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Review

Sustainable Last-Mile Logistics in Economics Studies: A Systematic Literature Review

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Abstract: In recent years, many cities throughout the world are facing the impact of last-mile logistics and the resulting rise in urban traffic and pollution. Effects on the environment have been curbed by these dynamics. Urban traffic has a considerable impact in terms of noise emissions, road safety and air pollution: hence, both public and private parties should undertake innovative solutions for reducing the negative effects of last-mile logistics and improving their operational effectiveness. This study aims to provide a systematic literature review of studies having as their main topic environmentally sustainable last-mile logistics with the perspective of economic studies. The review of the literature reveals that the majority of recent studies have been based on engineering and urban planning approaches. Costs and benefits of last-mile logistics are approached with a public economics focus, gathering details from the different papers, starting with the business studies and then exploring the technology-oriented ones. This study aims to detect the different topics and policies discussed in the literature, and it suggests how to incorporate them in creating new measures and policies for last-mile logistics in the urban area, or for revamping current ones.

Keywords: last-mile logistics; systematic review; urban freight transports; active transport; transport policy; sustainable mobility

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1. Introduction

Research on topics connected to urban mobility has significantly grown over the past years. Targets of research range from private and public means of transport to shared logistics applications, from the policy claims of institutions to the stakeholder's behavior and inclinations.

Urbanization is one of the main factors driving this growing tendency: by 2050, 70% of people and 90% of GDP will be imputable to urban areas [1]. The need to curb pollution and develop more sustainable forms of growth has become increasingly urgent. According to the International Energy Agency [2], the transport sector, which is the second most polluting industry, produces 25% of the total global greenhouse gases (GHGs), 75% of which are related to road transport. As a result, all the efforts to decarbonize logistics are now essential to addressing environmental externalities, such as noise pollution and road safety as well as climate change.

Before the COVID-19 outbreak,[3]pointed out that just-in-time delivery and internet shopping were increasing the use of freight vehicles. Although the COVID-19 pandemic's limits on movement and activity led to a 57% fall in the world's oil demand in the first quarter of 2020, global transport emissions rose by 0.5% compared to those for the same period in 2019 [4] Urban deliveries became essential in areas where governments imposed

strict restrictions on people's movements (e.g., France, Ireland, Italy, Spain, and the USA), allowing them to use specific services only at home (e.g., food and groceries deliveries). Additionally, even in the absence of restrictions, a number of retailers or supermarkets expanded their selection of home delivery services: according to [5], house deliveries of goods and food soared by 500% during the first pandemic months, making private services necessary overnight. Furthermore, the necessity to consider enhanced health protection procedures has given rise to new concerns, including certain measures, such as reduced capacity per vehicle in order to allow physical distancing, improved sanitation for public transportation, rear-door boarding, and design interventions (i.e., screens between seats, contactless sensors, hand sanitizers, and marked seats) [6–8]. In a short period of time, we have seen a rapid evolution in the sector. Services born during the pandemic, however, kept their relevance even after the emergency ended, thus making it necessary to make them environmentally sustainable.

The issue of sustainable development of the service determined increasing differentiations and subtopics in the scientific literature, thus making urban mobility a research area spanning many disciplines. Engineering is the most developed field, with applications in technology development, programming, and optimization of vehicles and controlling systems; when electric vehicles are used for services, battery optimization and renewable ways of charging are also investigated. On the other hand, research on urban mobility is becoming more and more popular in economics and management research, which focuses on operation management as well as transport and environmental economics. The legal field considers data compliance and the different kinds of contracts being created to implement policy and strategies.

This review aims to investigate the state-of-the-art literature on sustainable last-mile logistics. We scanned literature to detect trends and significant gaps in economic research dealing with urban deliveries, especially from a public perspective. New contributions from the public economic perspective, new studies with welfare evaluations presenting different alternatives to solve last-mile logistics issues, as well as cost–benefit analysis, will contribute to increasing the impact that research can have on new measures and policies.

As already mentioned, the analyzed matter encompasses several fields (e.g., engineering, economics, environmental studies, transport science, etc.), but, although we have not a priori limited the scope of our research, the point of view presented in this review will be mainly economic. Economic aspects are relevant to last-mile logistics as they heavily influence agents' choices in joining specific services, accepting technological changes for sustainable purposes, and also guiding regulatory decisions taken by local administrations. Moreover, considering the relevance of new services' environmental sustainability, we shall also translate into economic values the weight given to "sustainable" aspects by different agents.

The topic presents several aspects that need further study and, particularly from an economic point of view, it is difficult to zero in on one specific aspect as many interconnections are present. The scope of this review is to detect the main issues discussed in the literature and to find research gaps worth developing in the future, especially those which are critical to provide policy suggestions.

The remainder of the paper is organized as follows: Section 2 will be dedicated to describing the methodology used to perform the systematic literature review; Section 3 will present the topics detected by our review and, in particular, will focus on the discussions of the main findings relevant for economic research; finally, Section 4 will draw final conclusions and future insights.

2. Methodology

Last-mile logistics has a high impact on everyday lives of consumers, delivery companies, and society. The concept of sustainability may encompass several dimensions (e.g., environmental, social, or financial sustainability). Still, since transportation is one of the most polluting sectors in terms of GHG emissions and plays a significant role in the

energy transition process, the present review focuses mainly on issues connected to environmental sustainability, adopting an economic point of view for the analysis of existing literature on urban last-mile logistics.

Following the structure proposed by [9], we adopted a three-step protocol to select articles to be included in the systematic review: first, we selected a preliminary set of papers addressing our topic of interest and applied our inclusion/exclusion criteria; then, we refined our pool on the basis of titles and abstracts; finally, we further refined the selection of papers on the basis of the full-text review.

By definition, systematic literature reviews should detect major contributions to a research field or question through a comprehensive scan of the scientific literature. What sets systematic reviews apart from narrative reviews and commentaries is the transparency and replicability of the selection process [9].

2.1. Step 1: Inclusion/Exclusion Criteria

The first step was the identification of a preliminary set of scientific papers addressing our topic of interest. Then, we selected keywords to search in abstracts, titles, and keywords and we conducted keyword research in Web of Science (Web of Science is one of the leading research platforms for scientific publications worldwide. However, using a single platform may have increased the exposure to a geographical bias in the selection process). The selected keywords were as follows: *sustainable urban freight transport, sustainable last-mile delivery, and sustainable last-mile logistics*. Considering the object of the review, more recent papers are likely to include in their analysis a setup that is still relevant to current habits and available technologies, which are constantly evolving. Therefore, we decided to consider only papers published from 2017 onward, as we noticed an increase in interest for the topic starting that year.

Our preliminary pool considered 583 articles and was the result of two separate extractions: one performed in July 2021 and the other in November 2022. When merging the results of the two extractions from Web of Science, we checked for duplicates and eliminated them.

According to the language criterion, to make our work accessible to most of the scientific community, we considered only paper written in English; thus, three articles were excluded (i.e., two written in Spanish and one in Russian).

Finally, we eliminated all the publications which were not published in peer-reviewed scientific journals (mainly conference proceedings) to be sure of considering only well-established contributions in scientific literature. As a result of this reiterated elimination process, our pool of articles was composed of 365 papers.

2.2. Step 2: Selection Based on Title and Abstract

In the second step, we considered the title and abstract of each record. We discarded 204 papers that, despite automatic inclusion performed by Web of Science, were related to topics beyond our field of interest. These papers were either out of scope (i.e., the wording misled the automatic research), or their focus was different from urban last-mile logistics (e.g., works dealing with rural last-mile or private vehicles. Moreover, we decided to exclude reviews.

2.3. Step 3: Selection on Full Text

The final step was to read the full text of the records to exclude articles that lacked an economic perspective. At the end of the selection process, we ended up with 108 papers dealing with our research question.

We summarized the results of the exclusion process in Figure 1. As expected, the most noticeable drops in the number of articles were observed in the first two steps.

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

In the following paragraphs, we briefly describe the most interesting features of our selected articles. The final sample of papers covered a timespan of six years from 2017 to 2022 and, as shown in Figure 2, the scientific interest in urban last-mile logistics has increased over time. Furthermore, given that the interest in urban last-mile logistics encompasses many disciplines, selected works came from scientific journals covering different research areas.

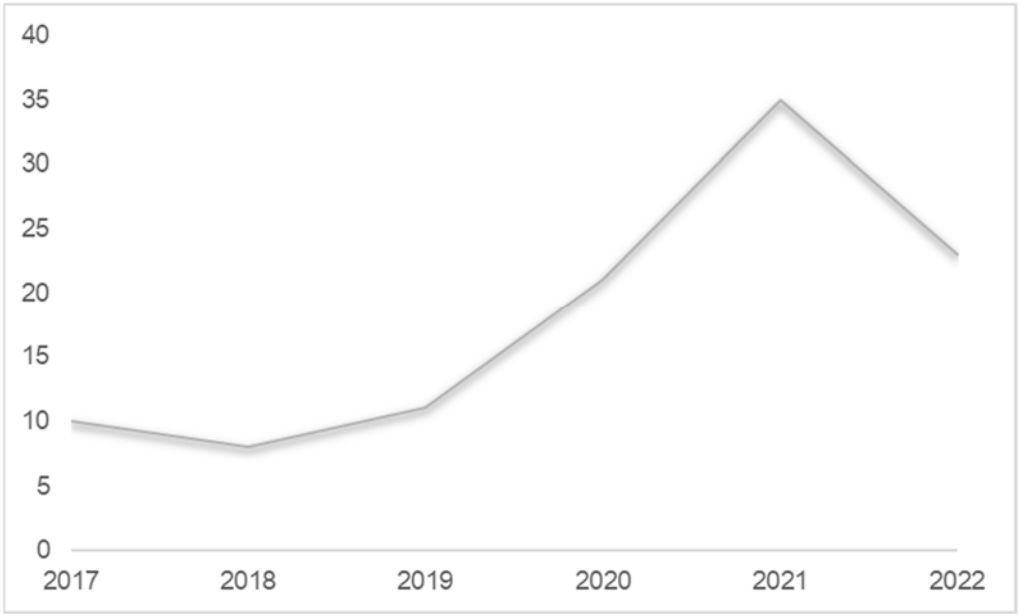

Figure 2. Number of papers per year in our final pool of articles.

3. Clustering of the Research Topics

To better discuss the evidence emerging from the systematic review, we decided to cluster the 108 selected papers into five main categories that seemed to represent the most discussed topics with an economic perspective. For the sake of clarity, in Table 1 we summarize the number of papers for each category. We identified the following categories:

(1) Agents' preferences and choices. This cluster collects works suggesting models analyzing or predicting choices of individuals, firms, and other relevant subjects, evaluating if and when to opt for last-mile logistics, but also how agents influence the development of last-mile services;
(2) Shared logistics. The category represents one of the most popular topics in logistics research, focusing on the sharing economy of the last leg of the process;
(3) The role of stakeholders. Differently from "Agents' preferences and choices", economic modeling has less consideration in the discussion, while the role of potential users, promoters, and society has a distinctive analysis;
(4) Studies on vehicles. The section represents an extensive stream of literature, which represents the effort that—especially, from an engineering perspective—is made to develop a more sustainable last-mile logistics both from an economic and environmental point of view;

(5) Policy and decisions. Papers clustered in this section deal with the role of public authorities and decision-makers in handling last-mile logistics through public investments and private–public agreements. Suggested incentive schemes and policies, where present as the main topic of the paper, will be reported in this section.

Table 1. Authors' Elaboration on the Review Dataset.

Number of Papers per Topic	
Agents' preferences and choices	28
Shared Logistics	34
Stakeholders	22
Studies on vehicles	38
Policy and decisions	9

The same paper could touch on topics covered in more than one cluster. For this very reason, in a few cases, we decided to allow inclusion in more than one category to account for multidisciplinary studies.

3.1. Agents' Preferences and Choices

3.1.1. Consumers' Side

The disruptive growth of e-commerce is frequently linked to an increase in the number and frequency of deliveries.

Consumer choices and preferences on product shipment are usually influenced by multiple factors: delivery time, location, and price, which is usually regarded as the most important attribute for consumer choices. These features are often investigated using stated preference surveys, even though there may exist a risk of inconsistency between stated preferences and people's actual behavior due to social judgment [10]. In their choice-based conjoint experiments, [11] find that almost one-third of consumers have a neutral attitude towards sustainability in last-mile logistics and, in general, consumers prefer the delivery option which guarantees orders are delivered by the very next day to an address of choice on regular office hours.

Nevertheless, there is evidence that providing additional information on last-mile deliveries' environmental and social impacts makes consumers more likely to choose more sustainable delivery options [10,12]. [10] investigate whether e-commerce customers change their preferred delivery option after receiving additional information on its sustainability using a survey based on five sustainability factors (i.e., delivery cost, delivery time, location of the delivery, drivers' working conditions, and CO_2 emissions). Likewise, [12] find that providing information on emissions and the environmental impacts of delivery is an effective strategy to alter preferences toward more sustainable solutions without hampering profit margins as it happens with price incentive strategies.

The use of non-financial incentives (i.e., information messages, order of delivery options, social media, and social norms) to push sustainable e-commerce delivery options is analyzed by [13]. In the online experimental study, presenting an informative message to consumers helps them to grasp the environmental benefits of opting for a slower delivery alternative and to bridge the time gap between the moment of choice and the one in which its impacts are manifested. However, social media and social norms also seem to positively influence the choice in favor of a "greener" delivery option [13].

It must be considered that individuals who differ in socioeconomic characteristics and sensitivity to environmental issues frequently show heterogeneous preferences. Different categories of consumers may present different attitudes towards the delay of deliveries to increase sustainability, or to whether it should be an individual (i.e., of the consumer) or a collective responsibility to require a more sustainable delivery service [14] .

Furthermore, consumer preferences may also consider the way that deliveries are performed, especially when introducing disruptive technologies, like automation. The introduction of automatic vehicles may radically change the delivery process as recipients will have different roles in the process [15]. Still, it might also offer interesting solutions for the main issues of urban logistics (i.e., urban congestion and transport emissions) [16].

In conclusion, it is widely recognised that the COVID-19 pandemic further boosted e-commerce and produced changes in consumers' preferences and habits. However, it is unclear if the modified patterns will be temporary or stable in time. [17] argue that the persistence of those mutations will be erratic for different categories of consumers (e.g., prior adopters, temporary and permanent new adopters, and non-adopters) and different categories of products (e.g., grocery, food, home goods, and other goods).

3.1.2. Firms' Side

The commitment of actors involved in last-mile logistics and the availability of adequate tools to evaluate options available are crucial to make processes and operations more efficient and sustainable.

[18] assess the sustainability of three delivery schemes with a focus on food products. These goods typically require frequent and fast deliveries and are characterized by low volumes, which prevents consolidation. The results show that the distribution channel must be chosen according to the consumer group to be reached.

Recently, crowd logistics gained considerable relevance among delivery options, as will be discussed in detail in the following section. Based on a theoretical model of a technological–organizational environment, [19] study various factors that affect the willingness of companies to implement this type of solution. However, retailers are frequently not directly involved in freight transportation. They entrust logistics activities to professional logistics service providers as long as the delivery service's reliability is guaranteed in terms of quality and time [20]. With respect to the latter aspect, retailers often face the challenge of complying with as short as possible lead times for their orders without having (full) control of some factors, such as urban dynamics or, in cases where the delivery activities are outsourced, delivery drivers [21]. On the one hand, some retailers may be willing to pay a higher cost to benefit from a more reliable service and reduced stock [20]; on the other hand, there are independent delivery contractors who, if adequately involved, can provide information about conditions and ways to create sustainable value in retail logistics [21].

The insight of this section is that, since consumers and distributors are likely to have different preferences towards how the delivery should be performed, and are subject to different types of cost, it is fundamental to integrate their perspectives to pursue overall efficiency and, consequently, sustainability, of delivery processes. [22] find that end-consumers incur monetary and non-monetary costs for e-commerce and propose a generalized distribution utility index that balances the losses of customers against profits created for the distribution system.

3.2. Shared Logistics

Sharing services are becoming more and more competitive, particularly in sustainable last-mile logistics. [23] pointed out that shared or collaborative logistics encompasses several solutions ranging from crowd logistics—particularly crowd-shipping—and the potential for businesses to share vehicles and/or distributional infrastructures. [24] define crowd logistics as "an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis and is compensated accordingly".

The crowd deliveries are made with full vehicle capacity, thus reducing the number of travels, whether couriers use their private vehicles, as reported by [24], or public trans-

portation, as pointed out by [25,26], creating the possibility of new income for non-logistics operators. Thus, it results in the implementation of monitoring and control systems, but it also lowers emissions and prevents the development of new traffic. [27] warn about the risk of distortions if participation is motivated exclusively by economic incentives, losing the benefits of exploiting ex ante planned trips.

[28] showed that no scheme directly and solely promotes ESG goals through the analysis of various crowd-shipping models: the use of private vehicles for shared logistics frequently results in an increase in environmental pollution. The lack of control over individual drivers not only causes negative impacts on the environment but also decreases quality for the end customer. Furthermore, [29] stated that crowd-shipping may support sustainability by using excess transportation capacity for freight deliveries without adding a new trip to the network, creating cost reduction and infrastructural development for the service. On the other hand, [30] demonstrated that the overall estimated cost is still quite high compared with the traditional supply chain. Nevertheless, [31] made clear that crowd-shipping is evolving into a desirable response to consumers' growing expectations for the effectiveness and sustainability of the service.

Last-mile as a service (LMaaS), mobility as a service (MaaS), or freight as a service (FaaS)—depending on distance and type of parcel considered—are promising concepts for transport systems based on digitalization and integration among freight and passenger. MaaS optimizes the environmental impact of the journeys, increasing the resilience by offering additional systems and reducing the costs of the service, as demonstrated by [30,32].

The implementation of innovative collaborative logistics is not straightforward and may require a transition period in which crowd-sourced and traditional delivery networks coexist [27]. According to [33], private companies typically develop crowd logistics during the seed or start-up phase. The potential for public–private investments and public incentives, as suggested by [28,34], are crucial success elements for sharing services. However, as pointed out by [25], crowd logistics services have a negative net present value; therefore, the potential for public involvement could play a significant role. Anyway, as a consequence of the SARS-CoV-2 pandemic, it may be reasonable to expect a decreased propensity to accept the reduction in the space available on public vehicles in favor of freight transport, according to [34].

A freight tram system can minimize the usage of commercial road vehicles, which reduces congestion, accidents, air pollution, noise level, and operational costs, as shown by [35]. However, drawbacks to employing a tram as a freight transport are noteworthy, mainly because the route is fixed and because the wagons need to be customized. A crowd-shipping service was proposed by [25] for last-mile B2C deliveries in which metro users pick up/drop off items in automated parcel lockers (APLs) situated within metro stations or in their neighborhoods. According to the simulation, they find a negative net present value if no public incentives converting the reduction in negative externalities for the whole society are guaranteed.

The use of facilities that carry out the process of consolidation of goods might improve the efficiency of last-mile logistics and reduce the externalities created. Urban consolidation centers (UCCs) are facilities in the city's suburbs, where various suppliers' freight can be consolidated and delivered into the city using a two-tier system: trucks make deliveries from distribution centers to UCCs, and then smaller vehicles make deliveries to the final customers [36,37]. According to [36], even if it has not yet been empirically shown, UCCs decrease the number of vehicles in cities, increasing the load capacity of vehicles and reducing traffic, pollution, and safety problems. UCCs, on the other hand, entail expenses, including personnel, vehicle, and material handling expenses. [36] pointed out that the UCCs present cross-subsidization issues because of the lack of a single impact on the logistical procedures, expenses, and service standards of suppliers. The presence of UCCs has key implications for policymakers, influencing the existing logistics processes of actors and stakeholders. [38] studied four different logistics scenarios and

their quantification in terms of the cost of wheel-to-tank emissions: the use of EVs for deliveries combined with UCCs coupled with access restrictions to city centers results in savings of about EUR 10.000 when compared to the base scenario that includes no UCCs at all.

UCC's shortcomings can be decreased by using lighter and more adaptable methods, such as micro-depots and mobile access hubs, as stated by [39,40]. Combining the lockers with crowd logistics, [41] stated that the use of non-dedicated public transport with parcel lockers and micro-depots represents an opportunity that potentially mitigates last-mile logistics inefficiency. Micro-depots are urban facilities that logistics providers use to perform different operations, such as loading or unloading, sorting, and warehousing items. [40] integrate a network of micro-depots used by various logistics service providers with parcel lockers that can be deployed either in the micro-depot or in key locations throughout the city. According to [31], the use of parcel lockers in a congested shipping network enables quicker trip diversions and more geographic coverage, even if it results in more movements for every shipment, which could result in more damage to the packages and more insurance costs. [42] suggested a multi-depot routing problem that considers sustainability from three perspectives: economic, social, and environmental. They highlighted that actions taken in favor of sustainability may conflict with the other two.

3.3. Stakeholders

The present review discusses various measures and actions to assess the issues related to sustainable urban logistics. Yet, to boost the success of such initiatives, feasibility in terms of resources and a deep understanding of the multiplicity of stakeholders involved are crucial elements. Different needs and perspectives often characterize stakeholders; identifying those differences can enhance a project's success chances [43]. Many sustainable last-mile logistics initiatives fail to reach their potential because of the lack of stakeholders' support and engagement [44]. This is the case, for example, with UCCs that often struggle to survive because their introduction affects various actors along the distribution chain, impacting them differently with respect to costs, processes, and services provided [36].

There are several types of stakeholders involved in urban freight and analyzing the reasons and objectives they may have to participate in city logistics is crucial also to improve the interactions between them [45]. A general distinction is between private and public stakeholders [46]. Nevertheless, there might be stakeholders not directly involved in logistics operations who are nonetheless affected by them, as is the case with citizens, whose perceptions have been frequently neglected [43,47].

A common way to obtain a better understanding of stakeholders' priorities is through freight quality partnerships (FQPs). FQPs are forms of cooperation between many stakeholders that aim to set up meetings and workshops to present problems relating to freight transport and work out consensual solutions [48]. The integration of complementary planning support tools can be helpful. Multi-actor multi-criteria analysis (MAMCA) is the method suggested by [49] to foster greater involvement of stakeholders in the decision-making process of urban logistics. The MAMCA methodology allows public authorities to identify the priorities of the stakeholders and, on this basis, guide the debate towards an integrated and pragmatic discussion of the best strategies to be undertaken.

Instead, [50] explore the use of stakeholder engagement workshops, a participatory approach different from MAMCA, to address current and future city logistics issues. The stakeholder engagement workshops are composed of four steps: stakeholder analysis, problem analysis, solution analysis, and final summary and conclusions. The choice of a participatory approach responds to the willingness to provide stakeholders with a framework to discuss problems and related causes and effects, and then to co-design a set of possible solutions considering drivers and barriers.

The behavioral components of decision-making matter greatly in designing and implementing effective urban logistics measures, as was already discussed in the section on

agents' preferences and choices. Engagement is crucial to enhance the acceptance of new policies [50]. [51] propose gamification as a tool to support the adoption of sustainable behaviors and encourage stakeholder engagement. Based on the case study in the Netherlands, [52] argue that behavioral factors, such as norms and attitudes, might significantly push individuals and organizations along the supply chain to engage in sustainable last-mile logistics.

Building effective interactions among stakeholders along all the stages of the project's development can be useful to align objectives and avoid conflicts, although this factor is often overlooked. [53], for example, point out the idea of cognitive consensus referring to the commonalities in stakeholders' conceptualization of fundamental issues that can support the decision process. They argue that "cognitive consensus" can be a powerful tool to broaden stakeholders' perspectives on freight policies, mitigate conflicts, and boost trust and cohesion among stakeholders.

The relevance of stakeholders' engagement and interaction appears evident considering how they can help coordinate the different needs and enhance cooperation in actual city logistics initiatives, especially in shared logistics solutions which, by construction, involve several actors [54–56]. Nevertheless, [57] investigate whether or not stakeholders are actually given enough power to affect the outcome in the planning of urban freight initiatives.

Finally, it is important to keep in mind that other important factors may affect the success of sustainable urban logistics initiatives (e.g., durability and local context specificities). Durability refers to the capability of a project to generate, monitor, and preserve, over the longest possible time horizon, its positive effects in improving the quality of life for all the inhabitants of a city [58]. The second aspect concerns the tendency, or rather the temptation, to "import" successful city logistics initiatives from one urban environment to another. Context-specific characteristics should never be overlooked, for what might work in one city or project might not elsewhere [43].

3.4. Studies on Vehicles

The decisions to exploit internal combustion engine vehicles (ICEVs) or zero- and low-emission vehicles (ZLEVs), light or heavy vehicles, and route optimization will play a crucial part in the decarbonization of the logistics industry. The above-mentioned decisions become even more relevant because the current study focuses on the final mile in an urban setting with stringent traffic constraints.

In particular, the adoption of light electric freight vehicles (LEFVs), such as cargo bikes and tricycles, are a key frontier for the development of last-mile logistics toward increased sustainability from an environmental and social perspective. According to [59,60], LEFVs have several advantages over other means of transport, including lower distribution costs, emissions, and noise, minor fuel cost, lower road occupancy, and ease of access and parking, which is a key drawback for delivery trucks. These advantages also result in less congestion and fewer accidents, increasing road safety. [61] pointed out several studies assume constant transportation costs in order to more easily implement optimal replacement policy; however, this assumption is relatively ill-defined and could lead to unrealistic solutions for real-world problems. On the other hand, as demonstrated by [60,62], LEFVs have a number of drawbacks that need to be studied, including the range, battery characteristics (i.e., high price and high procurement costs), and, most significantly, the accessibility of public charging infrastructures. Although [63] point out that the potential cost of employing an electric fleet will decrease, at the moment it still remains a barrier for logistics providers.

[64] identify four main market segments for commercial cargo cycles in last-mile delivery: postal services, courier services, parcel services, and home delivery. The uptake of cargo bikes, motorbikes, and tricycles by delivery companies is influenced by different crucial factors that push the switch from ICEVs. The reason is that LEFVs are a profitable

alternative for making last-mile deliveries more efficient in urban centers (i.e., lower operational costs and reduce total cost of ownership), but also because of the versatility of movements through densely populated cities and the lower environmental impact [64–66].

Comparing vehicles based on the cost of daily operations, trucks are the most expensive and cargo bikes are the most economical. The average distance travelled by freight bikes is 50 km, compared to the trucks that travel 160 km per day. Light trucks become the most cost-effective mode of transportation when measured in kilometers, while the cargo bike is the most expensive [67,68] pointed out that the most efficient business models to activate cargo cycles are on-demand carrier services consisting of pick-up and delivery requests and business-to-business delivery, allowing consolidation, route optimization, and last-mile deliveries in urban areas.

[69] evaluate an intermodal postal parcel delivery system in which deliveries are conducted while walking and assisted by LEFVs to move extra weight to designated locations (such as mobile depots) where they can be reloaded into mailbags. As a result, before moving to ZLEVs, there must be a transitional period in which the coexistence of ZLEVs and ICEVs must be handled effectively. The coexistence period needs to be managed carefully to reduce the possibility of cannibalization between conventional and green business models, which could lower the quality of the service [70,71]. According to [59], only 10% of traditional vans should be replaced by cargo bikes because of the distribution network effectiveness reduction. [72] proposed a model where deliveries weight 5 kg or less are performed by on-foot porters using wheeled bags, trolleys, or cycle couriers, implementing both environmental and financial conditions. In fact, according to their simulation, total cost reductions range from 34% to 39% (depending on how deliveries are made), along with a decrease in parking time and in CO_2 and NOx emissions.

The use of electric vehicles for commercial transport and distribution is still relatively unexplored, according to [73]; thus, further real-life trials and pilot projects will be essential to comprehend the needs and potential applications. [63] evaluated an electric pilot in Poland and showed that the service was not hindered by the delivery effectiveness or the battery's lifespan. However, the availability of charging facilities and the city's electric efficiency emphasize the lack of grid capacity for entire fleets [74]. Furthermore, according to [74], the literature has also shown that electrifying fleets can reduce GHG emissions by 42–61% when compared to diesel alternatives in urban environments in the US, by 69% in China, and by just 10% in Europe.

According to [75], utilizing technologies, such as automation, might achieve a competitive advantage over time by balancing sustainability and cost-effectiveness. Autonomous vehicles can aid in lowering fuel consumption by choosing the most cost-efficient route and cutting down working time. [75] show a cost reduction of 5% and a CO_2 emissions cut of 20%. Route optimization can increase delivery efficiency and sustainability, in addition to the reductions in trip distance and delivery time. The ideal route for a mixed fleet was demonstrated by [76], because EVs may enjoy free access to metropolitan areas where circulation is restricted by entry fees and time limitations. On the other side, EVs require more time to charge and have a shorter battery life. According to [15], people have a neutral view of the use of autonomous vehicles as a delivery option, which is consistent with expectations based on earlier studies on the acceptability of these vehicles.

3.5. Policy and Decisions

When considering urban freight's impact on local infrastructures, rules and policies have the power to encourage or limit innovations and changes in agents' behavior. Considering the presence of externalities (both positive and negative), the intervention of the public entity is not only desired but also necessary to achieve efficient results. Sustainable urban freight is strongly demanded by national and supra-national institutions: the European Union implemented Directive 2014/94/EU[77] on the deployment of infrastructure for alternative fuels, where electricity is going to play a major role in the transportation

sector. On the other hand, the EU also supported financing programs, such as Fit for 55, which aims to reduce GHG emissions by at least 55% by 2030. How public authorities are managing these aspects—and trying to evaluate how effective the management is in terms of achievements—seems to be particularly relevant.

The systematic review of the literature shows that the verification of the policy and regulation aspects are reported in few studies and are mainly linked to the analysis of case studies rather than to a theoretical analysis of the theme.

The focus can be on the evaluation of carbon emissions determined by specific services. [78] studied the impacts of on-demand meal deliveries in London, concluding that these kinds of deliveries are much more relevant in terms of impacts than other traditional forms of transport; in this study the impacts in terms of soil occupancy and interactions with other users (e.g., pedestrians) are also considered. Policy implications show that to promote the use of bicycles instead of more pollutant vehicles, like mopeds, specific investments in dedicated lines should be undertaken.

A similar object, but with a different research question, is investigated by [79]. The authors carried out a questionnaire in Norway regarding the use of e-groceries, matching this with the habits of personal traveling of the respondents; the results show that the use of e-groceries impact on other travels, making them more sustainable (e.g., on foot rather than by car since they do not need to carry heavy bags). Despite the sample not being representative of the Norwegian population, it shed light on an impact that should be taken into account while making a cost–benefit analysis of specific services and, consequently, while adopting new policies. The authors also suggest the inclusion of stakeholders in the early stages of the planning of city measures.

Still considering the analysis of cases, Astrid Bjørgen [80] extended the analysis on the integration of urban freight transport in city planning by looking at other cities in Norway. The analysis confirmed the previous finding on how stakeholder involvement is very relevant for the successful planning of services.

Also, in [81], the role of externalities is highlighted, comparing the two cases of Gothenburg (Sweden) and Delhi (India). The findings of the study show substantial dissimilarities between the two cities and indicate city-specific research as a solution to adopt the best sustainable urban freight measures.

Despite the interest arising from the discussion of cases, external validity is a big issue for this kind of approach, especially when it is not possible to understand to what extent the results could be used to approximate behaviors in other contexts (e.g., for analysis based on value transfer techniques). The contribution of these studies, however, is still helpful in the initial phases, to detect which kind of wider analysis should be performed.

Since the phenomenon is relatively recent—or, at least, recently the use of e-commerce and urban deliveries has become more relevant—the use of cases is widely justified, but a broader approach must be hoped for in order to be able to address the issue from a theoretical and political analysis point of view.

4. Conclusions

The scope of the work was to detect the main research paths connected to last-mile logistics, keeping as a critical issue the sustainability of the service from the environmental point of view. This aspect is considered widely relevant as transport is one of the areas on which to work more to complete the energy transition. Moreover, changing habits are making the last-mile deliveries increasingly used and strategic for consumers, firms, and authorities.

In the analysis, we wanted to detect how economic issues are treated in the literature. The topic is widely covered by engineering studies aimed at making more efficient tools, vehicles, and systems for the functioning of the service. In this sense, the approach is more related to business studies than economics with a theoretical perspective.

Technology drives studies that consider specific innovations, such as online platforms for crowd logistics, automated vehicles, and drones. Technological improvement

(i.e., routing optimization, automated warehouse management systems) might help in decreasing operating costs as innovations in business models and firm organization and operations, but currently presents specific barriers—mainly related to the coordination and harmonization of stakeholders' interests—prevent a full realization of such innovations. The conglomeration of deliveries, such as competing companies' parcels, crowd logistics, and last-mile as a service, might represent performing schemes in order to decrease operating costs and negative externalities (i.e., environmental impact and urban noise). The adoption of zero- or low-emission vehicles, mainly electric vehicles, is one of the most promising methods to reduce costs and environmental impact, but it suffers from several issues, such as purchasing costs of the vehicles and their technological limitations (i.e., battery, hydraulic tail, etc.). Implementing hybrid fleets seems to be the best solution at the moment, but this does not overcome the problem of evaluating the impact of electric fleets on the network. Even if we plan to power the fleets with renewable sources, the moment in which these are recharged is extremely important for assessing the real environmental impact of the electricity produced (evaluating the marginal emission factor of the technology produced at the specific time).

The prevalence of business approaches justifies the double interpretation of the term "sustainable", which is often used to mean financially sustainable—with a private approach—rather than with an environmental meaning which subtends institutional concerns related to public economics and policy approaches. What emerges from the review is a general lack of institutional perspective. This gap might be justified by the relative novelty of the topic, given the lack of policy application results and datasets, that mainly involves engineering and urban planning studies. Several issues, however, call for a deeper analysis from the public economics side.

The first justification for the interest of public economics in this field is the presence of externalities, both negative and positive, on the emission side (e.g., GHG and noise). As shown by several studies, last-mile logistics is one of the main sources of urban carbon emissions. The increase and the decrease in these externalities is dependent on the conditions set by local, government, and supra-national authorities, and on dedicated policies. The direct applications of urban vehicles access regulations (UVARs) or low emissions zones (LEZs) are the main policy applied by local authorities in order to decrease city center pollution. The implementation of such restrictions may also be an incentive for the conglomeration of deliveries among competing companies, because of the contingent quantity of travel that can be carried out inside the city center.

These kinds of policies and infrastructural applications are very common in Europe (i.e., France, Italy, Germany, Netherlands, and the United Kingdom), and they are also common in North America and Japan. Plenty of case studies on the EU and Japan are analyzed, in particular focusing on the cities of North-East Italy, London, Bristol, Paris, Monaco, Nijmegen, Tokyo, Fukuoka, and many more. The main shared points among these case studies are the policy support by the municipalities where they operate and the infrastructural presence of urban consolidation centers. The first item is very peculiar because almost all the cities considered have in common the enactment of policies, such as UVARs and LEZs, aimed at reducing GHG emissions and noise pollution. On the other hand, the presence of infrastructural facilities is common only among European countries and Japan. This is probably due to the characteristics of the city conformation and the type of goods transported. Last-mile delivery is not without consequences for companies, policymakers, and all the involved actors: transport firms would require considerable investments to expand and renew their fleets and warehouses, and policy-makers could create market distortion with policies that are too brave.

Given the vast amount of data collected in the optimization of urban systems, through delivery operations and the application of digital twins, privacy issues should be investigated, and data treatment must be considered a priority to avoid opportunistic behaviors and unbalances in market forces, even if most of the companies collect data privately and hardly share them.

Articles dealing with operations management and business studies of services in downtown areas highlight the relevance of stakeholders' coordination and the need to consider different perspectives. The public authority is the only entity that can implement policies and has the right to coordinate both private and public interests in developing last-mile and related services. However, it is necessary for the public authority to have its own perspective and objectives, which should be aligned with the general and supra-national policies, thus preventing the final services from being distorted in favor of large market operators.

The review suggests that there is a major gap in economic research dealing with the public perspective in the sector and it is necessary to work in this direction to complete other, more focused analyses that will be completed in the future, such as those related to the persistence of the effects of COVID-19 in the use of services, issues of space allocation in the city (e.g., electric vehicles charging points, delivery vehicles (un)loading spots, with a focus on historical cities, etc.), and on common instead of private lockers, acting in the same way as conglomerated deliveries, reducing the operative costs and environmental pollution. This can be considered the main contribution of this work, i.e., to call for a major involvement of public economics research in the sector.

The second message of this review is that interdisciplinary research is strategic, as only with a coordinated view will it be possible to detect and overcome barriers to practical solutions, and to align winning solutions to general policy targets for global sustainability of the last-mile logistic services.

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