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Research Article

Collection and delivery points in the last mile of cargo transportation: Sustainability benefits and challenges

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Abstract

The present work aims to analyze sustainability aspects related to the use of lockers, collection points, and other forms of fixed points, by transporters and consumers, in the last mile of cargo transportation, as an alternative to home delivery. For this purpose, a literature review was performed. Three distinct platforms were researched using strings in three different languages, Portuguese, English, and Spanish. From these databases, 31 articles were selected, all of them according to the subject studied. The papers highlighted the advantages of this type of delivery, embracing not only the environmental gains but also the economic and social ones, such as the reduction of traffic congestion and an overall lower operational cost. Reduction of greenhouse gas emissions and atmospheric pollutants are shown in 23 papers; lower operating costs for transporters in 26 papers, while 23 articles address congestion reduction. The biggest challenge identified is the distance traveled by clients/pedestrians, cited 21 times.

Introduction

The increasing awareness surrounding climate change and its main cause, the emission of greenhouse gases, pressured countries and companies to look for alternatives that could ensure sustainable economic growth. On the other hand, the economic prosperity of developing countries, fueled by the processes of globalization and connectivity through the use of online channels, promoted a scenario of a high volume of online purchases. In many cases, the origin of these products is far from their destination, thus requiring the use of transport, one of the leading consumers of energy and fossil fuels. Worldwide, most cargo transportation is carried out by road, generating 2.2 billion tons of carbon dioxide - CO_2 annually [1].

One key step to the conclusion of these deliveries is known as the last mile. This final stage involves the trip done by a courier to the consumer, usually from a close distribution center. Although responding for a small fraction of the extension of the trip, the last mile usually corresponds to the highest operational cost, due to its nature of sprawling and diluted destinations. This aspect, combined with the possibility of not finding the customer at home resulting in a failed delivery [2], causes the circulation of several vehicles in order to complete the deliveries, increasing the transport cost [3].

A possibility to mitigate the problem exposed above is the use of Collection and Delivery Points (CDP), strategically distributed throughout the city. These spots, counting with structures such as lockers, boxes, drawers, or other types of containers, could temporarily hold the purchases of consumers. This mode of delivery would place the burden of traveling the last mile on the consumer but would transform the procedure of receiving the goods more flexibly, both for transporters and buyers. Additionally, it is expected that fewer trips done by motorized vehicles would translate into an environmentally-friendly operation, with less greenhouse gas emissions.

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The main objective of the work was to examine the state-of-the-art sustainability aspects with regard to the use of lockers and other collection and delivery points for goods in the last mile of cargo transportation around the world. The work focused especially on identifying the benefits and challenges that accompany this type of delivery.

Methodology

A Literature Review (LR) of the available papers was conducted. Three databases were selected, so the LR became more robust [4], namely the CAPES, SciELO, and ScienceDirect platforms. Three languages were used to perform the queries: Portuguese, English, and Spanish. The strings searched were "Última Milha/Last Mile/Último Kilómetro" and "Entrega/Pick-up/Entrega" on said databases. A temporal criterion was established, starting from the year 2012 and thereafter. This criterion did not influence the results, as the topic of interest has only started being studied in recent years, from 2010 onwards. The results obtained were treated, removing the duplicate ones. In sequence, the titles of the papers were read, and those that did not possess a relation to the main theme were excluded. After this exclusion, the analysis of the abstracts was executed, filtering even more the papers obtained, and selecting those in consonance with the proposed theme, and that were fully available. The papers that still remained in accordance with the theme were included in the LR.

The analysis of the papers composing the LR was focused on detecting the advantages, *i.e.*, the gains derived from the mode shift from traditional home delivery to utilizing pick-up and collection points. It also mapped the difficulties of implementation of this mode of delivery, and also the disadvantages, if any.

Results and discussion

1.285 articles were obtained in the platforms using the strings and thirty-one papers were selected for adhering to the scope and aim of this study. Figure 1 showcases the selection process of the articles concerning the topic. Table 1 presents the 31 papers selected and their extracted data. Most articles found were concentrated in the last two years (2021 and 2022), each of these years responding to 07 papers, and the oldest one is from 2012. Furthermore, the majority of papers came from the European (13) and Asian (10) continents, with the Americas, both North and South, having a lesser share (06). The papers were divided into three groups, them being concerning models-algorithms of optimization of delivery routes (18), case studies (11), and Literature review (02), that verified the acceptability of users and the economy of resources by companies that, in opposition to standard home delivery, have chosen this method of delivery through collection points.

The papers address sustainability aspects in the usage of lockers as collection and delivery points. This delivery mode

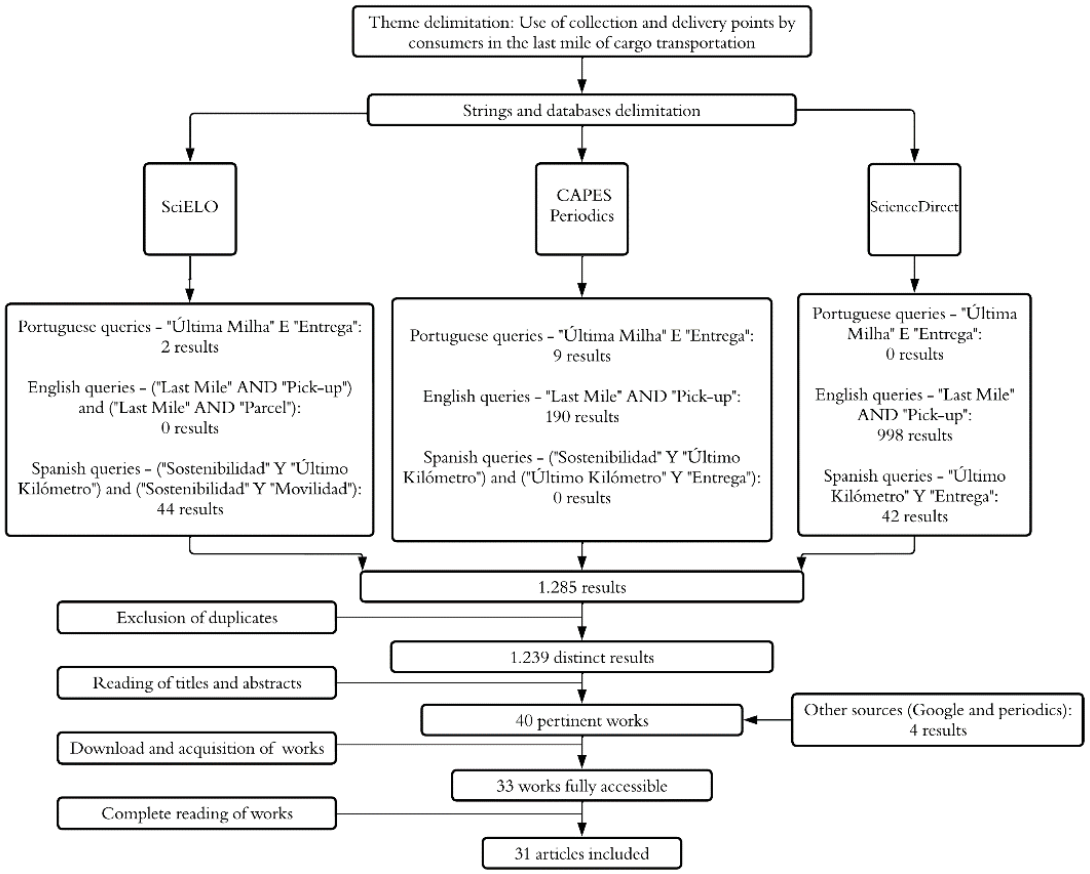

Figure 1: Selection process applied to the Literature Review.

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Table 1: Collection and Delivery Points in the Last Mile - Sustainability benefits and challenges.

					Locations			Benefits				Challenges
Authors	Year	Article continents	Method	Terms used	Shopping centers	Supermarkets	Transit stations and terminals	Reduction of failed deliveries	Reduction of traffic congestion/ Number of vehicles	Reduction of GHG emissions and atmospheric pollutants	Reduction of miles traveled / Number of trips	Location of the collection and delivery points in relation to the consumers
Dell'Amico M, Hadjidimitriou S [5]	2012	Europe	Optimization of delivery routes	Modular BentoBox (M-BBX)	x			x	x	x	x	x
Iwan S, *et al.* [6]	2016	Europe	Case studies	Parcel lockers	x	x	x	x	x	x	x	x
Oliveira LK, *et al.* [7]	2017	Americas	Case studies	Automated Delivery Stations	x	x	x	x	x	x	x	x
Cardenas ID, *et al.* [8]	2017	Europe	Optimization of delivery routes	Pick-up points		x	x	x	x		x	x
Rai HB, *et al.* [9]	2018	Europe	Case studies	Lockers				x		x	x	
Lachapelle U, *et al.* [10]	2018	Oceania	Case studies	Parcel lockers	x	x	x	x	x	x	x	x
Zenezini G, *et al.* [11]	2018	Europe	Case studies	Collection-and-Delivery Points	x	x	x	x	x		x	x
Zhang L, *et al.* [12]	2018	Europe	Optimization of delivery routes	Packstation				x		x	x	
Alves R, *et al.* [13]	2019	Americas	Optimization of delivery routes	Automated Delivery Stations		x		x	x		x	x
Oliveira LK, *et al.* [14]	2019	Americas	Optimization of delivery routes	Collection and Delivery Points	x	x		x	x	x	x	x
Silva JVS, *et al.* [15]	2019	Americas	Case studies	Pick-up sites	x	x	x		x	x	x	
Nahry, Vilardi AF. [16]	2019	Asia	Case studies	Parcel lockers	x		x		x	x	x	x
Lin LY, *et al.* [17]	2019	Asia	Case studies	Automated Parcel Stations	x		x	x		x	x	x
Wang Y, *et al.* [18]	2020	Asia	Optimization of delivery routes	Collection and Delivery Points					x			x
Chen CF, *et al.* [19]	2020	Asia	Case studies	Automated Parcel Stations		x	x			x		
González-Varona JM, *et al.* [20]	2020	Europe	Optimization of delivery routes	Parcel lockers				x	x	x	x	x
Huang Y [21]	2020	Asia	Optimization of delivery routes	Pick-up terminal				x			x	
Chaberek G [22]	2021	Europe	Case studies	Collection points	x	x	x		x		x	x
Iannaccone G, *et al.* [23]	2021	Europe	Optimization of delivery routes	Parcel lockers	x	x	x	x	x	x	x	x
Gielens K, *et al.* [24]	2021	Europe	Optimization of delivery routes	Pick-up points		x						
Lyu G, Teo CP [25]	2021	Asia	Optimization of delivery routes	Locker	x		x	x	x	x	x	x
Schnieder M, *et al.* [26]	2021	Europe	Optimization of delivery routes	Parcel lockers				x	x	x	x	x
Mancini S, Gansterer M [27]	2021	Europe	Optimization of delivery routes	Shared Delivery Location		x	x	x	x	x	x	x
Zhao H, *et al.* [28]	2021	Asia	Optimization of delivery routes	Courier site				x				
Oliveira LK, *et al.* [29]	2022	Americas	Case studies	Locker			x	x	x	x	x	x
Ma B, *et al.* [30]	2022	Asia	Literature review	Parcel lockers	x	x		x		x	x	
Moussaoui AEE, *et al.* [31]	2022	Africa	Optimization of delivery routes	Collection and Delivery Points		x			x	x	x	
Bonomi V, *et al.* [32]	2022	Europe	Optimization of delivery routes	Parcel lockers				x	x	x	x	x
Jamous R, *et al.* [33]	2022	Asia	Literature review	Parcel lockers				x	x	x		
Sweidan A, *et al.* [34]	2022	Asia	Optimization of delivery routes	Parcel lockers				x	x	x	x	x
Masteguim R, Cunha CB [35]	2022	Americas	Optimization of delivery routes	Pick-up points	x	x	x	x	x	x	x	x

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proposes that the last mile of cargo transport is traveled by the final consumer, not the carrier. During the process of the research, a great number of terms were employed to address this type of delivery, with the most used ones being: Parcel lockers or lockers (13), Collection and delivery points (04), and pick-up points (03). The non-standardization of these terms added an extra layer of difficulty to the research since the name of the technology could not be used as a research string, because otherwise, that could mean the exclusion of papers that were still on the topic of last-mile deliveries. Furthermore, the most cited places to implement the collection and delivery points were the supermarkets (16), followed by stations and transport terminals (15), and shopping centers (14). In Brazil, the possibility of using drugstores was considered, due to its high availability in the national territory [7,14,15]. In Poland, some benefits were raised for the locations where the cabinets are installed, such as the extra income obtained from renting the space, as well as a share in the indirect income from advertisements. It was found that visits by users of cabinets in commercial spaces generate potential buyers, by around 52% [6].

The work converged especially regarding the benefits of sustainability aspects entailed by the adoption of this delivery model. The main benefits highlighted and analyzed in the 31 texts that make up the LR are:

a) Environmental aspects: the reduction of greenhouse gas emissions and atmospheric pollutants (23 times);

b) Economic aspects: reduction in miles traveled or number of trips, which translates into lower operating costs for transporters (26 times), reduction in delivery failures, which burden the conventional home delivery operation and increase delivery times waiting for consumers (24 times);

c) Social aspects: reducing congestion and the number of vehicles circulating in road traffic (23 times).

The biggest challenge, brought to light by 21 papers, was the location of the collection and delivery points in relation to the consumers. Generally, most individuals were willing to travel one and a half miles (approximately two kilometers) at maximum until reaching a collection point, so that the whole trip would not surpass three miles. Some appeal strategies were suggested, so that a migration from home delivery to this kind of delivery would occur, *e.g.* a discount on the final price of the recently bought products, since a portion of the freight would now be under the responsibility of the consumer.

The articles analyzed show that last-mile deliveries are extremely important for the sustainable development of cities, in environmental, economic, and social aspects. More in-depth research is recommended, particularly looking for solutions that reduce the distance between CDPs and consumers.

Conclusion

The work carried out an LR as a way of analyzing sustainability aspects in the use of collection and delivery points by consumers in last-mile deliveries, in the context of cargo transport. The results obtained suggest that the main benefit of adopting this method of delivery is the optimization of operation, which could translate as economic benefits, both for carriers and consumers alike. Environmental gains were also recognized as one of the most prominent benefits, generating a reduction in emissions of greenhouse gases and atmospheric pollutants. It should also be noted that, besides the distance traveled by the consumers, other difficulties, such as merchandise security, were identified in developing countries context. Future research that focuses only on developing countries may be executed, so that the knowledge regarding and applicability of this mode of delivery can be expanded.

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