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Hunting for treasure: a systematic literature review on urban logistics and e-commerce data

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#### Keywords

E-commerce data; urban logistics; urban freight transport; city logistics; e-commerce mobility

#### Abstract

Online retail channels increasingly shape consumers' purchase behaviour: we access a diversity of product types through web-shops; employ both smartphones and digital screens in stores; navigate the retail space by browsing online; and order pantry items, fresh groceries as well as prepared foods to be delivered at our doorsteps. The profound impact of online retail on mobility in cities, where the concentration of consumers resides, is therefore an extensively investigated and growing topic of interest in research. In the field of urban logistics, studies that evaluate the various impacts of e-commerce or propose efficiency or sustainability enhancing applications are plentiful. Regardless, the general lack of solid urban e-commerce logistics data is supported widely. In this study, we systematically review the literature to identify and compare the types of e-commerce data that are currently known, employed and disclosed in urban logistics research as well as the data sources that provide access to them. Within the set of identified data, knowledge concentrates on consumer preferences and number of deliveries related to e-commerce. However, our findings confirm the general data paucity, specifically on delivery trip related information such as deliveries per trip, number of delivery rounds and vehicle specificities. Discrepancies are found in methodologies to collect and compile data, as well as data units used (e.g., orders, parcels, deliveries) that cause large variations in information possibly diverging from reality. The study contributes to current literature and practice by compiling and analysing currently available data on urban e-commerce logistics and by presenting recommendations and best practices for future enhancements in this research field.

#### Introduction

Internet-induced changes in consumer behaviour have significantly affected mobility in cities. The direction of the elicited impacts is an ongoing subject in research – providing evidence for transport reduction (e.g., by reducing personal shopping trips), transport generation (e.g., by fragmenting purchases) and transport modification (e.g., by favouring shorter supply chains) effects alike. E-commerce developments are crucial too in the growing field of urban logistics, that investigates goods transport to, from and within cities as well as warehousing (Dablanc et al., 2018). Studies on urban e-commerce logistics evaluate the economic, environmental and societal impacts of new types of supply chains and logistics activities on cities (e.g., residential delivery, urban warehousing). They also test more efficient or sustainable applications, theoretically or empirically, including

technological innovations (e.g., drones, electric vehicles, lockers), routing optimisation, location analysis and green policies. Whether the conclusions, implications and recommendations of these studies hold for a specific (or multiple) urban context(s), depends heavily on the underlying data and the quantity and quality in which they are available. Studies on urban e-commerce logistics benefit from using five types of data: (1) **general city** indicators such as number of inhabitants and population density; (2) **logistics infrastructure** indicators such as number of collection points and location of (urban) distribution centres; (3) **consumer** indicators such as adoption and use of online retail channels and delivery and collection preferences; (4) **delivery volume** indicators such as daily number of online orders and delivery density and (5) **delivery trip** indicators such as roundtrip distance, parcels per roundtrip and vehicle type. Some of these data are available on country-level, notably provided by Ecommerce Foundation who publishes yearly updates on a range of countries around the globe. On the urban level, these data are largely lacking. Among many others, Heitz et al. (2019) talk about the absence of detailed and precise data and conclude that “a good understanding of the logistics sector” is missing. Following a literature review on e-commerce and the last mile, Lim et al. (2018) establish a lack of real-world and quality data sets, limiting the advancement of domain knowledge and progress. As concluded by Dablanc (2018), “even simple information on the number of deliveries and pick-ups related to e-commerce are not easy to provide”. Paradoxically, online purchases by their digital nature generate data that are easier to collect and process in theory, yet are largely unavailable to researchers and governments as they are fully proprietary to retailers.

Judging from the growth witnessed globally in online retail adoption and online order frequency (Ecommerce Foundation, 2019; Pitney Bowes, 2018), we assume that research on urban e-commerce logistics continues to increase both in volume and importance in the years to come. Robust, comparable and appropriate data therein are vital. Therefore, we believe an evaluation of the current state of practice of e-commerce data in urban logistics research is warranted. Our objective is to support quality and accuracy of research findings, by identifying what is known and possibly lacking and by pinpointing, characterising and comparing the type of information that is used and disclosed in this field. Ultimately, better research supports policymakers and industry-professionals in their efforts to increase efficiency and sustainability. More than a matter of knowledge or mere improvement in urban freight models, such data are important to calculate the externalities associated with e-commerce mobility and essential in predicting the upcoming challenges cities have to face because of e-commerce growth, e.g., in terms of traffic management, urban planning, pollution and congestion (Dablanc, 2018).

This article continues with a description of the methodological approach in the second section. The third section elaborates on review findings while the fourth section continues with a discussion of research implications and recommendations and best practices for future research. It introduces three additional sources that have been excluded from the systematic literature review because of their document type but nourish the ongoing discussion. The fifth section ends with concluding remarks.

## Methodology

The study builds on a systematic literature review approach. Fink (2013) defines this methodology as “a systematic, explicit, and reproducible design for identifying, evaluating and interpreting the existing body of recorded documents”. It presents a valid tool for synthesising and refining scattered knowledge, for assessing and developing the knowledge

base within a research field and for assessing consistency among previous studies (Petticrew, 2001; Seuring et al., 2012). Seuring et al. (2012) specifically address the significance of systematic literature reviews in supply chain management. The methodology has been applied successfully as well in the field of urban logistics and e-commerce. For example, Lagorio et al. (2016) consolidate the knowledge on urban logistics and Mangiaracina et al. (2015) review the environmental implications of e-commerce from a logistics perspective. In line with theory (Petticrew, 2001), the objective of this systematic literature review is to locate, appraise and synthesise evidence within the field of urban e-commerce logistics.

Using three major scientific databases (i.e., ScienceDirect, Scopus and Web of Science) and twelve keywords resulted in a total of 143 unique articles on April 1<sup>st</sup>, 2020. The initial keywords used were: “city”, “urban”, “city logistics”, “urban freight” and “urban logistics” in the general search field and “e-commerce”, “online retail”, “omnichannel”, “omni-channel”, “multichannel” and “multi-channel” in the title, abstract and keywords specific search field. In a later stage, confronted with articles referenced in the literature base that appeared to be interesting yet missing, another keyword was added to the specific search field: “online shopping”. As a quality measure, only articles and reviews published in peer-reviewed journals were included. The timeframe of our search was set between 2015 and April 1<sup>st</sup>, 2020, which was selected to balance article quantity (i.e., large database of articles) and data quality (i.e., recent data are considered more useful and relevant).

All but 16 inaccessible articles were read, reviewed and analysed in a spreadsheet file, leaving a total of 127 articles to form the review’s corpus. This file was set up to include general article information (i.e., title, publication year, publication source), information about the city or cities studied in the article (i.e., number and name of city/cities), information on the applied research methodology, whether the article was considered on topic and whether the article included e-commerce data. When urban e-commerce logistics data were available, the file allowed to include information on mentioned data sources, number of respondents in case a survey method was used and the year of data collection. We used a categorisation of seven research methodologies, based on Lagorio et al. (2016): 1) case-study, 2) conceptual study, 3) interview, 4) literature review, 5) quantitative modelling, 6) simulation and 7) survey. Only the methodology that was considered most important was mentioned in the file. Given the provision of city-specific data, many articles could be considered case-studies, yet this category was only allocated when the article discussed application-specific or company-specific assessments, as well as pilot studies. Conceptual articles were added, to label methodological approach propositions. The quantitative modelling category is mainly composed out of vehicle routing problems, location analysis and (external) cost modelling. The survey category includes traditional survey articles, as well as discrete choice models that are based on revealed and stated preferences.

Reviewing the articles (or abstracts in case of article inaccessibility), 25 articles proved to be off topic. These studies investigate subjects such as economic growth and energy consumption in logistics, logistics resource sharing and reliability control of e-logistics systems. From the total of 127 articles, 45 disclosed data on urban e-commerce logistics. These data, despite vast variations in quantity and quality, were added to the spreadsheet file as well, categorised and analysed according to five types of information: 1) general information on the city under study, 2) information on infrastructure related to urban logistics and e-commerce, 3) information on consumer behaviour and preferences, 4)

information on e-commerce volumes and 5) information on e-commerce related freight transport.

The review findings are discussed in the next section. First, we provide a general overview of the review corpus in terms of geographical spread, applied methodologies and information on where and when the articles are published. Second, we discuss the types of data found in various qualities and quantities in the review corpus' core material, the data collection methodologies applied and its main sources. Third, we compile some of the data and provide four overview graphs. In this way, the findings section combines "narrative summary" and "statistical aggregation", as suggested for this type of research (Petticrew, 2001; Sutton et al., 1998) and perceived as a "specific strength" (Seuring et al., 2012).

## Findings

### Review corpus overview

Judging from the review corpus, the literature reporting on combined e-commerce and urban logistics research has grown steadily over the past years. Only 5% of our articles are published in 2015, increasing to a share of 35% of articles published in 2019. Articles published in 2020 cover only the first three months, yet they represent already 11% of the review corpus. Along the same lines, the majority of articles considered on topic and carrying relevant urban e-commerce logistics data are published more recently. Figure 1 visualises these findings.

The review corpus is published in a total of 61 journals, yet 33% of these titles are represented by one article only. A few publication sources stand out because of the volume of articles they contribute to the review corpus. With 16 articles, *Transportation Research Procedia* provides 13% of the review corpus' articles. Next meaningful contributors are *European Transport Research Review* (10%), *IFAC PapersOnLine* (6%) and *Transportation Research Part E: Logistics and Transportation Review* (5%). With four articles each, *Research in Transportation Economics* (3%), *Transportation Research Part C: Emerging Technologies* (3%) and *Transportation Research Part D: Transport and Environment* (3%) are noteworthy as well. Articles published in these journals are all considered on topic, apart from a few exceptions. Remarkably, only half of the articles that contribute to the review corpus carry relevant data on urban e-commerce logistics, i.e., data that fit within the five types of information as defined before. Noteworthy as well is the concentration of transport journals, at the expense of journals on management, business, supply chain or other fields that can be tied to the field of urban logistics.

In terms of research methodologies applied in the review corpus, 63 or about half of the articles rely primarily on quantitative modelling. Surveys (13%), simulations (13%) and literature reviews (11%) are fairly represented as well. The review corpus includes less articles in which interviews (6%), case-studies (5%) and conceptual propositions (2%) are the main approach. Yet despite the large share of articles that follow a quantitative modelling method, they account for 33% of articles carrying relevant data on urban e-commerce logistics. Not far behind are articles based on simulation and survey tools, that represent respectively 29% and 24% to the data-providing article base. Conceptual studies, literature reviews and interview-based articles are generally not very relevant from a data point of view. Figure 2 visualises these findings.

45 articles or 35% of the review corpus disclose relevant data on e-commerce and urban logistics, providing this study's core material. Figure 3 presents an overview of the fifty cities that are scrutinised in these articles (i.e., some articles cover more than one city). The bar

chart compiles articles studying an urban area in general and articles focusing on specific districts within that urban area, such as the 12<sup>th</sup> arrondissement in Paris (France). In terms of number of publications, Belo Horizonte (Brazil) and Rome (Italy) are most strongly represented. Next in line are New York and Berlin. With 52% of articles disclosing information on Antwerp (Belgium) and Amsterdam (the Netherlands) for example, European cities are represented best. Asian cities are contributing fairly as well to the review corpus, with 20% of data-rich articles allowing insight in cities such as Singapore (Singapore) and Shanghai (China). Articles on Brazilian cities São Paulo and Belo Horizonte make up 13% of the part of the review corpus that discloses urban e-commerce logistics data. North American cities represent 13% as well, with information on cities including Toronto (Canada). One city in New-Zealand, Christchurch, represents Oceania. Four articles in the review corpus provide data on a number of cities, or urban areas within a specific country as a whole. In this case, they are labelled as “multiple or unspecified” in the graph.

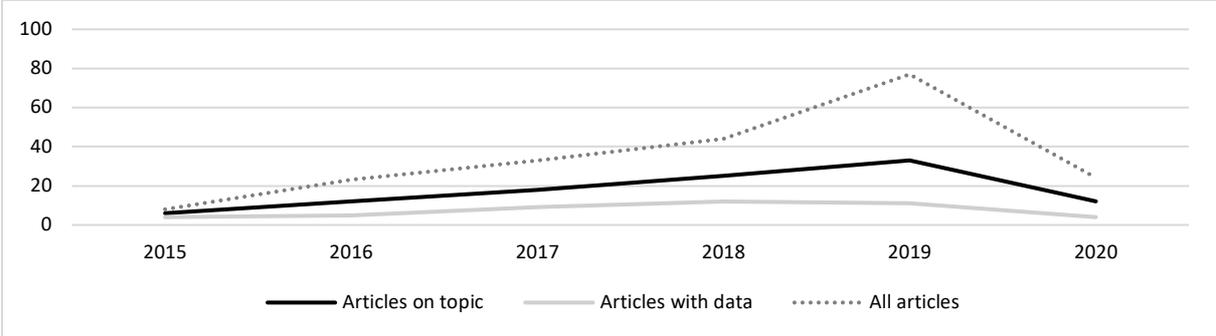


Figure 1. Review corpus overview of publication year.

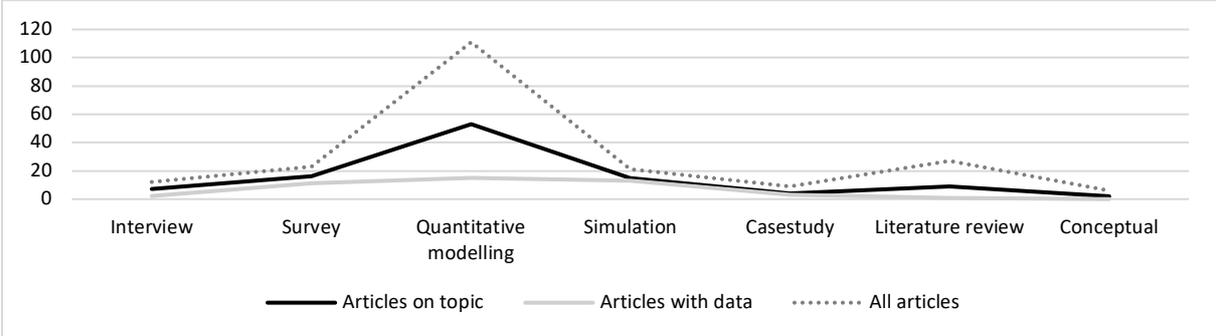


Figure 2. Review corpus overview of research methodology.

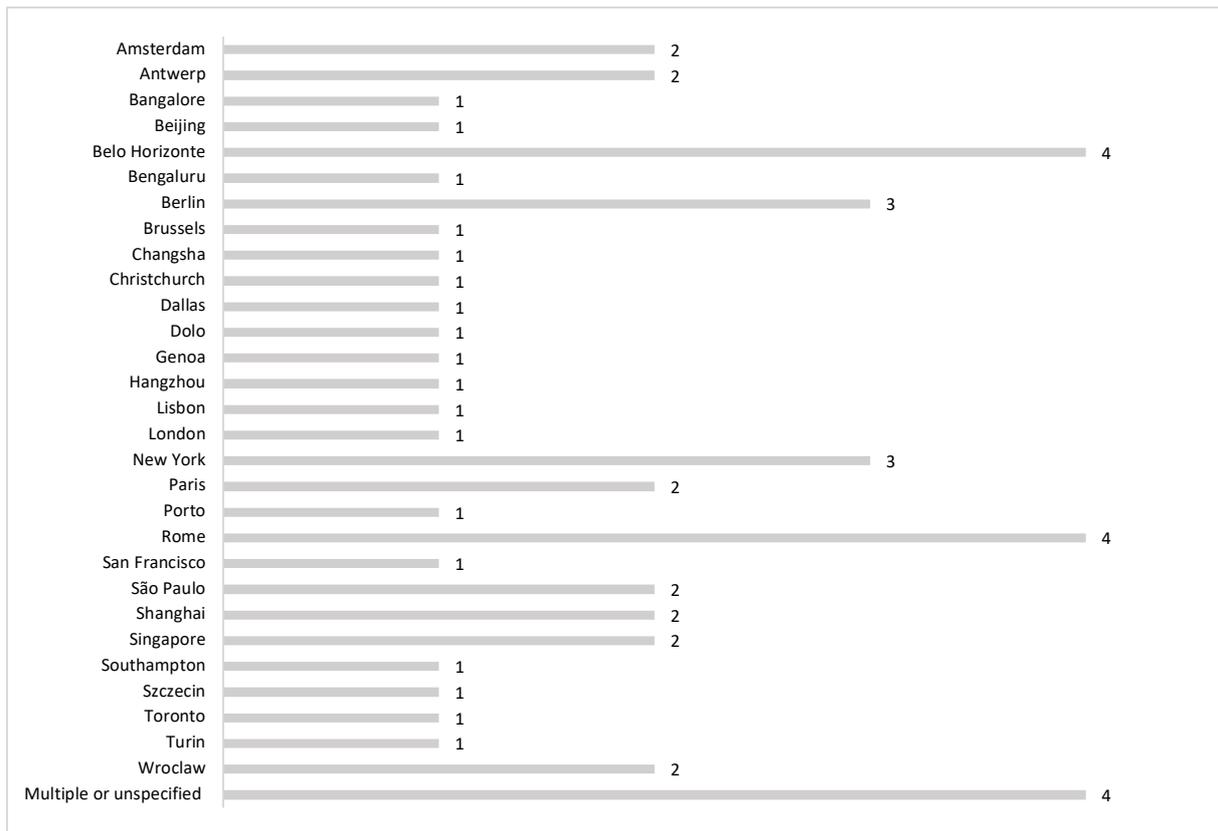


Figure 3. Overview of cities studied within the core material of articles with urban e-commerce logistics data.

#### Urban e-commerce logistics data, sources and methods

First, studies assessing urban e-commerce logistics in a particular city often provide **general urban** information as a means of giving context and meaning to data and developments related to e-commerce and urban logistics (roughly 60% of the 45 articles). Most frequently found data include number of inhabitants, area size (in square kilometre but also radius) and population density. Some studies include information on how the city is organised, e.g., describing the number of districts, quarters or zip-codes. If sources are provided, general urban information is without exception secondary data that rely either on governmental documents (e.g., census data, national statistics, urban statistics), scientific articles (often by the same authors) or open maps (i.e., OpenStreetMap, Baidu map).

Second, half of the articles share information on **infrastructure** related to urban logistics and e-commerce, e.g., number of collection points and logistics facilities. It concerns again secondary data but in this case originating from specific companies (i.e., InPost, Amazon, Flipkart), sector organisations (i.e., Belgian Institute for Postal Services and Telecommunications), scientific articles (often by the same authors) or open maps (i.e., OpenStreetMap, Baidu map, MetroData Tech). Although data from specific companies potentially provide only a partial view, authors of these studies stress the importance of the companies as major (e.g., Flipkart in Bengaluru, New Zealand Post lockers in Christchurch) or even sole payers (e.g., InPost lockers in Szczecin). One article collected primary data on the number of lockers and depots by means of a territory survey (Carotenuto et al., 2018). Other information collected on urban infrastructure relates to sources of freight generation, such as number of residential addresses. Apart from one article in which the authors self-collect the infrastructural data (De Oliveira et al., 2019), applied secondary sources are

governmental documents (e.g., urban open data), scientific articles or research reports (e.g., CIVITAS reports) and open maps (i.e., OpenStreetMap).

Finally, three articles share information on the average distance of distribution centres from the city centre, a measure investigated particularly in “logistics sprawl” research. Moshref-Javadi et al. (2020) share average distances for a major e-commerce platform in Sao Paulo (5.3 or 6.3 kilometres away from two customer populations under study) and Arnold et al. (2018) determine a stem distance of ten kilometres for a logistic service provider in Antwerp, while Heitz et al. (2019) capture this information for Paris based on a newly developed methodology. For logistics facilities in the Paris Region, the average distance from the centre is 19.9 kilometres. For facilities dedicated to parcels, this distance is 17.2 kilometres. With e-commerce flows relying in as much on buildings as it does on vehicles, indicators on urban logistics infrastructure are indispensable for any type of impact assessment of e-commerce on the city, environmental or other.

Third, information on **consumer behaviour and preferences** is shared in somewhat more than one third of the articles. Consumers being both the causal and receiving factor in e-commerce supply chains, data on their behaviour and preferences are incredibly important. Some studies analyse consumers’ socio-demographic characteristics to determine whether and how often they make purchases online. Such analyses are not found on an urban level, but Beckers et al. (2018) and Wang and Zhou (2015) created profiles based on representative surveys on country-level (respectively for Belgium and the USA). Beckers et al. (2018) find that well-educated, well-paid men in their thirties have the highest probability to shop online, while Wang and Zhou (2015) suggest that self-employed, highly-educated and white women who frequently use internet and have a high household income, children and more vehicles are the ones to generate more home deliveries. Remarkably, both studies agree that regional conditions or whether consumers live in an urban, urbanised or rural environment have limited influence. With cities being the main ground for innovation in e-commerce and urban logistics (e.g., instant deliveries, crowdsourcing), it is reasonable to assume that differences between urban and non-urban consumers amplified, and will continue to do so.

Specifically dedicated to consumers in cities, eight articles present rich primary information collected by means of surveys: on the use of unattended collection points or lockers (Iwan et al., 2016; Lemke et al., 2016; Moroz & Polkowski, 2016; Oliveira et al., 2017; Yuen et al., 2018), on the use and travel behaviour associated with e-groceries (Bjørger et al., 2019) and on purchase behaviour (Cherrett et al., 2017; Jaller & Pahwa, 2020). In five cases, the authors indicate that their respondent samples are not fully representing the urban population and sample sizes fluctuate between 164 respondents for street-intercept surveys in Singapore (Yuen et al., 2018) to 2,933 respondents for a survey among Polish InPost users (Lemke et al., 2016). Jaller and Pahwa (2020) analyse data from the 2016 American Time Use Survey in which information is logged from 10,493 respondents, yet their calculations for Dallas and San Francisco build on specific urban subsets. They find that “people in San Francisco are more likely to shop in-store compared to people in Dallas” and calculate vehicle-miles travelled for in-store, omnichannel and single channel purchases. Oliveira et al. (2017) employ stated and revealed preference techniques and Cherrett et al. (2017) combine an online shopping survey among university students with delivery audits in four halls of residence.

Other data methods to access information on consumer behaviour and preferences include proxy estimates based on data collection initiatives with a broader geographical scope (e.g.,

number of online shoppers), information provided by companies and sector organisations (e.g., home delivery preferences) and scientific articles (often by the same authors). Proxy data are a direct consequence of the lack of data, but they can distort reality (Heitz et al., 2019). We found this technique particularly applied for calculating the number of online shoppers. For example, both Oliveira et al. (2017) and Alves et al. (2019) use the general Brazilian online shopping percentage of 30% to find that 0.76 millions of consumers shop online in Belo Horizonte and 28,400 people make online purchases in Contorno, a region in Belo Horizonte.

Fourth, information on **e-commerce volumes** is disclosed in more than half of the studies. They provide basic but straightforward insights into e-commerce's impact on cities and are particularly of relevance to estimate the adequacy of existing infrastructure and the efficiency of trips, provided there is information available on that. In most cases, these data units are used as seemingly interchangeable and without explicit definition. While they are close in quantitative terms, conceptually they are not. One order is usually packaged in one parcel and usually results in one delivery. Yet it is possible as well that one order is shipped in numerous parcels, that can result in multiple deliveries. Particularly orders placed on large e-marketplaces can result in multiple deliveries, as each vendor chooses its own fulfilment facility (e.g., Amazon). The other way around is possible as well, although more uncommon: in which a retailer pools different orders in one parcel and delivery (e.g., Olive's consolidated deliveries<sup>1</sup>, "Amazon Day" delivery<sup>2</sup>).

Often, the unit of choice depends on the type of data that are available. Several data collection techniques are found. A first group of articles derives parcel quantities from secondary sources, spanning from scientific articles and research reports (Cepolina & Farina, 2015b; Dabidian et al., 2016) to governmental documents (Huang et al., 2018) and news articles (Guo et al., 2019; Moshref-Javadi et al., 2020). For a computational study set in Shanghai and Beijing, Huang et al. (2018) apply delivery density figures provided by the Chinese State Post Bureau. News reports give context in the articles of Guo et al. (2019) and Moshref-Javadi et al. (2020). Company data provide access to daily deliveries (Arnold et al., 2018; Bergmann et al., 2020; Janjevic et al., 2019; Zhang et al., 2018) and delivery densities as well (Bergmann et al., 2020; Janjevic et al., 2019; Moshref-Javadi et al., 2020).

A second group of articles relies on calculations that are based on company data (Buldeo Rai et al., 2019; Cárdenas et al., 2017), survey data (Cherrett et al., 2017; Wang & Zhou, 2015; Zhou et al., 2018) or proxy data (Akeb et al., 2018; Deutsch & Golany, 2018; Gatta et al., 2018, 2019; Guo et al., 2019; Oliveira et al., 2017; Serafini et al., 2018; Simoni et al., 2019). Through nine interviews with logistics service providers that capture Brussels' parcel volume, Buldeo Rai et al. (2019) find that approximately 45,000 business-to-consumer parcels are delivered to the Brussels-Capital Region every working day. Based on delivery information of a logistics service provider in Belgium and taking into account different morphological characteristics, Cárdenas et al. (2017) calculate that Belgian cities receive 0.33 deliveries per day per thousand inhabitants, leading to a daily delivery density of 0.43 per square kilometre. Survey-based calculations resulted in a daily number of 392.15 deliveries in Dolo, in which population and local online purchase statistics were taken into account (Carotenuto et al., 2018) and 5.2 home deliveries per person per year in New York State Capital District, which was found using an online purchase choice model and results of the National Household Travel Survey dataset (Wang & Zhou, 2015). Based on surveys and delivery

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<sup>1</sup> <https://www.shopolive.com/about>

<sup>2</sup> <https://www.amazon.com/b?ie=UTF8&node=17928921011>

audits, Cherrett et al. (2017) conclude that students in Southampton receive 14 packages per year. Deliveries magnify by a factor 2.4 during retail holiday “Black Friday”.

Yet the most popular calculation-method relies on proxy data extrapolated from national sources. Gatta et al. (2019) provide the most extensive explanation. Based on the percentage of the population making at least one online purchase, the percentage of orders requiring a physical shipment and the annual average frequency of online purchase, they obtain an e-shopping rate of 0.0262 daily orders per inhabitant in Rome. The same method and result is applied in Gatta et al. (2018), Simoni et al. (2019) and Serafini et al. (2018). Following this calculation, 21,317 orders are delivered in Rome every day (Serafini et al., 2018) and a per capita e-shopping rate of 12.4 orders per year is expected by 2025 (Gatta et al., 2019). A similar method is used by Deutsch and Golany (2018) who arrived at 9,025 orders per day in Toronto and Oliveira et al. (2017) who estimate 330,025 orders per year for Belo Horizonte.

While calculations in Rome and Toronto take consumers’ order frequency into account (Deutsch & Golany, 2018; Gatta et al., 2019), in Belo Horizonte one annual order per consumer is assumed (Oliveira et al., 2017). The methodology of Akeb et al. (2018) for arriving at 688,080 annual parcel deliveries in Paris’ 12<sup>th</sup> arrondissement is different. It is obtained by multiplying the total number of parcels in France (62,694,000 multiplied by five as their study focuses on 20% of the parcel market only) by the ratio of the population of the 12<sup>th</sup> arrondissement (0.22%). Some studies rely on assumptions and random parameters for their parcel volume quantifications (Alves et al., 2019; Cepolina & Farina, 2015a; Guo et al., 2017; Pan et al., 2015).

Fifth and final, information on e-commerce related **delivery trips** is provided in more than half of the articles. This share seems large, given ample suggestions in research that this type of data gravely lacks. As most identified data concentrate on context-specific delivery round and vehicle statistics, our findings confirm this statement. One notable exception is provided by Wang and Zhou (2015). From parcels quantities calculated based on the U.S. National Household Travel Survey and conversion factors based on housing structures, the authors estimate a total of 2.89 million annual business-to-consumer delivery trips in the New York State Capital District. According to their calculations, freight trips generated by residential areas are about 31% of the freight trips generated by businesses.

Delivery trip information provided by the remaining articles focuses on general insights on urban freight, delivery round statistics, vehicle statistics and delivery failure rates. From a sustainability perspective, this information is most easily translatable to externalities associated with e-commerce mobility. Most applied methodologies include scientific articles or research reports (Cepolina & Farina, 2015b; Gatta et al., 2018, 2019; Iwan et al., 2016; Jaller & Pahwa, 2020; McDonald et al., 2019; Moroz & Polkowski, 2016; Serafini et al., 2018) and company data (Arnold et al., 2018; Bergmann et al., 2020; Cardenas et al., 2017; Cárdenas et al., 2017; Janjevic et al., 2019; Kedia et al., 2017; Perboli et al., 2018; Rajan & Rajesh, 2020; Rosano et al., 2018; Simoni et al., 2019; Zhang et al., 2018). Some articles rely on self-collected data (Allen et al., 2018; Cherrett et al., 2017; Melo & Baptista, 2017) and survey-based modelling (Cattaruzza et al., 2017; Wang & Zhou, 2015).

Delivery round statistics reported include number of stops, roundtrip distance, roundtrip time, time per stop and driving speed. Different units are used that relate to the number of stops per roundtrip, i.e., number of items delivered, number of trips and number of customers served. Figures vary from 60 home deliveries in Rome (Simoni et al., 2019) and Wroclaw (Moroz & Polkowski, 2016) to 118 items delivered per round in London (Allen et al.,

2018); from 72 customers in London (Allen et al., 2018) to 99 customers served per round in Antwerp (Arnold et al., 2018). In the case of Janjevic et al. (2019), a delivery consists of slightly more than one item. Jaller and Pahwa (2020) cite a minimum of 15 and a maximum of 75 deliveries per roundtrip for an American context. Yet Arnold et al. (2018) assume 300 parcels as vans' capacity limit, suggesting that delivery vehicles are not loaded to its maximum. What's more, studies focused on Polish cities Wroclaw and Szczecin compare 60 parcels per roundtrip for deliveries at home to 600 parcels per roundtrip for deliveries to lockers (Iwan et al., 2016; Moroz & Polkowski, 2016). Roundtrip distances vary between 60 kilometres in Rome (Simoni et al., 2019) to 150 kilometres in Wroclaw (Moroz & Polkowski, 2016) and Szczecin (Iwan et al., 2016). A roundtrip distance within the delivery area in London is 11.9 kilometres (Allen et al., 2018). Roundtrip durations vary between six hours in Antwerp (Arnold et al., 2018) and 7.3 hours in London (Allen et al., 2018), while stops take 2.5 minutes in Berlin-Wilmersdorf (Zhang et al., 2018) and Antwerp (Arnold et al., 2018), three minutes in Rome (Simoni et al., 2019) and 4.1 minutes in London (Allen et al., 2018). Driving speed evidently depends on vehicle type but differs strongly from one city to another as well. Average vehicle speed for vans is seven kilometres per hour in London (Allen et al., 2018), between 15 and 17 kilometres per hour in Antwerp (Arnold et al., 2018; Cardenas et al., 2017) and 40 kilometres per hour in Turin (Perboli et al., 2018). In Belo Horizonte's Contorno area, trucks drive ten kilometres per hour (Alves et al., 2019). For cargo-bikes, twelve kilometres per hour is reported for Antwerp (Arnold et al., 2018) and twenty kilometres per hour is found in Turin (Perboli et al., 2018). Vehicle statistics include type of vehicles used (mostly vans), vehicle capacity in terms of travel limit and parcel volume and some reporting on vehicle volume and weight. Finally, probabilities that a delivery fails are reported: 9.3% in Belgium cities (Cardenas et al., 2017), 11% in Antwerp (Arnold et al., 2018), 6.5% in Berlin-Wilmersdorf (Zhang et al., 2018) and 10% in Christchurch (Kedia et al., 2017).

The appendix provides an overview of urban e-commerce logistics data disclosed in the core material of 45 articles.

#### Compilation of urban e-commerce logistics data

This section provides four overview graphs, compiling some of the data that have been disclosed in the review corpus' core material. Only data provided in sufficiently large quantities was taken into consideration, as well as data that allowed comparability. The differences in data collection instruments were considered too large to include data captured through consumer surveys. Still, creating the graphs required generating and calculating data. On data generation: basic information on urban size and population was collected using publicly available online sources. On data calculation: relative information was created from absolute figures using number of inhabitants and urban size in square kilometres. Monthly and yearly deliveries were generated based on multiplying daily deliveries by respectively 20 and 250, only including working days (or a calculation variation, depending on data availabilities). Admittedly, these calculations can be considered conservative as deliveries are increasingly taking place on weekends as well. All graphs demand caution in interpretation given the differences in methodologies and sources, as outlined in the previous section. For example, the data in various cities were collected in different years, which is important to consider given that the e-commerce sector grows year by year.

Parcel volumes generated in Chinese cities multiply those of other urban areas in the world, due to their large urban size, high population density and mature e-commerce market. Thereby, they heavily distort the visualisations. In response, Figure 4 shows absolute numbers on business-to-consumer deliveries that are distributed on a daily basis in European cities, while Figure 5 demonstrates the relative number of daily deliveries for all cities found in the review corpus. In line with the common research approach discussed in the previous section, we combine three data units to compile these graphs: number of orders, parcels and deliveries.

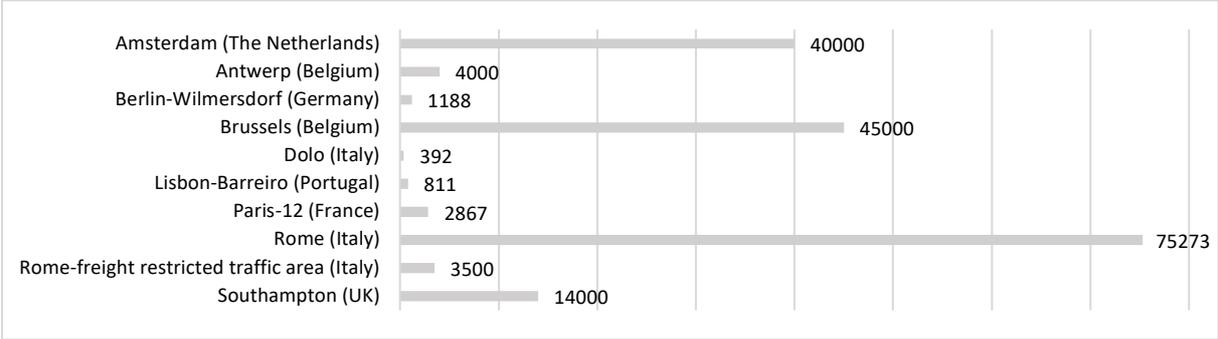


Figure 4. Daily business-to-consumer deliveries in European cities.

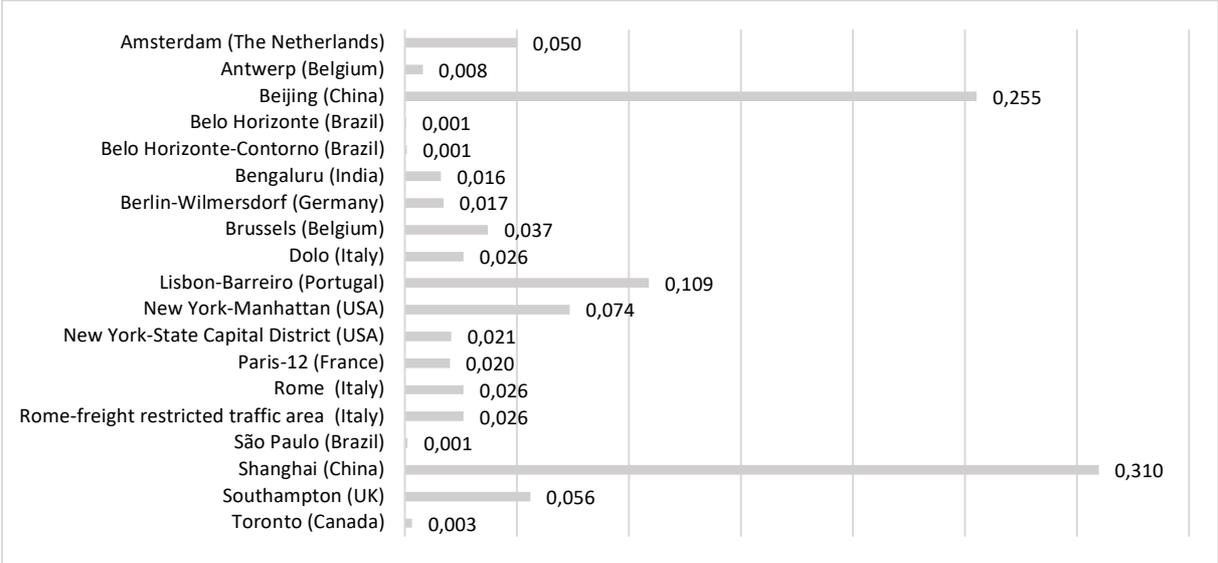


Figure 5. Daily business-to-consumer deliveries per inhabitant.

Where Figure 4 provides total numbers of deliveries, for cities or neighbourhoods of very different sizes, Figure 5 shows numbers per inhabitant. It shows clear differences between cities. As mentioned, Chinese cities as represented by Shanghai (China) and Beijing (China) stand out. South American cities as demonstrated by São Paulo (Brazil) and Belo Horizonte (Brazil) generate much less deliveries. These findings are unsurprising and in line with country-level reports (Ecommerce Foundation, 2019). The data also give an insight into intra-urban variation, as illustrated by the sharp differences between New York State Capital District and Manhattan (USA).

Yet more than visualising the differences in daily deliveries per inhabitant in various cities in the world, this graph also alludes to the variation in data collection methodologies and sources. For example, how to explain the particularly high quantities for Amsterdam (the

Netherlands), Lisbon-Barreiro (Portugal) and Southampton (UK) and very low quantities for Antwerp (Belgium) and Toronto (Canada), while very comparable numbers are produced for cities like Berlin-Wilmersdorf (Germany), Dolo (Italy), the State Capital District of New York (USA), Paris' 12<sup>th</sup> arrondissement (France) and Rome (Italy)? Some results can be explained based on the methodologies and sources. For example, results for Southampton (UK) are derived from investigating student populations, while results for Amsterdam (the Netherlands) and Manhattan (USA) are provided by news articles. Students are more active e-consumers and popular media possibly exaggerate, which explains the elevated volumes. Other incomparabilities are harder to explain based on the available information. For Europe, an average of 0.02 daily deliveries per capita seems an indicative benchmark, which is ten times smaller than estimations for Chinese cities and ten times larger than estimations for Brazilian cities.

Figure 6 reports delivery density in terms of number of deliveries per square kilometre, a data unit prone to provoke discussion. Although it is challenging to compare cities based on their size, ignoring specificities related to e.g., urban form, spatial activity and sprawl phenomena, we chose to visualise this information as it was directly included for four cities: i.e., Beijing (China), Shanghai (China), São Paulo (Brazil) and Bengaluru (India) (Bergmann et al., 2020; Huang et al., 2018; Janjevic et al., 2019). Similar to Figure 5, some cities stand out, albeit different ones. In line with its dense population, New York-Manhattan (USA) seems to receive about the double number of parcels as is distributed in Shanghai (China) and multiplies the number in other cities that are considered highly dense areas as well (e.g., Paris-12). In two cases (marked with an asterisk), the maximum delivery density is provided instead of an average. The article on São Paulo includes both: with an average delivery density of 6.5 and a maximum delivery density of 93, it provides more evidence for the importance of intra-urban variations.

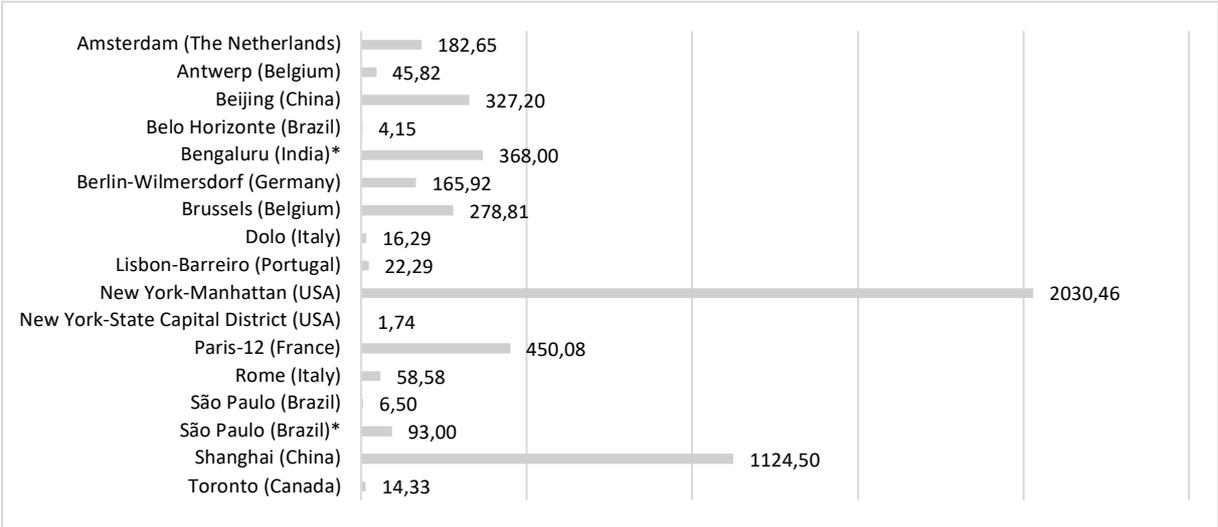


Figure 6. Daily business-to-consumer delivery density. \* = maximum deliveries per km<sup>2</sup>.

Finally, Figure 7 provides information on urban e-commerce logistics related infrastructure, by visualising the number of attended collection points (including post offices) and lockers per 1,000 inhabitants in various cities. Europe's leading position when it comes to collection point developments has been raised in research (de Oliveira et al., 2017; Morganti et al., 2014). Indeed, Berlin's (Germany), Brussels' (Belgium) and Dolo's (Italy) sizeable offers stand out. There is only one company in Belgium that offers locker solutions and it is open to all

logistics service providers (i.e., bpost), which facilitates comparability with figures from e.g., Toronto (Canada), Szczecin (Poland) and Singapore (Singapore) that reflect the locker network of respectively Amazon, InPost and SingPost. The e-commerce infrastructure for out-of-home delivery varies widely in cities around the world.

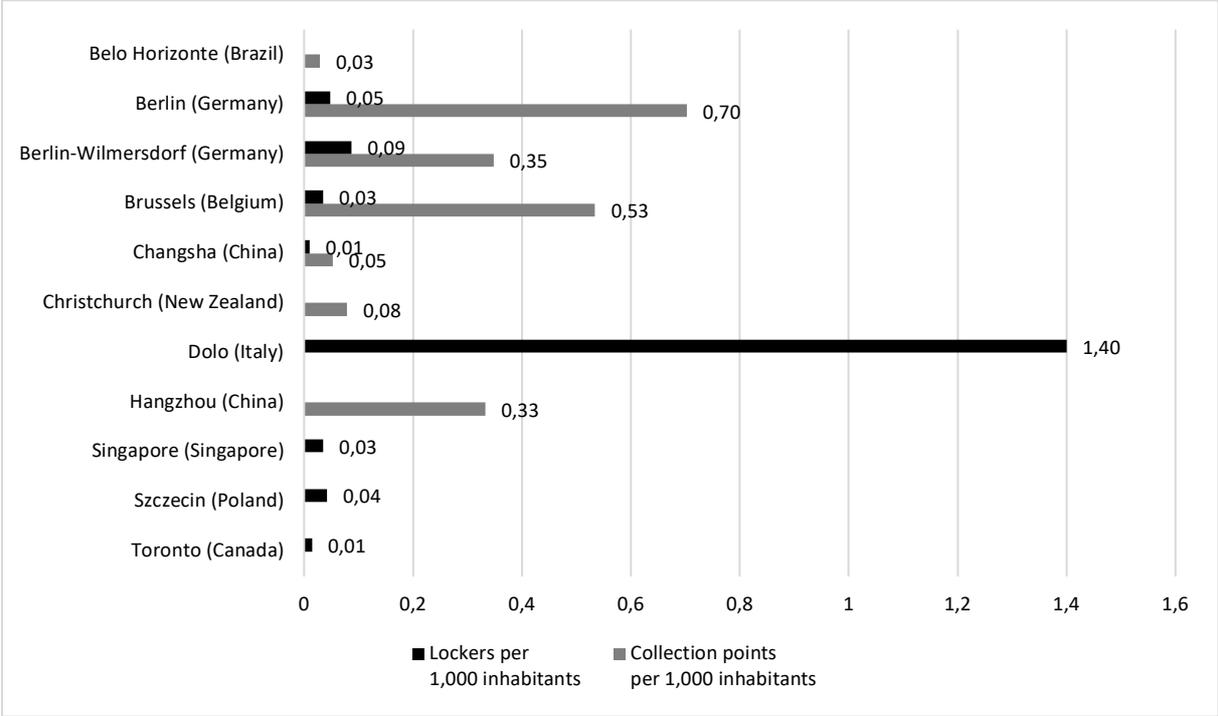


Figure 7. Number of lockers and collection points per 1,000 inhabitants.

Discussion

Several implications emerge from this systematic literature review: it shows the type of data currently available on e-commerce and urban logistics, while also indicating discrepancies in data collection and compilation methodologies as well as highlighting areas where data lack. We introduced three additional sources to this section that because of their document type (i.e., conference papers, consultancy report) did not appear in the systematic literature review (Gt, 2018; Gardrat et al., 2016; Holguín-Veras et al., 2019). Yet we found their insights essential in augmenting the discussion.

On data availability, we found that knowledge concentrates on consumer preferences and purchase behaviour on the one hand and delivery volumes in terms of number of urban deliveries on the other hand. For both types of data however, inter-urban comparison is challenging because of the ways in which they are collected. First, consumer preferences and purchase behaviour are usually generated by means of surveys, often not adequately representing the urban population and always based on unstandardised data collection instruments that differ widely. Particularly comparing findings from stated and revealed preference surveys is problematic, given the level of specificity and detail required in survey design. Second, delivery volumes rely mostly on proprietary company-data that, unless it concerns the sole service provider, depict an incomplete view of the urban situation. Although data from retailers and logistics service providers could provide important insights in how socio-demographic characteristics relate to e-commerce behaviour, such level of detail is rarely available. Proxy-calculations based on national statistics are common as well, thereby disregarding important urban characteristics and intra-urban differences.

What's more, data on both consumer behaviour and delivery quantities are marked by inconsistencies in terms of units. For consumer preferences and purchase behaviour, this comes down to differences between individual and household-level data. For delivery volumes, this translates in a blend of "parcels", "deliveries" and "orders" that are discussed without clear definition and used as seemingly synonyms. More importantly, some data appear to be wrong as they compare very strangely with cities of equivalent level of e-commerce development.

Addressing the areas where data lack requires matching the review findings with observations and statements made by researchers in urban logistics. Accordingly, the most pressing gaps seem to lie in delivery trip information on the one hand and urban e-commerce logistics infrastructure on the other hand. On delivery trip information, specifically the number of deliveries and pickup operations per online order (Dabanc, 2018), vehicle size information (Conway, 2020) and freight trip patterns (Wang & Zhou, 2015) remain unaddressed. Two questions seem crucial in this respect: how should an online order be defined and how many freight trips do e-commerce orders generate in a city? On defining online orders, Gardrat et al. (2016) make a fair point by stating that e-commerce is not the only channel that generates deliveries. By introducing the concept of "deferred purchase and reception" and developing a survey to quantify it on a household-level, the authors include other purchase types as well, including the increasingly popular purchases in-store that are shipped for delivery instead of immediately taken home. Using another terminology, the need to take stock of different types of purchases when assessing e-commerce mobility has been raised as well in omnichannel retail literature, such as the study by Buldeo Rai et al. (2019) included in the review.

Bridging to the second question, Gardrat et al. (2016) postulate that no statistics allow to measure the freight trips that new forms of purchase generate. On converting online orders to freight trips, we pointed to the study by Wang and Zhou (2015), who calculated a conversion factor based on housing structures (i.e., single unit house versus multi-unit apartments). Recently, Holguín-Veras et al. (2019) proposed to assume seven deliveries equal to one freight trip. The authors do not explain the rationale behind this conversion factor, providing leeway for further discussion. What's more, ongoing e-commerce developments further impede to develop adequate methodologies and ultimately strengthen our knowledge. For example: the increasing diversity in delivery vehicles (e.g., "white vans", bikes, public transport) and delivery staff (e.g., "the crowd"), changing order behaviour (e.g., large basket sizes incentivised by "free shipping", meal deliveries) and advancing e-commerce operations (e.g., consolidation and fragmentation of orders). On infrastructure related to e-commerce logistics, the locations of logistics facilities are notably missing. One crucial question is raised by Heitz et al. (2019) and relates to the heterogeneity of logistics facilities, that is not fully documented nor understood. In this case too, several trends further complicate the collection of accurate data, such as fluctuations in collection point networks, sharp increases in collection points, development of mixed-use logistics facilities (e.g., "logistics hotels", "ship-from-store") and emergence of micro-logistics spaces.

We argue that much more detailed and accurate data is needed in the field of urban e-commerce logistics to feed increasing research endeavours, calculate the externalities associated with e-commerce mobility and prepare cities for the future. Based on our findings, several recommendations and best practices can be formulated towards developing a **common data agenda for urban e-commerce logistics research**:

First and foremost, our systematic literature review exposes areas in research that are both under-developed and un-developed in this field. In response, future research efforts should be allocated towards addressing the most pressing gaps in data, on freight trips and logistics infrastructure indicators, as well as towards enhancing the quality of data that currently exists, on consumer and delivery volume indicators. Consideration should be made to avoid overly specific data for consumers and delivery trips, applicable to a characteristic case-study context only, but also to refrain from overly aggregate data that are uninformative on their own. We came across both scenarios throughout the review.

Second, our systematic literature review also demonstrates the difficulties in comparing urban knowledge between different contexts and over different points in time, therefore limiting our understanding of past and current developments and more importantly impeding our perspectives for the future. One way to move forward is to pursue data collection standardisation: by being more explicit about the data collection instruments we employ, by sharing survey questionnaires, interview topic-lists and observation protocols and by intentionally building on past efforts and instruments to collect new data. A comparative e-commerce mobility study by research bureau 6t (2018) provides a thoughtful example in its description of survey sample, applied terminology, questionnaire set-up and context specificities in comparing practices between Paris and New York.

Another way to enhance comparability, is to explicitly and consistently disclose the methodologies that have been applied to collect, compile and calculate the presented data, the sources that have been used to provide access to the presented data, the temporal and spatial information to which methodologies, sources and data relate and the precise units in which the data are expressed. All too often, it remains a challenge to find this type of essential background information. The study of Gatta et al. (2019) provides a counterexample by describing in detail the calculation-method, sources and formula applied to obtain the per capita e-shopping rate in Rome.

Third, our systematic literature review presents evidence that articles based on surveys, case-studies and simulation are most productive in supplying data on urban e-commerce logistics, while data disclosed in modelling and interview work is generally limited. These findings translate into two recommendations. First, much in line with an argument made earlier, articles reporting on modelling research should increase and enhance their information on data, parameters and assumptions used to feed the models, as exemplified by Bergmann et al. (2020) in their study on integrating delivery and pick-up operations for Flipkart's e-commerce activities in Bengaluru (India).

Yet as this type of research often depends on proprietary company information, it is likely that issues for dissemination need to be tackled. On a bigger scale and as mentioned earlier as well, company-level data risk providing a partial view only of urban freight reality.

Therefore, the second recommendation builds on interview-based research, which often generates information from multiple parties. Next to capturing rich qualitative content, interviewers could probe for some quantitative figures and facts as well, thereby highlighting multiple aspects of urban e-commerce logistics developments and optimising their valuable contacts. Buldeo Rai et al. (2019) employed this methodology to compile daily parcel deliveries in Brussels.

Moving towards future enhancements of this research field, several areas can be explored further. A variety of data collection efforts exists outside of scientific research. Could it be that useful data exist but are missed by the urban logistics community? If so, in what ways can we further facilitate to include new sources and align our data collection efforts?

Levering technological opportunities, new ways of collecting data are increasingly available. How can we employ these solutions to enhance urban knowledge, while mitigating the issues of private (e.g., navigation apps) and public (e.g., Automatic Number-Plate Recognition or ANPR cameras) data ownership? Ultimately, a key question remains in terms of data accessibility and how we can move towards open data sharing platforms beneficial to all.

While the margins of this systematic literature review have clearly been defined in the methodological section, it is important to appoint its main limitations: among which publication bias and missing data (Sutton et al., 1998). Despite the significance of the selected scientific databases and careful formulation of keywords and search strategy, an inevitable consequence of the applied methodology is to exclude insightful articles (Petticrew, 2001). By including 127 articles and analysing 45 articles in detail, we hope to have caught the state of practice in urban e-commerce logistics research and its essence when it comes to the data that we build on. Still, some topics are absent, such as delivery volumes and delivery trips associated with crowdsourced and instant deliveries and consumers' return rates. Their impacts on cities are emerging and increasing, presenting important avenues for future research.

## Conclusion

Recognising the importance of e-commerce mobility in our cities and its growing significance towards the future, this article presents a systematic literature review to identify and compare the types of e-commerce data that are currently known, employed and disclosed in the research field of urban logistics. Solid, comparable and appropriate data are vital to evaluate the various impacts of e-commerce and to propose efficiency or sustainability enhancing applications. More than a matter of knowledge or model input, data on urban e-commerce logistics are essential in predicting the upcoming challenges cities are faced with because of e-commerce growth.

In an attempt to synthesise and refine scattered knowledge, assess the knowledge base and verify inconsistencies in urban e-commerce logistics research, we find that knowledge concentrates on consumer preferences and purchase behaviour on the one hand and delivery volumes in terms of number of urban deliveries on the other hand. Some approximate data points can be distilled from the review corpus:

Average of 0.02 daily deliveries per capita for European cities, ten times smaller than estimations for Chinese cities and ten times larger than estimations for Brazilian cities.

Actualisations post-COVID-19 are however necessary.

Delivery volumes more than double during retail holidays such as "Black Friday".

Delivery roundtrips account for 60 to 120 home deliveries in European cities and between 15 and 75 home deliveries in American cities. Deliveries to lockers instead of homes have the capacity to increase the number of deliveries tenfold.

Delivery roundtrips vary from 60 to 150 kilometres, including stem distances. Within dense delivery areas only, delivery distances are around 12 kilometres. Stem distances to delivery areas vary between 5 and 17 kilometres.

Delivery roundtrips take around 6 to 7 hours.

Delivery stops take between 2.5 and 4 minutes.

Vans and trucks drive between 7 and 40 kilometres per hour and cargo-bikes drive between 12 and 20 kilometres per hour in cities. Driving speed tends to be higher in smaller cities and lower in bigger cities.

About 10% of deliveries fail.

Because of diverging data collection instruments and varying data units, comparability remains a challenge. Some data are also suspected to be wrong. Additionally, we determine data paucity for information related to delivery trips and urban e-commerce infrastructure. Based on the systematic literature review, we propose a common data agenda for urban e-commerce logistics research, focused on addressing data gaps and topics that are under-developed and un-developed; pursuing data collection standardisation; disclosing data collection methodologies and sources; and specifying temporal and spatial information as well as units of data. Some data methodologies and sources can be recommended for future research: using interviews to collect quantitative data; collaborating with sector organisations; exploring open maps; employing existing household and time use surveys; and leveraging technological opportunities and new ways of collecting data.

Declaration of interest statement

No potential conflict of interest was reported by the authors.

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## Appendix

Table 1. Urban e-commerce logistics data disclosed in the core material of 45 articles.

Reference	City	Method	Data collection			Indicators					Data level
			Source(s)	N	Year	General city	Logistics infrastructure	Consumer	Delivery volume	Delivery trip	
(Buldeo Rai et al., 2019)	Brussels	Interview	LSP annual reports; news articles; interviews with LSP managers	9	2014-2018	NA	Pick-up points: 646 Lockers: 42	NA	Parcels: 45,000/day	NA	Urban
(Moroz & Polkowski, 2016)	Wroclaw	Survey	GEN Y university students ( <b>not representative</b> )	234	2015	NA	NA	Reasons for choosing parcel machines	NA	NA	Individual
(Moroz & Polkowski, 2016)	Wroclaw	Survey	Bilik (2014)	NA	2014	NA	NA	NA	NA	Parcels/courier/day parcel: 60; Km/courier/day: 150; Parcels/courier/day (lockers): 600; Km/courier/day (lockers): 70	Urban
(Cepolina & Farina, 2015b)	Genoa	Simulation	Estimations; Osservatori.net; interviews; websites; Genoa road network; local and national databases; published case studies	NA	2012	Area: 1.2 km <sup>2</sup> ; Inhabitants: 20,000	Buildings: 5,000; Commercial activities: 2,106; Freight vehicles reserved areas: 151; Controlled gates: 12	NA	Deliveries to commercial activities: 4,700/day (4.5-5 packages or pallets/delivery); Package size: 40% big, 20% medium and 40% small	Freight vehicles entering the historical centre: 1,303/day	Urban
(Bjørgeren et al., 2019)	NA	Survey	Norwegian consumers ( <b>not representative</b> )	270	2018	NA	NA	Familiarity e-groceries; use of e-groceries; non-use of e-groceries; aspects importance of e-groceries; change in travel due to e-groceries; time use for groceries	NA	NA	Household
(Akeb et al., 2018)	Paris-12	Modelling	FEVAD; Demographia World Urban Areas; INSEE; assumptions and calculations	NA	2015	Inhabitants: 146,251; Surface: 6.37 km <sup>2</sup> ; Population density: 22,959/km <sup>2</sup>	NA	NA	Parcels (requiring 2nd delivery): 137,616/year; Parcels: 11,468/month	NA	Neighbourhood
(Carotenuto et al., 2018)	Dolo	Modelling	Dolo population; online purchase statistics in Dolo; matrixes for road itineraries	NA	2017	Inhabitants: 15,000	Lockers: 21; Depots: 3	NA	Deliveries: 392.15/day	NA	Urban
(Guo et al., 2019)	Amsterdam	Simulation	Literature; website of a grocery retailer; Ecommerce News (2018); Syndicate Plus (2014)	NA	2018	Inhabitants/supermarket: 4,550	NA	Supermarket visits: 640/day	Supermarket e-orders: 85/day; Supermarket orders/neighbourhood population: 85/4,550	NA	Neighbourhood
(Guo et al., 2019)	Amsterdam	Simulation	<a href="https://www.parool.nl/nieuws/over-10-jaar-100-000-pakketten-per-dag-in-amsterdam~bd76e46c/?referer=https%3A%2F%2Fzimbra.enpc.fr%2F">https://www.parool.nl/nieuws/over-10-jaar-100-000-pakketten-per-dag-in-amsterdam~bd76e46c/?referer=https%3A%2F%2Fzimbra.enpc.fr%2F</a>	NA	2016	Inhabitants: 800,000	NA	NA	Parcels: 40,000/day	NA	Urban

(Serafini et al., 2018)	Rome	Survey	Metro users ( <b>not representative</b> ); Politecnico di Milano; Netcomm; BEM Research	240	2016-2017	Inhabitants: 2,875,447; Inhabitants (catchment area): 647,154	NA	NA	Deliveries: 21,317 orders/day; Deliveries: 2.62 orders/day/100 inhabitants	NA	Urban
(Iwan et al., 2016)	Szczecin	Case-study	InPost Company; results of analysis by AGH University of Science and Technology in Krakow; data from 100 internet shops in Poland	NA	2012-2013	NA	Lockers: 17	Rating of lockers; reason of utilization; expectations of locations; evaluation of locations	Deliveries to 17 lockers: 5,682/22 months; Deliveries to 17 lockers: 335-443/month	Km/day (courier): 150; Km/day (lockers): 70; Parcels delivered/day (courier): 60; Parcels delivered/day (lockers): 600; Average costs/delivery (lockers): €2,18; Average costs/delivery (Polish Post): €2,57; Average costs/delivery (couriers): €3,39	NA
(Huang et al., 2018)	Beijing	Modelling	Beijing Bureau of Urban Planning; State Post Bureau of P. R. China	NA	2017	NA	NA	NA	Deliveries: 327.2/km2/day	NA	Urban
(Huang et al., 2018)	Shanghai	Modelling	Beijing Bureau of Urban Planning; State Post Bureau of P. R. China	NA	2017	NA	NA	NA	Deliveries: 1,124.5/km2/day	NA	Urban
(Allen et al., 2018)	London	Case-study	GPS tracking data from 83 parcel carrier vehicles and their drivers; daily data for each vehicle; 25 vehicle rounds	NA	2016	NA	NA	NA	NA	Round duration: 7.3 h; Proportion parking duration: 62%; Driving distance: 11.9 km; Average vehicle speed: 7.0 km/h; Items delivered: 118; Items collected: 9; Walking distance: 7.94 km; Walking distance per customer: 105 m; Customers served: 72; Parking stops: 37; Proportion on street parking: 95%; Time to deliver/collect: 4.1 min/customer	Neighbourhood
(de Oliveira et al., 2017)	Belo Horizonte	Survey	Stated ( <b>representative</b> ) and revealed ( <b>representative</b> ) preference survey among Brazilian online shoppers; E-bit; estimations	457+124	2015-2016	Inhabitants: 2.5 million; Surface: 331,401 km2; Population density (for 78% of population): from 745.16/km2 to 3165.18/km2	Correios facilities: 68	Online shoppers: 0.76 million; Preference for using automatic delivery station when implemented: 63%; Preference for receiving a security code: 83%; Preference for locations: supermarkets (26%); stores (22%); shopping malls (21%); Preference for access times: 18:00-20:00 (24%); 20:00-	Online orders: 330,025/year	Vehicles: 1,714,233 (68% cars; 16% light freight vehicles; 12% motorcycle; 3% heavy freight vehicles; 1% buses); Use of private vehicle to automatic delivery station: 59%; Travel time of 15-30 min to automatic delivery stations: 39%	Urban

								00:00 (19%); 14:00-18:00 (16%); Attribute importance: "information and traceability" (39%); "delivery time" (27%); "transportation cost" (22%); "location" (11%); Preferred delivery solution: home delivery			
(Lemke et al., 2016)	4 cities	Survey	InPost Company	2.933	2015	NA	% of lockers located in the vicinity of a city's logistic entities (gas stations; public transport stops; shopping centres/shops)	Satisfaction with lockers: 8.7-8.9/10; Evaluation of lockers; evaluation of lockers compared to other services; share of orders via lockers; probability of lockers recommendation; criteria for use of lockers; criteria for choosing lockers; evaluation of lockers location	NA	NA	Urban
(Bergmann et al., 2020)	Bengaluru	Modelling	Flipkart; OpenStreetMaps; GoogleMaps	NA	2016	Inhabitants: 12.4 million	Distribution center: 1; Fulfillment hubs: 17	NA	Deliveries: 200,000/day; Pick-ups: 3;100; Max delivery density: 92/day/0.25 km <sup>2</sup> ; Max pick-up density: 18/day/0.25 km <sup>2</sup>	Motorbike deliveries: 90%; Small vans or motorized tricycles deliveries: 10%; Delivery traffic footprint: 1,283,000 km/year; Delivery traffic footprint: 4,100 km/working day; Pick-up traffic footprint: 433,000 km/year; Pick-up traffic footprint: 1,400 km/working day; Delivery and pick-up traffic footprint: 1,716,000 km/year; Delivery and pick-up traffic footprint: 5,500 km/working day; Delivery distance travelled at 500x500 m level: 73-1,735 km; Pick-up distance travelled at 500x500 m level: 73-772 km; Delivery route efficiency: 0.4957 km/stop; Pick-up route efficiency: 0.7098 km/stop; Delivery route	Urban

										efficiency at 500x500 m level: 0.06-1.41 km/stop; Pick-up route efficiency at 500x500 m level: 0.13-1.41 km/stop	
(Jaller & Pahwa, 2020)	Dallas	Survey	American Time Use Survey data (representative)	10,493	2016	Population: 2,513,054; Area: 957,812	NA	NA	NA	VMT single channel in-store: 10,159,374; VMT omni channel: 9,429,994; VMT single channel online: 1,260,982	Individual
(Jaller & Pahwa, 2020)	San Francisco	Survey	American Time Use Survey data (representative)	10,493	2016	Population: 847,192; Area: 382,286	NA	"people in San Francisco are more likely to shop in stores compared to people in Dallas"	NA	VMT single channel in-store: 4,460,713; VMT omni channel in-store: 4,169,172; VMT single channel online: 553,570	Individual
(Jaller & Pahwa, 2020)	2 cities	Survey	California Air Resource Board; literature	NA	2018	NA	NA	NA	NA	Minimum of 15 deliveries/tour; Maximum of 75 deliveries/tour; Average of 35 deliveries/tour; 11.25 miles/in-store purchase; 1.4 miles/online purchase	Urban
(Zhang et al., 2018)	Berlin	Simulation	OpenStreetMap; Census Berlin; <a href="http://www.paketda.de/paketd/epot-alle.html">http://www.paketda.de/paketd/epot-alle.html</a>	NA	2011-2018	Private persons: 3,290,406; Potential commercial clients: 9,019	Distribution centers parcels: 31; Pick-up points: 2,312; Packstations: 157	NA	NA	NA	Urban
(Zhang et al., 2018)	Berlin-Wilmersdorf	Simulation	OpenStreetMap; Census Berlin; <a href="http://www.paketda.de/paketd/epot-alle.html">http://www.paketda.de/paketd/epot-alle.html</a>	NA	2011-2018	Inhabitants: 68,925; Commercial clients: 1,629	Distribution center: 1; Post offices: 24; Packstations: 6	Consumers home during delivery: 93.5%; Private parcels to households: 77%; Private parcels to Packstations: 23%	Parcels (DHL): 3,700/day; Private parcels (DHL): 1,188/day; Commercial parcels (DHL): 2,519/day	Failure rate (DHL): 6.5%; Average delivery time (DHL): 2.5 min	Neighbourhood
(Cárdenas et al., 2017)	NA	Modelling	LSP that "covers 10% of the total delivery market" four-month dataset	NA	2015	Inhabitants/km2: 1299.17; Delivery density: 0.43/day/km2	NA	NA	Deliveries (Belgium): 1,143/one logistics carrier/four months; Deliveries urban: 0.33/day/thousand inhabitants	Line-haul VKT estimation urban: 552.36 km; Delivery tour VKT estimation urban: 2327.64 km; Total VKT estimation urban: 2880.00 km	Urban
(Kedia et al., 2017)	Christchurch	Interview	Residents of Christchurch; personal communication with Traffic Design Group (2008)	34	2017	Population density: 600 persons/km2; Population: 341,469; Area: 610 km2	Post offices (New Zealand Post): 25; Post agents (New Zealand Post): 36; Non-collection and delivery point shops (New Zealand Post): 43; Conventional collection and delivery point shops (New Zealand Post): 18; Non-conventional collection and delivery	NA	NA	Number of light vehicles (2006): 1.7/household; Delivery failure (major courier company): 10%	Urban

							point shops (New Zealand Post): 9				
(Wang et al., 2016)	Singapore	Modelling	Singapore bus; Singapore taxi; GeoLife; <a href="https://www.mypopstation.com/locations">https://www.mypopstation.com/locations</a> .	NA	NA	NA	Pop-stations (SingPost): 124	NA	NA	NA	NA
(Janjevic et al., 2019)	São Paulo	Modelling	"Largest online retail platform in Brazil" B2W	NA	NA	Area: 2,400 km2	Distribution hub: 1; Satellite facilities: 7 (capacity of 6,000 daily items)	NA	Deliveries: 15,500/day; Average demand density: 6.5/km2; Max demand density: 93/km2	Items/delivery: slightly more than 1; Delivery vehicle: minivans	NA
(Dabidian et al., 2016)	Berlin	Simulation	Literature; case studies; published texts; statistics; primary data analysis; German Classification of Economic Activities (2008); Statistik Berlin Brandenburg (2015)	NA	2008-2015	Inhabitants: 3.5 million; Districts: 12; Quarters: 96; Surface environmental zone: 88 km2	Environmental zone: 88 km2	Companies: 171,000; Retailing companies: 11,500; Gastronomy companies: 11,000; Service companies: 58,500; Organisations or universities: 473	NA	Number of vehicles (CEP service providers): 211,000	Urban
(Moshref-Javadi et al., 2020)	São Paulo	Modelling	Data of a major e-commerce platform in São Paulo; Google Distance Matrix	NA	NA	NA	Distribution centre distance: 5.3-6.3 km	NA	Delivery density: 28-101 customers/km2	NA	Neighbourhood
(Moshref-Javadi et al., 2020)	Manhattan	Modelling	<a href="https://www.citylab.com/transportation/2017/04/cities-seek-deliverance-from-the-e-commerce-boom/523671/">https://www.citylab.com/transportation/2017/04/cities-seek-deliverance-from-the-e-commerce-boom/523671/</a>	NA	NA	NA	NA	NA	Deliveries: 120,000/weekday	NA	Neighbourhood
(Pan et al., 2015)	Hangzhou	Simulation	Open databases of taxi GPS traces and locations of shops	500	NA	Area: 15km*30km	Number of "shop type" points of interest: 3,000	NA	Number of packages: 2,000/month/852 shops	NA	Urban
(Guo et al., 2017)	Shanghai-Pudong	Modelling	Google Maps data; assumptions	NA	NA	NA	NA	Return: 10% of demand	Demand: 150 items/day/customer group	NA	Neighbourhood
(Yuen et al., 2018)	Singapore	Survey	Street-intercept survey at three locations in Singapore ( <b>not representative</b> )	164	2016	NA	NA	Compatibility; relative advantage; complexity; trialability; observability; intention to use self-collection services	NA	NA	Urban
(Rosano et al., 2018)	Turin	Simulation	City map; travel times; customer locations; speed from city sensors; international transportation courier operating in Turin	NA	2014-2015	NA	NA	Customers offline: 70%; Customers online: 30%	NA	Traditional couriers (vans): 15; Green couriers (cargo-bikes): 5; Single transportation courier: 25 new requests for parcel deliveries per day	NA
(Wang & Zhou, 2015)	New York State Capital District	Survey	U.S. National Household Travel Survey: personal related variables; household related variables; regional specific variables	239,092	2009	Counties: 11; Zip code areas: 106; Area: 7,228 m2; Population (2010): 837,937	NA	NA	Home deliveries: 3,14 million/year; Home deliveries: 5.2/person/year; Home deliveries: 0.43/person/month; Home deliveries: 1 out of 69 persons/day	Total residential freight trips: 2,89 million; Total business freight trips: 9.25 million; "The freight trips generated by residential areas are about 31% of the freight trips generated by businesses."	NA

(Cherrett et al., 2017)	Southampton	Survey	Delivery audit of four halls of residence at the University of Southampton (5,050 residents); annual package receipt records from Southampton Solent University halls (2,294 residents); online shopping survey to Southampton University students the week following "Black Friday" (486 responses, <b>not representative</b> )	486	2015-2016	Population: 250,000	Universities: 2	Attitudes towards home delivery options	28,000 packages/8,886 residents (= 2 universities, 14 student hall complexes) /year; 14 packages/student/year; Black Friday: 2.4 x higher for frequent online shoppers	14 packages/student/year = 13,500 visits across 20 different LSPs; "Saturday was the least busy day (34 visits), while weekdays saw a fairly even spread of between 45 and 51 visits in total across all four sites."; Carrier delivery frequency and vehicles	NA
(Alves et al., 2019)	Belo Horizonte	Simulation	Ebit data; Oliveira et al.; Brazilian Institute of Geography and Statistics; directly collected information from transport service providers; literature	NA	2019	Inhabitants: 2.5 million; Surface: 331 km <sup>2</sup>	NA	Online shoppers: 30% of population; Online shoppers interested in lockers: 43%	NA	Motorized vehicles: 1,714,233; Motorization index: 1.46 inhabitants/vehicle	Urban
(Alves et al., 2019)	Belo Horizonte -Contorno	Simulation	Ebit data; Oliveira et al.; Brazilian Institute of Geography and Statistics; directly collected information from transport service providers; literature	NA	2019	Inhabitants: 93,684	NA	Online shoppers: 28,400	Customer order quantity: 1/year; Orders amount: 79/day	Number of trucks: 6; Weight of trucks: 1,500 kg; Volume of trucks: 10 m <sup>3</sup> ; Speed of trucks: 10 km/h; Truck stoppage time: 15 mins; Truck unloading time: 8 mins; Customer average time to receive orders: 9 days	Neighbourhood
(Gatta et al., 2019)	Rome	Survey	Stated preference survey among inhabitants in Rome (demand-side; <b>not representative</b> ), stated preference survey among metro users in Rome (supply-side; <b>not representative</b> ), information derived by elaboration of data from different sources, <a href="https://www.bemresearch.it/report/e-commerce-italia/">https://www.bemresearch.it/report/e-commerce-italia/</a>	240 +240	2017-2018	Inhabitants (Rome): almost 3 million	NA	NA	E-shopping rate (2017): 0.0262 orders/day/inhabitant; E-shopping rate (2017): 6.5 orders/year/inhabitants; Likely e-shopping rate (2025): 12.4 orders/year/inhabitants; Orders/day: 14,100	Morning peak trips by citizens: around 700,000; Lost hours due to congestion: about 135 million; Operator vehicles employed in the city center: 32,700; Loading and unloading operations: 35,000/day	Urban
(De Oliveira et al., 2019)	Belo Horizonte	Modelling	Oliveira et al. (2017); data and locations for establishments	NA	2017	NA	Drugstores: 128; Gas stations: 52; Post offices: 73; Supermarkets: 18; Malls: 30	Willingness to parcel pick-up: 63%; Travel to collection points	NA	Motorized population: 1,907,891 vehicles (69% cars, 15.2% light freight vehicles, 13% motorcycles, 2% heavy freight vehicles, 0.8% buses); Motorization index of 1.31: 1.31 inhabitants/vehicle	Urban
(Gatta et al., 2018)	Rome	Survey	Stated preference survey among inhabitants of the city of Rome ( <b>not representative</b> )	240	2017	Inhabitants (Rome): almost 3 million	NA	NA	E-shopping rate (2017): 0.0262 orders/day/inhabitant	Morning peak trips by citizens: around 700,000; Lost hours due to congestion: about 135 million; Operator	Urban

										vehicles employed in the city center: 32,700; Load factor (volume): 50%	
(Perboli et al., 2018)	Turin	Simulation	Interviews with CEO and logistic director of an international parcel delivery company and of an e-commerce company; data on customer distribution and delivery volume; city network; Google Maps	NA	2014-2015	Area (centre+semi-central area in Turn): 2,805 x 2,447 km	Distribution centre (outskirts): 1; Mobile depot (city centre): 1	Three different-sized operational contexts with respectively 500, 250 and 100 potential customers. Each context contains 70% of offline customers and 25% of prime members	NA	Van: 40 km/h; Cargo bike: 20 km/h	Neighbourhood
(Castillo et al., 2017)	New York-Manhattan	Simulation	Literature; <a href="https://nycopendata.socrata.com/">https://nycopendata.socrata.com/</a> ; discussions with managers from courier companies in San Francisco, Dallas, Nashville, and other major American cities; NYC government database	NA	NA	NA	Amazon's Manhattan fulfillment center; Business and residential addresses: 94,000	NA	NA	Follow-up delivery acceptance rate of 75%	Neighbourhood
(Arnold et al., 2018)	Antwerp	Simulation	LSP dataset; interviews with drivers and managers; field study of accompanying a driver on a typical delivery day; Open Street Maps	NA	NA	Area (Antwerp): 4 km <sup>2</sup>	NA	NA	Deliveries (large LSP; centre of Antwerp): 2,000/day; Deliveries (smaller LSPs; centre of Antwerp): 100/day	Average time per delivery: 2.5 min; Probability that a delivery fails: 11%; Driving speed (van): 17 km/h; Capacity limit (van): 300 parcels; Stem mileage (van): 10 km; Delivery tour (van): 6h; Activities before and after delivery tour (van): 2h; Customers/tour (van): 99; Driving speed (cargo bike): 12 km/h; Capacity limit (cargo bike): 10 parcels	Urban
(Deutsch & Golany, 2018)	Toronto	Modelling	Berman, Krass, and Wang (2006); Friend (2015) and McKinnon (2015)	NA	2006-2015	Population (2006): 2.5 million; Population (2017): 2.79 million	Lockers (Amazon; 2017): 40	NA	Number of orders: 9,025/day	NA	Urban
(Cardenas et al., 2017)	Antwerp	Modelling	Surveys with two of the bigger parcel logistics companies in Belgium; secondary sources	NA	NA	Inhabitants: over 500,000; Radius: 8.07 km	NA	NA	NA	Average car speed: 15.61 km/h; Number of stops (single carrier): 350/day; Number of stops (all carriers): 4,000/day; Standard shipping rate (Amazon): \$2.5	Urban
(Cepolina & Farina, 2015a)	Lisbon-Barreiro	Modelling	NA	NA	NA	Area (old part): 1 km <sup>2</sup>	NA	NA	Packages to consumers: 811/day; Packages to commercial activities: 11,864/day	NA	Neighbourhood
(Rajan & Rajesh, 2020)	Bangalore	Simulation	Interviews with three cargo bike drivers (Amazon, Flipkart) and two truck drivers (light &	NA	NA	NA	NA	NA	NA	Cargo bikes/trucks target: 100 to 120 packets/day; Driver's	Urban

			heavy vehicles); video graphic study							travel limit/day (cargo bikes): 80-90 Km; Driver's travel limit/day (light vehicle): 60 Km; Driver's travel limit/day (heavy vehicle): 30 - 40 Km	
(Melo & Baptista, 2017)	Porto	Simulation	Wind shield survey	NA	NA	Inhabitants: 237,000	NA	NA	NA	90% of stores: 1 parcel/day; "At some stops, the driver makes deliveries to more than one store."	Urban
(Cattaruzza et al., 2017)	NA	Literature review	NA	NA	NA	NA	NA	NA	% of deliveries with respect to the total number of deliveries	Road occupancy rates; % of routes to total number of routes; % of weight delivered to total delivered weight	Urban
(Heitz et al., 2019)	Paris	Modelling	Location of warehouses and terminals in Paris; SIRENE file; aerial and street photographs; field studies; local planning documents; NACE codes	NA	NA	Population density (Paris): 21,347/km <sup>2</sup> ; Population density (Petite Couronne): 6,767.6/km <sup>2</sup> ; Population density (Grande Couronne): 458.5/km <sup>2</sup> ; Population density (total): 986.7 km <sup>2</sup> ; Average size (Paris): 5,164.5 m <sup>2</sup> ; Average size (Petite Couronne): 5,610.6 m <sup>2</sup> ; Average size (Grande Couronne): 12,986.7 m <sup>2</sup> ; Average size (total): 9,599.1 m <sup>2</sup>	Average distance from center (Paris): 4.3 km; Average distance from center (Petite Couronne): 12.1 km; Average distance from center (Grande Couronne): 26.7 km; Average distance from center (total): 19.9 km; Share of total of facilities (Paris): 1.2%; Share of total of facilities (Petite Couronne): 44.7%; Share of total of facilities (Grande Couronne): 54.1%	NA	NA	Average number of logistics facilities employees (Paris): 49.5; Average number of logistics facilities employees (Petite Couronne): 49.2; Average number of logistics facilities employees (Grande Couronne): 77.3; Average number of logistics facilities employees (total): 64.4	Urban
(Xue et al., 2019)	Changsha	Modelling	Point of interest data; Changsha Statistical Yearbook	NA	2018	Land area: 11,819.5 km <sup>2</sup> ; Area: 11,819.5 km <sup>2</sup> ; Population: 6,959,900 Density: 0.036/km <sup>2</sup>	Express business sector 2018-2019: +30,65%; Total delivery points: 437; Cainiao Stations: 367; China Post stations: 70	NA	NA	NA	Urban
(Simoni et al., 2019)	Rome-freight restricted traffic area	Simulation	Mobility Agency of Rome; Google Traffic; Municipal Police in Rome; Serafini et al. (2018); interviews with major carriers	NA	2018	Inhabitants: 73,000; Surface: 5 km <sup>2</sup>	NA	NA	Online daily purchase rate: 2.62%/inhabitant; Parcel deliveries: 3,500/day	Delivery route: 50 stops; Delivery route: 60 deliveries; Tour distance: 60 km (from main depot); Delivery stop: 3 min	Neighbourhood