionnaire was revised and was circulated a second time using the help of FEBETRA [89].

The INFACT[15] project was implemented with the aim of better understanding the organisation of freight traffic in urban areas, as well as the impact of the strategies and policies involved. Here, the "Intercept and Follow" approach was used. This means that customers were selected at the exits of different shops in Jette, and their purchasing behaviour was followed for one week, by means of a log book. Further, traffic was simulated with a freight model in which three types of urban transport were included: direct transport, indirect transport using an urban transport distribution centre and indirect transport using *cross-docking* to an urban destination [89].

In the framework of the Bluegate-project in Antwerp, research was conducted in 2012 concerning freight streams from and to this city. This information was not available and had to be specially collected for this project [99].

GERMANY

In Germany, the Güterkraftverkehrs-Statistik has been in operation since 1994. This is a data collection by the government on freight traffic by road(see Table 11). This data is collected every month by consultancy companies KBA and BAG. From these data, urban distribution data can be extracted by disaggregation models. However, this is limited to transport between and not within urban areas. The data that can then be determined are the number and type of drivers, the size and type of vehicles, volume, weight and type of goods, vehicle-kilometres and tonne-kilometres [16].

Table 11 Data collection actions in Germany

	Institution	Method	Indicators
GENERAL			
Freight traffic, 1994	City of Cologne	Survey by mail	Amount and type of trips by utility vehicles in the inner city
Freight traffic, 1994-1995	City of Dusseldorf	Survey by mail	Trips by utility vehicles in different sectors, type of vehicles and goods, duration of trips, structure of destinations
Freight traffic 1995	Dortmund	Survey by	General freight traffic,

[15] Integrated Freight Analysis within CiTies

	Region	mail	number of trips on the road, type of goods, use of vehicles in different sectors, use of computer systems and telecommunication
Freight traffic, 1996	Stuttgart Region	Survey by mail	Trips of vehicles in the rental sector, amount and type of vehicles, volume and type of goods, destinations
Operational database for urban distribution, 1998	Muenster Region	Survey by mail	Amount and type of private businesses and public institutions in the city, volume of logistic services and waste, weaknesses of the infrastructure, collaboration interests, demand for logistic services
CASE STUDIES URBAN DISTRIBUTION			
GüKStat (Güterkraftverkehrs-Statistik)	Government	Survey by mail	Year first vehicle registration, location of registration, total weight vehicle, type of vehicle, engine, number of axles, economic sector, mileage tachograph, type of transport, empty driving, trips with goods, type of trips, trips with interruptions, distance of trips, load factor, trips to other countries
KID (Kraftfahrzeugverkehr), 2001-2002	Ministry of Transport	Survey by mail and electronically	Amount and type of trips of vehicles, objective of trips, speed of trips within different zones, structure of professional and private vehicle owners, volume and type of transported persons and goods, departure and destination locations, determination of route
FLE 2002	IVT, KBA	Survey by mail with manual and reminder calls	Type of vehicle, destination and objective of trip, day of delivery and hour of the day, age and race of drivers, amount of traveled kilometers in a certain time period

Source: Own composition based on [16]

A second data collection initiative in Germany is KID, Kraftfahrzeugverkehr in Deutschland. This data collection was also initiated by the government and executed by the Institut für Verkehr und Stadtbauwesen and KBA, Institut für Verkehr and Tourismusforschung and PUTV in 2001-2002. Urban distribution data can also be obtained from this database, but only by geographical feature: overpopulated areas, urban areas and rural areas [16].

The third major data collection initiative is FLE 2002. This collection was performed by the IVT and KBA using surveys sent by mail with telephone follow-up as a reminder. Here, data was collected on type of vehicle, point of time of the trips, the driver and the distance travelled. Urban distribution data is not collected separately and therefore cannot be extracted from the available data [16]. Table 12 provides an overview of indicators used in the German studies for urban distribution.

Table 12 Indicators urban freight distribution in Germany

Indicator	Measure unit
Vehicle:	
Size	Load capacity and total weight in tonnes, number of axles, year of first registration
Type	As recorded by central licensing office, international naming
Communication technology	Type of technology used in vehicle
Owner vehicle:	
Sector	17 groups of international naming
Profession	National and regional statistics
Size	Number of employees, vehicles, type of vehicles
Location	Type
Trip	
Trip	Number of loaded trips, amount of empty runs, trip type, origin and destination location, start and finish time of trip
Trip chain	Amount of interruptions of trip
Trip distance	Amount of km, stand tachograph
Route	Route of the trip, length in km, road abroad
Trip length	Time between start and stop of trip, speed in km/hour
Objective of trip	
Type of trip	Loading/unloading, end work, commercial use, transport of people, trip towards home
Performance of trip	Length of trips in km
Transport of goods	Gross weight of the load in tonnes, types of goods
Load factor	Use of volume in m^3 and weight in tonnes
Load shape	As shown in official statistics
Users	
Users/ customers	Registered sectors of customer, location of customers, size of transport customers
Driver	
Driver	Race, age
Time	
Duration of transport	Time between start and ending point of the ride, downtime, driving time

Source: [16]

FRANCE

In France, the SIRENE-database is the primary database, constructed by the Institut National des Statistiques et des Etudes Economiques (INSEE) (see Table 13). This database is easily accessible and costs around €0.1 to retrieve a data element. In the database, data can be found on employment, location of retailers, commercial activities, etc. In addition, there is the SITADEL database. This is the list of new buildings, as well as their addresses, surface and planned activity [17].

The French Ministry of Transport conducts a continuous survey on heavy vehicles. This way, data is collected on origin and destination of trips, types of goods, distances travelled, weight of goods, type of vehicle, etc. From this data, different indicators can be identified, such as the amount of lifted tonnes, the number of vehicle-km travelled, the amount of fulfilled tonnes-km, average distance of the trip, volume empty driving and the load factor. In France, automatic traffic counts are often carried out, by using magnetic loops or counting loops, executed in urban areas. Usually, the city authorities are responsible for this [17].

Table 13 Data collection in France

	Institution	Method	Indicators
GENERAL			
SIRENE database	INSEE	n.b.	Employment, location, activity, status (headquarters or branch), type, big/small shop, number of establishments
SITADEL database	Regional authorities	n.b.	New buildings, their address, surface and planned activity
TRM-SITRAM	Ministry of transport	n.b.	Heavy vehicles: origin and destination of trips, type of goods, distance travelled, weight of vehicles loaded/unloaded, type vehicle, type industry, rental details
EAE survey	Ministry of transport	Continuous survey to transport companies	Size, revenue, employees, number of vehicles, type of company
CASE STUDIES URBAN DISTRIBUTION			
Establishment surveys in Bordeaux, Marseille, Dijon	LET	Survey and by telephone	See FRETURB model
Survey in shop area in Paris	n.b.	Street observation and traffic count	Departure and destination time vehicle, type vehicle, parking method, loading/unloading, type product, packaging size, treatment method

Source: Own composition based on [17]

In Paris, data are collected by means of street observations. This method allows information to be collected on the number of delivery vehicles per minute, the type of vehicle and the size, parking habits, respect for the law and the type of goods delivered [17]. As for Germany, Table 14 gives now for France some of the most common indicators to characterise urban freight distribution.

Table 14 Urban freight distribution indicators in France

Urban freight distribution indicator	Unit
Loading/unloading density	Number of deliveries/pick-ups per km^2 in a zone
Loading/unloading intensity per activity	Number of deliveries/pick-ups per activity in a zone
Loading/unloading time	Number of hours double parking on the street for delivery/pick-up in a zone per vehicle per activity
Number of loading/ unloading	Number of deliveries and pick-ups per week per employee per activity
Length covered for loading/unloading	Number of km for one delivery/pick-up in a zone per vehicle per activity
Average length for first trip from platform to delivery area	Kilometre
Average distance covered per delivery/ pick-up	Kilometre per delivery/pick-up
Total travel distance on roads in the urban area during which goods are transported by heavy and light vehicles	Total vehicle km per week in urban areas
Average time needed per delivery	Minutes per delivery
Average speed per route (incl. and excl. stops to deliver)	Kilometers/hour
Greenhouse gases and pollution	Grams pollution per covered km, gram CO_2 per covered km, litre fuel per km corresponding the zone, the vehicle, the activity

Source: [11], [17]

THE NETHERLANDS

In **The Netherlands**, freight transport data is collected by the Central Office of Statistics[16], NEA Transport Research and Education and local governments (Table 15). Aside from these institutions, there is also the Platform Urban Freight Distribution, which develops a number of products that can be used by local governments to increase, for instance, the accessibility of the inner city. This can be done by means of a vehicle matrix, which makes the correspondence between freight vehicles and local accessibility conditions[36].

Table 15 Data collection actions in The Netherlands

Level	Institution	Method	Indicators
GENERAL			
Aggregated freight transport and traffic data	Central Office of Statistics	Surveys	National transport via road, rail, IWW, regional transport data, national traffic intensities, number of vehicles, sales of new and second hand vehicles
Business economic transport data	NEA Transport research and education	n.a.	No urban data
Vehicles	Local	Periodic or	Number of vehicle

[16] Centraal Bureau voor de Statistiek in Dutch.

	governments	occasional traffic counts	movements
CASE STUDIES URBAN FREIGHT DISTRIBUTION			
Accessibility conditions	Platform Urban Freight Distribution, local governments	Vehicle matrix	Vehicles, accessibility conditions inner city
Connekt MG-11	City of Utrecht, Connekt	Determination of delivery profile on the basis of surveys	Economic feasibility and attraction, traffic safety, liveability, accessibility, delivery quality

Source: [36]

An important example from The Netherlands is the identification of the delivery profile of the city of Utrecht within the context of the Connekt MG-11 project, executed in 2002. This profile is displayed in Table 16. In addition to measurements, the database also includes a number of estimations. An example of the number of delivery trips, calculated as the number of deliveries per week divided by the average number stops per round trip. This study had a price tag of in total €100,000[36].

Table 16 Delivery profile city of Utrecht

Indicator	Unit
Economic liveability and attraction	Number of generated deliveries or freight volume, average dwell time, share of residents that experiences the shopping climate as "good"
Traffic safety	Share of residents that is happy with the traffic safety level, number o fatal accidents, share of freight vehicles in accidents, material damage or physical damage
Liveability	Share of residents that experience the liveability as "good", causes of hindrance by deliveries (e.g. noise, vibrations)
Accessibility	Share of residents, receivers, drivers that experiences the accessibility of the city centre as "good", time needed to drive from the ring road around the city to the inner city, average time of the vehicle in the inner city
Delivery qualit	Share of small vehicles in deliveries, dispersion of the deliveries over the week, dispersion of deliveries over the day, share of residents that experiences the accessibility of the area as "good", share that experiences the locations for delivery and pick-ups and the transport distance as "good"

Source: [36]

The following Chapter gives an overview of different data models, developed in the past, aiming at generating data on the basis of existing data collection efforts.

4.3 Data models

One model for urban freight flows developed by Sonntag[100] in Germany is the **WIVER** model. The output of this model is information on total distance covered, the number of trips, the daily traffic distribution per type of vehicle, the economic sector and the O/D relationships. The model is amongst others used by the COST 321 and REFORM project [101].

Another model, developed by the LET[17], is the **FRETURB** model. This model is developed on the basis of an urban goods movement survey, executed in 1997 in Bordeaux, Marseille and Lyon. The model simulates the number of vehicle movements in a certain zone, the impact of the economic activity on the occupancy rate of the road, the environmental impact and other indicators. The only data needed as input for the model are establishment registers, and geographic and network data including zones, road network and average speed. New regulations and developments such as time windows and e-commerce can also be implemented in the model [4], [17], [102][17][4].

The FRETURB model works in three stages. Firstly, the number of movements, i.e. loading and unloading operations, is generated for each establishment. Subsequently, this information is grouped per zone. Secondly, the number of movements is converted to the number of trips. Thirdly, the covered distances are estimated on the basis of a typology of logistics practices and the geographic configuration of the urban area [102]. Gonzalez-Feliu et al. [101] apply the FRETURB model in their research to Lyon.

Other models are **VISEVA-W** and **VENUS**. The former was developed in 2004 and builds further on knowledge from the WIVER model, but is less complex. Traffic volumes of different industries and vehicle types are calculated simultaneously and independently of each other[103]. The VENUS model was developed by the company IVV Aachen. In this model, trips are differentiated by means of the gravity model[104] on the basis of the objective of the trip.
Furthermore, some other **authors** exist who present their own methods of generating data. Russo & Carteni [105] developed a model based on the simulation of the dependency between consecutive trips of the same distribution channel. As input for this model, aggregated data from national traffic counts in Italy are used. The output of the model is an estimation of the probability distribution of O/D choices. The model was extended later by Russo & Comi [106], in which freight quantity flows were converted to freight vehicle flows.

Gentile & Vigo [107] developed a model that defines the number of operations in a supply chain as a function of the Nace code and the number of employers in an establishment. This model was tested in multiple cities in Italy and can also be used for other cities without having to execute additional surveys.

[17] LET = Laboratoire d'Economie des Transports; the current name of the laboratory is now LAET, i.e. Laboratoire Aménagement Economie Transports.

Chapter 5 Case study

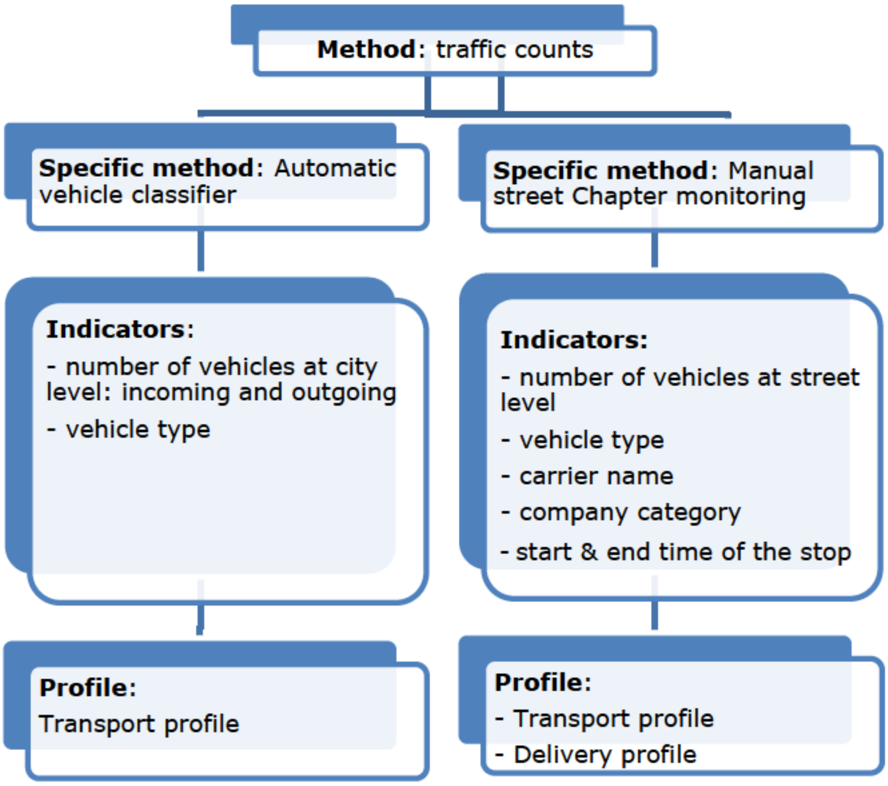
The previous Chapter gave an overview of several types of data collection methods. For the current Chapter, one of these methods is selected to be discussed in more detail by means of a case study. The selected method is traffic counts, applied to the case of Antwerp.

The research by Van Dyck [108] demonstrates which data can be collected by means of manual traffic counts for the City of Antwerp (Belgium). The objective of this case study is to show that useful data can be collected on the basis of traffic counts, but that other data are still lacking when only this collection method is used. Another remark is that the traffic counts are observations based on two half days, which does not lead to general conclusions. In order to be able to draw more general conclusions, the traffic counts should take place on multiple days, preferably on every single day of the week[109].

Van Dyck [108] studied the urban freight distribution bottlenecks for the city of Antwerp. As part of this analysis, the author performed traffic counts at the level of the main shopping street "Meir", but also relied on traffic counts provided by the Flemish Traffic Centre (Vlaams Verkeerscentrum) at the level of the entire city.

Figure 2 displays the highlights of the case study, namely the specific methods used and the quantitative and qualitative indicators collected. Following Patier & Routhier [18], the observation unit is chosen and is respectively the city (left panel) and street level (right panel).

Figure 2 Traffic counts in Antwerp



Source: [86]

In the first stage, an overview of the incoming and outgoing traffic is provided for the city of Antwerp. These data are collected by means of traffic counts of the Flemish Traffic Centre at the access and exit roads of the Antwerp Ring road. In total, 37 traffic counts are executed.

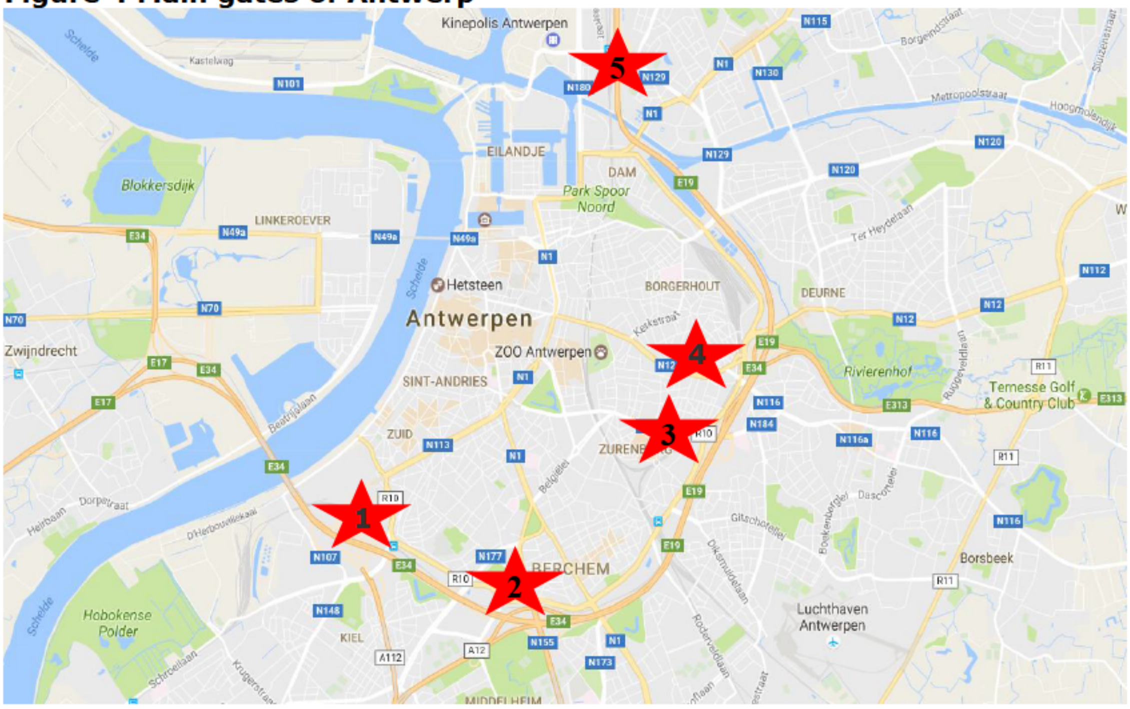
Figure 3 shows the distribution of different vehicle types of traffic entering or leaving Antwerp on weekdays. Passenger cars represent the largest share. When considering only freight transport, vans in particular appear to be important[18].

Figure 3 Vehicles entering and leaving Antwerp daily

Source [92]

Figure 3 demonstrates that, on the basis of the traffic counts of the Flemish Traffic Centre, a distinction can be made between the type of vehicles and more specifically between the type of freight vehicle entering and leaving the city. Figure 4 displays the five main gates through which the traffic enters and leaves the city.

Figure 4 Main gates of Antwerp

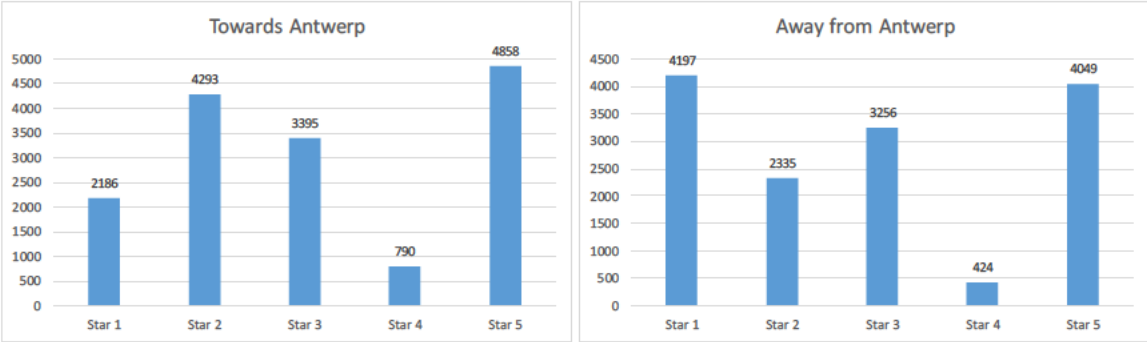


Source: [108]

For each of the five main gates, Figure 4 shows the traffic distribution. Based on Figure 3 and Figure 4, the traffic intensity of main nodes can be determined.

[18] Vans are in these traffic counts vehicles with a length between 4.9m and 6.9m.

Figure 5 Traffic from and to Antwerp per working day per gate



Source: [108]

In the second stage, traffic counts took place at street level, more specifically at the main Antwerp shopping street "Meir". The counts were executed on Wednesday 23rd of May 2012 and on Tuesday 3rd of July 2012 between 7am and 11am at the locations[19] where lorries enter and leave the Meir, according to a calculation of the Flemish Traffic Centre on the basis of the main access and exit gates and a route on Google Maps. The results of the traffic counts are displayed in Table 17.

Table 17 Traffic counts at Meir Street

Timeframe on Wednesday 23 May 2012	Passenger cars	Vans	Light goods vehicles	Heavy goods vehicles	Total traffic	Total freight traffic	Total freight traffic (in%)
7am – 8am	18	23	17	8	66	48	72.73
8am – 9am	25	15	12	5	57	32	56.14
9am -10am	28	23	12	6	69	41	59.42
10am - 11am	20	20	7	2	49	29	59.18
Total	91	81	48	21	241	150	62.24

Timeframe on Tuesday 3 July 2012	Passenger cars	Vans	Light goods vehicles	Heavy goods vehicles	Total traffic	Total freight traffic	Total freight traffic (in%)
7am – 8am	20	27	13	4	64	44	68.75
8am – 9am	22	13	5	4	44	22	50.00
9am -10am	25	20	12	9	66	41	62.12
10am - 11am	22	16	9	1	48	26	54.17
Total	89	76	39	18	222	133	59.91

Source: [108]

Besides quantitative information, the traffic counts also reveal qualitative information. Some interesting observations are displayed in Table 18. Another observation is that crowded traffic situations originate during the time windows[108].

[19] From gates 2 and 5 this is Lange Klarenstraat. Time windows in this area of Antwerp are between 6am and 11am.

Table 18 Qualitative observations on Meir street

Passenger cars	Mainly passenger cars parked on Meir, which leave gradually between 7am and 11am
Vans	Window cleaners, apparel carriers, couriers, other
Light goods vehicles	Supply Chain orchestrators[20], groupage operators, other
Heavy goods vehicles	Construction industry, large retailers/ supermarkets, garbage trucks (both public and private)

Source: [108]

This case study illustrates which data can be gathered through traffic counts. The examples shown here are simple, but satisfy the objective of the case study; to show which type of data can be collected by means of this collection method.

[20] Chain orchestrators are actors providing the organisation of the transport chain.

Chapter 6 Conclusions

This report has focused on data collection in urban freight distribution. It has determined the common specific indicators needed in an urban freight context and the common data collection methods used to obtain these indicators.

Firstly, there is, in most countries, a lack of publicly available data on urban logistics. It is therefore important that local authorities are aware of the need for data, of the need for having data collected under the co-ordination of a local authority, and of the use that can be made of such data, with suitable analysis. Freight transport in general is neglected in most studies, and more specifically concerning urban freight. Only a limited amount of data is publicly available. Where data are collected, they often cannot be compared due to different data collection methodologies. Furthermore, they are often not analysed because this is too expensive or because the existence of the data is unknown.

Secondly, different urban indicators are important, depending on what one wants to measure. Consequently, no unambiguous overview can be provided on the specific urban indicators that need to be collected in general. This research provides common indicators used to describe the shop profile, delivery profile, transport profile, analysis of logistics rules, stakeholder analysis and other data.

Thirdly, different data collection methods exist and are necessary to collect different data in different situations. The four most important categories of collection methods are establishment-based, vehicle-based, trip-intercept-based and tour-based methods. Each method has its own advantages and disadvantages, and is therefore suitable for certain specific situations.

Finally, a case study illustrates one of the collection methods, namely traffic counts. This example indicates that using one method, only certain data can be collected. The traffic counts deliver information about the types of vehicles passing and the traffic intensity, both at city and street level and further on, also quantitatively as well as qualitatively.

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