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Urban Freight Last Mile Logistics—Challenges and Opportunities to Improve Sustainability: A Literature Review

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Received: 16 September 2020; Accepted: 20 October 2020; Published: 22 October 2020

Abstract: Last mile logistics (LML) is the least efficient and complex part of supply chain. The main objective of this study was to identify major challenges of urban freight LML and opportunities for intervention. For this, 42 peer-reviewed full papers published after 2010 and three additional references were used. The findings indicated that urban freight flow has a trend of steady growth. The main driving forces behind this steady growth are population growth, urbanization, densification, globalization, online and omni-channel (OC) retailing, and urban economic development. Using typology analysis, three main potential freight LML configurations were mapped and discussed. Freight LML configurations that involve light cargo vehicles and cargo bike-based delivery schemes could be more attractive freight LML models if the delivery failure is minimized. The LML challenges were categorized as technological, infrastructural, LML system and management, and logistic cost related challenges, and discussed broadly. Similarly, the potential opportunities were discussed from environmental, economic, and social sustainability aspects. Finally, this report has pinpointed future potential research agendas related to LML. The study could be a knowledge base useful for academicians and practitioners, logistics and technical service providers, policy makers, and customers.

Keywords: freight last mile logistics; LML typology; LML challenges; LML sustainability; urban freight flow

1. Introduction

In urban areas freight flow is growing [1–3]. This in turn increases transport related problems such as greenhouse gas (GHG) emissions, congestion, air and noise pollution, traffic accidents, and damage to infrastructure such as road networks [1,4]. The GHG emissions from the transport sector is estimated to be responsible for about 20–25% of global GHG emissions [1]. On top of this, the increasing transport demand increases loss of time and money. Especially, the increasing trend in urban freight flow highly affects last mile logistics (LML) which is an important but inefficient and very expensive part of supply chain [1,5,6].

1.1. Driving Forces behind the Growth of Urban Freight Flow

The driving forces behind the steady growth of urban freight flow include globalization, economic development, population growth, urbanization, densification, and e-commerce and omnichannel (OC) retailing [1–3,6,7]. Due to globalization, goods production locations are distributed over large regions or countries. This in turn has increased freight transport distances. Regarding urbanization, the global urban population was about 4.2 billion in 2018 and expected to be 6.7 billion in 2050 [3]. In 2018, the urban population in Europe was about 54% which is expected to be 66% in 2050 [1]. In relation to urbanization, economic activities and development increase [3,8] leading to the increase of urban freight flow.

During the past two decades, the increase of Internet infrastructure and growth of e-commerce contributed significantly to the increase of urban freight flow both in freight volume and freight traffic [2,5,9]. Hubner et al. [10] discussed that online grocery is increasing and will surpass online sales of consumer electronics. As a percentage of enterprise sales, the share of e-sales in EU-28 increased from 13% in 2008 to 20% in 2017 [11]. Online shopping could increase further due to different factors: Increasing demand of online shopping by young and older people; traditional shopping stores are reducing due to economic crisis caused by competition with Internet shops; increasing online grocery shopping; and increasing use of smart phones and apps for online shopping [3,4].

1.2. Definitions

The term 'last mile' was used in telecommunication referring to the final leg of a telecommunication network [12]. In the case of goods supply chain, LML is "the last stage of the supply chain" [13]. Business-to-consumer (B2C) LML is "the final leg in a B2C delivery service whereby the consignment is delivered to the recipient, either at the recipient's home or at a collection point" [14]. Conceptually, definition of last mile logistics is the same for goods transport and public transport. In this study, the focus is on last mile freight logistics in urban areas, and the term 'freight LML' is used to clearly distinguish from LML of public transport service.

LML is the real contact point between service provider and customers. However, there is limitation in defining LML. There should be clear definition of LML that identifies its scope along the goods supply chain, i.e., from where LML starts and ends [13,15]. For instance, it is not clear if the term 'last stage' refers to the transport segment between distribution center (DC) and last destination (consumer home) or between local distribution center and last destination or only between pick-up point and last destination (see Section 3). In order to avoid this confusion, in this study, the freight LML is understood as transporting freight along last part of supply chain from distribution center (regional warehouse) to consumer's address. That means the national and international freight supplies to DC is not the focus of freight LML (see Section 3).

There is also problem of inconsistence in using LML related terms in different studies. In some cases, 'last kilometer' is used as alternative term for 'last mile' [16]. Logistics facility terms such as urban consolidation center (UCC), regional warehouse, hub, depot, and distribution center are often used interchangeably. Similarly, micro distribution center, local depot, and local distribution center are used interchangeably. Other terms such as proximity station, proximity point, pick-up point, parcel pick and pay point, pick own parcel (pop)-station and locker self-service are used basically to describe the same concept [1,17–20]. In relation to LML, the influence of e-commerce is also discussed in many publications. From these publications it was noticed that terms like e-commerce, online shopping, online retailing, e-sales, web-based business, e-business are often used interchangeably [13,15].

1.3. Urban Freight Last Mile Logistics (LML)

Freight LML is part of freight transport service. Freight transport plays an important role in the economy of a country and has an increasing trend. In EU-28, the inland goods movement increased from 2.263 trillion tkm in 2011 to 2.277 trillion tkm in 2015, and to 2.362 trillion tkm in 2016. If international road and air transport as well as maritime is considered, the freight transport performance of EU-28 could be about 3.37 (2011), 3.39 (2015), and 3.546 (2016) trillion tkm [11]. In EU-28 countries, the major inland freight transport modes are road, rail, and waterway. Based on average data of six years (2011–2016), road transport represents about 75% of inland freight transport of EU-28 followed by rail with 18% [11]. This indicates that, as part of road transport, freight LML has a significant negative impact on sustainability of urban development [21] as it is already known as fragmented and the least efficient part of the goods supply chain [6,16,22]. Although the mode of last mile delivery could be road transport, water transport, air transport (drones), the focus of this study is on road transport.

Understanding the main characteristics of freight LML is important to design a more sustainable LML system for a given urban area or a city. Freight distribution is mainly characterized by involvement of many actors (e.g., carriers, supplier, etc.), short routes, low speed driving, short time of effective driving, long vehicle downtimes, labor intensive, space restriction, limited traffic infrastructure compared to high demand for transport, inefficiency (low load factor, empty running), high population density, and related high environmental concern [23,24]. Urban freight LML is also known for its dependence on local conditions and infrastructure limitations (e.g., unloading spaces) and trends such as increasing service demand, complexity, and inefficiency [21,23,24]. Especially, freight LML is characterized by high degree of fragmentation of freight flow, use of smaller vehicles, and low use of vehicle capacity. These features reduce the effectiveness of LML [25]. Therefore, more studies are important to investigate these LML characteristics and increase important knowledge base.

There are an increasing number of studies related to LML, but most of them focus on one or limited aspects of city logistics and are fragmented [12]. There are few literature review-based studies that include freight transport related to LML [1,3,4,6,18]. However, each of the review works often focus on specific objectives and research questions. In addition, the discussion on LML from a sustainability point of view is very limited. Many existing studies on urban freight transport focus on environmental and economic aspects while social dimensions are rarely addressed. Strategically, firms should develop and implement more sustainable freight LML systems, and evaluate from economic (transport cost, infrastructure, source of employment, etc.), environmental (land use, energy consumption, GHG emissions, etc.), and social (traffic safety, security, noise, etc.) aspects. To address this gap, more comprehensive studies that discuss the complex issues of urban freight LML are important. In this study, three major research questions were formulated within the scope of this literature review work:

Q1—What are the main types of freight LML logistics configurations?

Q2—What are major challenges causing inefficiency of urban freight LML?

Q3—What are opportunities for interventions to improve sustainability of urban freight LML?

1.4. Objectives

The main objective of this study was to identify major challenges causing inefficiency of freight LML and opportunities for intervention. Based on literature review (using literature-based knowledge), this study targets to discuss potential opportunities to increase the sustainability performance of freight LML through reducing logistic cost, environmental impact, and negative social externalities. The current study also targeted at contributing to the efforts to increase a comprehensive and holistic understanding on freight LML in the dynamic urban conditions.

2. Methodology

2.1. Literature Search

This study used structured review approach, i.e., planning, searching, screening, and extraction [1,12]. In this process, well-defined protocols and procedures have been applied. First, based on the objective and research questions (see Section 1), online search keywords and databases were determined. Two search keywords "Last mile logistics" and "last mile delivery" and two databases Scopus and Web of Science were used. Firstly, the search was done with search string such as "last mile deliver*" AND "review*" and "Last mile logistic* and review*". This helps to highlight available review works in relation to the topic. Then, "Last mile deliver*" AND "Urban logistic*" were used in both Scopus and Web of Science databases (see Table 1). The highest number of hits was 115 on Web of Science database with search string "Last mile deliver*" AND "Urban logistic*" followed by 112 on Scopus database. Then some criteria were used to screen the search results: the paper should employ at least part of LML; written in English language; published in 2010 or after; and it should be a peer-reviewed journal article or conference proceeding.

Table 1. Search keywords and number of hits for search trials run on 18 April 2019.

Search Keyword	Source	Total Hits	<2010	2010–2014	≥2015
Last mile deliver * AND review *	Scopus	18	1	3	14
Last mile deliver * AND review *	Web of science	18	1	6	11
Last mile logistic * AND review *	Scopus	26	1	2	23
Last mile logistic * AND review *	Web of science	31	1	4	26
Last mile deliver * AND Urban logistic *	Scopus	112	4	3	95
Last mile deliver* AND Urban logistic*	Web of science	115	4	10	101

*: asterisk added to a word to search for multiple variations of that word.

The year 2010 was considered after noticing that most papers related to LML were published in recent years. Publications related to public transport, traffic regulation, and rural distribution were also excluded. However, this searching and screening process could have some limitations. A limited keyword-based search may not spot all relevant papers. In this case, only full text papers are considered, i.e., posters and abstracts have been excluded. There might also be some relevant papers published prior to 2010.

Through reading title and abstracts and/or conclusions, most relevant papers were identified. Although the final literature search was done in April 2019, some additional relevant papers have been added later on. Some potential papers were also included using a snowballing technique by identifying other relevant sources based on reference lists of the selected literature [1]. Finally, 38 peer-reviewed and LML-focused papers were read fully. In the general discussion, three documents [11,26,27] and four papers [28–31] were used as additional references. In total, 45 references are listed in this paper. Figure 1 provides the descriptive analysis of read papers (38 peer-reviewed articles). It clearly indicates the increasing trend of research works on freight LML. This confirms the fact that the inefficiency of freight LML is understood in recent years and the influx of literature on the topic indicates that researchers and practitioners are working to identify and promote sustainable LML solutions [18].

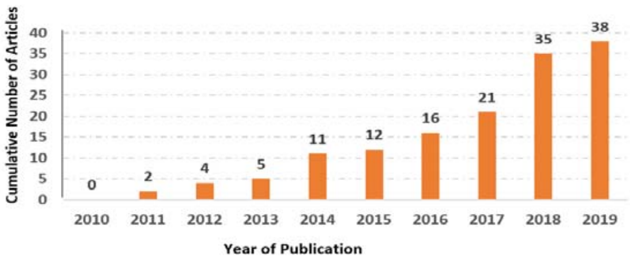


Figure 1. Descriptive analysis of read papers.

2.2. Analysis Approach

Freight LML could be evaluated using one or a combination of parameters such as load factor, transport distance and time, number of routes, delivery time window, custom (conventional) cost, externalities cost, energy consumption, emissions, and other impacts (economic, environmental, and social), etc. [1,2,15]. In this study, a combination of parameters was taken into consideration while identifying the constraints and opportunities to promote sustainable LML services. Firstly, the typology of urban freight LML was developed and described. Then the challenges within freight LML were identified systematically and categorized as technological, infrastructure, LML system and management, and logistic cost (See Section 4), and discussed. Similarly, the opportunities for tackling the challenges and increasing the sustainability of urban freight LML were identified and described from environmental, economic, and societal aspects of sustainability (see Figure 2). Finally, extended discussion was provided (see Section 6).

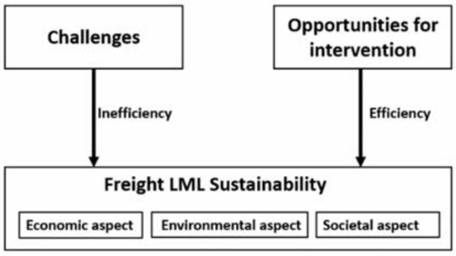


Figure 2. Conceptual framework of analysis used in this study.

3. Typology and Characteristics of LML

Different firms use different logistics network configurations for goods distribution in different urban areas [32]. At the aggregated level, logistics chain of urban freight distribution can have three stages (see Figure 3). In this case, the main actors in urban goods distribution have been grouped into three: Shippers—producers, wholesalers, freight forwarders (consolidators); Transport service providers—carriers, couriers, own account; and Receivers—retailers, end consumers [33].

Figure 3. Simplified illustration of the relationship between main actors in urban goods distribution system. Source: Own illustration based on Nuzzolo et al. [33].

Figure 4 presents a simplified freight supply chain structure constructed based on works of other authors [2,4,19,32]. In this case, DC is considered as a regional warehouse or outside city hub. It is considered as end point for commercial trip and serves as storage and distribution center. Therefore, its strategic location is very important. Freight supply to DC can be from international (import) and national sources. Local distribution center (LDC) could represent local depot, retailer store, consolidation center, mobile depot, or transshipment point depending on different characteristics of the LML service of firms. Pick-up points (PP) could be 'Bentobox', reception points, lockers (automatic lockers that can serve 24/7 year round), or service points such as small stores, petrol stations, and railway stations [6]. Dell'Amic and Hadjidimitrou [19] discussed the 'Bentobox' concept i.e., a freight LML system where parcels are stored in the Bentobox and then picked up by customers. It has trolleys with drawers containing parcels, customer special codes, and user interface for customer.

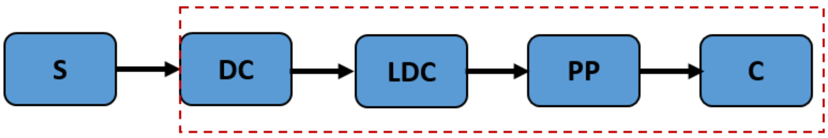
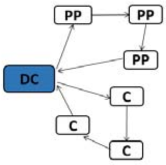
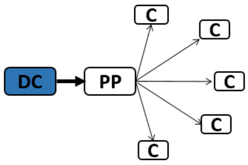
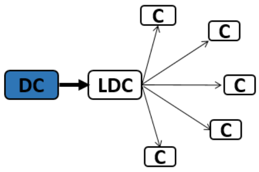
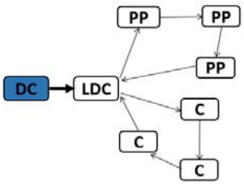
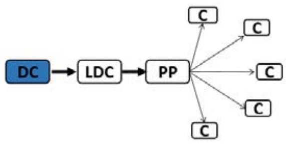


Figure 4. Simplified typical freight supply chain structure. S = supplier; DC = distribution center; LDC = local distribution center; PP = pick-up point; C = final consumer or receiver. The dotted line indicates the focus area of freight LML in this study. Source: Author's own illustration.

Based on the conceptual scope and definitions described above, new typology of freight LML configurations were developed (see Table 2). The potential LML configurations have been categorized into three main types: Type-I—distribution center-based delivery (DC delivery); Type-II—local distribution center-based delivery (LDC delivery), and Type-III—pick-up point-based delivery (PP delivery).

Table 2. Typology of urban freight LML from logistics configuration point of view.

Type of LML Configuration	Illustration	Description
Type-I (option-1)		DC Delivery: DCs distribute the parcels directly to consumers home or PPs. [2,32].
Type-I (option-2)		DC Delivery (option-2): DCs distribute parcels only to PPs from where customers pick up their items.
Type-II (option-1)		LDC Delivery (option-1): DCs distribute parcels to LDCs from where customers pick up their items. Delivery scheme could be used from DC to LDCs.
Type-II (option-2)		LDC Delivery (opition-2): DCs carry parcels to LDCs and then the parcels will be distributed to customers home or PPs [19].
Type-III		PP Delivery: Parcels are carried from LDC to and stored at nearest PPs and then picked up by customers [4,19].

In Type-I, the distribution can be done with light delivery vehicles, but the longer travel distance could increase its negative impacts. In Type-II and Type-III, parcels could be distributed from DC to LDCs using large trucks. Type-II has two options. In option-1, customers collect their consignment from LDC using their own cars (mostly passenger vehicles). In option-2, small vehicles and cargo bikes (or a combination) could be used to perform home delivery service. In some cases, there is the possibility to extend the service area by combining light vehicles and cargo bikes where the light vehicle can serve also as local (mobile) depot from where goods are distributed using bikes [22]. In Type-III, parcels could be delivered to PPs using small freight vehicles or cargo bikes. To collect parcels from PPs, customers mainly walk or use cycles. Such a PP-based delivery concept has been implemented by companies such as DHL, Post-24 in Austria, and SmartPOST in Estonia [4,19].

Delivery schemes where light cargo vehicles and cargo bikes are used could reduce the travel distance and related impacts, but there is risk of delivery failure. Therefore, if the delivery service is well planned and manages to minimize delivery failure, LML configuration Type-II (option-2) and Type-III could be more sustainable freight LML models. The developed freight LML typology could be useful to understand well and improve the home delivery services. Home delivery services started before the rise of the Internet (e-commerce) when mail orders were used for home delivery of furniture and large electronic goods by retailers [4]. Currently, home delivery service is increasing due to factors such as growing online and OC retailing and information technology infrastructures [4,25]. OC is a retailing system where customers use different communication channels (e.g., phone, e-mail, live-chat, social media) to request services.

Home delivery services can be direct delivery to home (e.g., Type-I and Type-II (option-2)) or pick-up points (Type-I (option-1) and Type-III) which can be parcel service points in supermarkets and stores (staffed) or unmanned pack stations [4]. In some cases, click and collect (a system where retailers receive order via Internet and customers pick up their goods at retailer stores) is used. This click and collect system could increase the certainty of product availability for customers, and the competitiveness of traditional retailers to compete with web-based shops. However, click and collect systems involve customer trips and this may increase environmental impact [4].

4. Challenges of Freight LML

LML is the most expensive and polluting part of the entire supply chain [4,34]. Especially, urban freight transport is less efficient [3], and increasing its sustainability is not easy due to the dynamic nature of the urban environment and economic activities. On top of this, existing research works rarely address sustainability issues [3]. In addition to environmental impacts and operational costs, the increase of freight vehicles in LML system has externality costs, i.e., social costs (impacts) such as traffic accidents, congestion and stress, and mobility barriers (possibility for absence of car or not able to drive) [16,24,35]. In this section, the major challenges facing urban freight LML have been organized and discussed considering different aspects such as technological aspect, infrastructural aspect, LML systems and management, and logistics costs (see Table 3).

Table 3. Category and description of challenges constraining the sustainability of freight LML.

Category	Description	Reference
Technological	Speed and capacity limitations of cargo bicycles and health problems when excess load weight is applied.	[22]
	Emerging new technologies have potential to highly disrupt the existing urban freight LML systems. Example, application of 3D printing and unmanned aerial vehicles (UAVs) or drones	[36]
	Challenges of goods delivery planning and execution associated to rapidly growing online and OC retailing businesses e.g., difficulty to handle fragmented and many small quantity orders that come from online customers	[3,4,6]
	Integrating the emerging new technologies such as digitization and automation into LML system design and operation strategies is not easy	[13]
Infrastructural	Difficulty to change infrastructures (e.g., road network, loading/unloading facilities) in existing cities to accommodate increasing freight volume and changing distribution systems	[2,37]
	Strict regulations in relation to freight distribution, and limitation of facilities	[35,37]
	Limitation of space and access in urban areas	[7]
	New technologies such as electric vehicles and cargo cycles need new infrastructures such as recharging infrastructure and new road network	[22]
	Impedances due to conditions such as geographical difficulties and historical centers	[22]
LML system and management	Difficulty in addressing competing interest of potential actors of urban freight logistics chain regarding services, policies and interventions	[16,21,23,37]
	Problems related to vehicle routing, vehicle utilization and fleet management, inventory and warehousing, as well as order management	[38]
	Establishing coordination between actors is difficult due to uncertainty and dynamic conditions of freight LML	[39]
	Lack of understanding on LML and how to design best LML models by some companies	[12]
	Acquisition of accurate and adequate data on LML operations and related impacts	[20,40]
	Delivery failure (return) and repeated delivery, especially the return rate is high in case of online shopping	[4,6,14,19]
	Complex order fulfillment associated to online and OC retailing (e.g., in grocery retailing)	[10]
	Long time of goods delivery	[4]
	Possibility of increased transport distance due to online shopping which allows goods to be sourced from anywhere around the Globe	[9,36,40]
	Increased networking of companies due to application of Industry 4.0 could make logistics solutions of supply chains more complex.	[17]
	Less acceptance (by customers) of cargo cycles as a suitable mode of transport	[41]
Logistics cost	Unmanned Airal Vehicles (UAV) based delivery is more expensive compared to van-based delivery. For instance it needs additional investment cost for facilities such as landing stations for drones.	[36]
	New technologies could lead to the need of new transportation and logistics facility infrastructures of high investment cost.	[21,22]
	High fleet acquisition and operational cost of electric light vehicles for some firms	[22]
	High cost associated to online and OC grocery retailing	[10]
	Rejection (by online retailers) of some delivery orders due to limited LML service capacity	[5]
	High cost of first and repeated deliveries	[4]

4.1. Technological Aspect

For urban freight transport electric and human-powered cargo bicycles are used as an alternative to vehicles where applicable [41]. However, they are associated with some problems [2,22,24]. Human-powered bicycles could cause health problems especially when excess load weight is applied. Speed limit and capacity limit constrain their application. Even though the speed limit depends on characteristics of the cities, the speed of bicycle/tricycle often varies from 2 to 6 km h^{-1} while that of light vehicles could reach 25 km h^{-1}. In dense urban areas the typical average speed is about 30 km h^{-1} for vans and 24 km h^{-1} for electric bikes [2]. Some limitations of these cargo bikes include the inability to climb steep slopes, the need for policy change in some cities (i.e., cargo bicycles are illegal in some city areas), potential risks due to extreme weather conditions and severe collisions [2].

Although UAV delivery is more applied in rural areas so far, there is potential for a substantial switch from van-based goods delivery to drone-based delivery in urban areas [1,36]. There are some challenges related to use of drones for urban freight LML services: Legal restrictions on UAV-based goods delivery in many countries; limited service area of a drone, i.e., drone service areas are limited within a radius of about 15 km or less; less productivity than van-based delivery, for instance, a van can deliver about 120 non-food items within eight hours, while a drone can deliver only about one item per hour; risks of bad weather, collision and crashing into people, deliberate attack, and theft of payload; difficulty to integrate environmental acceptability and cost efficiently, i.e., drones are allowed to fly within limited altitude in urban areas (often about 0.12 km) and it is difficult to avoid concerns regarding privacy and noise disturbance in the service area; the confined delivery routes (limited to less sensitive environments) should be also traded off with transit time, energy use, and logistics cost.

Information communication technologies (ICT) tools promoted the growth of e-commerce. However, LML is associated with large losses for companies involved in e-commerce due to operational and logistical problems [6,24,34]. Fragmentation of orders is one of the big problems. Other major LML problems related to e-commerce include tight delivery time window, large number of small orders, and increased customer requirements [30]. Customers could buy a small quantity of goods, but they need on-time delivery. This leads to poor load rate and more carbon emissions [20,25]. Depending on the variations in assumptions made and logistics structures, the carbon footprints of last mile delivery varies, e.g., from 21 to 650 g CO_2 eq per kg of goods [20]. In addition to the possibility of increasing smaller customer orders and home delivery activities, online shopping may not avoid personal trips for supplementary shopping. It even could increase transport distance since goods could be sourced from anywhere around the globe [9,36,40].

4.2. Infrastructural and Planning Aspect

Freight LML problems should be considered as both logistics and urban planning challenges [4,37,41]. There are three major dimensions of urban planning that influence the efficiency of LML: A built environment (with attributes such as population density), planning control (a system dealing with parking, loading, and unloading issues), and transport control (a system dealing with speed limits, traffic lights, bus lanes, railway crossings, etc.) [37].

The structure and geographical location of a city affect the LML activities as there are space, access, and distance related problems in urban areas [7,22]. There are impedances due to geographical difficulties, historical centers, population density, and restrictions on truck movement. Challenges in relation to urban narrow streets, strict regulations, and limitation of facilities for fast loading and unloading have impacts on performance of LML systems [31,37]. For existing cities, it is not easy to change (old) road infrastructure to accommodate increasing freight volume [2]. In such cases, alternative solutions such as e-cargo bicycles play a good role. However, the geographical conditions could make the use of cargo bicycle/tricycle difficult [22].

New technologies could lead to the need for new transportation and facility infrastructure. For instance, for electric cargo bicycle/tricycle, there is inadequate road infrastructure, capacity constraint in terms of weight and dimension, and customer concerns (some customers prefer larger distribution companies than small firms operating with cargo bicycle/tricycle). In addition, for electric light vehicles and bicycle/tricycles there is inadequate recharge infrastructure, cargo deconsolidation (and consolidation) centers, and capacity constraints [15,22]. On top of this, such logistics infrastructures are associated with high investment cost.

4.3. Freight LML and Management Aspect

Although freight LML is becoming a complex part of logistics management for firms, there has been misconception on this transport segment in the supply chain [1] and relatively less attention is given. There are some innovative solutions suggested and tested to address urban freight distribution problems. However, there is no single solution that fits all problems of freight LML services in different cities. Some models can be replicated in different cities but specific action protocols that fit the logistics environment should be prepared [23]. Urban freight LML is characterized by uncertain and dynamic conditions where coordination between actors of supply chain is difficult [39]. This indicates that determining effective freight LML system and its management for specific urban conditions, type of freight, and customers' interests is a complex task. For instance, conflicting interests of potential actors such as city councils, citizens, dealers, carriers, and suppliers is one of the factors that make urban freight LML more complex, especially when there is lack of interaction between stakeholders [21,23].

Satisfying customers is difficult for online retailers. Modern consumers need agile, lean, and just-in-time logistics, which aggravate the problems of LML [37]. On the other hand, to be profitable, online retailers might be forced to reject some delivery orders depending on the available transport capacity, delivery time window, order volume, and order value [5]. In many countries, consumers' awareness on environmental impacts has increased and they demand reduction of emissions. However, many customers are not often ready to pay more for improved LML logistics services making LML management more complex [14].

Not only in online retailing, but OC businesses are also associated with management challenges [6,40]. In OC, there is a challenge in allocating energy consumption and other related environmental impacts of online and conventional retail at warehouse level [40]. In addition, seasonal variation of warehouse stockholding levels, different levels of warehouse automation (less automation is required for online channels), and different amount of packaging used in the online and conventional channels make the allocation of energy and emissions between different channels more difficult. Dividing energy and emissions between different consignments during vehicle-based delivery is challenging [40]. It is not easy to know the energy consumption in production and use of the ICT infrastructures and the impact of online ordering due to computers, lighting, etc., [20]. There is difficulty to generate adequate data on logistic operations and environmental impacts of freight LML services in both cases of conventional and online retailers [40]. There is also difficulty to get or estimate the freight data and understand the future business views in changing urban conditions [7,20].

How to improve freight LML services and reduce their impacts on sustainability of freight transport (in urban area) is an important challenge for researchers too. Moreover, the future freight LML solutions should integrate the digitization and automation technologies into LML system design and operation strategies enhancing real-time decisions based on data harnessing and dynamic analysis [13,16]. The use of unstandardized junk of logistics terms related to urban freight distribution increases the difficulty of digitization and automation effort to improve efficiency of LML services. For instance, some logistics terms often used interchangeably include: 'freight transport' and 'goods transport'; 'distribution hub' and 'regional warehouse'; 'urban consolidation center' and 'local distribution center'; 'pick-up point' and 'proximity station' [7].

One management related problem of LML service is goods delivery failure which is associated with negative impacts (see Table 4). For example, Dell'Amico et al. [19] discussed that 10% and 50% failure rates could increase the CO_2 emission by 15% and 75%, respectively. In home delivery schemes, delivery failure rates of about 12–60% were reported in the UK with the additional possibility of failure in redelivery [20]. Visser et al. [4] discussed that first-time delivery rate is about 12% while about 2% cannot be delivered at all and are returned to central distribution center (DC).

Table 4. Home delivery failure rates of online retailing.

Item	Delivery Failure Rate (%)
Books	3
Small electrical items	5–10
Fashion clothing	20–44
Grocery (first time delivery)	34

Source: Author's own work based on data from [40].

There is a higher risk of delivery failure in attended delivery than unattended delivery [6,14,25,40]. This risk could be reduced by providing specific delivery time window, but this solution may compromise routing efficiency [13,14]. Home delivery efficiency is also time sensitive. Longer lead time could result in dissatisfaction of customers. On the other hand, same day delivery service is a challenge for online retailers and logistics service providers [4]. For instance, just in time and leagile concepts in the supply chain increase goods shipment frequency and inefficiency in load factor [7].

4.4. Cost Related Challenges

Freight LML is associated with conventional and externalities costs [1]. It contributes about 28% of the total goods delivery cost [1,5,6,34]. Main cost drivers of LML include consumer service level, delivery type and security, geographical area and market penetration, technology and fleet management, consumer awareness, and environmental and societal impact of LML service [14].

The growing online and OC grocery retailing is associated with high costs and complex fulfillment for items bought online [10]. Especially, the delivery processes are associated with high cost and complexity. In some cases, there is even additional cost for repeated delivery (due to failure of first-time delivery) [4]. Attended home delivery has less initial investment cost, but it has high delivery cost due to high failed deliveries and forced presence of customers at home during delivery activity [25]. Delivery costs are sensitive to factors such as service time, service area (from DC), driver cost, and investment cost. Driver cost could affect cost of delivery with electric cargo bikes as this alternative increases the driving time [2]. Not only the cost of delivery, but also cost estimation and planning for goods delivery is not easy as it is associated with many constraints related to cargo capacity, driver working hours, and battery capacity (for e-cargo-bikes) or charging interval of e-vehicles [2]. Another dimension of complexity for LML service is that growing e-commerce has low profit margins for firms while customers expect higher service quality [5]. For some firms, electric light vehicles used for LML have high fleet acquisition and operational costs [22].

5. Opportunities for Improving the Sustainability Performance of LML

In previous sections, it was mentioned that urban freight LML is not sustainable and more innovative solutions are required. Some innovative LML solutions include innovative vehicles, proximity stations, collaborative and cooperative urban logistics, route and transport management optimization, and policy related innovations [17]. At aggregated level, sustainability of a product or system can be evaluated from economic, environmental, and social point of view. Each aspect has its own sustainability metrics. In evaluation of LML sustainability, the major sustainability metrics include environmental (emission to air, energy consumption, land use); economic (product quality, cost efficiency, time efficiency); and social (noise disturbance, health issue, employee satisfaction, customer satisfaction) [27]. In this section, the major opportunities for improving sustainability of LML services are discussed.

5.1. Opportunities for Improving Environmental Sustainability

In urban LML services, small improvements can have huge impacts over longer time horizons, because urban goods delivery services are repeated activities. There are also geographical implications, i.e., small improvements (e.g., reduction of GHG emissions) over a small area can lead to significant advantages if applied over large areas of a city or other cities [19].

From a technological innovation point of view, in the near future urban freight LML services could be widely carried out by unmanned vehicles, robots, and UAVs [35,36]. This could create opportunities for integrating digitization and automation across logistics industries including freight LML areas [13]. Digitization enables the development of more efficient, flexible, and customer-focused supply chain solutions. Digital supply chains can provide interconnected logistics systems, smart warehousing, and advanced information analysis tools to efficiently manage entire supply chains. In this way, for instance, both first mile logistics (FML) and LML areas of supply chain could be optimized in an integrated manner [38]. Appropriate application of digitization and automation of LML systems could reduce delivery failure in cases of home delivery services and facilitate optimization of goods transport systems such as vehicle routing problems (VRP). Specifically, firms can combine VRPs with electric vehicles to improve LML efficiency [1]. Simulation model-based evaluations of urban freight solutions are increasing in recent years. This facilitates the development of knowledge base and enables many stakeholders to increase their understanding on the dynamic urban freight logistics systems [42]. Such simulation models could be used to develop and analyze different alternative freight LML systems.

For urban freight LML, light vehicles are more sustainable alternatives to large trucks [22]. In particular, electric vehicles are environmentally friendly but cannot avoid spatial constraints (parking and congestion problems), compared to electric cargo bikes which reduce congestion problems as they use bike lanes [2,24]. These bikes also produce less emissions and noise pollution and reduce parking problems (and idle tile) as they can park on sidewalks [2,22].

Using alternative energy (to petrol and diesel) for cars, and cars with more capacity of filtering vehicle exhaust gases is part of the technical innovation to reduce environmental impact [4]. In addition to innovative vehicles (electric, hybrids, and fuel cell electric vehicles) and car-sharing (ride-sharing), technological solutions to increase LML sustainability include application of ICT, ITS, and Industry 4.0 [1,13,18,35]. Promoting sharing economy and cooperation among the stakeholders increases the efficiency of resource utilization. Replacing passenger vehicle travel (used for goods transport) with goods delivery routing schemes (with smaller and electric vehicles) reduces the impacts of freight LML [32].

Introduction of Industry 4.0 solutions in supply chain management using advanced technologies such as vehicle identification, GPS, and smartphone tools enables to carry out smart scheduling and real-time optimization of LML services [13,38]. It enables manufacturing and service providing companies to increase their efficiency. Introducing Industry 4.0 technologies leads to increased cooperation among actors of LML chains. Such a cooperation could minimize the energy consumption and order fulfilment time [13,22]. In optimizing energy saving in LML, goods delivery time frame and vehicles loading capacities are important parameters (constraints) to be considered, because these factors can significantly influence the reliability, flexibility, and cost and environmental efficiencies of goods delivery services.

In city freight transport, logistics innovations are being realized as 'incremental' and 'radical' innovations [36]. In radical innovations, there would be a clear departure from existing practices. The recent development in the use of UAVs is a good example of radical innovation in city logistics. Another example of radical innovation in city logistics is the adoption of 3D printing enabling consumers to produce products at their homes. Firms should understand these trends. Although both 3D printing and UAV deliveries have less potential of mass application within short and medium terms, they have potential to disrupt the urban freight LML systems [1,36]. For instance, significant application of 3D printing technology at domestic (consumer) level could result in some advantages. These include saving materials (as structures can be hollow); elimination of reverse flows of damaged or unwanted products as consumers produce the product on-demand according to their preferences; and reduction of the ton-km and cubic meter-km of goods transport; reduction of the number of lightly loaded cars in the traffic. It is interesting to note that materials for 3D printing can be delivered from out-of-town warehouses to customers infrequently and in large quantity which could have environmental and economic advantages [36].

Technology alone cannot solve the complex challenges of freight LML. The management aspect should be integrated well in the design of best LML [21]. Firms with efficiently organized logistic configurations and management have competitive advantage [12]. For instance, appropriate implementation of innovative approaches such as collaboration, sharing economy, use of parcel lockers (pick-up points), satellite facilities such as transshipment locations could have economic and environmental benefits [24]. One innovative management approach is goods collection and delivery at night. This could reduce fuel consumption and CO_2 emissions by about 20%. Multi-use lane practice could lead to 10% and 7% reduction in fuel consumption and CO_2 emissions, respectively [23]. Off-peak hour and night delivery using more silent trucks can improve sustainability of LML [33].

From a management point of view, the development in ICT and Industry 4.0 promotes optimization of urban logistics where algorithms and different optimization techniques can be applied. Especially, in developing algorithms and optimization techniques in LML, the following factors are important: Real-time data, dynamic route planning algorithms, fleet management solutions, tracking devices, identification devices [1].

Proper localization of LML infrastructures such as UCC, and parcel lockers, is one of important factors that positively influences the efficiency of LML system [25]. For instance, in cases of using cargo bikes, UCC in a city center enables to shorten final delivery distances and provide delivery services in an economically competitive way [41]. The location analysis of such facilities should consider maximization of economic and environmental benefits while addressing the concerns of customers and local authorities. Alvarez and de la Calle [23] discussed some of the innovative freight logistics practices in Europe with positive outcomes: Temporal load spaces, silent night unload, consolidation center, electric vehicle based goods distribution, multi-lane use (use of public road for different operations such as goods loading, unloading, and parking). Delivery with 'Bentobox' concept enables to improve a balance between optimization of logistics operations and customers' interests while improving environmental impacts. It increases successful unattended deliveries and reduces the number of car stops and deliveries.

Distribution centers are important facilities for de-bundling, storing, and redistributing goods with more efficient LML services [37]. Therefore, DCs should be developed strategically. It is very innovative to introduce a mobile depot at areas where building DC facility is less desirable or not feasible. The mobile depot can be adapted to dynamic nature of LML services over time, geographic location, and traffic conditions [7,37].

Home delivery service is associated with goods de-consolidation and consolidation processes. Consolidation increases the efficiency of home delivery [4]. Big-lot goods transport need to be de-consolidated at their terminals in order to deploy small vans for home delivery. On the other hand, small-lot orders need to be consolidated to be delivered by delivery route with vans (via optimized routes) [4]. Reducing (avoiding) delivery failures by implementing unattended delivery (reception boxes) system could lead to significant environmental benefits [40]. For example, replacing home delivery by delivery to local depot can reduce CO_2 by 60% [20]. From evaluation of UCCs-based LML concepts using four pilot studies in Europe [15], the introduction of UCCs was found to be a promising approach which contributed towards sustainability through emission reduction, better capacity utilization (e.g., more than 70% fill rate), and LML cost efficiency [15]. For instance, a pilot study in Paris applied a 'supply to UCC and delivery from UCC', where electric vans and electric cargo tricycles as well as ICT- and GPS-based real time intelligent route planning systems for roads and cycle lanes resulted in a reduction of noise and pollutant emissions (i.e., CO_2 by 82%, PM by 82%, NOx by 80% [15]).

Effective logistics management is a critical factor for success of e-commerce business. For instance, in OC business, consumers place orders virtually anywhere [36]. In such case, implementing multiple digital mediums at customers' convenience could enable OC service centers to provide greater customer loyalty and higher satisfaction. OC retailers use traditional as well as online channels, with data integration and sharing across all channels [6]. In some cases, it is not easy to acquire accurate and adequate data on LML operations and related impacts [20,40]. To overcome such difficulty, there is the possibility of using forecasted (estimated) data and scenario based analysis to evaluate LML [7].

Effective freight LML management also depends on proper policies. For example, proper policies and regulations needed to implement ICT, ITS, and Industry 4.0 within cities. Issues like delivery time windows, VRP with time windows, and night delivery times are also related to policy issues [1]. Home delivery services can be improved through implementing innovative policies, reducing distance traveled by road vehicles, modifying driving speeds [4].

5.2. Opportunities for Improving Economic Sustainability

Urban freight transport has a great role for economic and social development [3,28]. In LML logistics processes, city characteristics, and the final receiver attributes are variables that influence the cost effectiveness. Therefore, firms should evaluate their performances using these attributes within context and scope of their LML services. Stop time, distance from depot, distance between stops, traveling speeds, vehicle and maintenance costs, as well as depot costs are variables influencing logistic costs [24]. In relation to city characteristics, city size and delivery area, population density, available infrastructure, congestion levels, local wage, and fuel price are variables influencing LML cost-effectiveness [24]. The final receivers determine total demand volume, product size, weight, and value. Stop density and drop size per delivery are determined by number of receivers in a given distribution area [24].

In strategic planning of retailers, both back-end fulfilment and last mile distribution play vital role for business economic successes [10]. Back-end fulfilment focuses on the management of activities at the place of shippers (picking) operations. It focuses on picking location, picking automation, and picking integration levels. The last mile distribution mainly focuses on delivery mode (e.g., home delivery, click and collect), delivery time, delivery area, and return of goods [10].

Electric vehicles are costly, but their operating costs are less when compared with conventional vehicles [1]. Electric cargo bicycles could be cost effective if the delivery area is in close proximity to the DC, if there is high density of residential units, and low delivery volume per stop. When delivery area is large and the delivery volume per stop is large, delivery trucks are more cost effective [2].

Electric cargo bikes have less depreciation costs than diesel vans and relatively less operational costs due to reduced energy consumption [2,22]. Bicycle/tricycle and light vehicles have the advantage of delivery time flexibility and reduce traffic congestion leading to cost and resource saving [22]. Unlike vehicles, bikes also spend little time searching for parking. Vehicles spend, on average, considerable time looking for on-street parking. For example, it takes about nine minutes in Seattle while it takes about 15 min in New York [2].

Delivery by van is more efficient than personal shopping trips [20]. For example, personal trips to collect books from shops could generate about 24 times the CO_2 generated by a van delivery scheme in the UK [20]. In goods delivery planning, widening the delivery time window improves the efficiency, e.g., doubling the time window could reduce transport costs by about 24% [20] and increase the effectiveness of logistics [9].

In OC, online retailers can offer virtually limitless assortment while only limited assortment is possible in the case of traditional stores, i.e., online retailing creates a virtual shelf extension. In addition, OC has the possibility of inventory sharing between different channels with benefit of cost reduction [6]. However, it should be managed well using a robust ICT system avoiding potential conflicts to be generated between different channels sharing the inventory data. The adoption of smart technologies (e.g., ICT, ITS, Industry 4.0, innovative vehicles) could lead to reduction of labor force. This could be more adaptable in some countries to reduce the high labor cost [22].

Some firms introduce sharing economy business model to overcome logistics challenges related to rising freight transport demand [9,24]. Example of 'sharing economy' business models in relation to LML are UBER and Lyft. 'Sharing economy' provides a quick delivery performance and promotes resource sharing (collaborative use of resources). This enables firms to avoid fixed costs, empty moves, and idle-time cost by employing drivers who own vehicles [9]. In addition to collaborative use of resources, effective demand planning (process of forecasting demand) and demand fulfilment (order promising and due date setting) are needed to have cost effective LML [5]. For instance, well planned delivery schemes such as unattended deliveries could result in reduction of about one third the delivery cost compared to attended deliveries with two-hour delivery time window [5].

5.3. Opportunities for Improving Societal Sustainability

The impact on health (due to pollutants) is high in urban areas due to the proximity of residents to road networks [28]. Therefore, with increasing freight LML activities in urban areas, liveability and societal health need attention. Increased freight transport demand is associated with accidents with fatality and injury, property damage, delivery delay, wastage of time due to traffic congestion, and air and noise pollution [1,7,18]. In addition to health issues, employee and customer satisfaction are relevant aspects in evaluation of social sustainability of LML services [27]. For instance, OC business models could be a more innovative approach to address the issues of customer satisfaction and LML management [6].

More sustainable mobility of goods needs an integrated socio-technical solution, not solely technological approach. For instance, fully autonomous vehicles can make drivers less stressed. However, further assessments are required on cost and socio-technical aspects of the systems [35]. Growing use of (electric) bicycle/tricycle and light vehicles increases job creation and quality of life due to reduced CO_2 emissions and other atmospheric pollutants that cause health problems [22]. Freight LML services with light vehicles and bikes increase jobs (driving jobs) and create more relaxed working conditions for drivers of tricycles (i.e., less parking restrictions) [15]. Similarly, online shopping creates more job opportunity for city freight LML providers. However, in some cases, e-commerce could lead to the closing down of many conventional shopping centers which could not compete with new trends [4].

Online retailing changed the patterns of freight transport and increased pressure on road traffic and related environmental impacts even though the impact varies from region to region (and from one country to another country). It also affects the consumer behavior [4]. In Europe, retailers use advantage of increasing environmental awareness of consumers by asserting the benefit of online shopping for environment (e.g., load consolidation and van-based delivery reducing personal car trips for shopping) [40]. However, online shopping has its own environmental and societal consequences and further research should be conducted and communicated well to consumers.

Some measures that could lead to urban air quality includes introducing car-sharing, bike-sharing, and increasing use of electric vehicles. Electric vehicles also reduce noise and enable night deliveries of goods. Policy-based restriction of gasoline and diesel vehicles from entering inner city areas could reduce road traffic flows and improve air quality in the city area [43]. However, in some cases, providing more sustainable LML services could lead to extra costs. In such cases, residents should be willing to pay the delivery service and potential consumers need to be convinced about the benefits of more socially sustainable LML services via well planned dialog forums [15].

6. General Discussion and Future Research

6.1. General Discussion

In general, urban goods distribution is vital for economic development and city life [19,33]. However, world population growth, urbanization, consumerism, and e-commerce have increased urban goods flow and affected freight distribution [39,42]. The diverse and dynamic (spatially and temporally) nature of delivery needs in LML also affect the urban freight LML [2]. This dynamic in transport demand is disrupting traditional logistics operations in the last part of transport services or goods supply chains [32]. This has increased the complexity of LML. In urban freight transport, there is also complexity due to conflicting interests in relation to multi-stakeholder decision making processes [29,30]. Especially, increasing online retailing and urban traffic levels have a more complex relationship than originally thought [31,36]. This complexity is aggravated also by public transport sector in urban areas. As a result, in public transport sector, both the first mile (from start point like work place or home to commuter) and last mile (from commuter to work place or home) are equally important and are getting the attention of transportation policy makers and planners [26]. Regarding the first mile part of freight transport, supply to distribution hubs is done usually in bulk supply. However, the distribution of freight from the hub to downstream of the supply chain, where the activities are handled by LML, is done in small quantities.

6.1.1. Technological Innovation and Urban Freight LML

From a technological aspect, electric cars and cargo bicycles are environmentally friendly solutions. However, electric vehicles have high investment costs which discourage LML service providers to invest [43]. Therefore, incentive measures are needed to promote the use of electric vehicles where they are more effective. In relation to communication technologies, growing online trading will continue to disrupt the freight LML services. This could affect more small enterprises. Currently, the share of e-sales is high in large and medium enterprises than small enterprises [11].

The online retailing has a share of about 10% in many countries, but the growing rate of online retailing is greater than conventional shops [20,40]. Transition from conventional to online retailing changes the logistics: goods transport, storing, type of ICT, and packaging. The traditional retailers are forced to add an online channel to their marketing system while the online retailers had to have physical stores to provide a more satisfactory service [6]. Traditionally, products widely purchased online include CDs, DVDs, books, and clothing. Nowadays, food and grocery online shopping is also increasing [40].

6.1.2. Urban Freight LML System and Management

Urban planning concept such as 'compact city' promotes minimized land use, more efficient public transport systems, and increased opportunities for walking and cycling. However, the LML services are not well considered in such urban planning. Problems related to loading space, increased control on LML vehicles, etc., are not addressed in such urban planning [37]. Innovative LML models should be integrated into the urban planning processes. For example, a last mile corridor strategy with time-window-based off-street loading/unloading, can be implemented along road networks to reduce environmental impact operational costs [37]. Such LML models should take into consideration a comprehensive understanding of the changes in shopping, travel behavior, consumer behavior, and technology utilization [4]. In some urban centers, freight transport could be planned in coordination with passenger transport [21].

Different supply chains should have different LML models depending on type of goods and operation area. For instance, food supply chains require logistics service depending on freshness of the food, cold chain requirement, vehicle hygiene, etc. [17]. Some LML solutions help to solve specific problems but could be associated with some challenges. For example, 'sharing economy' could increase efficient resource utilization and, at the same time, increase delivery uncertainty due to unstable vehicle fleet and creates risk of competition between consumers (transport service buyers) [9]. In some cases, crowdsourcing logistics (CSL) concept can be applied for LML services. Crowdsourced last mile delivery uses independent drivers (contractors using their own vehicles). In such cases, delivery time window, demand fluctuations, and resource constraint (vehicle supply) affect the LML performances [9].

In the case of home delivery, the major delivery failure is related to the delivery time window. This problem could be tackled by improving home delivery planning with more choice of delivery time and date for the customers; reducing the time gap; introducing unattended reception options; and improving communication between carriers and customers with more precise information [4]. Home delivery schemes could reduce personal shopping trips and traffic in the city. However, it is more complex to identify how far the shopping trip is reduced since customers may go for supplementary purchases or could be motivated to plan other trips using time saved by online shopping and home delivery. It is difficult to know how the freight and passenger traffic changes in terms of ton-km or vehicle-km due to increasing home delivery [4]. The impact of home delivery also depends on drop density, speed, and frequency of delivery, and return policy [20].

6.1.3. Sustainability of Freight LML

Freight LML should be designed to be cost efficient, customer oriented, and environmentally friendly. However, companies often focus only on cost-efficiency and customers' needs rather than environmental sustainability [34]. Therefore, there is an urgent need for solutions for urban freight logistics problems, especially in highly urbanized areas [15]. The sustainability performance of LML in cities can be increased by taking innovative measures in technological aspects (adopting and improving electric vehicles and ICTs); smart logistics aspects (adopting logistics digitization, generation and use of relevant data); structural aspects (restructuring LML networks/systems, introducing proximity stations and facility location); and management aspect (adopting collaboration, cooperation, coordination, and integration for instance via developing a shared digital platform, and stakeholder involvement) [1,13,17,19,21,36]. However, it should be noticed that freight LML models and practices implemented and successful in some cities may not be successful in other cities. The success depends on geographical conditions, citizens habits, and the motivation and effectiveness of companies involved [23].

Online shopping has some benefits for consumers such as greater product choice, no spatial barrier, and better price comparison [34]. However, from a logistics point of view it increases the complexity of LML [34]. Firms should give special attention when determining type of delivery systems to be used [44]. For instance, attended home deliveries could be about three times more costly than unattended home deliveries [34]. However, it is also difficult to totally eliminate attended home deliveries due to various reasons such as security concern, perishability of goods, possibility of additional service (or expert support) in relation to delivered goods [34].

The current study has four major scientific contributions: It provides a comprehensive review of up-to-date scientific literature related to LML; develops typology of freight LML; identifies the major challenges in relation to urban freight LML; and highlights opportunities for interventions to increase the sustainability of freight LML activities. Finally, it pinpoints future potential research agendas related to LML. The study could be a knowledge base useful for academicians and practitioners, vehicles and logistics service providers, providers of ICT and related technologies, conventional and online retailers, policy makers, and customers.

6.2. Future Research

Not only is LML fragmented, but the research on LML is a fractured field in logistics [6,12,22]. On the other hand, new technologies are emerging that could disrupt the traditional freight LML used in urban cargo transformation. This creates opportunity not only to develop new business models in freight LML but also to plan considerable research projects in freight LML. In general, there is significant research potential for freight LML [24] and some major research topics are suggested here.

- In the supply chain management, more attention has been given to manufacturing issues than transportation [37]. Especially, LML has become a research topic very recently [17,34]. However, more investigation is required on LML management, e.g., addressing topics such as subcontracting [44] of LML services' conflicting interests of multiple stakeholders [29,30].
- The typology analysis has resulted in three major potential LML configurations. In depth quantitative analyses could be conducted to identify more sustainable LML options.
- In comparison to LML, first mile logistics (FML) (e.g., in case of return management or collection of goods from producers) has not received attention from researchers [16,34]. Future studies on urban freight LML could integrate freight FML.
- The rapidly growing online shopping, OC business, and their impacts on LML, have potential research stream in near future [6,20]. Such studies can be designed considering goods delivery failure and its management, packaging, delivery scheme, delivery time window, transport distance, warehouse (or retailer) location, ICT infrastructure, vehicle type, and load factor, etc.
- The comparison of conventional and online retailing requires more complex and detailed research works [35]. This type of study could be conducted taking into consideration factors such as geographical variations, urban variation, and goods variation.
- Within rapidly changing urban environments, the awareness of urban residents and authorities increases. This leads to changes of logistics-related policies and regulations. This makes logistics planning and management issues more complex and difficult [7,45]. Therefore, more strategic research of urban freight LML performances are essential.
- Emerging technologies such as 3D printing for localized goods production and UAVs for freight delivery [36] and digitization and automation technologies for logistics management [13] could lead to interesting innovative LML solutions. In this regard, it is important to standardize and define the use of technical terms related to LML. The performance of these innovative LML solutions should be assessed in the future as their application is scaled up.
- Existing studies related to LML focus on one or two aspects of sustainability. Integrated research projects that consider the environmental, economic, and societal aspects are needed to develop sound knowledge base and improve sustainability of LML activities.

7. Conclusions

This paper presents the literature-based study on last mile logistics (LML). The main objective of this study was to identify major challenges causing inefficiency of freight LML and opportunities for intervention. In this literature review work, 38 peer-reviewed papers published after 2010 were screened based on defined criteria and fully read. In the general discussion section, four additional scientific papers and three documents were referred to. After the identified papers were reviewed systematically, limitations of definitions of LML and related logistic terms were discussed. The findings of this study indicated that urban freight flow has a trend of steady growth. The driving forces behind this growth include population growth, urbanization, densification, globalization, e-commerce and OC retailing, and economic development. From the developed typology, three main potential freight LML configuration types were mapped: Type-I—distribution center-based delivery (DC delivery); Type-II—local distribution center-based delivery (LDC delivery), and Type-III—pick-up point-based delivery (PP delivery).

The challenges constraining freight LML were identified and categorized as technological, infrastructural, freight LML system and management, and logistic cost related challenges, and discussed broadly. Similarly, the opportunities for tackling the challenges and increasing the sustainability of urban freight LML were identified and discussed from environmental, economic, and social sustainability dimensions. More studies with demonstrations using innovative solutions could improve the sustainability performance of urban freight LML. For instance, these studies could consider the technological aspects—adopting and improving electrical vehicles and cargo bikes, and ICTs, Industry 4.0, logistics digitization and automation technologies; infrastructural aspects—restructuring LML networks/systems, introducing appropriate logistics facilities; and management aspects—adopting collaboration, cooperation, coordination, and integration, for instance via developing a shared digital platform for facilitating e-commerce and involvement of multiple stakeholders at different stages.

Funding: This research received no external funding.

Acknowledgments: The author is grateful to the anonymous reviewers and the academic editor for their valuable comments to improve the earlier version of this paper.

Conflicts of Interest: The author declares no conflict of interests.

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