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Original
A Literature Review of City Logistics Assessment and Evaluation Methodologies / Zenezini, Giovanni - In: Sustainable City Logistics Planning: Methods and Applications. Volume 1 / Anjali Awasthi. - ELETTRONICO. - [s.l] : Nova Publishers, 2019. - ISBN 978-1-53616-521-0.

Availability:
This version is available at: 11583/2781053 since: 2020-01-16T12:15:23Z

Publisher:
Nova Publishers

Published
DOI:

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14 December 2024

Chapter 1

A LITERATURE REVIEW OF CITY LOGISTICS ASSESSMENT AND EVALUATION METHODOLOGIES

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ABSTRACT

Scholars and practitioners have adopted a wide variety of quantitative and qualitative methodologies to assess and evaluate City Logistics (CL) projects. Traditionally, the aim of CL assessment was to solve optimization problems and thus depicting the response of private actors to the introduction of public policies. Other methodologies, such as Multi-criteria Decision Making models (MCDM) or survey-based methods, have been put forward in recent years with the evaluation objective in mind. More in general, CL assessment and evaluation should take into account the many stakeholders that are affected by the introduction of new CL policies. In this chapter a literature review aimed at providing insights into the ability of existing methods taking into account the objectives of various stakeholders is proposed. Moreover, existing literature will be addressed in terms of quantitative vs. qualitative methodologies, so as to highlight the strengths and potential shortcomings of both approaches in relation to the CL assessment goal.

Keywords: Literature review, Assessment, Methodologies, City Logistics, Stakeholders

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INTRODUCTION

City Logistics (CL) fosters the optimization of urban freight distribution activities. Since this term was coined by Taniguchi (2001) scholars and practitioners have devoted considerable efforts in devising assessment and evaluation methodologies to study how different stakeholders are affected by newly introduced CL projects. As a matter of fact, performance assessment is one of the most important topics in CL literature, accounting for roughly 30% of published papers (Lagorio, Pinto and Golini, 2016). The aim of all proposed methodologies should be to assess the impacts on all aspects relevant to this context, and to identify the projects with the highest potential for operational, economic and environmental long-term sustainability (Balm et al. 2014). Some reviews on CL assessment and evaluation methodologies are already present in extant literature. For instance, Ambrosini and Routhier (2004) focus on survey methodologies, and explore objectives, methods and results obtained by surveys carried out in CL. Anand et al. (2012), provide a review of existing efforts in CL modelling. Danielis, Valeri and Rotaris (2015) review a wider variety of assessment and evaluation methods for City Logistics projects, but only take into consideration the proceedings from the International City Logistics Conference. The aim of this literature review is to review existing assessment methodologies to underline their advantages and disadvantages, along with possible research gaps. In this chapter, a different perspective on the classification of existing literature is proposed, by looking at how different assessment methodologies take into consideration and evaluate several aspects of the multi-faceted topic that is City Logistics. Furthermore, future trends in the assessment of urban freight initiatives are presented. The chapter is structured as follows: in Section 1, the review framework is presented. Then, the methodologies are presented in terms of the data used in section 2, and their scope in section 3. Finally, discussions and conclusions are drawn in section 4.

REVIEW FRAMEWORK

Since the interest on urban freight distribution is recent, this literature review spans from 1999 to present days. The source of data is provided by the main scientific databases, namely Google Scholar, Science Direct, SpringerLink or Scopus, as well as the proceedings from the main conference in the field (i.e. The International City Logistics Conference).

A first dataset of papers was built by searching for the field specific key words (and their combination), such as “city logistics”, “urban goods movement”, “urban freight transport”, “urban distribution”, and “urban logistics”. Then, the initial set of papers was refined by selecting only those that presented a clear focus on assessment and evaluation. This refinement returned a total of 26 type of methodologies presented in 72 papers (Table 1). The list of papers is shown in Table 6 in Appendix to this chapter.

The review is constructed on two dimensions, namely the type of data used in the evaluation, and the scope of application. Concerning the first dimension, evaluation methods differ significantly depending on their use of quantitative vs. qualitative data. Quantitative methods use quantitative data to develop simulation model or scenario analysis. Qualitative approaches mainly comprise focus groups or interviews with stakeholders to identify decision-making criteria and evaluate possible alternatives or illustrate different point of views (Steckler et al. 1992). Concerning the scope of assessment and evaluation, I argue that existing methodologies should cover at least one of three funding aspects of urban freight distribution systems. First, a methodology is used to assess at least one of the private or public CL measures categorized by the literature (Russo and Comi 2011; De Marco, Mangano, and Zenezini 2018). Second, a methodology should take into account the objectives of the stakeholders of urban freight distribution systems (Ballantyne, Lindholm, and Whiteing 2013; Taniguchi and Tamagawa 2005). Third, assessment methodologies should explore the effect of CL measures on at least one of six impact areas identified in the literature, namely environmental, economic, social, operational (Patier and Browne 2010). Two additional impact areas, namely Employee and Customer Satisfaction, are added to account for new development in CL assessment methods (De Assis Correia, De Oliveira, and Guerra 2012; Macharis, Milan, and Verlinde 2014).

USE OF DATA

As previously discussed, the 26 methodologies are first subdivided according to the type of data used in the assessment. Table 1 depicts the methodologies with the associated number of papers and the data type. The main scholars for each methodology are also underlined. The sum of papers in Table 1 is higher than the number of papers in the corpus, due to the presence of several multi-methodologies papers.

Results show that the vast majority of papers focuses on quantitative methodologies (i.e. 66 methodologies out of 80). Hence, in the next sub-section I

outline the most important quantitative methodologies for evaluating and assessing CL initiatives.

Table 1 Methodologies, number of papers and data type

Methodology	# of papers	Data type	Main scholars	Papers
Multi-criteria decision-making method (MCDM)	10	Quantitative	Macharis C. (4 papers), Verlinde S. (3 papers), Milan L. (2 papers)	5, 6, 8, 34, 35, 39, 40, 63, 68, 69
Discrete-choice model	7	Quantitative	Marcucci E. (3 papers), Gatta V. (2 papers)	16, 18, 41, 42, 43, 52, 61
Vehicle Routing Problem (VRP)	7	Quantitative	Taniguchi E. (2 papers)	2, 19, 45, 51, 65, 71, 72
Agent-based modeling	6	Quantitative	Taniguchi E. (4 papers), Teo J., Qureshi A. (3 papers)	32, 37, 64, 66, 67, 70
Quantitative case study	6	Quantitative	Fifteen authors with 1 paper	4, 11, 13, 15, 25, 58
4 step model	4	Quantitative	Muñuzuri J., Cortés P., Onieva L., Guadix J. (2 papers)	24, 29, 48, 49
Modeling quantitative equations	4	Quantitative	Holguin-Veras (2 papers)	21, 27, 28, 44
Case study	4	Qualitative	Several authors with 1 paper	3, 22, 26, 46
Multi-method assessment framework	4	Qualitative	Browne M., Leonardi J. (2 papers)	7, 12, 38
Survey	3	Quantitative	Browne M., Allen J. (2 papers)	1, 10, 55
Tour-based models	3	Quantitative	Seven authors with 1 paper	9, 30, 54

Discrete-event modelling	2	Quantitative	Eight authors with 1 paper	32, 33
Mathematical Modeling/optimization algorithms	2	Quantitative	Four authors with 1 paper	17, 44
Panel of indicators	2	Quantitative	Four authors with 1 paper	21, 56
Social Cost Benefit Analysis (SCBA)	2	Quantitative	Eight authors with 1 paper	7, 36
Business Model	2	Qualitative	Quak H., Balm S. (2 papers)	7, 59
Conceptual framework	2	Qualitative	Five authors with 1 paper	14, 62
Cellular automata modelling	1	Quantitative	Seven authors with 1 paper	31
Dynamic game theory	1	Quantitative	Four authors with 1 paper	20
FREILOT	1	Quantitative	Seven authors with 1 paper	57
Lifecycle sustainability assessment (LCA)	1	Quantitative	Three authors with 1 paper	53
Overall Equipment Effectiveness (OEE)	1	Quantitative	Four authors with 1 paper	47
Micro-traffic simulation modeling	1	Quantitative	Four authors with 1 paper	33
Survey	1	Qualitative	Four authors with 1 paper	50
Systems of Innovation	1	Qualitative	Three authors with 1 paper	60
Geographic Information System (GIS)	1	Quantitative	Four authors with 1 paper	23

Quantitative methods

Quantitative research methodologies are used to quantify a problem by generating numerical data. These methods are adopted in CL to present observed or simulated effects of CL policies by using measurable data. In CL literature, the large majority of quantitative methods comprises Multi-criteria decision making models (MCDM), structured surveys with closed questions, optimization algorithms and freight modelling techniques. The latter group of methods aim at simulating or evaluating the outcomes of new project on existing freight distribution systems, in terms of vehicle flows, commodity flows, pollutant emissions, and monetary outcomes. Such methods require, in most of the cases, a significant amount of data in order to be validated and generate robust results.

Freight modelling techniques

The focus of scientific works in urban freight contexts has been for several years in freight modelling techniques. Modelling approaches focus mainly on traffic flow and freight flows, as well as land use and location, and are derived from more consolidated passenger flows models. For instance, the traditional four-step approach, which comprise trip generation, trip distribution, mode choice (often omitted) and traffic assignment (Hosoya 2003), has been adopted by Muñuzuri et al. (2010) to simulate traffic flows generated at peak hours by replenishment deliveries to local retailers and home deliveries. A further development by the same authors (Muñuzuri et al. 2012) introduce multi-stop routes, based on retailers location and the average distance travelled between stops. However, as Hunt and Stefan (2007) noted, the four-step approach still overlooks the strong tour-based nature of urban commercial traffic flows. These authors adopted a tour-based model for simulating own account flows, including service trips. This type of modelling approach is more detailed in the sense that it considers several features of the delivery trip, such as the purpose of the tour, the specific tour start time, and the characteristics of the stops on the tour (Nuzzolo, Crisalli, and Comi 2011). This level of detail of course is seen as an advantage of this approach, but it is in turn time and data consuming. A possible solution is to implement an aggregate approach (Chow, Yang, and Regan 2010), using probabilistic approaches to generate the choice of the next destination stop and to make the decision of whether return to the base (warehouse) or not on each tour.

Vehicle-Routing Problems (VRP)

Vehicle-Routing problems (VRP) aim at optimizing the delivery route of CL commercial vehicles in terms of costs, number of trips, or environmental

emissions. The VRP can be described as "the problem of designing optimal delivery or collection routes from one or several depots to a number of geographically scattered cities or customers, subject to side constraints" (Laporte 1992). Real-time data from traffic can be used to improve the optimization given by the VRP problem in a dynamic traffic model (Taniguchi and Van Der Heijden, 2000). As a matter of fact, travel times in congested cities can be uncertain and VRP problems should take this into account (Ando and Taniguchi 2006). Moreover, local regulations such as delivery time windows may impose some additional costs on carriers' operations and VRP problems are suited to evaluate the effect of CL policies on carriers' costs (Muñuzuri et al., 2013). At the same time, VRP techniques can be adopted to optimize both economic and environmental costs of the carriers' CL operations, so to take into account the trade-offs between costs, emissions, and service quality (Wygonik and Goodchild 2011). Several authors have adopted different assessment methods to evaluate specific case studies, exploiting the availability of data from stakeholders directly involved in a CL project. For instance, both Quak and de Koster (2007) and Browne and Gomez (2011) use VRP to investigate the impact of time windows and other policies on receivers and logistics service providers respectively, by retrieving data from logistics service providers themselves. Data from an online retailer are used by Zissis, Aktas, and Bourlakis (2018) to evaluate a collaborative CL model by means of a VRP approach.

Agent-Based modelling

A branch of urban freight modelling that is gaining importance is represented by agent-based modelling, which might provide a feasible alternative to overcome the issue of stakeholders' interactions that is rarely taken into account in "traditional" traffic models. In agent-based modelling, each stakeholder can be modelled as an agent possessing objectives and decision-making attributes. In Wisetjindawat et al. (2007) the stakeholders, namely retailers, wholesalers, manufacturers, suppliers, and carriers, interact with each other within an urban supply chain through information and material flows. In Wisetjindawat et al. (2007) the stakeholders, namely retailers, wholesalers, manufacturers, suppliers, and carriers, interact with each other within an urban supply chain through information and material flows. Scholars often use agent-based modelling as a modelling framework to encapsulate the components of urban freight systems as agents, and then adopt multiple quantitative approaches to have the agents do things (e.g. generating traffic flows). Jlassi et al. (2018) adopt a discrete-event logic to model the activities of ordering and delivery tour generation within an urban supply chain. Taniguchi and Tamagawa (2005) simulate traffic flows

considering stakeholders' behaviors and objectives, adopting a genetic heuristic algorithm to model the vehicle routing problem (VRP) of minimizing cost with constraints. A combined approach agent-based with vehicle routing has also been proposed by Teo, Taniguchi and Qureshi (2012) and van Duin, van Kolck, Anand, Tavasszy, et al. (2012). Agent-based modelling shows great potential for capturing the changing distribution patterns in response to urban freight initiatives, with significantly less data required for the simulation. However, different interactions between agents have to be modelled according to the initiative that is the focus of the evaluation process (Knaak, Kruse, and Page 2006).

Survey-based methodologies

Some quantitative methods leverage on subjective evaluation by CL stakeholders to evaluate different alternatives. For instance, surveys are a suitable option for assessing stakeholders' responses to freight policies (see Allen, Browne and Cherrett (2012) for a review on surveys on urban freight transport). Anderson, Allen and Browne (2005) developed an evaluation framework aimed at defining the companies' response to policy measures through interviews, and a set of indicators retrieved from survey data. The evaluation is performed as a comparison between the actual scenario and the scenario constructed by applying the companies' responses to existing data depicting the actual operations. The selection of the policy measures is also part of the methodology, since changes in operations are directly assessed with the companies involved. Stated or revealed preference surveys in discrete choice models comprise a stream of CL literature that analyzes qualitative data (i.e. choice of respondents) with quantitative methods such as multinomial logit models, in order to define a utility function for a category of stakeholders based on their preferences over a set of CL alternatives. Discrete-choice modelling methods have so far been used to evaluate CL policies such as UCC (Marcucci and Danielis 2008), off-hour deliveries (dell'Olio et al. 2016; Marcucci and Gatta 2017), or regulations such as parking policies and low emission zones (Marcucci, Gatta, and Scaccia 2015; Filippi et al. 2010). Regulations are investigated from the perspectives of carriers (Muñuzuri et al. 2016; Filippi et al. 2010; Marcucci, Gatta, and Scaccia 2015) and UCCs and off-hour deliveries from the point of view of retailers (dell'Olio et al. 2016; Marcucci and Gatta 2017; Marcucci and Danielis 2008). The main issue with these methods lies in the fact that evaluation attributes highly depend on the alternative at issue.

Multi-criteria decision-making methods (MCDM)

Contrary to discrete-choice modelling, in multi-criteria decision-making methods (MCDM) the attributes are more general in scope and only the evaluation by stakeholders depends on the CL project subject to evaluation. The multi-stakeholders evaluation method (MAMCA) developed by (Macharis, De Witte, and Ampe 2009), has been emerging as a comprehensive tool for ex-ante evaluation of CL measures. Through this methodology, it is possible to identify the objectives of the different stakeholders involved and translate them into weighted criteria. Quantitative and qualitative key performance indicators (KPI) are then assigned to each criterion, allowing for the evaluation of each alternative about a given criterion. Therefore the major advantage of such method is to include stakeholders in the decision making process so to foster a successful implementation of the most preferred measure. However, some scholars question the academic rigor of methods that integrate stakeholders' analysis with traditional MCDM methods, such as in the case of MAMCA (Marttunen, Lienert, and Belton 2017). Other multi-criteria methods, such as Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP), are used in the first place to define the objectives of CL planning, and in second place to evaluate alternatives. These methods involve different stakeholders in the evaluation process, but in a less explicit way than what happens with the MAMCA approach. Awasthi and Chauhan (2012) integrated these two goals adopting a combined approach with AHP for defining the objectives of CL planning and a TOPSIS algorithm for evaluating different scenarios against criteria highlighted with the AHP. The TOPSIS method is a technique for ranking alternatives by the level of similarity to an ideal solution, which maximizes the benefit criteria and minimizes the cost criteria. The AHP method does not allow for a dynamic modelling of the environment, since the elements that compose it are uncorrelated and influenced by a hierarchical structure (Meade and Sarkis 1998). In response to this problem, the Analytical Network Process (ANP) might represent a solution, since it depicts the dynamic relationships between decision attributes (Kaszubowski, 2012). Tadić, Zečević, and Krstić (2014) proposed a hybrid model using ANP in combination with two other MCDM methods and adopt a fuzzy logic for the selection of CL policies. ANP is still not widely used as a MCDM for CL evaluation, probably due to the complex framework that requires identifying several criteria and explicitly depicting their relationships.

Quantitative case study

Assessing the potential demand for a CL initiative is a problem suited for a quantitative case study, as shown by Gruber, Kihm and Lenz (2014) and Correia,

Oliveira and Guerra (2012). In fact, the former retrieve logistics data from a carrier and integrate them with findings from a survey to bike messengers, to evaluate the potential market and the willingness to adopt a delivery system with cargo bikes. The latter instead assess the potential demand generated by retailers for a UCC via a stated preference survey based on four attributes: costs, delivery service, and reliability and stock levels. Finally, the problem of assessing the financial and operative viability of a CL project is tackled with economic and environmental formulations within a quantitative case study. For instance, Arvidsson and Pazirandeh (2017) formulated a mobile depot scenario and compared it with the cost of conventional urban freight distribution using vans.

Other methods

Comprehensive methodologies that integrate the freight flows simulation with policy identification and urban freight planning scenarios are also available in literature (Filippi et al. 2010). Some of the methods integrate qualitative aspects in a quantitative assessment framework. Patier and Browne (2010) developed a set of indicators pertaining to Economy, Social, Environmental and Logistics domains of the CL, and ranked the innovations based on a qualitative assessment given for each indicator on a three grade scale (0,1,2). Evaluation is based on a comparison between achieved results and target goals. This leaves questions over the level to which these goals are set and if this influences the evaluation. Cost-Benefit analysis (CBA) has been used to assess whether the benefits connected to a transport project exceed the costs and / or achieve an efficient use of resources (Suksri and Raicu 2012). Social cost-benefit analysis (SCBA) is an extension of the traditional CBA used for transport projects appraisal, which includes non-market effects of decisions. SCBA methodology has been recently adopted for the STRAIGHTSOL project (Balm et al. 2014). SCBA aims at giving a quantitative evaluation of all stakeholders' objectives, but several assumptions have to be made for treating non-quantifiable effects in the quantitative evaluation of the monetary value of the project.

Qualitative methods

Qualitative Research methods concern mostly exploratory, inductive research, where the goal is to gain an understanding of underlying reasons and motivations behind stakeholders' decision-making processes.

Some qualitative assessment methods are based on purely subjective evaluation by a panel of experts or selected stakeholders. These methods are mostly used to assess the transferability of CL innovation and best practices. For

instance, Business model analysis (BMA) has been adopted from management and innovation research fields in order to investigate the feasibility of urban freight initiatives from a business-oriented perspective (Posthumus et al. 2014). Another qualitative methodology used in CL assessment comes from the BESTFACT project (Leonardi et al. 2014). Such methodology comprises a multi-criteria assessment built along four categories: innovation and feasibility, magnitude of impacts, information accessibility, and transferability. Each criterion is evaluated using a scoring system between 0 and 3, by three experts independently, and an average value is given to each innovation. In essence, these approaches show some relevance in terms of involving the stakeholders from the selection of the best policy measure to be adopted. However, they have some shortcomings in terms of introducing quantitative information in the evaluation framework.

Finally, conceptual frameworks and qualitative case studies are developed to draw insights on the implementation process of CL initiatives, as well as on the organizational and operational changes that new ways of delivering goods in urban areas produce (Gammelgaard 2015). Conceptual framework can also be validated by means of case study, as in Harrington et al. (2016).

SCOPE OF ASSESSMENT

The second dimension around which the assessment methodologies retrieved from the literature are analyzed is the scope of assessment. According to the view proposed here, a methodology can have a broader or narrower scope, based on three aspects:

1. The range of CL measures it is used to assess;
2. The number and type of stakeholders included in the assessment process;
3. The categories of potential impacts measured through the methodology;

The analysis of existing CL assessment and evaluation methodologies returns a main tenet, which is that various methodologies do not share the same scope of application. This argument stems from the fact that they do not also share the same underlying goal. On the one hand most of the simulation and optimization models provide a general, modelling framework for simulating traffic flows by calibrating the parameters of the model according to the measure that is being evaluated, and rarely include a wide range of stakeholders and correlated impacts (although information needed from stakeholders for calibrating the model could vary slightly according to the type of measures investigated). On the other hand, qualitative methods and quantitative methods that use evaluation from the

stakeholders (e.g. MCDM, discrete-choice models) explicitly include the measure in the evaluation process, hence committing the whole process to that specific measure. The latter group of methodologies hence could be used for a wider range of measures due to their lower need for quantitative data and their stakeholder-based approach.

Measures

The most studied CL policy is represented by Urban Consolidation Centers (UCC), followed by ICT measures (Table 2). UCCs are the most studied initiatives due to their great potential in bringing operational benefits to private stakeholders in terms of increase in inventory control (M. Browne et al. 2005), and to the environment as well, because goods are consolidated and therefore fewer vehicles are needed for urban deliveries (although this positive outcome is still debated by scholars).

Following the categorization proposed by De Marco, Mangano, and Zenezini (2018), we find that Infrastructure measures, namely consolidation schemes such as UCCs and MCCs and curb side parking, are by far the most investigated measure in urban freight literature. In fact, 54 different infrastructure measures are assessed by papers in the corpus. Then, 35 CL Regulations such as time windows or road pricing and 19 technology measures such as ICT platforms and alternative vehicles are analyzed by the papers in the corpus.

Both qualitative and quantitative methodologies retrieved in the literature could potentially be used to assess and evaluate any kind of CL measures. However, taking into account the argument previously made, we can identify that a particular set of CL methodologies, namely modelling and optimization techniques such as VRP or traffic model, mostly investigates measures that change the organizational aspects of supply chains, such as consolidation and cooperation schemes (Boerkamps and Binsbergen 1999; Muñuzuri et al. 2010), or measures that have an effect on the overall logistics costs, such as low emission zones and road pricing (Nuzzolo, Crisalli, and Comi 2011).

Regulations measures are more likely to be investigated through quantitative modelling. In fact, 87% of Regulations are quantitative papers (Table 3), whereas this figure drops to 60% for Technology measures.

Table 2 CL measures investigated

Measure	# of papers	% of papers	First paper published	Main Scholars	Papers
Urban Consolidation Centers	29	40%	1999	Browne M. (4 papers), Leonardi J., Balm S., Macharis C. (3 papers)	5, 6, 7, 9, 12, 14-16, 18, 22, 23, 26, 29, 36-39, 41, 46, 48, 51, 55, 56, 62, 63, 67
ICT	16	22%	2000	Browne M., Leonardi J., Macharis C. (3 papers)	7, 12, 19, 20, 26, 33, 35, 38-40, 57, 59, 61, 65, 67
Micro-consolidation centers	13	18%	2004	Balm S., Browne M. (4 papers), Leonardi J., (3 papers)	7, 13, 17, 37, 38, 56, 59, 61, 63, 69
Curbside lay-by areas	12	17%	2008	Muñuzuri J., Cortés P., Onieva L., Guadix J. (3 papers)	4, 11, 12, 14, 31, 35, 38, 43, 50, 51, 52, 57
Time windows	12	17%	2005	Muñuzuri J., Cortés P., Onieva L., Guadix J. (2 papers)	1, 2, 5, 11, 12, 32, 35, 49, 51, 58, 62, 71

Low emission vehicles	12	17%	2012	Arvidsson N., Browne M. (2 papers)	3, 4, 7, 8, 22, 25, 33 35, 38, 60, 62, 63
Off-hour deliveries	11	15%	2008	Balm S., Browne M. Holguin-Veras J., Leonardi J., Macharis C. (2 papers	7, 16, 21, 27, 28, 35, 39, 42, 51, 68
Restrictions on weight and volume	10	14%	2000	Taniguchi E. (3 papers	1, 5, 14, 29, 32, 53, 62, 64, 65, 66
Road pricing	7	10%	2003	Several authors with 1 paper	1, 5, 11, 29, 35, 51, 66
Low emission zones	6	8%	2005	Browne M. (3 papers), Allen J. (2 papers)	1, 10, 11, 18, 35, 44
Fiscal incentives	4	6%	2008	Marcucci E. (2 papers)	14, 35, 42, 44

Table 3 CL domains and type of data used

CL domain	Qualitative methods	Quantitative methods
Infrastructure	29%	71%
Regulations	13%	87%
Technology	40%	60%
All Papers	19%	81%

The reason for this gap can be traced back to the very nature of most qualitative methodologies: the alternatives are assessed in a subjective way by stakeholders who are not able to fully grasp the extent of the impact of policy changes on the urban context. Another reason might be related to the current implementation of such methods. These methods found their relevance for most of the recent large-scale European funded projects, which aimed at fostering knowledge sharing and involving all stakeholders in the process. Consequently, the focus might have been towards solutions that provide real operational and economic benefits for private operators, such as Technology measures, as opposed to public policies that might only increase the complexity of urban freight distribution.

Stakeholders

The point previously made on qualitative papers yields an opposite view on the stakeholders' involvement in the assessment process. Qualitative methods, MCDM and discrete choice models have emerged in the context of urban freight distribution in the last years whereby including stakeholders' behavior became more and more relevant.

Therefore, it is not surprising that a wider range of stakeholders are taken into account in those methodologies compared to other methodologies. As a matter of fact, all simulation and optimization based methods considered only carriers, with the exception related to the introduction of receivers (Hunt and Stefan 2007). Moreover, surveys and methods to assess innovation transferability only take into account carriers, and sometimes citizens (H. Quak, Balm, and Posthumus 2014) or employees (Patier and Browne 2010). On the contrary, three papers using agent-based modelling investigate a subset of at least four stakeholders among the most

important ones of urban freight, namely shippers, receivers, carriers, citizens and public authorities.

In general, the most assessed stakeholders in CL literature are carriers, receivers and local authorities, as seen in Table 4. The main scholars in terms of paper published are also outlined.

Impacts

Concerning the type of impact assessed by the methodology, it is clear from the analysis of the literature that most papers focus on economic, operational and environmental impacts. Such categories of impact are in fact assessed by 51, 47 and 46 papers each, and the first paper published for each of these areas can be traced back to 2005 (Table 5).

Some methodologies cover a broader set of impacts than others. In particular, the conceptual framework by Harrington et al. (2016), the BMC by Quak, Balm, and Posthumus (2014) and the MAMCA papers cover 5 of the 6 impact areas. Other encompassing quantitative methodologies are the one proposed by Patier and Browne (2010) and the SCBA by Kin et al. (2016) with 5 impact areas covered each, and the agent-based model by Taniguchi and Tamagawa (2005) and the quantitative case study by Arvidsson and Pazirandeh (2017) with 4 impact areas each. It can be noted that the highlighted methodologies take into account the objectives of stakeholders in the evaluation process, both directly as in case studies, surveys or multi-criteria methods, or indirectly as in agent-based models or BMC.

For each impact area, several indicators can be identified. Environmental indicators are represented by the reduction of CO2 and other pollutant emissions; operational indicators refer to, for instance, the level of service to customers, the number of stops, the number of deliveries, or the punctuality of pick-up and delivery. Some papers provide a more detailed description of urban freight indicators. Patier and Browne (2010) identify 24 core indicators pertaining to 5 impact category: Economic indicators comprise investment costs, customers' satisfactions etc.; social indicators include working conditions and employment. Finally, The STRAIGHTSOL project covers all the main impacts with 31 indicators, such as cost per item or investment costs (Economic impact), employee satisfaction, attractiveness of urban environment or accessibility perceptions (Social and transport system impacts).

Table 4 Distribution of stakeholders among the selected papers

Stakeholder type	# of papers	% of papers	First paper published	Main Scholars	Papers
Carriers	50	63%	2000	Taniguchi E., Muñuzuri J., Cortés P., Onieva L., Guadix J. (3 papers)	1, 2, 4, 5, 7, 8, 10, 13, 17-24, 27-33, 35-37, 39, 41, 43, 45-47, 49, 51, 52, 54, 56, 57, 60, 62, 64-67, 70-72
Receivers	33	41%	2007	Macharis C., Verlinde S. (3 papers), Taniguchi E. (2 papers), Holguin-Veras J. (2 papers)	4, 5, 7, 12, 14-16, 20, 22, 23, 27, 28, 30, 35, 36, 39-42, 46, 50, 53, 55, 58, 60, 62, 66-70
Local authorities	28	35%	1999	Macharis C. (4 papers), Verlinde S., Browne M. (3 papers), Arvidsson N., Awasthi A., Leonardi J. (2 papers)	3-7, 9, 11, 12, 22, 23, 26, 33, 35, 38-40, 46, 48, 53, 57, 60, 62-64, 66, 68
Citizens / final customers	15	19%	2005	Macharis C. (5 papers), Verlinde S. (4 papers), Balme S. Browne M. (2 papers)	4, 5, 7, 12, 26, 35, 39, 40, 61, 62, 64, 68, 69
Shippers	14	18%	2005	Macharis C. (3 papers), Verlinde S. (2 papers), Balm S., Browne M. (2 papers)	5, 7, 14, 20, 28, 39, 40, 53, 64, 66, 69, 70
Logistics service providers	11	14%	2003	Macharis C. (3 papers), Verlinde S. (2 papers)	11, 12, 14, 25, 29, 35, 40, 44, 53, 59, 69
Other operators	10	13%	2005	Arvidsson N. (2 papers)	3, 4, 15, 22, 25, 26, 36, 46, 64, 67

Vehicle manufacturers	3	4%	2014	Eight authors with 1 paper	4, 60, 70

Table 5 Impact areas and papers

Impact area	# of papers	%	First paper published	Main Scholars	Papers
Economic	51	64%	2000	Macharis C. (6 papers), Verlinde S., Browne M. (5 papers), Marcucci E. (4 papers)	1, 4, 5, 7, 8, 10-12, 14-17, 19-21, 23, 25-27, 32, 34, 36-45, 47, 49, 52, 53, 56, 58, 59, 61-69, 71, 72
Operational	47	59%	2005	Macharis C. (5 papers), Verlinde S., Browne M. (4 papers), Taniguchi E. (3 papers)	1, 2, 4, 5, 7, 8, 10-15, 17, 19-21, 23-26, 30-36, 38-40, 43-47, 49, 50, 54, 56, 58, 61, 64, 67, 69, 70, 72
Environmental	46	58%	1999	Macharis C., Taniguchi E. (5 papers), Verlinde S., Browne M. (4 papers)	1, 2, 4, 5, 7-13, 18, 25, 26, 28, 29, 31-41, 44, 45, 48, 51-53, 56-58, 63-69, 71
Social	22	28%	2005	Macharis C. (6 papers), Verlinde S. (5 papers)	4, 5, 7, 8, 12, 23, 26, 34, 36, 38-41, 44, 53, 56, 62-64, 68, 69
Customer satisfaction	12	15%	2004	Macharis C., Verlinde S. (3 papers)	7, 15, 16, 26, 36, 40-42, 47, 55, 59, 69
Employee satisfaction	4	5%	2010	Macharis C., Verlinde S. (3 papers)	40, 56, 68, 69

DISCUSSION AND CONCLUSION

This chapter presents a literature review of CL assessment and evaluation methodologies, identifying their applicability to different aspects of the CL issue. The point of view of this literature review is that CL assessment methods should encompass the objectives of CL stakeholders in the evaluation, provide insights on different impact areas and should be used to evaluate a wide array of CL measures.

The vast majority of methodologies studied use quantitative data, which can be retrieved from carriers' operations or by means of survey submitted to the stakeholders. The most studied measures are Infrastructure measures lead by UCCs, whereas Technology measures are the least studied. The former group of measures are more likely to be studied through qualitative papers compared to Regulation measures, mostly due to the fact that European projects focusing on measures for private operators have fostered a surge in qualitative assessment methodologies, while Regulation policies have been the focus of early CL papers that provide mostly modeling and optimization techniques. Such quantitative methodologies provide simulation frameworks for traffic flows and consumers' demand, and have more potential for including changes in stakeholders' behaviors or introducing new measures in the system. However, simulation models usually need high quality of data for the development and validation. On the other hand, a significant number of quantitative and qualitative methodologies include the stakeholders in the assessment process, and are applicable to a wide array of CL solutions. However, the evaluation of future outcomes by stakeholders may negatively affect the ability of such methodologies in identifying the best CL solution.

Only some of the analyzed methodologies propose sets of performance indicators to evaluate the overall success of an initiative. Moreover, very few papers integrate indicators within an *ex-post* evaluation framework. In this sense, it is argued here that a proper assessment methodology should make leverage on the indicators for the continuous monitoring of the performance of the measure implemented. However, a strong barrier hinders the development and use of such methodologies: the lack of detailed data available to public and private stakeholders.

Finally, the literature has shown a growing trend towards the involvement of more stakeholder types in the evaluation process, through methodologies such as agent-based modelling and MAMCA. Figure 1 depicts the compounded amount of stakeholders included in the papers together with the cumulative number of papers presented. The analyzed data show that, besides some predictable

oscillations, the average number of stakeholders included in the assessment and evaluation methodology, represented by the grey line, grows quite consistently until 2016.

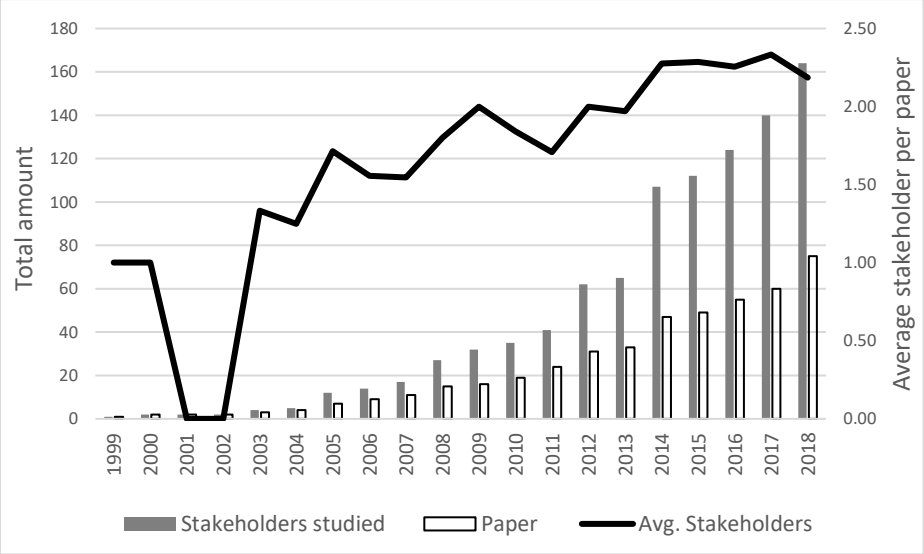

Figure 1 Total and average number of stakeholders studied in the literature

This is considered a shift from the initial development that mainly opted for transport system modelling and scenario simulations based on quantitative data retrieved from secondary quantitative data. Future development in urban freight assessment, such as the interactive MAMCA, CL living labs or agent based modelling for decision-making, are currently deepening the debate on stakeholders' interaction and involvement.

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APPENDIX

Table 6 Full list of papers included in the Literature Review with identification number

#	Paper
1	Anderson, Stephen, Julian Allen, and Michael Browne. 2005. "Urban Logistics - How Can It Meet Policy Makers' Sustainability Objectives?" *Journal of Transport Geography* 13 (1 SPEC. ISS.): 71–81. doi:10.1016/j.jtrangeo.2004.11.002.
2	Ando, Naoki, and Eiichi Taniguchi. 2006. "Travel Time Reliability in Vehicle Routing and Scheduling with Time Windows." *Networks and Spatial Economics* 6 (3–4). Springer: 293–311.
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