Preprint

Research in urban logistics: a systematic literature review

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Abstract

Purpose. The last decades have witnessed an increased interest in urban logistics originating from both the research and the practitioners' communities. Sustainable freight transports today are on the political, social and technological agenda of many actors operating in urban contexts. Due to the extent of the covered areas and the continuous progress in many fields, the resulting body of research on urban logistics appears quite fragmented. From an engineering management perspective, this paper presents a systematic literature review that aims to consolidate the knowledge on urban logistics, analyse the development of the discipline, and provide future research directions.

Design/methodology approach. The paper discusses the main evidence emerging from a systematic literature review (SLR) on urban logistics. The corpus resulting from the SLR has been used to perform a citation network analysis and a main path analysis that together underpin the identification of the most investigated topics and methodologies in the field.

Findings. Through the analysis of a corpus of 104 articles, the most important research contributions on urban logistics that represent the structural backbone in the development of the research over time in the field are detected. Based on these findings, this work identifies and discusses three areas of potential interest for future research.

Originality/value. This paper presents an SLR related to a research area in which the literature is extremely fragmented. The results provide insights about the research path, current trends and future research directions in the field of urban logistics.

Keywords: urban logistics; city logistics; urban freight transport; systematic literature review

Article classification: Literature Review

INTRODUCTION AND BACKGROUND

The continuously increasing share of the population living in urban areas, the concerns for pollution and safety in cities, the issues of traffic and congestion, and the newly available technological opportunities have attracted the attention of researchers and policy makers of urban transport. Focusing on freight transport, several problems must be addressed, such as the increasingly fragmented demand due to the spread of e-commerce (Esser and Kurte, 2005) and the synchronization and harmonization of the different flows of goods (Alho and de Abreu e Silva, 2015; Rose et al., 2016). Freight transport has also been acknowledged as a significant disturbance to the liveability and quality of urban spaces, especially near areas of historical and artistic value that must be preserved and made accessible and enjoyable to citizens and tourists (Dablanc, 2011). Consequently, this paper focuses on urban logistics, frequently referred to as city logistics (CL) or urban freight transport, whose solutions aim, on the one hand, to reduce all of the aforementioned negative impacts and, on the other hand, to offer better and faster deliveries. Throughout this manuscript, the terms city logistics and urban logistics are used interchangeably.

Even though urban logistics has been investigated for several years, the subject is still evolving because of the continuous changes in citizens' habits, such as e-commerce and greater sensitivity to environmental issues, and the unceasing technological evolution enabling new delivery scenarios, such as electric vehicles with greater autonomy, drones and driverless vehicles. However, despite its importance and increasing relevance, the literature on urban logistics is quite fragmented, thus hindering a holistic understanding of the topic and making it difficult to highlight the gaps that must be addressed. An initial review performed at the beginning of our study revealed the lack of a comprehensive and systematic literature analysis that consolidates the knowledge on urban logistics and analyses the development of the discipline. On the contrary, there are many contributions in many different fields and a considerable number of papers that refer to very specific problems, such as the distribution of drugs in pharmacies or specific typologies of food such as milk in urban centres, schools, and hospitals as well as other urban logistics problems related to temporary construction sites or large events. Therefore, this paper presents the results of a systematic literature review (SLR) on urban logistics from a logistics and management perspective. An SLR allows for a detailed longitudinal analysis of literature and thus enables the consolidation of the knowledge on urban logistics and the analysis of the development of the discipline to provide potential directions for future research development. Gathering information from 104 papers published in peer-reviewed journals for the period 2000 to 2015, this paper provides an overview of the main topics and their evolution over time as well as a review of the main methodologies employed. Through a citation network analysis, seminal contributions that oriented the development of the discipline over time are also identified and discussed.

Objective of the research

In the scientific literature regarding urban logistics, it is possible to identify different focuses and different subjects of investigation. Some papers focus on specific topics or specific areas, whereas others are less focused and discuss several topics at once. For instance, McLeod et al. (2011) focus on loading bays, while Stathopoulos et al. (2012) discuss the broader area of stakeholder reactions to innovative public policies. Some papers focus on steps, tools and models to design an urban logistics solution (Qureshi et al., 2009), whereas others explore the economic and environmental performance of an urban logistics solution (Lebeau et al., 2015; Lindholm and Brown, 2013). Because no systematic analysis of these topics is available, the first research question (RQ) addressed in this paper is:

> **RQ1.** What are the main topics, that is, the main subjects of discussion in a paper, in urban logistics and what are the evolutions of those topics over time?

Another important element is the research methodology employed in the various studies. In this respect, the literature reveals exceedingly different approaches that range from case studies (i.e., an in-depth and detailed examination of a subject of study (Figliozzi, 2011; Arvidsson, 2013) to mathematical and statistical modelling (Hensher and Puckett, 2005; Yang et al., 2015) to survey and stated preferences (Dablanc, 2007; Anand, 2012). While it can be hypothesized that certain methodologies better suit certain topics, this analysis has never been realized. Nonetheless, such an analysis can provide interesting insights on the most suitable approaches when dealing with a topic, or it can identify which methodologies are necessary to offer complete coverage of a topic. Consequently, the second research question is:

> **RQ2.** What are the main research methodologies employed and how are they related to the main topics?

Finally, given the variety of the topics and the various research methodologies, the last objective is to understand the core line of the development of the discipline, not only for historical reasons but also to identify the most viable directions for future research. Thus, the third research question is:

> **RQ3.** Which papers were most instrumental in driving the development of the literature thus far?

To answer the above RQs, we opted for a systematic literature review (SLR) with a specific focus on urban logistics solutions and the methods by which these solutions are implemented. The remainder of the paper is organized as follows. First, the SLR protocol, the classification of the papers and the analysis that led to the answering of the research questions are discussed. Next, the main findings from the collected corpus of papers are reported, distinguishing the main topics addressed and their evolution over time, thus answering RQ1. The following sections then discuss the main methodologies employed in the corpus, report the results of the analysis of the main papers and the concepts presented in those papers, and highlight three possible areas for future research that emerged from the analysis of the corpus, thus answering RQ2 and RQ3.

THE RESEARCH METHOD

The SLR is selected as the research method for this study because of the nature of the research questions, which aim at understanding trends and detecting existing gaps in the scientific literature. The SLR method has been used to consolidate emerging topics in other areas, such as the role of logistics in achieving agility (Gligor and Holcomb, 2012), the extensions of sustainability codes to suppliers (Gimenez and Tachizawa, 2012), and the servitization of manufacturing (Lightfoot et al., 2013).

A review earns the adjective "systematic" if it is based on clearly formulated questions, identifies relevant studies, appraises their quality and summarizes the evidence by use of explicit methodology (Khan et al., 2003). In this way, a systematic literature review overcomes the perceived weaknesses of a narrative review (Tranfield et al., 2003). Moreover, an SLR provides a replicable research protocol (Denyer and Tranfield, 2009), and the detailed documentation of the performed steps within the SLR enables in-depth evaluation of the conducted study (Kupiainen et al., 2015).

This study followed the guidelines provided in the most prominent articles (Kitchenam et al., 2007; Kitchenam and Brereton, 2013; Touboulic and Walker, 2015; Tranfield et al., 2003) to devise a robust and replicable study. In particular, a three-step protocol was developed to identify a valid procedure for performing an automated research so the SLR can be replicated by other researchers (Kitchenam et al., 2007).

Step 1: Inclusion/exclusion criteria

First, a preliminary list of the keywords and inclusion criteria were identified, and the concept of urban logistics was defined by its various synonyms (e.g., urban freight transport, urban delivery) in the keywords, making our research as comprehensive as possible (Wong et al., 2015). Moreover, the research focused on papers published in refereed journals in the field of logistics, transportation, management and economics for the period 2000 to 2015. The starting year was selected because, even though the term "city logistics" first appeared in the 1990s (Wissman, 1994; Nemoto, 1997), the major push in the scientific literature began around the year 2000. Conference proceedings and grey literature, i.e., technical reports and works in progress, were excluded from the corpus. Therefore, the review was limited to peer-reviewed publications to gain consistency between themes and sources (Touboulic and Walker, 2015) and to ensure the quality of the selected papers (Burgess et al, 2006). Although excluding grey literature or relevant conference proceedings from the sample can limit the assessment of recent, ongoing research efforts, this approach has often been followed by other researchers to ensure the level of quality of the included material (e.g., Netland and Aspelun, 2014; Gimenez and Tachizawa, 2012).

The search was launched based on a first set of criteria similar to that reported in Table 1. Major publishers' databases and library services, such as Elsevier, Sciencedirect, Emerald, Springer, and Wiley, were selected for the analysis. Following this, a double-blind control test was performed (Tranfield et al., 2003) on 50

papers to verify and refine the selection criteria. More specifically, each author carried out a manual selection of the articles to verify their coherency with the inclusion and exclusion criteria. Every paper that met with disagreement regarding inclusion/exclusion criteria was read and discussed until agreement was reached. This led to the definition of the final selection criteria as reported in Table 1. The query was then launched again, which resulted in the extraction of 298 papers (Figure 1).

Inclusion Criteria	**Description**
Keywords	urban logistics, city logistics, urban freight, last mile delivery, urban delivery
Language	English
Document types	Articles
Source types	Peer-reviewed journals
Time Interval	2000 - 2015

Table 1 – Inclusion criteria for paper selection

Step 2: Selection based on title and abstract

Each researcher reviewed the titles and abstracts of selected papers. Following a discussion among the authors, papers out of the research scope were removed from the corpus. In particular, 161 papers that did not focus strictly on urban logistics but focused instead on issues such as health, urban planning, climate change or social aspects and papers that adopted an approach other than logistics or management, such as mathematical, chemical, energy, or an environmental approach, were excluded.

Step 3: Selection based on full text and snowballing

The last step of the protocol involved the refining of the list of selected papers. After reading the full versions of candidate papers, 34 papers were not in the scope of our research, i.e., engineering management approaches to urban logistics, and were excluded.

Authors then checked the references of all selected papers, i.e., backwards snowballing, and identified the most cited papers, i.e., those with more than five citations from other papers already selected. If these most cited papers were missing from the corpus and coherent with inclusion criteria, they were added (Browne et al., 2011), leading to a final corpus of 104 papers. The results in terms of the number of papers resulting from the selection protocol in the SLR are summarized in Figure 1. The complete list of papers is available from the authors upon request.

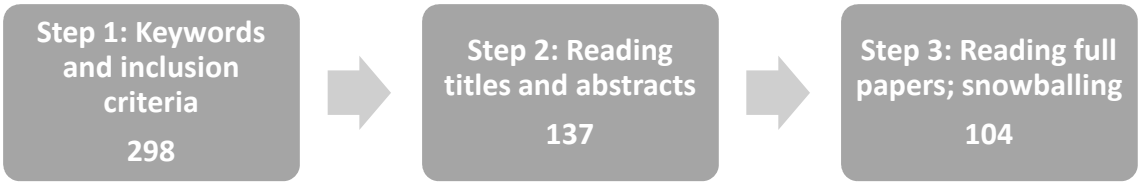

Figure 1 - Systematic literature review results according to the selection protocol

Considering the corpus of 104 papers, some descriptive statistics were first performed. To answer RQ1 and RQ2, a classification of the papers based on the topics and methodological approaches was performed. Finally, to respond to RQ3, a citation network (CN) was developed and main path analyses were conducted to highlight the backbone of the development of the scientific field and provide a dynamic perspective by analysing the chronological network of citations. The details of these analyses and an explanation of how they were performed are reported in the next sections of this paper.

DESCRIPTIVE ANALYSIS OF THE CORPUS

Figure 2 presents the distribution by year of the papers in the corpus. Despite some fluctuations in the considered time interval, it is possible to appreciate the steady increment of contributions regarding urban logistics in the last five years, thus confirming the current relevance of the subject.

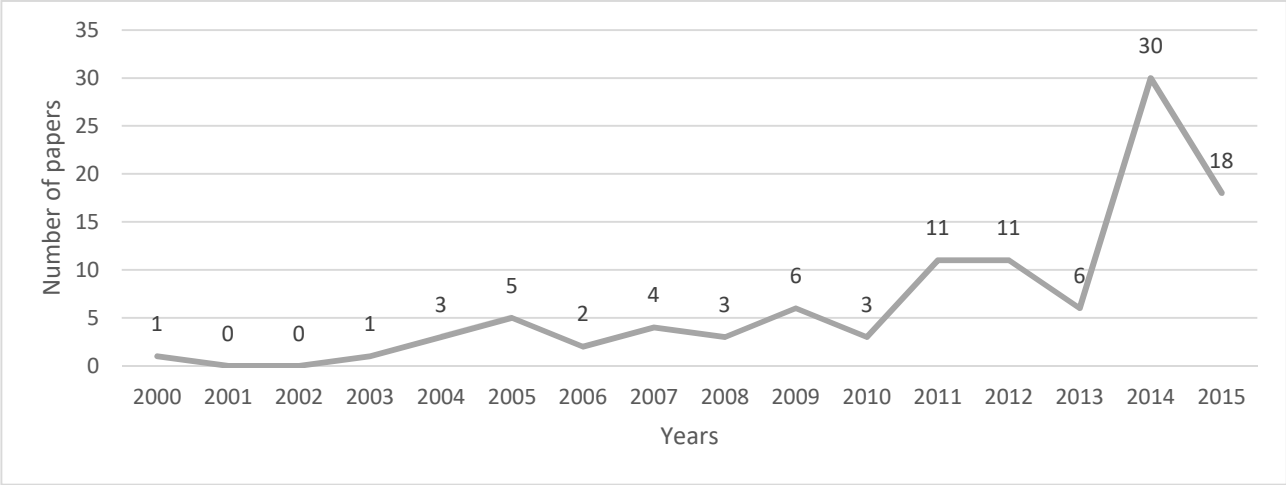

Figure 2 - Papers distribution by year of publication

The peak in the number of papers in 2014 is partially due to a special issue titled "Managing Freight in Urban Areas", which appeared in the journal, "Research in Transportation Business & Management" (Volume 11, July 2014). In fact, 12 papers of the corpus appeared in this special issue (which accounts for 15 papers in total). However, as the scope of the special issue was exceptionally broad and featured a wide range of topics, it did not bias the subsequent analyses. Moreover, even excluding the papers published in this special issue, there would still be a peak of 18 articles in 2014, again confirming the growing trend in the articles published on urban logistics through the years. Altogether, our corpus includes 24 different journals (Figure 3), and there is no dominant journal, even if urban logistics is primarily addressed by journals focus on transportation as their main subject of investigation. Despite this, the corpus also comprises journals focusing on management, operations and logistics disciplines.

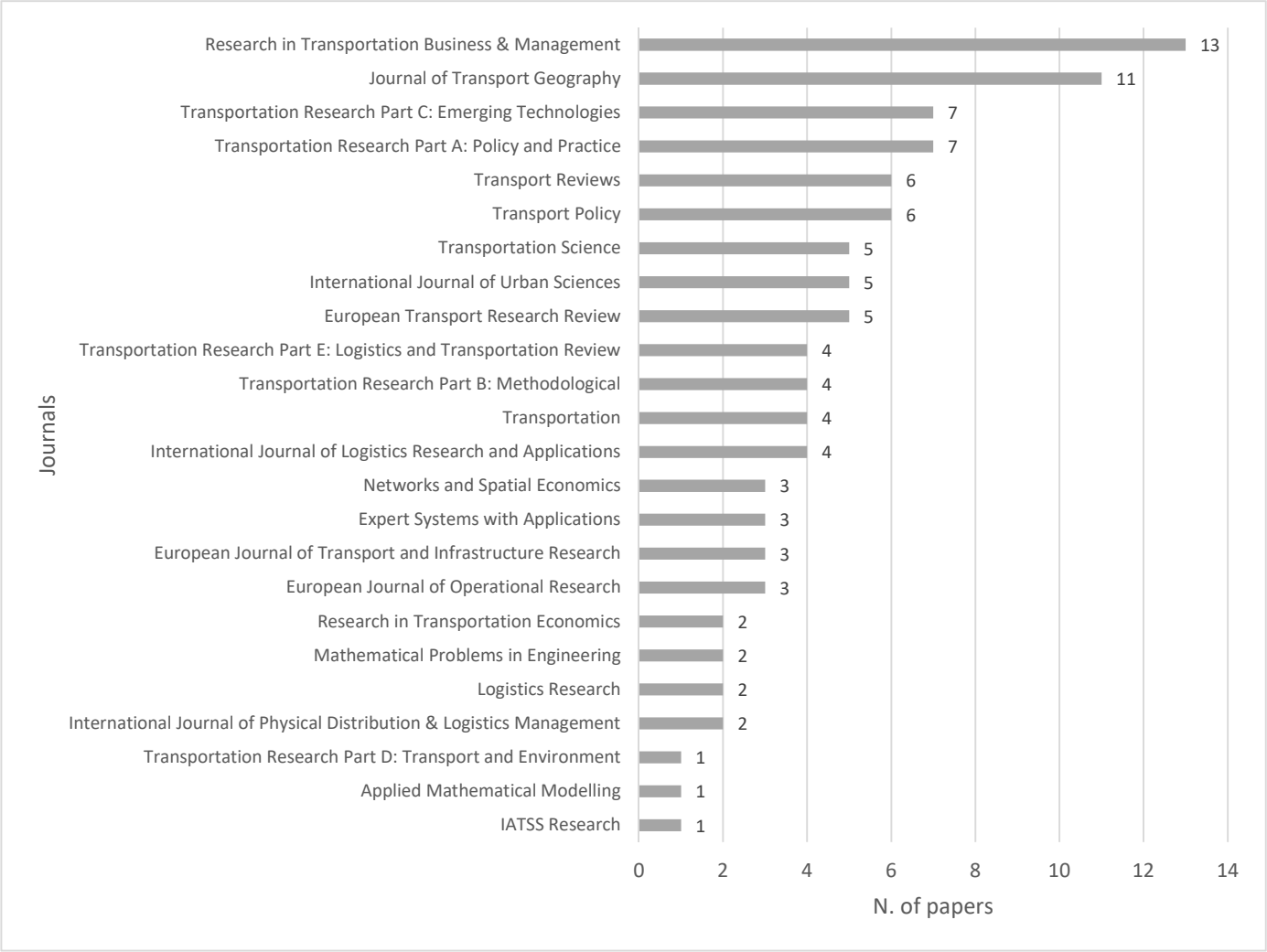

Figure 3 – Number of papers for each journal in the corpus

CLASSIFICATION OF THE PAPERS

To respond to RQ1 and RQ2, a classification of the papers based on the main topics addressed was performed. The classification followed a two-stage approach. First, each author independently analysed the same subset of 64 random papers and inductively defined his/her own list of topics. After a review of the lists and a discussion among the authors, the final topics list was defined and applied to the remaining 40 papers. This second stage highlighted the substantial stability of the classification as there were few disagreements. These few disagreements were resolved by the authors on a case-by-case basis.

The results of the topics identification are reported in Table 2. It is noted that each paper resulted in one or more topics being addressed with a maximum of five topics being addressed per paper for papers 2, 64, and 67.

Topic	Description	Papers
LTZ	A limited traffic zone (LTZ) is an urban area subject to traffic restrictions (e.g., time windows, limitations regarding weight, width and type of fuel).	19, 20, 22, 25, 41, 47, 48, 52, 57, 64, 75
Loading/ Unloading Areas	Papers related to loading/unloading areas refer to their ideal location to serve the largest number of commercial activities, their management system and rules for use and booking.	32, 33, 35, 45, 80, 85
Off-hour Deliveries	Shifting deliveries of goods from the standard time window (e.g., 9.00 am - 6.00 pm) to another period of the day (early morning or night).	17, 27, 46, 67
Road Pricing	All measures that involve payment of a toll for the use of a particular infrastructure (i.e., access to an LTZ, use of a bridge or of a bypass road).	17, 48
Multi-use Lanes	Sharing lanes between public transit and trucks.	6, 38
Tram for Goods	Use of trams to deliver goods in urban areas.	95
Stakeholder Involvement	Stakeholders' engagement and management in urban logistics projects.	2, 7, 9, 13, 14, 16, 17, 18, 19, 21, 25, 31, 33, 34, 35, 37, 40, 41, 42, 43, 46, 48, 49, 51, 58, 62, 63, 65, 67, 68, 69, 75, 78, 82, 86, 87, 91, 93, 94, 97, 100
Solution Performance Assessment and Comparison	This topic includes all methods to calculate the impact of urban logistics solutions on the transportation system (e.g., benchmarking, KPIs, definition) and the comparison among different urban logistics solutions to evaluate the optimal one that best fits the context.	1, 2, 3, 5, 7, 8, 15, 17, 19, 21, 34, 41, 43, 47, 49, 52, 54, 55, 58, 63, 64, 65, 67, 72, 80, 89, 91, 93, 94, 101
UCC/UDC/TP	Infrastructures that allow the consolidation of goods before the last mile delivery. These facilities are usually classified into three main types, namely, urban consolidation centres (UCCs), urban distribution centres (UDCs) and transit points (TPs), depending on how long goods remain in the warehouse and what type of actions are performed regarding freight (i.e., consolidation, transhipment).	5, 10, 13, 25, 28, 30, 37, 42, 45, 48, 50, 52, 64, 67, 70, 85, 92, 97, 98, 100, 103, 104
VRP Solutions	Vehicles routing problems (VRP) solutions refer to the optimization of paths of individual vehicles or a fleet of vehicles to reduce routes, waiting times, emissions of pollutants and traffic congestion.	1, 2, 4, 10, 11, 12, 15, 19, 20, 21, 22, 24, 25, 26, 29, 30, 32, 34, 36, 37, 39, 42, 44, 45, 50, 51, 52, 57, 59, 61, 64, 66, 67, 70, 71, 72, 73, 74, 83, 84, 90, 95, 98, 99, 103
ICT/ITS	The design and implementation of information and communication technology (ICT) solutions in urban logistics projects. The intelligent transport systems (ITS) includes advanced applications aimed to provide innovative services related to different modes of transport and traffic management and to enable various users to be better informed and thus make safer, more coordinated, and smarter use of transport networks.	2, 3, 4, 10, 12, 23, 24, 29, 32, 39, 57, 59, 64

E-Commerce	This topic concerns on-line goods purchasing and the related delivery processes. Papers addressing this topic were considered of interest because they considered the typical e-commerce customer living in an urban centre.	53, 60, 61, 74, 76, 77, 81, 84, 85, 88, 102
Pick-up Points	Pick-up points are prearranged places where people go to collect their on-line ordered parcels. Parcel lockers are last generation automatic dispensers that allow the delivery and retrieval of goods and documents around the clock.	53, 61, 74, 81, 85, 88
Green Vehicles	Use of vehicles powered by sustainable or less pollutant fuel (i.e., electrical, liquefied petroleum gas, compressed natural gas).	33, 38, 82, 83, 95, 96, 104
Bike Delivery	Use of cargo-bike for freight distribution in city centres.	56, 79, 100, 104
Low Emission and Pollution Technologies	Ways to reduce vehicle pollutant levels (i.e., CO2, NOx and PMx, and acoustic).	1, 2, 7, 12, 27, 28, 33, 35, 36, 44, 50, 56, 59, 81, 82, 88, 92, 96, 104
Drones	Use of drones to deliver goods in urban areas.	90

Table 2 – Topics in the paper corpus

Figure 4 displays the frequencies of the various topics as they appeared in the papers. It is noted that a paper can address more than one topic. The three most frequently addressed topics were:

- *Vehicle Routing Problems Solutions:* adaptation of VRP models to urban logistics problems (e.g., the location of a UCC, location of loading/unloading bays, optimal vehicle routing from the UCC, etc.)
- *Stakeholder involvement:* as stakeholders are fundamental to the success of city logistic projects, several papers describe how to engage stakeholders in the development of city logistic projects (e.g.,, Macharis et al., 2014; Gatta and Marcucci, 2014).
- *Solutions Performance Assessment and Comparison:* definition and assessment of quantitative (e.g., CO_2 emissions and other air pollutants, congestion, load factors, delivery times, etc.) and qualitative (e.g., liveability, accessibility, etc.) indicators to measure the impact or compare city logistics projects.

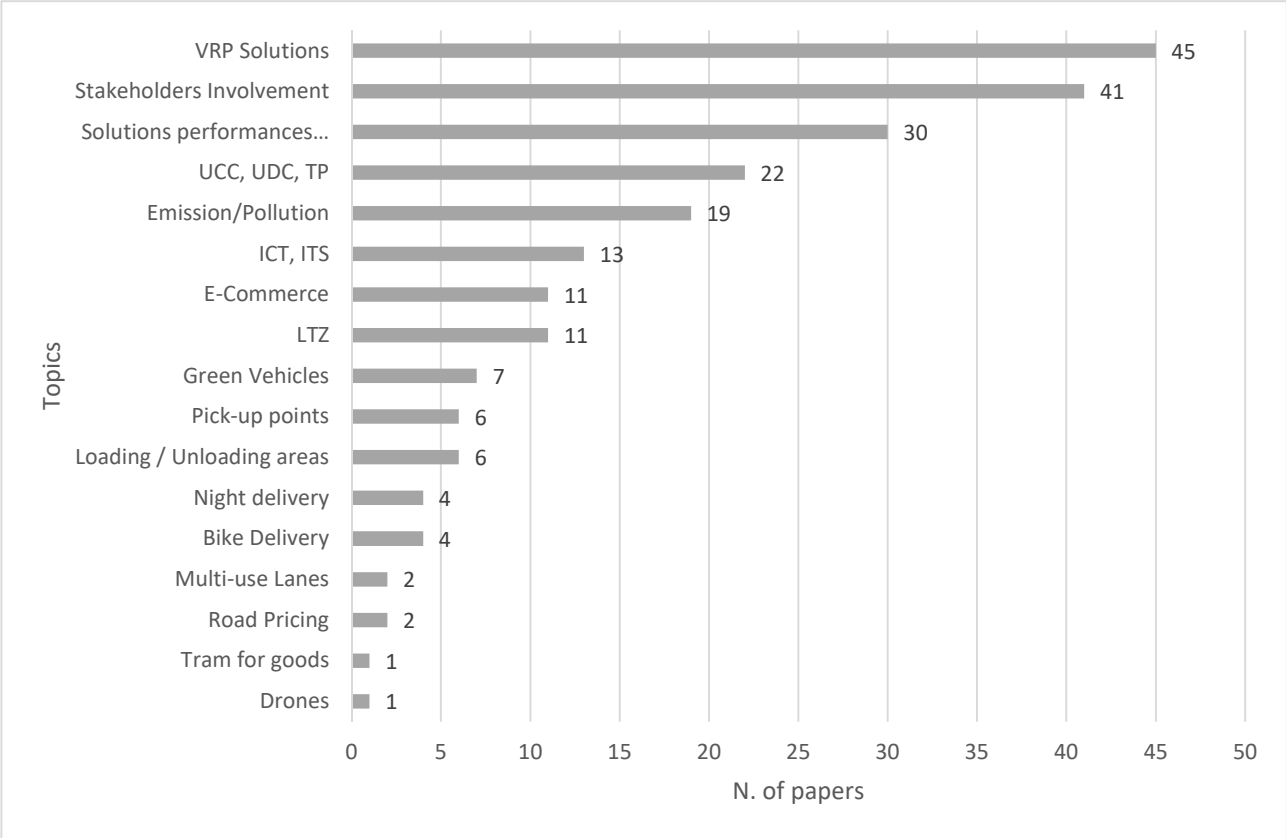

Figure 4 - Number of papers addressing each topic (each paper may refer to more than one topic)

Analysis of the relevance of the topics over time

The research efforts devoted to the different topics has changed over the years (Figure 5). At the beginning of the considered time period (2000 to 2005), only certain topics were being explored, such as, VRP solutions, ICT (especially on-board GPS instruments), emissions, and performance and solutions comparisons.

In a second phase (2006 to 2010), there was a growing interest in topics such as stakeholder involvement, LTZ, UCC, and VRP on a more complex level than those considered in the first phase and also encompassing time window problems and stakeholder behaviour). In recent years (2011 to 2015), the focus on some topics, such as road pricing and reserved lanes, has diminished whereas many new topics have surfaced, such as bike delivery, pick-up point deployment, e-commerce and drone deliveries, among others, while the interest related to stakeholders, VRP and evaluation of urban logistics solutions performances has remained substantially unchanged.

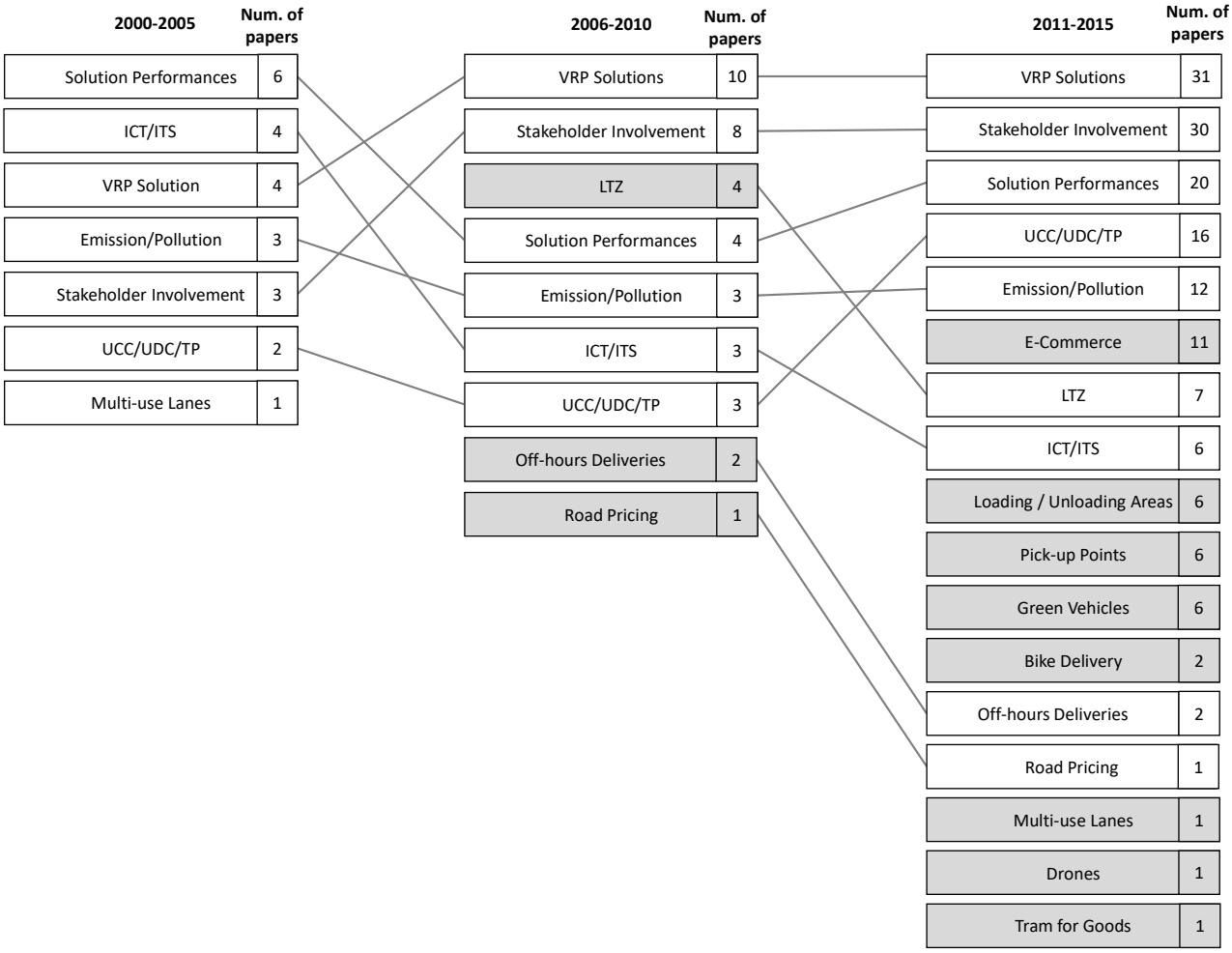

Figure 5 - Topic relevance over time (grey background = new topics addressed during the studied period)

MAIN RESEARCH METHODOLOGIES EMPLOYED AND RELATIONSHIP WITH THE MAIN TOPICS

To classify the research methodologies, the analysis followed an inductive approach similar to the one previously discussed for the classification of the topics. Each author independently classified the methodologies used in the papers based primarily on his/her own experiences. Then, following a discussion, a common classification table was developed by revising and grouping the various methodologies identified. For instance, case studies (single or multiple) and interviews were merged because they are always used jointly in our corpus.

The resulting classification is reported in Figure 6, where each paper could adopt more than one methodology, although the maximum number of methodologies per paper in the corpus is two.

In addition to the research methodology, it is important to consider the type of data collected and used in the study. Therefore, the analysis distinguished between qualitative (or unstructured) and quantitative (or structured) data. Quantitative data can be quantified and verified and are amenable to statistical manipulation. Such data include traffic flows, flows of goods, distances covered by a vehicle, orders from a store or from e-commerce customers. Conversely, qualitative data, such as opinions of stakeholders, cannot be measured directly. More simply, quantitative data define whereas qualitative data describe. By

using the two types of data together, a more complete examination of the phenomena being studied can be conducted (Creswell, 2009). The results of the classification of data are reported in Figure 7.

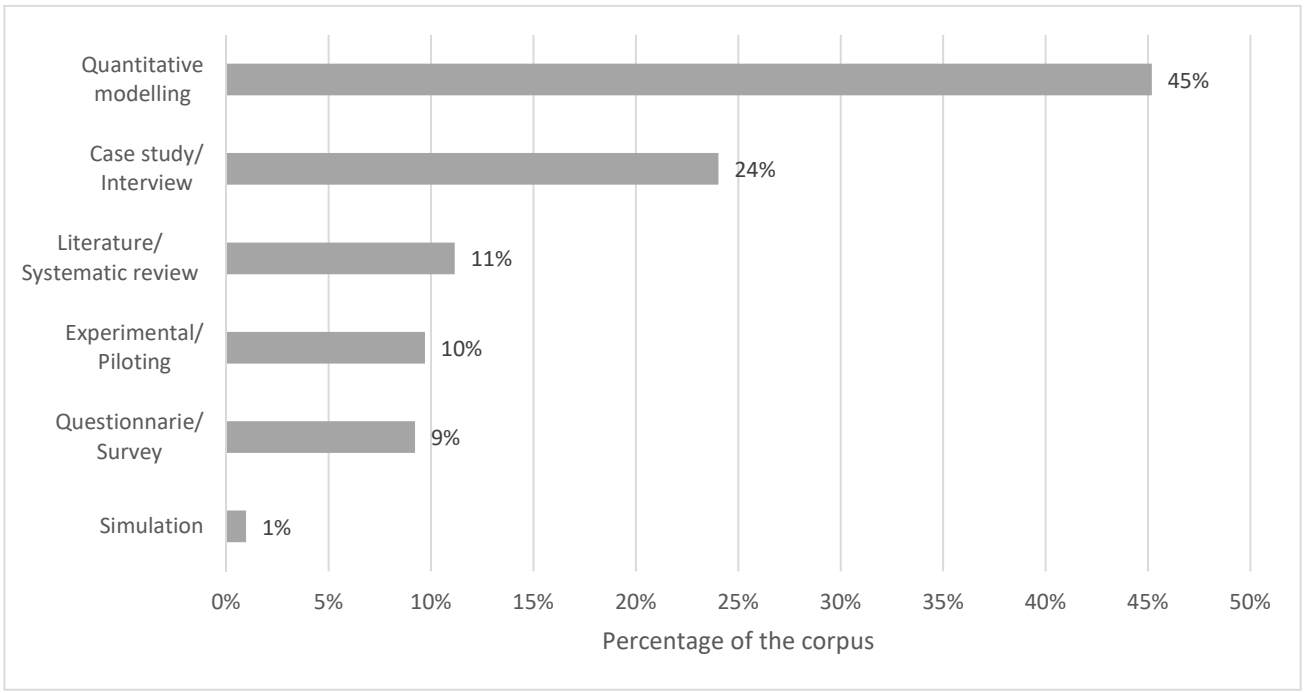

Figure 6 - Types of research methods in the corpus

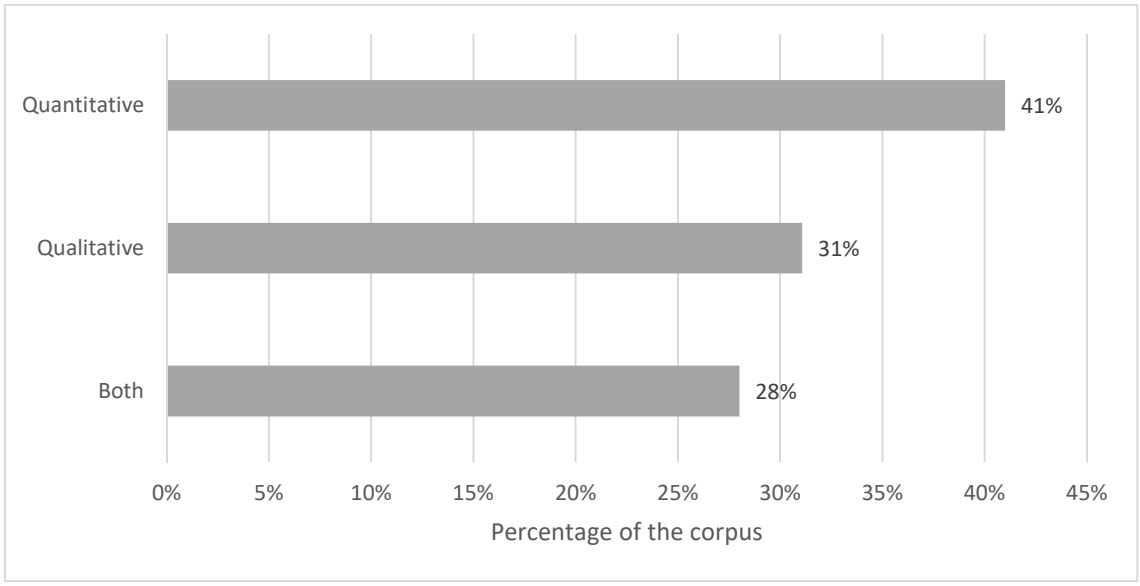

Figure 7 - Types of data used

Finally, linking the research methods with the topics covered in each paper, the results are displayed in Table 3. It is observed that there has been little use of experimental or piloting projects, surveys or literature review. As expected, quantitative models are mainly used for routing and scheduling problems to

optimize deliveries (Taniguchi and Shimamoto, 2004), identify the optimal location of UDCs (Yang and Moodie, 2011) or predict the behaviour of the actors involved through agent-based decision-making methods (Baindur and Viegas, 2011). Similarly, interviews and case studies are more often used to assess the potential effectiveness of urban logistics solutions (Himanen et al., 2005), to make comparisons between cities (Ballantyne et al., 2013) and to understand the views of the stakeholders involved in the decision-making process (Lindawati et al., 2014). Questionnaires and surveys, however, are adopted to a lesser extent compared to the previously discussed methodologies. These findings reveal potential areas for the application of surveys to extend and generalize findings resulting from the interviews and quantitative models. Only a few cases of reviews were found, and they are mainly reviews of projects rather than reviews of literature (Allen et al., 2012) and are, for the most part, related to the ITS or e-commerce sector (Giannopoulos, 2009; Vanelslander et al., 2013). This result highlights the applied rather than the theoretical character of urban logistics as a discipline that focuses on solving specific problems rather than on developing a shared vision of the key concepts. This last finding supports the contribution of this paper by providing a solid foundation of knowledge regarding urban logistics, as this analysis did not find evidence of literature reviews with a broad or longitudinal perspective of urban logistics.

	Case study/ Interview	**Quantitative Modelling**	**Questionnaire / Survey**	**Experimental / Piloting**	**Literature/ Systematic Review**	**Simulation**
VRP Solutions	19, 20, 32, 50, 51, 64, 67, 71, 73, 90, 99	1, 2, 4, 11, 12, 15, 20, 21, 22, 25, 26, 29, 30, 34, 36, 37, 39, 42, 57, 59, 61, 66, 74, 84, 95, 98, 99, 103	10, 45	32, 44, 52, 59, 71, 72	24, 70	83
Stakeholder Involvement	7, 16, 19, 33, 40, 41, 49, 51, 62, 67, 69	2, 9, 13, 17, 18, 21, 25, 31, 34, 35, 37, 42, 46, 48, 58, 65, 68, 82, 86, 91	14, 63, 87, 101	13	43, 75, 78, 93, 94	-
Solution Performance Assessment and Comparison	7,8,19,41,49,55	1,2,5,15,17,21,34,58,65,89	63,80,101	5, 47, 52, 72	3, 43, 93	-

UCC/ UDC/ TP	50,64,67,100, 104	5,13,25,30, 37,42,48,98,103	10,45,97	5,13,28,52,85	70,92	-
Low Emission and Pollution Technologies	7,33,50, 56,81,88, 104	1,2,12,35,36, 59,82,88,96	-	27,28,44,59	92	-
ICT/ITS	32, 64	2, 4, 12, 29, 39, 57, 59	10	32, 59	3, 23, 24	-
LTZ	19, 20, 41, 64	20, 22, 25, 48, 57	-	47, 52	75	-
E-Commerce	76, 81, 88, 102	53, 60, 61, 74, 77, 84, 88	102	76, 85	-	-
Loading / Unloading Areas	32, 33	35	45, 80	32, 85	-	-
Pick-up Point	81, 88	53, 61, 74, 88	-	85	-	-
Green Vehicles	33, 104	82, 95, 96	38	-	-	83
Off-hours Deliveries	67	17, 46	-	27	-	-
Bike Delivery	56,79,100, 104	-	-	-	100	-
Road Pricing	-	17,48	-	-	-	-
Multi-use Lanes	-	6	38	-	-	-
Drones	90	-	-	-	-	-
Tram for Goods	-	95	-	-	-	-

Table 3 – Topics and methods used in the corpus

MAIN CONTRIBUTIONS DRIVING THE DEVELOPMENT OF THE LITERATURE

To complement the analysis illustrated in the previous sections and to provide an answer to RQ3, a citation network analysis was performed to provide a better and deeper understanding of the literature in the field of urban logistics. Citation networks (CNs) are directed, acyclic networks whose nodes represent existing papers and whose edges connect citing papers to cited ones. A CN enables the analysis of the links between papers to discover relationships and to support the identification of connected topics. Furthermore,

citation networks can also direct researchers to specific knowledge areas and related subfields/communities.

The assumption underpinning a CN analysis is that researchers in the same field tend to cite each other to better position their work in the field (Hummon and Doreian, 1989). Intuitively, the papers most recognized as key contributors in the field are those receiving many citations from other authors.

The CN in Figure 8 was built from the corpus of the 104 papers resulting from the SLR and from analysing the respective citations. This paper adopted the convention according to which each arrow goes from the cited document to the citing document, thus representing the “is cited by” relationship. The CN comprises a large, well-connected portion of the collection as well as a set of isolated nodes, those listed on the right of the figure. These papers are those that neither cite nor are cited by the rest of the papers in the collection. Among these, approximately two-thirds are relatively recent works (published after 2012), for which the citation count can be influenced by their reduced exposure on the research stage. Regarding the less recent contributions, some do not focus exclusively on urban logistics, and others are based on grey literature (e.g., reports, projects, conferences) or are extremely focused on niche topics. Still, as all of these isolated papers do not cite any other paper in the corpus, they will likely not become nodal works in the development of the discipline (Yin et al., 2006; Lucio-Arias and Leydesdorff, 2008). Therefore, they were disregarded in the following analyses.

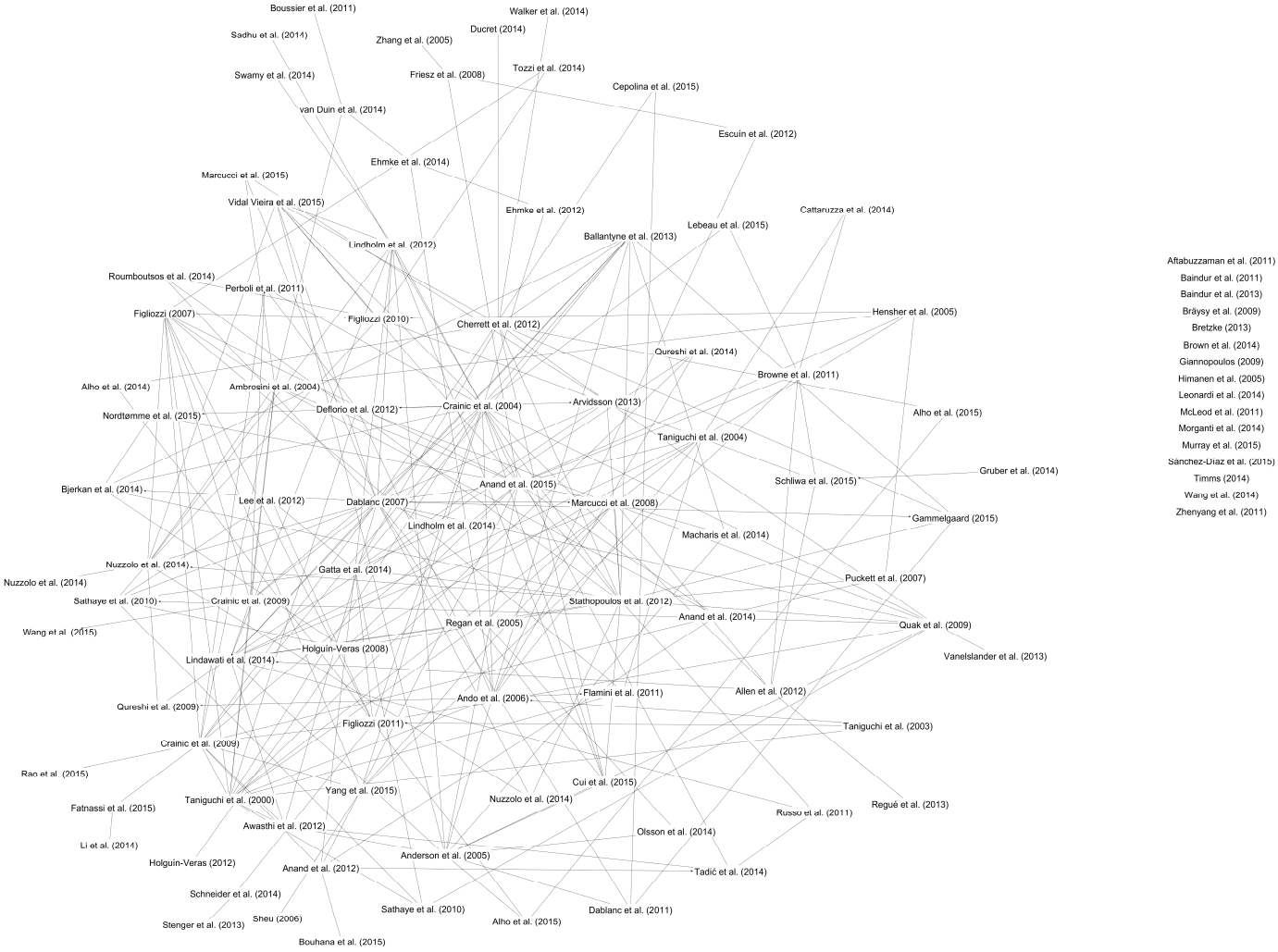

Figure 8 - Citation network from the corpus

To summarize the relevance of the papers in the corpus using the CN analysis, three indicators for each paper were computed:

1. Global Citation Score (GCS): total number of citations as in Scopus (i.e., from other papers within or outside the CN); the GCS measures the overall relevance of the paper in the literature.
2. Local Citation Score (LCS): number of citations only from other papers in the CN; the LCS measures the relevance of the paper in the corpus.
3. Closeness Centrality (CC) within the CN (Sabidussi, 1966): measured as the average distance in terms of the number of nodes to cross, as computed using the Pajek software, to reach all other papers; the CC identifies those papers that are highly cited or are cited by other highly cited papers and are therefore assumed to provide a relevant contribution to the theory (Colicchia and Strozzi, 2012).

Table 4 reports the ten most frequently cited papers according to the GCS, and it also reports the related LCS and CC values. As displayed in Table 4, the values of the different indicators are not always coherent

with each other. For example, a highly cited paper can have a lower CC than a paper cited fewer times. The discrepancy in the consequent rankings can be attributed to the fact that the LCS and GCS consider only direct citations, whereas CC considers all the citation links within the CN (Colicchia and Strozzi, 2012).

Title	Authors & Year	Journal	GCS	LCS	CC
Advanced freight transportation systems for congested urban areas	Crainic et al. (2004)	Transportation Research Part C: Emerging Technologies	100	20	0.3062
Goods transport in large European cities; difficult to organize, difficult to modernize	Dablanc (2007)	Transportation Research Part A: Policy and Practice	99	22	0.2678
Models for evaluating and planning city logistics systems	Crainic et al. (2009)	Transportation Science	82	9	0.1080
Intelligent freight-transportation systems; assessment and the contribution of operations research	Crainic et al. (2009)	Transportation Research Part C: Emerging Technologies	77	3	0.0310
Intelligent transportation system based on dynamic vehicle routing and scheduling with variable travel times	Taniguchi et al. (2004)	Transportation Research Part C: Emerging Technologies	76	5	0.0662
Urban logistics - How can it meet policy makers' sustainability objectives?	Anderson et al. (2005)	Journal of Transport Geography	73	12	0.1714
An evaluation methodology for city logistics	Taniguchi et al. (2000)	Transport Reviews	58	14	0.3185
Travel time reliability in vehicle routing and scheduling with time windows	Ando et al. (2006)	Networks and Spatial Economics	58	6	0.0618
Objectives, methods and results of surveys conducted in the field of urban freight transport: An international comparison	Ambrosini et al. (2004)	Transport Reviews	47	9	0.1811
Dynamic game theoretic model of multi-layer infrastructure networks	Zhang et al. (2005)	Networks and Spatial Economics	46	1	0.0174

Table 4 – Top 10 most frequently cited documents in the corpus (ranked by GCS)

Main path analysis

A main path analysis (MPA) highlights the structural backbone in the development of a scientific field and thus provides a dynamic perspective by analysing the chronological network of citations (Colicchia and Strozzi, 2012). In fact, the main path in a CN highlights those papers that build on prior papers, and it continues to act as an authority in reference to later works (Yin et al., 2006; Lucio-Arias and Leydesdorff, 2008). Indeed, citing previous works and being cited by subsequent literatures positions a paper in relation to other papers (Hummon and Doreian, 1989), and by defining these positions, main path algorithms make the structural backbone of a literature visible (Lucio-Arias and Leydesdorff, 2008).

The main path is built by calculating the connectivity of the links in terms of their degree centrality and outlining the path formed by the nodes with the highest degree. In terms of a CN, this degree measure considers the number of citations a paper receives (out-degree, according to our convention of arrow direction) as well as the number of cited references in the paper (in-degree). The main path is then constructed by selecting the papers with the highest scores until an end document is reached, that is, a paper that is no longer cited or one that contains no further references within the considered set (Batagelj,

2003). The main path resulting from the CN built from the considered collection is depicted in Figure 9 (using the Pajek software).

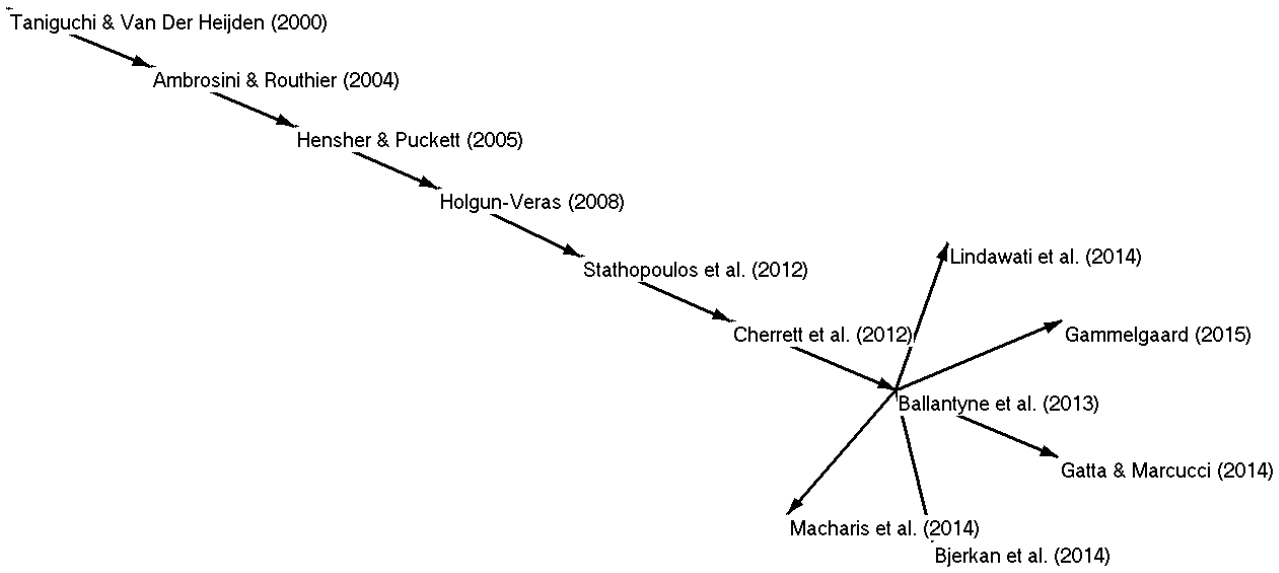

Figure 9 – Main path in the corpus

Analysing the main path, we conclude that the early research on urban logistics focused mainly on the evaluation of different methods to minimize adverse impacts on the environment and on the cost of freight transport in urban areas (Taniguchi and Van der Heijden, 2000; Ambrosini and Routhier, 2004). Later, it was realized that one of the main factors for the effective implementation of new solutions in urban freight was collaboration with stakeholders (Hensher and Puckett, 2005; Holguin-Veras, 2008). In urban logistics, there are various stakeholders (traders, traditional transporters, couriers, eco-friendly trucking companies) who, while pursuing the same objective, that is, the on-time delivery of goods to the destination point, have different operating characteristics and interests that make collaboration complex. For instance, Holguin-Veras (2008) investigate the acceptability of off-hour deliveries by stakeholders and highlight the negative elements as well as the benefits of delivery over time for both carriers and traders. Later, among the various stakeholders, the role of public authorities is analysed (Stathopoulos et al., 2012) as is the need to consider the characteristics of the different flows (Cherrett et al., 2012). Finally, Ballantyne et al. (2013) analyse the studies conducted in different countries, specifically, Sweden, the UK, and the Baltic region, and find that public authorities do not have a good understanding of urban logistics issues because they have not yet found an assessment method that simultaneously considers the complexity of the different solutions and the conflicting interests of the stakeholders. From this point, the main path shows the various ways different authors have tried to find this assessment method for decision making. Macharis et al. (2014) proposed a multi-actor multi-criteria analysis (MAMCA). According to Bijerkan et al. (2014) and Lindawati et al. (2014), the solution lies in overcoming barriers to collaboration among industry players so

they can support themselves in the implementation of new green solutions. Gatta and Marcucci (2014), however, suggest the use of an agent-specific approach that takes into account the specific characteristics of each stakeholder. Finally, Gammelgaard (2015) emphasizes that the implementation of new urban logistics solutions follows the same dynamics as those of the change process by alternating dialectical processes and purposes. Accordingly, this finding implies that the correct implementation of urban logistics solutions does not follow a linear path from start to finish but instead proceeds by trial and error.

MAIN RESEARCH ISSUES, GAPS AND FUTURE LINES OF RESEARCH

In addition to providing answers to the three research questions, the perusal of the literature on urban logistics allowed us to identify some directions for research that deserve further investigation by both academics and practitioners. At the European level, the European Road Transport Research Advisory Council (ERTRAC) and the Alliance for Logistics Innovation through Collaboration in Europe (ALICE) jointly published a roadmap that identifies future challenges related to urban freight delivery, returns and urban logistics to improve the efficiency, sustainability and security of these activities (ALICE/ERTRACT, 2015). However, the future directions of research proposed in this paper are based on the retrospective analysis of the evolution of the literature. Thus, the suggestions for future research presented in this paper focus on those areas that can help the discipline to consolidate and evolve cohesively while simultaneously addressing the future challenges noted in the literature. Therefore, three main areas of possible investigation from which future research could stem are proposed.

Stakeholder involvement

An element that emerges from the analysis, particularly with respect to the main path, is that there is not yet a shared and final perspective on how to involve stakeholders in the making of decisions related to urban logistics (see Figure 5). While recent research has begun to address this issue (Macharis et al., 2014; Gatta and Marcucci, 2014), still much research in urban logistics is focused on improving the technical aspects of the existing solutions or on proposing new solutions. Scholars seem to forget that many cities are still in the beginning phase of their urban logistics journey and are thus more focused on solving conflicts among stakeholders or that urban logistics solutions may sometimes appear simple from a technical perspective but be difficult to implement in a context where there are many stakeholders, none of whom wield sufficient power to enforce decisions (Lindholm and Browne, 2013).

Consequently, greater attention must be given to the development of new methods to support decision making for the ex-ante evaluation of the possible solutions and must taking into account the interests and preferences of the different stakeholders. Because stakeholder management has been addressed in numerous areas, such as corporate social responsibility and project management, it may be possible, from both the theoretical and practical perspective, for urban logistics researchers to inherit from the large body

of research already available (e.g., Bryson 2004; Fassin, 2012). For example, the literature suggests different ways to identify, classify, prioritise and engage the stakeholder based on certain key characteristics, such as power, interest, and legitimacy (Mitchell et al., 1997), even in the specific context of public-private partnerships (Schepper et al., 2014). Such an approach should be complemented by a toolkit for stakeholder management actions, such as approach, communication, and involvement, that are able to bring on board the key stakeholders (Bourne, 2008; Stathopoulos et al., 2012).

In this way, rather than passively include the opinion of all stakeholders, the project owner, for example, the municipality, can attempt to proactively influence and orient the attitude of the key stakeholders, thus enhancing the value and the acceptability of an urban logistics solution (Dablanc et al., 2011).

Pinto et al. (2015), for example, on the basis of the interactions with stakeholders, explain how a progressive approach that begins with data sharing and then moves towards easier solutions, such as loading/unloading bays optimization, and finally to more complex solutions, such as the UDC, can result in greater commitment from the stakeholders.

Urban logistics ecosystem

One of the causes of the fragmentation of the literature regarding urban logistics is the broad variety of topics, as presented in Table 2, which lists 17 different topics. Consequently, there is a lack of studies analysing urban logistics as a whole and comprehensive issue. An urban logistics solution, in fact, does not live in isolation, but rather, it represents a system within a larger system of systems, for example, a city. Nevertheless, exploring the literature, researchers usually adopt a traditional analytical or reductionist approach, which aims at decomposing all systems into ultimately simple indivisible parts to be investigated separately. Although effective in general descriptions, the main drawback of reductionism is that it neglects the reciprocal effects that the separated parts can have on each other as well as the circular feedbacks involving the different parts (Daellenback and McNickle, 2005).

According to a systemic view, the interaction among these parts (including stakeholders, as discussed in the previous section) yields the actual performance of the whole system; therefore, the critical factors or the success/failure of an urban logistics solution, particularly from the economic point perspective, should sometimes be sought outside the solution itself. For example, Rose et al. (2016) contend that understanding the interactions between urban logistics providers and the urban environment can allow for better management both of urban space and transportation firms.

In this respect, the interaction of two key components of an urban logistic ecosystem, namely, people and technology (together referred to as socio-technical systems), can be an interesting and relevant focus for future research. In particular, rather than taking a technology-centred approach, researchers could examine how people are influenced by and react to different technologies (Nam and Pardo, 2011), which

may lead to systems that are more acceptable to end users and deliver better value to stakeholders (Baxter et al, 2011).

As a recommendation for future research, the investigation of the impact of urban logistics solutions should be conducted using a systemic (or holistic) approach as such a perspective allows for focusing on the interactions between the elements rather than on the elements themselves (Senge, 2006). For example, the integration of a UDC and the related freight activities should consider the effects on other solutions that are either directly or indirectly related to urban logistics to highlight the reciprocal benefits and drawbacks and to identify potential synergies.

Common frameworks and data sharing platforms

As emerged from the analysis, in the literature, there is great interest regarding the comparison of different urban logistics solutions (Figure 4). Several papers based on in-depth case studies performed on single cities can be found, thus generating a useful library of experiences (e.g., Hesse, 2007). Nevertheless, these case studies are difficult to compare, as the time frame, data collection methods and contexts of the cities are often quite different. To overcome this problem, it would be useful to develop common frameworks to collect and analyse data. For instance, the creation of shared platforms, such as the Smart City Logistic (http://smartcitylogistics.org/), can help not only to create a common framework of analysis of urban logistics cases but also to incentive public and private stakeholders to provide data that, when combined, can prove to be extremely valuable to them (Golini et al., 2014). Through these platforms, researchers and policy makers can collect, analyse and visualize relevant urban logistics data for policy development (Merchan et al., 2015). Moreover, it would be possible to consider simultaneously the different characteristics of the urban ecosystem, such as the distribution of the population (e.g., Gatta and Marcucci, 2015) or the presence and extent of historical centres that feature a higher tourist concentration and narrow streets (e.g., Muñuzuri et al., 2005), a combination that can heavily affect the distribution of goods. Finally, the possibility to access and visualize the data (e.g., Public Participatory Geographic Information Systems) can create the conditions for an effective stakeholder engagement process (White et al., 2010).

The creation of data-sharing platforms would also solve another problem that emerged from the analysis, specifically, the lack of data concerning vehicle traffic flows and deliveries (i.e., delivery points, times, routes and frequencies, and load factors). As demonstrated in the analysis results, despite many case studies and many quantitative models, only 10% of the corpus used a pilot or an experimental method (Figure 6), and there was a limited amount of modelling-oriented contributions applied to real-world case studies employing large databases. This may be due to the lack of systems aimed at gathering and organizing information at the necessary level of detail and frequency (Crainic et al., 2004). Furthermore, privacy and confidentiality issues, such as license plates of vehicles being subject to privacy regulations and data sharing, which increases the risk of information spill-over to competitors, may also negatively

influence the availability of data. Consequently, models are rarely tested extensively and with sufficient sample sizes. Moreover, some models require real-time data (e.g., dynamic vehicle routing) that are often unavailable.

However, given the increasing availability of sensors spread throughout the cities (e.g., cameras, ground sensors, user provided data) as well as the progress of the Internet of Things (IOT) applications, data should become increasingly more available over time. Because of this, future research should focus on exploiting this growing amount of data and identifying proper methodological techniques to do so. In a matter of a few years, the problem of a lack of data could be completely reversed, becoming, instead, an excess of data issue. New analytical competences, such as those related to data manipulation and data mining, will be required of scholars in the urban logistics field. Accordingly, it may be relevant to introduce new tools and methods typical of big data analysis to exploit additional information regarding deliveries and traffic flows.

CONCLUSIONS

The purpose of this paper is to provide a systematic analysis of the scientific literature that addresses urban logistics from a logistics and management perspective. To the best of our knowledge, such an effort has not, to date, been undertaken, although it seems necessary given the fragmentation of the literature addressing this topic that emerged in the early stages of the research. Moreover, the topic of the urban transport of goods is receiving growing attention as witnessed by the increasing number of papers every year and the available funding at the local and European levels. Therefore, the objective of this work was to understand the origins of the literature and offer suggestions regarding the best directions for future research.

It is difficult to be, in any sense, exhaustive, when examining a topic such as urban logistics, which covers many different research areas. Consequently, in this paper, we focused specifically on urban logistics solutions and methods by which these solutions are implemented from a transportation management, logistics and operational perspective. Thus, this research has purposefully excluded certain related topics and areas such as sociology, urban planning and geography.

As a first result, a broad variety of topics was found, some of which have remained popular over time (e.g., VRP solutions), while others have emerged only recently (e.g., e-commerce). Furthermore, although several methodologies have been applied to study these topics, there is room for further methodological investigation, especially with respect to the newer topics. Moreover, considering the analysis of the corpus, the citation network and the main path analysis allowed us to observe how interest shifted from the identification of the characteristics of the urban transport of goods in the early 2000s to the identification of KPIs and methods to evaluate ex ante the impact of urban logistics solutions in recent years. Most recently, the focus has moved to stakeholder involvement in the decision making process, where much work may still be necessary. Finally, this paper identifies three areas for further investigation, specifically,

stakeholder management, urban logistics ecosystem and data availability. Research in these areas, in our opinion, may contribute to consolidating the extant body of literature on urban logistics and maintaining the necessary multidisciplinary character of the research field.

We believe that this research can help practitioners to better understand urban logistics as a discipline and assist researchers to orient their efforts in a way that is consistent with past development and future perspectives.

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