Parking Slots: The Last Mile Literature Review

Blanca Idalia Pérez-Péréz and Giovanni Lizárraga

Abstract In this study, an investigation was made of what has been applied to the problem of the so-called last mile. The delivery of the last mile is considered one of the most expensive and least efficient sections of the supply chain. Designing the last mile system efficiently is very important to serve customers efficiently and economically. They comment that the challenges that logistics and cargo transportation have faced are increasingly complicated due to transitions in the economic structure, city design, urbanization, the transportation system, and the external situations typical of the logistics activities in urban areas. Despite the fact that logistics is an important generator of employment, the negative aspects that arise in cargo transportation have increased. These situations are pollution, congestion, and inefficient use of resources. These inefficiencies can cancel your long-term benefits. Attention to the "last mile problem" leans or tends towards the best allocation of resources so that the level of service is maximized and costs are minimal in the final segment of transport. In this chapter, we talk about the parking slot problem for urban distribution and some solutions. The following document provides a literary review of logistics in the cities, their problems, and how they have tried to solve the last mile problem. The sections of this chapter are divided into introduction, problem statement, and state of the art for a local case study.

Keywords Logistics · Supply chain · VRP · Smart cities · Parking slots · Last mile

B. I. Pérez-Péréz (✉) · G. Lizárraga
Universidad Autónoma de Nuevo León, San Nicolás de los Garza, México
e-mail: blanca.perezprz@uanl.edu.mx; giovanni.lizarragalz@uanl.edu.mx

F. Torres-Guerrero et al. (eds.), *2nd EAI International Conference on Smart Technology*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-031-07670-1_10

1 Introduction

The logistics that occur in a city are a major problem for urban centers affected by the growth and consolidation of economic and industrial activities with traditional and human activities. The latest majority of studies follow the traditional transport approach with the aim of explaining variables related to transport supply instead of analyzing real demand [1].

In 2017 [2], it is commented that the challenges that logistics and cargo transportation have faced are increasingly complicated due to the transitions in the economic structure, the design of cities, urbanization, the transportation system, and the external situations proper of logistical activities in urban areas.

In urban areas, we note that the increase in freight transport vehicles and current trends in their growth are responsible for a critical increase in traffic congestion, air pollution, noise, and other externalities. This is usually replicated in the main cities of the world. New technologies and organizational strategies allow us to more efficiently manage the delivery of the last mile in urban areas [3].

Another key aspect is delivering products on time. In this aspect is where the logistics specialists have difficulties, since the merchandise must be delivered in a profitable and sustainable way for the organization. Existing literature that talks about last mile delivery manages the efficient use of resources, operations, distances, and time [4].

Despite the fact that logistics is an important generator of employment, the negative aspects that arise in cargo transportation have increased. These situations are pollution, congestion, and inefficient use of resources. These inefficiencies can cancel long-term benefits [2].

The awareness of public authorities related to urban logistics has also been increasing, and in this way, the level of public regularization can be increased. In some cases, it is through parking restrictions, limited access to certain areas, time windows, and truck restrictions in cities [5]. When authorities propose short-term regulations, such measures can increase other costs or transfer costs to other geographic areas [6].

According to [7], urban logistics is centered in three elements: (1) vehicles and flow of goods, (2) characteristics of the goods, and (3) focus of the investigation. Within the first element, vehicles and flows of goods can be analyzed independently or jointly.

The 28% of the total transportation costs of a product are attributed to the final section of the supply network [8]. Attention to the "last mile problem" leans or tends towards the best allocation of resources so that the level of service is maximized and costs are minimal in the final segment of transport [9].

Double parking is a bad practice that is commonly used by drivers to save time in search of "available bay" and unload their products to the delivery's client. However, this leads factors like road congestion, noise, insecurity, and air pollution from other vehicles blocked by the transport in question to increase. For local government zones, there are bay zones available for parking. Nonetheless, if the availability of these spaces is insufficient, drivers park in prohibited zones in an attempt to improve their productivity [10].

Due to this issue, authorities from big locations are forced to increase the number of available bays, in addition to regulating its use to free them up for as long time as possible [11].

The logistics problem of the last mile has increased in importance. The information that was found is described below.

2 Theorical Framework

Urbanization generates big populations that grow constantly, bringing forth mobility, pollution, and residue management problems. There are new information and communication technologies that unite to form solutions for smart cities [12]. Some concepts will now be mentioned.

2.1 The Last Mile

The delivery of the last mile is considered one of the most expensive and at the same time least efficient sections of the supply chain. Designing the last mile system efficiently is very important to serve customers efficiently and economically [13].

2.2 Smart City

It is a concept of utmost importance for the scientific community [14], since planning the transformation of cities of a sustainable type is a task of vital importance in the development of cities [15]. The architecture of smart cities can be structured in four layers: application, middleware, network, and detection [16]. The evolution of a low-carbon energy system is a vital part of achieving sustainable development, where transport is an extremely important link for long-term carbon reduction [17].

2.3 VRP

VRP, or the vehicle routing problem, is a variation of the extensively investigated traveling salesman problem. The feature of fluctuating travel duration enables VRP to account for the current conditions such as urban congestion, where the traveling speed is not constant due to variation in traffic density [18].

3 State-of-the-Art Problem Statement

3.1 Free Slots Algorithmic Forecast Design

There are many factors to consider in order to find parking spots in cities. It is subject to a low percentage of variability which depends on local regulations (subject to a slow rate of variability). (This variability is due to local regulations.) Other conditions that need to be considered are important events, day of week (normal or holiday), weather conditions, time of year, and unexpected situations like floods; the number of vehicles varies. As a consequence, there is a random distribution in the free parking spaces (the availability of parking spots). Therefore, the available parking places are considered in an algorithm as a stochastic process, where the number of places is a random variable, which is also a function of the travel time with the variables to be defined [19].

An example was applied in Zaragoza, Spain. This city has a population of 664,938 inhabitants [20]; thus, we can generalize the results to any medium-sized city. The parking data are among those selected on the platform [21]. Four-month data were used for training or analysis, while data from 6 weeks were used to verify the forecast algorithm. Verification is explained in subsection B in this section. In this way, we analyzed parking data from September 2017 to January 2018 (Fig. 1).

The following factors were considered to classify the different patterns:

- Working days versus weekends (Saturdays and Sundays) and holidays.
- Days with adverse weather (rain, wind, etc.).
- As a data mining tool for the analysis of historical data, the IBM SPSS Modeler application was used. As an example of the analysis, we present the results

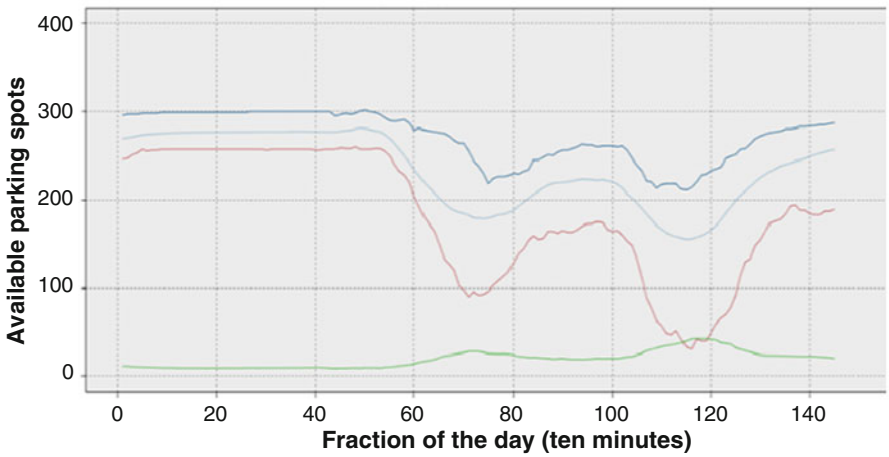

Fig. 1 Parking patterns for working days in parking lot #1 in Zaragoza

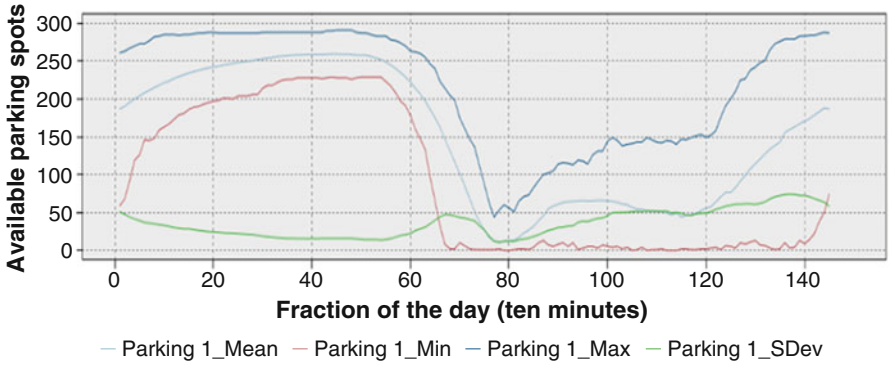

Fig. 2 Parking patterns for weekends and holidays in parking lot #1 in Zaragoza

Table 1 Forecast algorithm results

Type of day	Number of days	MPE
Working days	28	5.23%
Weekends	8	4.58%

MPE is the mean percentage error

obtained on working days and compared them with the ones obtained on weekends and holidays. The Christmas period was excluded (Fig. 2).

We considered the mean percentage error (MPE) as a measure of the accuracy of our forecast algorithm. MPE is defined as shown in Eq. (1), where at is the actual value, ft is the forecast, and n is the number of times the variable has been forecasted [22].

$$\text{MPE} = \frac{100\%}{n} \sum_{t=1}^{n} \frac{a_t - f_t}{a_t} \tag{1}$$

The results are shown in Table 1.

An optimization model for parking slot rent [23] comments that local governments stimulate sharing parking spots [24]. The proposal is a mathematical optimization method for establishing where to put reserved slots at disposal of the users. The contributions are:

- An overview of the regulations and policies of a set of major cities where carsharing has been introduced, particularly highlighting the importance of parking policies in making carsharing a success and discussing the Italian case mining.
- A mathematical optimization model to represent the decision problem of the council of a municipality that must choose which parking slots to rent to carsharing companies in a city. A linear programming problem, which includes

Fig. 3 Parking patterns for weekends and holidays in parking lot #1 in Zaragoza

Boolean variables to represent the possibility of renting or not a cluster of parking slots [24]. The following key performance indicators are managed:

- If the slot is rented or not (not rented to leave space for crashed vehicles or crashing services)
- Maximum number of rentable slots, that does not exceed the number of available slots
- Function objective

An example of the application of this model was in Rome, Italy, in 2019 (Fig. 3).

3.2 ACO: Ant Colony Optimization

It is the most common technique for merchandise delivery; however, it has the characteristic of assuming that customers will be at home or receive the product in their warehouses in a pre-established period of time, lacking flexibility. It is possible that the client is not found or cannot receive the product in his warehouse due to an emergency or the transport exceeds the pre-established time range due to traffic or some adverse situation. In this case, a second delivery would have to be scheduled which is inefficient and time consuming. To counteract the problem of inflexibility, the shared reception box delivery mode is used in cities with high population densities. This system consists of managing an intelligent reception box that is installed in a public area of the communities or at the entrance of a building or industrial park. When the products are delivered, a text message is automatically sent to the corresponding client, which contains a unique code with which the box can be opened and thus can be collected in the client's available time. Ant colony optimization, or ACO, helps build an effective and efficient delivery route. This algorithm simulates the feeding behavior of the ant colony by releasing pheromones in its pathways, which can provide heuristic information for other ants. Hormone density increases if more ants walk the same path, building the best path to the food source [25].

Attended Home Delivery (AHD). The inherent feature of AHD is that customers have to be at home during a prearranged time period and the deliveries have to be achieved within that time period. This mode is required under some circumstances; for example, the purchased goods have to be examined due to its high value or need to be signed for delivery confirmation. However, such a delivery mode lacks flexibility. Customers may not be available when the delivery arrives due to some emergency or the deliveries could not arrive due to the traffic issue. In that case, the courier may have to conduct a second delivery, which has low efficiency and is time consuming.

Shared Reception Box (SRB). When the courier delivers the purchased goods to SRB, SRB can automatically send a text message to the corresponding customer, which contains a one-off code for opening a corresponding box. After that, the corresponding customer can pick up the goods from SRB at their available time. The application of SRB can release the time constraints for both customers and couriers obviously. Moreover, the application of SRB can protect customers' privacy. Instead of using home address when purchasing online, customers can use the SRB as the consignment address. More and more e-commerce enterprises deploy SRBs in large cities so as to facilitate their business [30].

Figure 4 shows a map with the location of the 20 clients to visit (light blue diamonds). In the center is the warehouse or starting point (red square) of the delivery vehicle. The green triangles represent the savings zone. The colored dates are the seven routes that the method throws. The optimal solution purchased with AHD mode consists of seven routes, due to limitations of vehicle capacity and customer time windows [13].

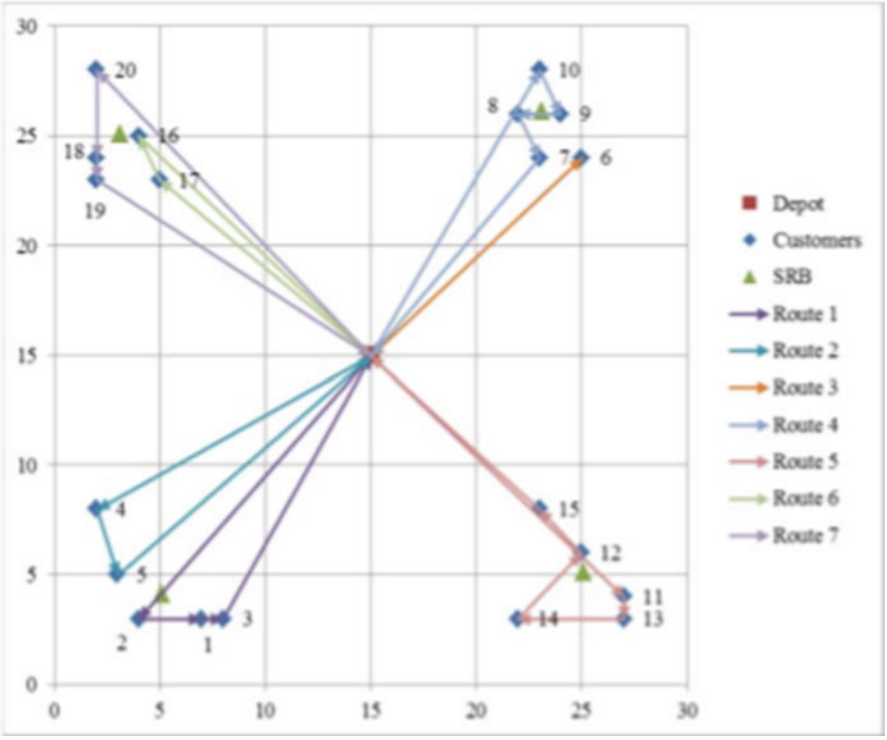

Fig. 4 Ant colony

In recent years, a boom in artificial intelligence applications and services has been observed, ranging from the management of a personal assistant to complex surveillance systems that use audio and video. With the spread of the Internet of Things, millions of devices connect to the Internet, generating millions of bytes of information on the network [13].

Another option is shared parking applications in high congestion cities, such as Beijing, Shanghai, and Hangzhou, in China. It is also possible to prepare instructions for shared parking, for example, in the Standing Committee of the Beijing People's Congress (2017) where the Regulation of Parking Management for Motor Vehicles was disclosed to the public, where it is recommended to open spaces to the public assigned that are owned by government agencies, companies, institutions, and private users with the shared pattern supported by applications, for example, Airparking, solving small-scale parking problems [26].

The literature also describes vehicle routing problem (VRP) options. A taboo algorithm is described to solve traffic and have a specific waiting time for clients. He also talks about joint trips to lower costs. A collective delivery method is managed in the last mile assisted by an application where the person closest to the customer makes the delivery. With this, the payment to the person carrying out the

delivery to the end customer is the minimum possible. The mathematical model and pseudocode to define delivery routes is also presented [18].

3.3 Policies in the Logistics Sector

The implementation of policies in the logistics sector could generate unexpected side effects that sometimes undermine the performance of key economic activities of logistics operators, especially in areas such as transport service, sustainability of operations, etc. Especially for the latter, there is a lack of understanding of how sustainability performs if retail logistics solutions are affected by policy implementation and, in turn, by operator response measures.

A sustainability analysis of proven and innovative retail logistics solutions is presented that addresses the research question: "What are the effects of retail logistics solutions on overall cost and sustainability performance?" The analysis is carried out in a framework based on indicators and on the key components of sustainability (economy, environment, society), enriched by the addition of the transport component. The framework evaluates three different scenarios together with a business such as Urban Consolidation Center, Anchorage, and Shared Bus [27].

Completing urban cargo deliveries is increasingly challenging in congested urban areas, especially when delivery trucks are required to meet deadlines. Depending on the characteristics of the route, electric assistance cargo bikes can serve as an economically viable alternative to repair trucks. The purpose of this document is to compare delivery route cost offsets between box delivery trucks and electric assistance cargo bikes that have the same route and delivery characteristics and to explore the question, under what conditions do they work electric assistance cargo bikes at a lower cost than typical delivery trucks? The independent variables, constant variables, and assumptions used for the cost function comparison model are collected through data collection and a review of the literature. A delivery route was detected in Seattle and considered as a base case. The same route was modeled using electric assistance cargo bikes. Four separate delivery situations were modeled to assess how the following independent route characteristics would affect the cost of the delivery route: distance between a distribution center and a neighborhood, number of stops, distance between each stop, and number of packages per stop. The analysis shows that three of the four modeled route characteristics determined the cost offsets between repair trucks and electric assistance cargo bikes. Electric assistance cargo bikes are more cost-effective than delivery trucks for affected deliveries to the distribution center (less than 2 miles for the observed delivery route with 50 packages per stop and less than 6 miles for the hypothetical delivery route with 10 packages per stop) and in which there is a high density of residential units and low volumes of delivery per stop [28].

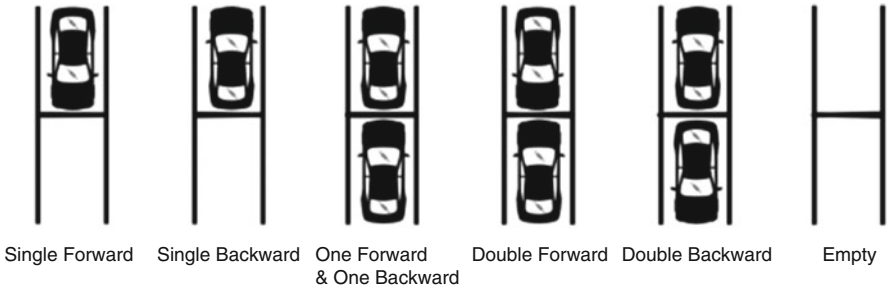

Fig. 5 Types of oriented parking lot

3.4 Forward and Reverse Parking Lot

Another aspect to consider to save time is parking methods: straight ahead or reverse. Reverse parking is considered a safer way to park in the cargo shipment, as it tries to make the environment safer when the driver leaves the parking space and can see their surroundings clearly. In a study by the National Highway Traffic Safety Administration (NHTSA), on average, 76% of drivers park straight ahead, the way many of us are used to. This situation makes sense to some extent. For example, in a double-row parallel parking lot, people have a high probability of not parking in reverse when the opposite parking space is already occupied; in a single-row parking lot, people are less willing to reverse parking because it would take more time and reduce speed of the vehicles behind them as seen in Fig. 5 [29].

3.5 Predicting Bay Available

In this part, a smart system that is capable of recognizing its surroundings, learn, and make decisions. It can predict the vacancy of parking slots in real time from the origin to the delivery area and vice versa. First, it predicts available slots in real time and notifies the user. The prediction methods used were the following: linear regression, gradient boosting, random forest, and neural networks. These methods analyzed the history of occupied spaces to predict their future availability. The experiment took place with historical data from 2017 from the city of Melbourne where 4300 ground sensors were installed in 303 segments of 35 areas of the central business district. The different techniques gave the following graphics of Fig. 6 [10].

When analyzing the error metrics, the method with the best results (lowest MSE) was random forest with 1.69%, followed by regression tree with 2.10%. In the third place was the artificial neural network that in addition had a high computational time of 6 hours against the 12 minutes maximum that other methods took, getting 2.62%. In the last place was stacking with 5.41%. For most of these models, predictions are more exact when available spaces are fewer or equal to 50. The performance of this

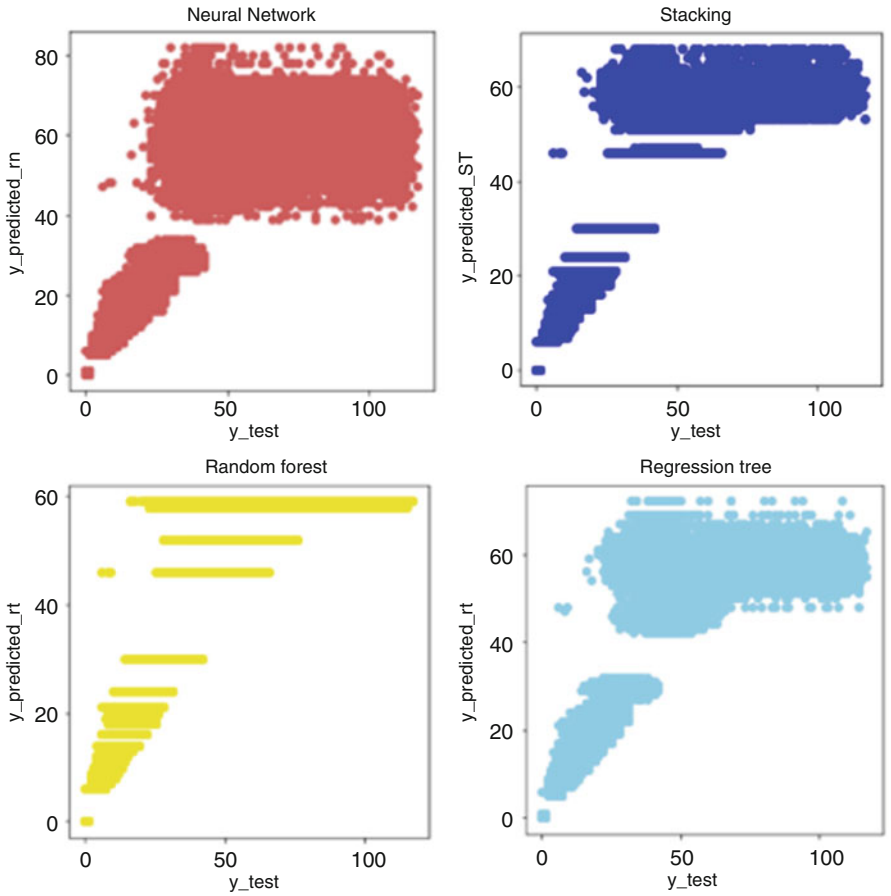

Fig. 6 Comparative graph between the predictions obtained by some techniques and the real value

case is conditioned to the drivers' respect of their reservation and times of arrival. With this, if required, a penalty to drivers that do not comply with their schedule is suggested so as to not risk the system's function [10].

4 Conclusions

Freight parking is a serious problem in big cities. As cities grow, the merchandise transportation problem increases with them. So, finding effective methodologies that help us increase the number of available slots for merchandise delivery in the last mile is of utmost importance, and just like that, we could contribute to the reduction

of the time a driver looks for a slot. With it, we contribute to the reduction of gasoline expenses, noise, and traffic.

Currently, we want to solve a last mile problem in a central area of San Nicolás de los Garza, Nuevo León, Mexico, where various businesses converge along with a central plaza. The problem is that deliveries are made by suppliers at the same time, who struggle to find a place where they can park their delivery vehicles. Delivery vehicles usually waste time looking for a parking slot, or worse: they will be parked in prohibited places or in places that block the streets. This review is the beginning to put forth a solution to this situation. We hope to have the results approximately in a year and a half.

References

1. J. Sepúlveda, J.W. Escobar, W. Adarme-Jaimes, Un algoritmo para el problema de ruteo de vehículos con entregas divididas y ventanas de tiempo (SDVRPTW) aplicado a las actividades de distribución de PYMEs del comercio al por menor. DYNA (Colombia) **81**(187), 223–231 (2014). https://doi.org/10.15446/dyna.v81n187.46104
2. I. Cardenas, Y. Borbon-Galvez, T. Verlinden, E. Van de Voorde, T. Vanelslander, W. Dewulf, City logistics, urban goods distribution and last mile delivery and collection. Compet. Regul. Netw. Ind. **18**(1–2), 22–43 (2017)
3. S. Digiesi, M. P. Fanti, G. Mummolo, B. Silvestri, Externalities reduction strategies in last mile logistics: a review, in *Proceedings – 2017 IEEE International Conference on Service Operations and Logistics, and Informatics, SOLI 2017*, *2017-Janua*, 248–253. https://doi.org/10.1109/SOLI.2017.8121002 (2017)
4. J. Holguín-Veras, I. Sánchez-Díaz, C. Lawson, M. Jaller, S. Campbell, H. Levinson, H.S. Shin, Transferability of freight trip generation models. Transp. Res. Rec. **2379**, 1–8 (2013)
5. J.L. Routhier, C. Raux, An attractiveness-based model for shopping trips in urban areas, in *12th World Conference on Transport Research*. (2010a)
6. E. Verlinde, N. De Laender, S. De Maesschalck, et al., The social gradient in doctor-patient communication. Int. J. Equity Health **11**, 12 (2012). https://doi.org/10.1186/1475-9276-11-12
7. J. González-Feliu, M.G. Cedillo-Campos, J.L. García-Alcaraz, An emission model as an alternative to OD matrix in urban goods (2014)
8. R.W. Goodman, Whatever you call it, just don' t think of, in *Global Logistics and Supply Chain Strategies*, *December*, 1–6 (2005)
9. B. Balcik, B.M. Beamon, K. Smilowitz, Last mile distribution in humanitarian relief. J. Intell. Transp. Syst. Technol Plan. Oper. **12**(2), 51–63 (2008). https://doi.org/10.1080/15472450802023329
10. H. Errousso, N. Malhene, S. Benhadou, H. Medromi, Predicting car park availability for a better delivery bay management. Procedia Comput. Sci. **170**, 203–210 (2020). https://doi.org/10.1016/j.procs.2020.03.026
11. A. Comi, B. Buttarazzi, M. Schiraldi, Smart urban freight transport: tools for planning and optimising delivery operations, in *Simulation Modelling Practice and Theory*, vol. 88, (Elsevier Ltd, 2018), pp. 48–61. https://doi.org/10.1016/j.simpat.2018.08.006
12. D. Bruneo, S. Distefano, M. Giacobbe, A. Longo Minnolo, F. Longo, G. Merlino, D. Mulfari, A. Panarello, G. Patanè, A. Puliafito, C. Puliafito, N. Tapas, An IoT service ecosystem for Smart Cities: the #SmartME project. IoT **5**, 12–33 (2019). https://doi.org/10.1016/j.iot.2018.11.004
13. L. Zhou, Y. Lin, X. Wang, F. Zhou, Model and algorithm for bilevel multisized terminal location-routing problem for the last mile delivery. Int. Trans. Oper. Res. **26**(1), 131–156 (2019). https://doi.org/10.1111/itor.12399

14. R.K.R. Kummitha, N. Crutzen, How do we understand smart cities? An evolutionary perspective. Cities **67**, 43–52 (2017)
15. S.C. Addanki, H. Venkataraman, Greening the economy: a review of urban sustainability measures for developing new cities. Sustain. Cities Soc. **31**, 1–8 (2017)
16. T. Watari, B.C. McLellan, D. Giurco, E. Dominish, E. Yamasue, K. Nansai, Total material requirement for the global energy transition to 2050: a focus on transport and electricity. Resour. Conserv. Recycl. **148**, 91–103 (2019)
17. A. Alkhamisi, M.S.H. Nazmudeen, S.M. Buhari, A cross-layer framework for sensor data aggregation for IoT applications in smart cities, in *Proceedings of the 2016 IEEE International Smart Cities Conference (ISC2), Trento, Italy*, 12–15 September 2016
18. H. Desai, B. Remer, B. Chalaki, L. Zhao, A. Malikopoulos, J. Rios-Torres, *Vehicle Routing for the Last-Mile Logistics Problem*. http://arxiv.org/abs/1904.05464 (2019)
19. J. Barbancho, J. Ropero, J. Luque, A. Caraballo, C. León, Social parking: applying the citizens as sensors paradigm to parking guidance and information. Sustainability (Switzerland) **11**(23), 1–19 (2019). https://doi.org/10.3390/su11236549
20. Ayuntamiento de Zaragoza. Movilidad. 2018. Available online: http://www.zaragoza.es/ciudad/viapublica/movilidad/estacionamientos/. Accessed 12 July 2018
21. El Tiempo en Zaragoza. Histórico. 2018. Available online: https://www.eltiempo.es/zaragoza.html?v= historico. Accessed 10 December 2018
22. S. Makridakis, S.C. Wheelwright, R.J. Hyndman, *Forecasting: methods and applications*, 3rd edn. (Wiley, New York, NY, USA, 1998)
23. R. Dowling, J. Kent, Practice and public-private partnerships in sustainable transport governance: the case of car sharing in Sydney, Australia. Transp. Policy **40**(3), 58–64 (2015)
24. S. Carrese, F. D'Andreagiovanni, T. Giacchetti, A. Nardin, L. Zamberlan, An optimization model for renting public parking slots to carsharing services. Transp. Res. Procedia **45**, 499–506 (2020). https://doi.org/10.1016/j.trpro.2020.03.064
25. Zhang, Y. Guo, W., Zhang Xu, M., Li, L Z. (2016). Parking spaces repurchase strategy design via simulation optimization. J. Intell. Transp. Syst. 20 (3), 255–269
26. H. Xiao, M. Xu, How to restrain participants opt out in shared parking market? A fair recurrent double auction approach. Transp. Res. C Emerg. Technol. **93**(June), 36–61 (2018). https://doi.org/10.1016/j.trc.2018.05.023
27. K. Papoutsis, W. Dewulf, T. Vanelslander, E. Nathanail, Sustainability assessment of retail logistics solutions using external costs analysis: a case-study for the city of Antwerp. Eur. Transp. Res. Rev. **10**(2) (2018). https://doi.org/10.1186/s12544-018-0297-5
28. M. Sheth, P. Butrina, A. Goodchild, E. McCormack, Measuring delivery route cost trade-offs between electric-assist cargo bicycles and delivery trucks in dense urban areas. Eur. Transp. Res. Rev. **11**(1) (2019). https://doi.org/10.1186/s12544-019-0349-5
29. G. Mangano, G. Zenezini, The value proposition of innovative last-mile delivery services from the perspective of local retailers. IFAC-PapersOnLine **52**(13), 2590–2595 (2019). https://doi.org/10.1016/j.ifacol.2019.11.597
30. S.Z. Zhang, C.K.M. Lee, *Flexible vehicle scheduling for Urban Last Mile Logistics: The emerging technology of Shared Reception Box. 2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*.https://doi.org/10.1109/ieem.2016.7798211 (2016)