Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 72 (2023) 572–579

Transportation Research Procedia

www.elsevier.com/locate/procedia

Transport Research Arena (TRA) Conference

Greening urban logistics: Introducing a method to evaluate optimised decoupling hub locations

Maike Scherrer[a]*, Albert Steiner[b], Viola Rühlin[a]

[a]*Zurich University of Applied Sciences, School of Engineering, Institute of Sustainable Development, Technikumstrasse 9, 8401 Winterthur, Switzerland*
[b]*Zurich University of Applied Sciences, School of Engineering, Institute of Data Analysis and Process Design, Rosenstrasse 3, 8401 Winterthur, Switzerland*

Abstract

Sustainable urban logistics has become challenging over the course of the last decades due to logistics sprawl and increased demands of goods in urban areas. To overcome this problem, a fine-grained network of decoupling hubs, separating suppliers and customers in a spacial and timely manner, are needed. The paper at hand introduces a model of how to calculate optimal decoupling hub locations within urban areas with the goal that inhabitants walk or cycle to the next decoupling hub and do not take a motorised vehicle. The study at hand uses the northern district of Zurich as unit of analysis and shows that by using the developed model, 80% of the inhabitants need to walk less than 250 metres to their next decoupling hub, which is within the radius of 100 metres to the next public transport stop. This supports the integration of picking up or dropping off deliveries while commuting.

Keywords: decoupling hubs; sustainable urban logistics; facility location probem

1. Introduction

City centres nowadays face multiple challenges, many of which are linked to transport and logistics. Traffic increases air pollution, noise, and even excess heat, which have a negative health impact on the urban population (Lagorio, Pinto, & Golini, 2016). Traffic also competes for rare space in the city centres and overload causes congestions (Gössling, 2016). While fulfilling the customer wishes, logistics is supposed to be sustainable, should not harm the safety in cities, and should be socially acceptable for inhabitants (Akyol & De Koster, 2018). Since logistics is noisy and valuable space in cities is more attractive to sell for housing or offices rather than logistics spaces, logistics activities have been pushed out of the city centres towards suburban or rural areas (logistics sprawl) over the last couple of years (Schmid, Ruesch, & Bohne, 2019). This led to longer delivery routes, as products have to be brought from further away into city centres, causing additional traffic, congestion, air pollution and noise.

* Corresponding author. Tel.: +41 58 934 40 43
E-mail address: maike.scherrer@zhaw.ch

10.1016/j.trpro.2023.11.441

The situation is expected to aggravate in the close future. The United Nations (UN) forecasts that about 68% of the world's population will live in urban areas by 2050. The cities will be densified, more inhabitants cause more personal traffic, while the traffic infrastructure cannot be extended anymore. This results in a relative decrease of traffic infrastructure availability for logistics services.

Speaking of Switzerland, in 2019, 84.4% of the Swiss population lived in urban regions (BFS, 2021). The urbanisation trend still increases. Due to this and the fact that online shopping has gained popularity (Becker, Müller, Nägele, & Ziegler, 2021), the traffic load on a city's infrastructure has increased dramatically. Currently, 10% of the transport performance (in vehicle-km) on Swiss roads is caused by freight transport, causing 21% of transport related CO_2 emissions (BAFU, 2022; Becker *et al.*, 2021). Due to e-commerce popularity, it is expected that the parcel volume will increase by another 75% and freight transport by 31% until 2040, leading to an extended logistics fleet of 37% (ARE, 2016). In this, light commercial vehicles like vans are expected to have the highest growing rate of 53% (ARE, 2021). This large growth is because products in the B2C sector are to be delivered ever faster. It is expected that the situation will tighten further as forecasts predict that medication and grocery, especially fresh products such as fruits and vegetables, are just at the beginning of their growth phase in e-commerce (Mazur, Urban, & Starzyk, 2019), requiring fast delivery. Fast deliveries contradict bundling effects, optimal route planning, and the synchronisation and harmonisation of different flows of goods, leading to additional congestion, air pollution, and safety issues (Lagorio *et al.*, 2016).

All this leads to challenges in the three sustainability dimensions as shown in Figure 1.

Fig. 1. Challenges due to increased freight traffic in cities

It becomes obvious that there exist contradicting requirements in terms of fast and convenient delivery to the consumer's homes against the request to reduce traffic in urban regions and the corresponding negative impact on the liveability in urban regions.

One possibility to decrease the amount of traffic within cities is the implementation of decoupling hubs between suppliers and consumers in the B2C environment. A decoupling hub decouples suppliers and customers in the sense that the supplier can drop off a delivery whenever it fits the delivery schedule, while a customer can pick up the delivery at any suitable time no matter if it is during the day or at night. With this special and timely separation between sender and receiver, the first delivery rate will increase to 100%, as the logistics service supplier does not require a signature from the parcel receiver anymore. Opening the decoupling hub with the customer's app equals a physical signature on the parcel delivery sheet. Furthermore, the logistics service suppliers can deliver all parcels for one neighbourhood in a bundled manner without having to stop at every doorstep to deliver individual parcels.

A look into the existing body of literature shows that academics and practitioners alike have recognised the need to solve the challenges especially in the last-mile delivery in urban areas. It also becomes clear that researchers either analyse isolated questions such as the type of vehicles used to deliver on the last mile (de Mello Bandeira *et al.*, 2019), model optimal or sustainable distribution solutions (Akyol and De Koster, 2018), or newly available technological opportunities (Bates *et al.*, 2018). To the best of our knowledge, literature does not discuss optimal locations to decouple customers and suppliers in a timely and local manner to increase the first delivery-rate to 100% that leads to a decrease of traffic generated by unnecessary delivery attempts from logistics service providers.

The research paper at hand aims at developing a model to analyse where to locate decoupling hubs, i.e. parcel lockers, micro hubs, or urban distribution hubs to support consumers in picking up their parcels without using a motorised vehicle to do so. The northern district of Zurich, Switzerland, serves as unit of analysis. The research question for the paper at hand is the following:

RQ: *How can optimal locations for decoupling hubs be defined?*

To answer this question, we analyse the following sub-questions:

(i) SQ1: Which relevant factors need to be considered in the location evaluation? (ii) SQ2: What benefits do parcel hubs (decoupling) offer to customers, providers, and the respective city? (iii) SQ3: To what extent can parcel lockers reduce transport-related emissions?

2. Literature review on sustainable urban logistics

The attention to sustainable urban logistics has increased over the last decade. Within research, a central issue is the reduction of the impact of urban freight transport (Gonzalez-Feliu *et al.*, 2014). One important topic in this is the discussion of how to reorganise urban freight streams by considering urban distribution centres (Kin *et al.*, 2016). In these centres, all incoming flows of material into a city are received and delivered in a bundled manner close to the receivers of the goods. At the final distribution level (i.e., decoupling hub between suppliers and customers such as parcel lockers), locations are discussed in which commercial and private receivers of goods can pick them up (He *et al.*, 2017). Logistics service providers can benefit from drop density of delivered goods, decrease the distance and time travelled and emissions for final deliveries, especially if the decoupling hub locations are close to residential areas (Vural and Aktepe, 2021). A dense network of decoupling hubs even has the potential of motivating consumers to pick their deliveries up by foot or on bicycle (Collins, 2015). While balancing customer convenience with efficiency goals of logistics service providers, decoupling hubs have the potential to enhance environmental sustainability and reduce negative traffic effects of urban deliveries (Vural and Aktepe, 2021). Even though, the concepts of hub distribution have gained attention, there can hardly any concepts be found which are successful (Strale, 2019). In line with this, researchers claim a lack of understanding sustainable logistics innovations (Björklund and Forslund, 2018).

3. Methodology

3.1. Facility location problem

To determine the optimal number and location of decoupling hubs at minimal overall costs, the so-called capacitated facility location problem (CFLP) needs to be solved, where a set of potential hubs at defined locations and a number of parameters are provided. Computations are carried out using R, RStudio, and the Gurobi™ Optimizer as solver. For a general overview on FLPs, see, e.g., Çelik Türkoğlou & Genevois (2020).

A number m of potential decoupling hub locations and n addresses that need to be supplied, are given. Each decoupling hub has a limited capacity, i.e., a number of parcels, which is denoted by a_i, with $i = 1, \dots, m$, where it is assumed that this value is the same for all hubs. The average demand of parcels per address is denoted by b_j, with $j = 1, \dots, n$. The calculation of this demand is explained below in section 3.2. The transport costs c_{ij} in Swiss Francs cover the walking costs of customers between hub location i and address j and the operational costs to run a decoupling hub at location i is denoted by f_i. x_{ij} is the transport volume between hub location i and address j, and finally y_i is a binary variable with $y_i = 1$, if the decoupling hub at location i is selected, and $y_i = 0$ otherwise. x_{ij} and y_i are the outputs of the optimisation.

For solving the CFLP, several parameters need to be considered: The number of compartments of the parcel locker and the percentage of the total parcel quantity to be delivered to the parcel locker are determined. Likewise, operating costs are assigned to each parcel locker and a value is determined for the transport costs incurred for collection on foot. The operating costs consist of 250 working days multiplied by an amount in Swiss francs (CHF) per day. To calculate the transport costs of the customers for picking up their parcels (see equation 1), savings of 26.70 CHF per hour of walking of a customer ($VTTS_{\text{walk}}$; Value of Travel Time Saving for walking; for details see Schmid *et al.* 2021) between his/her address and the parcel locker (with distance d_{ij}) is assumed. This determines the transport costs in proportion to the walking distance. The average speed on foot is $\bar{V}_{\text{walk}} = 1.34$ m/s. Since the pedestrian's way does not correspond as the crow flies, d_{ij} is multiplied by a reasonable factor $\delta = \sqrt{2}$. In addition, each distance is multiplied by two, as the customer needs to walk from home to the parcel locker and back.

Based on the distance matrix **D** (with dimension m x n) and its elements d_{ij} that were computed using the geographic information system software QGIS, the elements of the cost matrix are calculated as follows:

$$c_{ij} = 2 \cdot \delta \cdot \bar{V}_{\text{walk}}^{-1} \cdot 3600^{-1} \cdot VTTS_{\text{walk}} \cdot d_{ij}. \tag{1}$$

The transport costs are directly proportional to the walking distance. Fixed costs are the operating costs of the parcel locker, excl. the investment costs. The transport costs of the CEP service supplier are not taken into consideration (see also section 5). Based on these variables and parameters, the capacitated facility location problem CFLP is written as follows:

$$\min \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} + \sum_{i=1}^{m} f_i y_i \tag{2}$$

$$\text{s.t.} \sum_{j=1}^{n} x_{ij} \leq a_i y_i \quad \text{for all } i = 1, \dots, m \tag{3}$$

$$\sum_{i=1}^{m} x_{ij} = b_j \quad \text{for all } j = 1, \dots, n \tag{4}$$

$$x_{ij} \geq 0 \quad \text{for all } i = 1, \dots, m \text{ and for all } j = 1, \dots, n \tag{5}$$

$$y_i \in \{0,1\} \quad \text{for all } i = 1, \dots, m \tag{6}$$

The overall costs in equation (2) cover both the transport and the operational costs. Equations (3) to (6) contain the constraints to be met: (3) takes care of adhering the decoupling hub capacity a_i, (4) limits the deliveries per address to its demand b_j, (5) guarantees that transport volumes are always non-negative and (6) is a binary variable.

3.2. Calculation of the population and demand per address

For each address within the area of Zurich North, its corresponding demand b_j needs to be calculated as required by equation (4). Without going in too much detail, the main steps shall be explained. The data used consist of the following sets: (i) open data (population, building data (ground space, height), addresses, and public transport stations), (ii) parcel demand (data from Swiss post, DHL, and DPD).

The procedure to calculate the average parcel demand per address is as follows: (i) Get the ground space and height per building from the data and compute the number of floors per building; (ii) Compute the overall living space per building; (iii) Get the overall population per zip code-area and the population per hectare raster cell, and compute the population per building: (iv) Compute the population per address based on the value per building and the corresponding address data; (v) Compute the average demand per zip code-area; (vi) compute the demand per building based on its population and the average demand per zip-code area, with the assumption, for the sake of simplicity, that the demand per person is independent of the building.

4. Analysis

4.1. Data base

To conduct the analysis, the northern district of Zurich was selected as unit of analysis. In this perimeter, a potential city hub is located in close distance to the main train station in 8050 Oerlikon (see Figure 2), from which the last mile distribution to the decoupling hubs (i.e., parcel lockers) is organised in a white-label approach. This means that all parcels that need to be distributed in the northern district of Zurich are brought from all logistics service suppliers to the central city hub in Oerlikon. There all parcels are transhipped and bundled to be distributed collectively by a dedicated logistics service supplier independent lorry per postcode district (i.e., 8046 Affoltern, 8052 Seebach, 8050 Oerlikon, 8051 Schwamendingen-Mitte, 8057 Unterstrass). It is expected that these bundled deliveries will decrease the amount of logistics vehicle kilometres significantly. At the time of the study, however, the final location of the city hub had not yet been determined and hence the transport costs between the city hub and the parcel lockers were not considered in the CFLP.

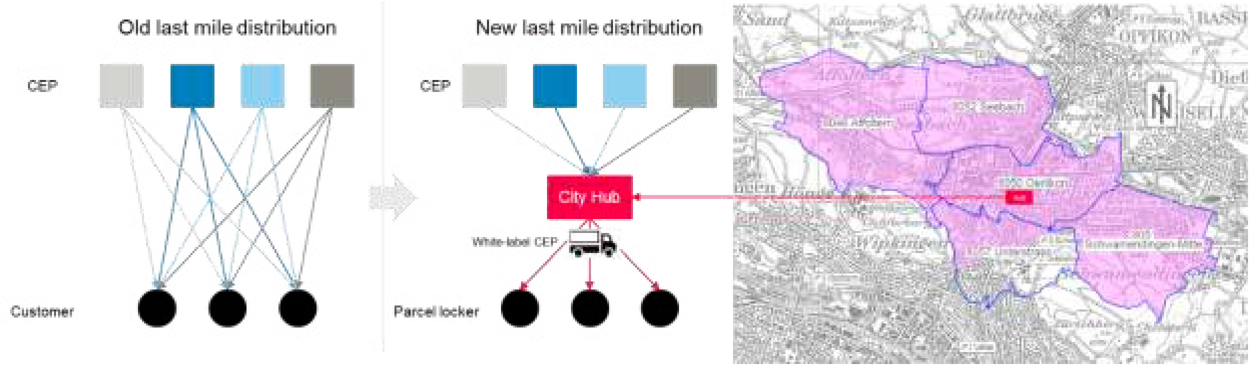

Fig. 2. Zurich North as unit of analysis with new last mile distribution scheme, considering population and parcel demand per address

For the study at hand, the parcel volumes of the Swiss post, DPD and DHL were used. Data from 18 month prior to the covid crisis was considered, as during the covid crises, the e-commerce shares increased above average and distorted the average parcel volumes. In sum, the Swiss post, DPD and DHL hold more than 90 % of the parcel delivery market share in Switzerland. The northern district of Zurich has 122'504 inhabitants, receiving in an average month 7'435 parcels per day. This equals 61 parcels for 1'000 inhabitants every day. To verify the number, the parcel volume shares per person in other Swiss cities were taken and compared with the shares in Zurich. The shares match, the overall average volume per day in Swiss cities equals 60 parcels per 1'000 inhabitants per day. Subsequently, the 61 parcels per 1'000 inhabitants per day that we received as a number from the CEP service suppliers were used for the analysis of the northern district of Zurich.

4.2. Criteria for parcel locker location optimization

To be able to calculate the optimal locations for parcel lockers, criteria for location possibilities are:

- The parcel lockers need to be accessible from delivery vans for easy loading and unloading. Subsequently, the parcel lockers need to be tied to the street network (Ruesch *et al.*, 2011).
- Non-accessible or private areas such as buildings, private gardens, waters, fields, and forests are excluded from the possible parcel locker locations.
- To integrate parcel pick-up into the commute, public transport stops are considered as possible locations. To not disturb the public transport, parcel lockers should be located in a radius of 100 m around the public transport stop.
- Since it is the goal that consumers walk or cycle to the next parcel locker for parcel pick-up or drop-off, they should be located close to apartment buildings. Literature provides a reference value of 250 m (Kuwok and Asdecker, 2015). If a distance is longer than this, consumers tend to use a motorised vehicle to travel the distance. Hence, the parcel lockers need to be located in an aerial radius of $250/\delta \approx 176$ m (for details on δ see equation 1) around apartment buildings in order for consumers to walk or cycle for parcel pick-up.
- The parcel demand needs to be covered from the parcel locker capacity. Based on a reference value from another Swiss city, the minimum locker compartments equal 38.

All these criteria have been translated into different layers that have been used as input for the geographic information system software QGIS and combined with calculations in R. The subsequent figure shows the result by means of different layers. The core of the green circles is a public transport stop, where the radius around the stop equals the defined 100 m. The red shapes are apartment buildings or private houses and the black dots show the addresses that belong to these buildings or houses (see section 3.2 for details). Overall, 10’127 addresses were incorporated in the model. The red lines represent the street network, based on the OpenStreetMap roads data set for Switzerland. The light yellow to dark purple squares of the grid cells (100 m x 100 m) depict low and high population density, respectively. To calculate the number of inhabitants per grid cell, the number of inhabitants in Zurich North per postal code were divided by the number of apartments in each postal code. The data was cleaned and the parcel demand per postal code was calculated as shown in section 3.2. As a simplification, a homogenous demand was assumed per postal code. Finally, the number of inhabitants per address were multiplied by the average parcel demand to get b_j (as used in equation 4). All these steps are needed to calculate the cost matrix (with variables c_{ij}) used to formulate the CFLP (see equations 1 and 2).

Fig. 3. Overlay of the different input layers in the geographic information system software QGIS

4.3. Analysis results

Before performing the optimisation, five scenarios are defined. They vary in terms of operating costs, the parcel volume, and the capacity of the parcel locker. As the goal of this work was a proof of concept rather than an in-depth study, the parameter values do not span the full range required. With one exception, parcel volumes were chosen based on the assumption that approximately ⅓ of the receivers would be willing to pick their delivery up from a parcel locker. The costs per day to run a locker station base on experiences in other Swiss cities and were extended in a reasonable range to allow for a simple sensitivity check for scenarios 1 to 3. The number of parcel lockers was based on a reference value from another Swiss city (see section 4.2).

Table 1 shows the parameters of the scenarios. The changed parameters in the different optimisation scenarios are highlighted in bold.

Table 1: Parameters for the optimisation of parcel locker locations

Scenario no.	Parcel volume [% of overall demand]	Number of parcel lockers	Costs per year per locker station [CHF]
1	33	38	15’000 (250 days * **60** CHF per day)
2	33	38	7’500 (250 days * **30** CHF per day)
3	33	38	22’500 (250 days * **90** CHF per day)
4	33	**57**	22’500 (250 days * **90** CHF per day)
5	**50**	38	15’000 (250 days * **60** CHF per day)

The calculations performed were based on the methodology described in chapter 3. The calculation provided the following results (see Table 2). The lowest costs and the highest percentage of inhabitants walking ≤ 250 metres are highlighted in bold:

Table 2: Results of the calculations to the get the optimal (in terms of overall costs) parcel locker locations

Scenario no.	Optimal number of parcel locker stations	Calculated transport costs per day for the optimal number of parcel locker stations [CHF]	Calculated fixed costs per day for the optimal number of parcel locker stations [CHF]	Inhabitants walking 250 m or less between home and parcel locker station [%]
1	68	6'728	4'080	78.76%
2	76	**6'420**	**2'280**	**82.48%**
3	65	6'957	5'850	75.80%
4	48	7'502	4'320	69.50%
5	98	11'343	5'820	72.43%

5. Discussion and Conclusion

As Table 1 and Table 2 show, the parameters used of the optimisation differed in number of parcel boxes per locker station (increase in scenario 4) and the percentages of parcels from the overall demand put into a parcel locker instead of direct delivery to the consumers. Scenario 2, which is the one with the lowest assumed operating costs per locker station is the one that achieved the best financial results and the lowest walking distance for the inhabitants between their home and the nearest parcel locker station.

A part that has been left out in the table but is very important are the investment costs. A parcel locker station costs approximately 50'000 CHF. Multiplying this with the 76 parcel locker stations needed in scenario 2 ends with investment costs of 3.8 mio CHF. The operating costs are 570'000 CHF (76 locker stations * 7'500 CHF). These are big investments that someone must carry. There exists a trade-off between the number of parcel locker station to be installed and the walking distance between a customer's home and the nearest parcel locker station. If a city desires that the inhabitants have a parcel locker in walking distance, they have to instal a fine-grained system of parcel lockers. If the distance to the next parcel locker is too far, customers tend to use a motorised vehicle for the parcel pick-up.

If a white-label approach is followed, the CEP service suppliers expect access to these parcel locker stations but are not willing to invest in them. Conducted interviews with stakeholders, that we also conducted in the overall project on which this paper bases on provided insights that CEP service suppliers expect the city's government to provide the boxes. The government on the other side claimed that investing in logistics infrastructure is not part of their tasks. They expect a market solution. To the best of our knowledge, Hamburg is the only city that has a white-label parcel locker station system of 21 parcel locker stations, which are installed in train stations. The majority of solutions that exist are those where private companies (i.e., the Post, Amazon, DHL, etc.) invested in parcel locker stations. Nevertheless, a white-label solution seems desirable from a city's perspective, as the goal to bundle orders and decrease vehicle kilometres on the city's ground can be achieved in an efficient way through a white-label logistics solution with parcel locker stations to decouple suppliers and customers in a special and timely manner. Subsequently, further research is needed in calculating the number of vehicle kilometres that can be saved when implementing such a find-grained decoupling hub system as introduced in the paper at hand to achieve a special and timely separation between CEP service suppliers and customers. If the effect is high enough and a city is truly interested in the implementation of a sustainable urban logistics concept, a collaborative financing between private and public institutions might be better achievable.

Another possibility that cities can discuss is whether they want to incorporate the necessity to build a parcel locker station in every apartment complex that is newly built. If the parcel locker is already considered while planning the new apartment houses, the number of parcel lockers will increase over time, supporting the city in the goal to achieve a liveable city with a sustainable urban logistics solution.

In a future analysis, two things should be considered: (1) In the CFLP, the transport costs between the city hub and the parcel lockers were not considered, as the final city hub location was unknown at the time of conducting this study. Additionally, the main focus in the paper at hand is a proof of concept. However, this shall be addressed in a future study. (2) The integration of the parcel pick-up in the commute is not considered in the optimisation but could be focus in a future study too to extend the existing model.

Acknowledgements

Many thanks to Innosuisse, the Swiss Innovation Agency, for financial support of the Flagship project Smart Urban Multihubs, our interviewees, and the two anonymous reviewers whose inputs help to improve the quality of this paper.

References

Akyol, D.E., De Koster, R.B., 2018. Determining time windows in urban freight transport: A city cooperative approach. Transportation Research Part E: Logistics and Transportation Review 118, 34-50.

ARE, 2016. Perspektiven des Schweizerischen Personen- und Güterverkehrs bis 2040, Hauptbericht. Bundesamt für Raumentwicklung ARE, Bern.

ARE, 2021. Externe Kosten und Nutzen des Verkehrs in der Schweiz. Strassen-, Schienen-, Luft- und Schiffsverkehr 2018. Bundesamt für Raumentwicklung ARE, Bern.

BAFU, 2022. Kenngrössen zur Entwicklung der Treibhausgasemissionen in der Schweiz 1990-2020. Bundesamt für Umwelt BAFU, Bern, Schweiz.

Bates, O. et al., 2018. Transforming last-mile logistics: Opportunities for more sustainable deliveries. Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, pp. 1-14.

Becker, H. et al., 2021. Zukunft der Mobilität in der Schweiz. McKinsey Center of Future Mobility, Zürich, Schweiz.

BFS, 2021. Statistik der Bevölkerung und Haushalte (STATPOP) 2020. Bundesamt für Statistik, Neuenburg, Schweiz. URL: https://dam-api.bfs.admin.ch/hub/api/dam/assets/19106709/master (last access: 15 May 2022)

Björklund, M., Forslund, H., 2018. Exploring the sustainable logistics innovation process. Industrial Management & Data Systems.

Çelik Türkoğlou, D., Genevois, M., 2020. A comparative survey of service facility location problems. Annals of Operations Research 292, 399-468.

Collins, A.T., 2015. Behavioural influences on the environmental impact of collection/delivery points. Green logistics and transportation. Springer, pp. 15-34.

de Mello Bandeira, R.A., Goes, G.V., Gonçalves, D.N.S., Márcio de Almeida, D.A., de Oliveira, C.M., 2019. Electric vehicles in the last mile of urban freight transportation: A sustainability assessment of postal deliveries in Rio de Janeiro-Brazil. Transportation Research Part D: Transport and Environment 67, 491-502.

Gössling, St., 2016. Urban transport justice. Journal of Transport Geography 54, 1-9.

Gonzalez-Feliu, J. et al., 2014. Sustainable urban logistics: Concepts, methods and information systems. Springer.

He, Y., Wang, X., Lin, Y., Zhou, F., Zhou, L., 2017. Sustainable decision making for joint distribution center location choice. Transportation Research Part D: Transport and Environment 55, 202-216.

Kin, B. et al., 2016. Is there life after subsidy for an urban consolidation centre? An investigation of the total costs and benefits of a privately-initiated concept. Transportation Research Procedia 12, 357-369.

Kuwok, F., Asdecker, B., 2015. Grüne Logistik-Lösungen auf der letzten Meile: Sind Packstationen ökologisch nachhaltig? Mobility in a Globalised World 2014 12, 139.

Lagorio, A., Pinto, R., Golini, R. (2016). Research in urban logistics: a systematic literature review. International Journal of Physical Distribution and Logistics Management 46 (10), 908-931.

Mazur, M., Urban, G., Starzyk, M., 2019., PwC CEE Transport & Logistics Trend Book 2019, PwC, Poland.

Ruesch, M. et al., 2011. Güterverkehrsplanung in städtischen Gebieten. Handbuch (Entwurf).

Schmid, B. et al., 2021. The value of travel time savings and the value of leisure in Zurich: Estimation, decomposition and policy implications. Transportation Research Part A: Policy and Practice 150, 185-215.

Strale, M., 2019. Sustainable urban logistics: what are we talking about? Transportation Research Part A: Policy and Practice 130, 745-751.

Vural, C.A., Aktepe, Ç., 2021. Why do some sustainable urban logistics innovations fail? The case of collection and delivery points. Research in Transportation Business & Management, 100690.