Estimating the benefits of dedicated unloading bays by field experimentation

Fransoo, Jan C.; Cedillo-Campos, M. Gaston; Gamez-Perez, Karla M.

Published in:
Transportation Research Part A: Policy and Practice

DOI:
10.1016/j.tra.2022.03.023

Publication date:
2022

Document Version
Peer reviewed version

Estimating the benefits of dedicated unloading bays by field experimentation

Jan C. Fransoo[1], M. Gastón Cedillo-Campos[2], and Karla M. Gámez-Pérez†

[1]Tilburg University, School of Economics and Management, Tilburg, the Netherlands, jan.fransoo@tilburguniversity.edu

[2]Instituto Mexicano de Transporte, Queretaro, Mexico. gaston.cedillo@imt.mx

July 26, 2021

Abstract

In most dense urban environments in emerging markets, retail deliveries are very fragmented to thousands of nanostores. It is not uncommon for a delivery route to include more than 60 stops. Unloading bays are often blocked by regular traffic. Due to the complex urban environment, it is difficult to estimate the benefits of making unloading bays available. In this study, we conduct a field experiment in an urban field lab of one square kilometer in the downtown of Querétaro, Mexico. During the treatment period of one week, we obtain help from the local traffic police to keep the unloading bays available for unloading only. Using advanced GPS devices and extensive manual field observations, we are able to capture the change in driver behavior and the direct efficiency increases. We find a high efficiency gain, not only in travel time (39%) but also –remarkably - in the total time parked (17%). Corrected for other effects, we estimate a gain of about 44% in total time per delivery. Apart from the insights on unloading benefits, we also provide insights into the method of field experimentation in such a complex environment.

*Keywords:*urban logistics, nanostores, parking, unloading bays, field experiments, retail.

1 Introduction

Urban logistics has received increased attention although most of the research and innovation has been conducted in the developed world. In emerging markets and other developing countries, the freight transportation landscape is quite different from those in the developed world (Mareï and Savy, 2020). Especially the retail sector is much more fragmented, with small family-owned stores dominating the retail landscape. Fransoo et al. (2017) designate these stores as nanostores and estimate that in the grocery sector alone, there are about 50 million nanostores in the developing world, many of them located in very large cities. Due to limited space and limited cash flow, nanostores are delivered in small quantities in high frequency, in many cases directly by the manufacturer (Fransoo et al., 2017; Boulaksil et al., 2019; ?). For instance, in Mexico Coca-Cola bottler FEMSA serves about 1.3 million points of sale (nanostores and restaurants) directly , while Sigma Alimentos serves refrigerated meat and dairy products to about half a million points of sale.

Considering the large number of stops in a route, the high density of stops, and the short average duration per stop, serving nanostores in an urban environment is more akin to express delivery in developed markets than it is to retail delivery in such markets. In an urban nanostore route, more than 60 stops are typically included. Further, most of the time in a route is spent while the delivery is taking place, i.e., when the vehicle is parked. It is not uncommon that of the total shift time, a nanostore delivery vehicle is parked more than 80% of the time. Hence, the last 50 meters of delivery very much drives the efficiency of the process, much more so than the typical "last mile"(Goodchild and Ivanov, 2017). An important part of these last 50 meters relates to the problematic parking for unloading. This is the subject of study in our paper.

Urban logistics has been the subject of study for decades, with many innovations having received attention, many of which focusing around consolidation and deconsolidation, the separation of freight and passenger traffic in space and time, and the introduction of new technologies. Much of this research relies on field trials and policy interventions with extensive stakeholder consultation, thus providing for a high level of external validity. An excellent and recent overview is provided by Thompson and Taniguchi (2017). In parallel, an increasing share in the transport optimization literature addresses problems in urban logistics, with extensive attention for routing, time windows, crowdsourced deliveries, and distribution concepts including novel technologies such as parcel lockers and drones. Savelsbergh and Van Woensel (2016) provide a recent overview of developments.

Within this large body of literature, parking of freight vehicles for unloading in cities has received surprisingly little attention. Jaller et al. (2013) develop an approximation of freight parking needs based on a freight trip generation model. They conduct a case study for Manhattan. Interestingly, while on average there is ample parking space available, they identify that in specific zip code areas and specific time slots, substantial deficits exist in parking space. Their empirical data suggest that about 10% of all trucks stops are conducted using (illegal) double parking. In their paper, they also argue that virtually all prior parking research has been focused on passenger vehicles rather than freight vehicles. A series of innovative recent papers document commercial parking behavior and effects based on extensive field-work in downtown Seattle (Girón-Valderrama et al., 2019; Dalla Chiara and Goodchild, 2020; Jashami et al., 2020), documenting and addressing issues like the impact on other traffic, illegal parking, and the extensive cruising as a consequence of shortages in commercial parking availability. A limited but growing number of papers develop optimization or (micro-)simulation models of loading/unloading bays in urban environments (e.g., Alho et al., 2014; Muñuzuri et al., 2017; Iwan et al., 2018), while Marcucci and Gatta (2014) and Nourinejad et al. (2014) elicit preferences of the various actors around unloading bays. Probably the richest micro-simulation model to date is reported in the study by Alho et al. (2018). As in our study, they also focus on a limited space of about 1 km^2. In their micro-simulation, they explicitly model double parking. They report substantial reductions in double parking and some reductions in traffic flow distortion if the number of bays is increased, showing that there are decreasing marginal returns if the number of delivery bays is increased further. Unlike our study, they do not study the efficiency from the route perspective. Further, since our study is empirical, we are able to capture also any behavioral changes that may occur due to bay parking availability.

It is not trivial to assess the impact of unloading bays on the operational performance in the route, and on the traffic and space usage in the city. Having sufficient unloading bays available may reduce the search time for parking space but, on the other hand, may increase the walking time in the last 50 meters as the bay may be less close to the retail store than an illegal double parking spot. Moreover, since in emerging markets the number of drops on a route is very large, the effect on overall route efficiency is not obvious.

In this paper, we empirically investigate the effect of systematically available unloading bays. We investigate this using a rarely used method in urban logistics or operations management, namely field experimentation. Field experimentation allows us to conducts a semi-controlled experiment comparing actual driving, parking, and delivery behavior of a set of trucks in an urban area. We conduct the experiment in a 1 square kilometer area, in downtown Querétaro, a city of about two million people, with a UNESCO-designated World Heritage city center. The square kilometer under study counts about 900 nanostores, of which about 100 receive consumer packaged goods, the subject of our study. We manipulate the availability of loading bays to allow us to measure the effect of such availability.

Our results show that making available loading bays substantially increases delivery efficiency on the route, with the driving time normalized per delivery reduced by more than 50%. Remarkably, also the time parked per delivery reduced by almost 38%, indicating a change in delivery strategy with more of the final deliveries being conducted by walking.

While the absolute numbers need to be taken with care, the large differences do suggest that there is a substantial effect in routing efficiency once delivery bays are available. Moreover, since also the time spent in the experimental area and the time spent parking is reduced, there seem to be clear societal benefits of allocating space to freight.

The remainder of this paper is organized as follows. In Section 2, we outline the design of the study. We also discuss in detail the extensive efforts required for a field experiment like this. In Section 3 we discuss the processing of the data and present and discuss the numerical results. We conclude in Section 4.

2 Methodology

Field experimentation is not common in transportation, operations, or logistics research. A likely reason is that it is very difficult to arrange for a field experiment to take place in an actual field environment of the city, especially if this involves making actual changes in the urban space, such as the availability of unloading bays. For our purpose, the area of study is an area of one square kilometer. The street layout is in a perpendicular grid, with 2 sets of 8 streets within the square kilometer, implying about 16 kilometers of street-length. Less then 2 kilometers of these 16 kilometers are pedestrianized and hence not accessible to cars or trucks, so the area has about 28 kilometers of curbside. All streets have one-way traffic. Spanish colonial architecture and its associated narrow streets, of which many are cobble-stoned, characterize the area.

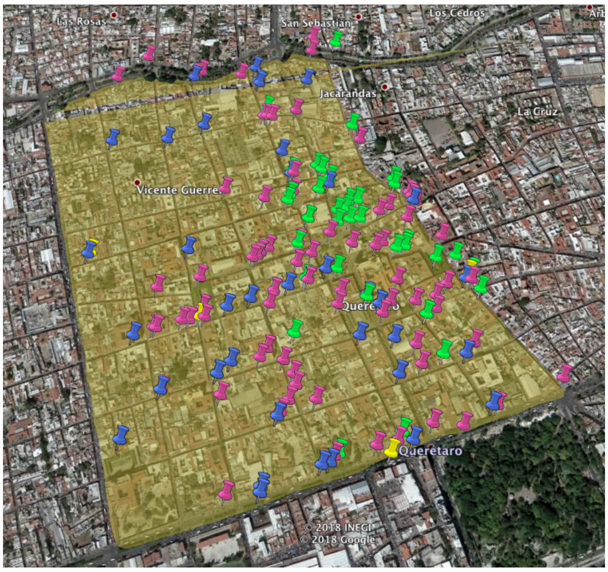

Figure 1: Overview of the experimental area in Querétaro, Mexico. The markers indicate the nanostores where the four companies taking part in the study do deliveries

Our area of study is both residential and commercial, with about 900 nanostores and other small businesses such as restaurants and bars within this single square kilometer. Nanostores in Latin America may receive up to 50 deliveries per week, depending on the category (Fransoo et al., 2017), with grocery stores at the high end of this number, and apparel at the low end. Four of these suppliers take part in our experiment. All four suppliers operate in the food and beverage category (beer and soda, water, fruit juices, and bread) Depending on the size of the store and the product characteristics, a single supplier may visit a single nanostore 1-3 times per week. The suppliers provide us with their delivery-related data, such as the stores visited and the number of cases delivered on each visit. In total, 11 delivery vehicles are involved in the experiment. While the number of stores within our experimental area by each company on a single day is smaller than what a single vehicle could carry, still these stores could be part of multiple routes for various reasons. For each route, most of the other deliveries are outside our experimental area. Figure 1 provides an overview of the area, including the stores that the suppliers taking part in the experiment deliver to.

We distinguish two periods of data collection, which we designate as the *control* and the *treatment period*. In the control period, we use the natural environment of the urban traffic reality. This is characterized by bays effectively not being available for a significant part of the time. There could be multiple reasons for bays not effectively being available. An important reason is poor designation; signs may be hidden or poorly painted on the wall. Furthermore, many taxis or rideshares falsely interpret a freight-unloading bay as intended for passenger loading and unloading (as also documented by Girón-Valderrama et al. (2019) for Seattle). Another, and very important, reason is extensive illegal parking of passenger vehicles in bays. In the area under study, street parking is free and scarce. Alternatives exist in terms of parking lots and an underground parking garage. These, however, require payment and further walking by the passenger to their final destination. Enforcement of parking rules is weak, as few traffic police are available. Effectively, in the control period, designated freight-unloading bays are rarely available for delivery.

For the treatment period, we conduct an intervention: we clearly designate the unloading bays (by placing pylons), and — by extensive training and commitment of the local traffic police — ensure that these bays are available for freight unloading only. Deploying this experiment requires considerable preparation. The preparation essentially focused on making the enforcement also implementable. This required a behavioral change with the traffic police, and required also more traffic police in the area during the treatment period. While normally (and hence - in the control period) 3 police patrol the experimental area, during the treatment period 20 police patrolled the experimental area, substantially increasing oversight. Increasing numbers however does not necessarily improve enforcement, as such a sudden change in operational policy could lead to conflicts between police and residents and visitors. To this end, one of the authors developed a training for police providing them with an understanding of logistics and the benefits to the area of using unloading bays only for the purpose that they were designed with. All 20 police took part in this half-day training. Further, meetings were held with the association of local residents in the historic center of Querétaro to obtain their support for the experiment. Many local residents have developed a virtual overnight "ownership" of a parking spot in front of their home and may still have the car parked there in the morning, while this effectively is a loading bay. The intervention effectively ensures that during the treatment period all loading bays are available for freight unloading only. Since this is a very noticeable difference with the control period, this allows us to compare data between the two periods.

The control period was in April (2018) and the treatment period was in July (2018). Neither of the periods were in a holiday season with substantial different traffic or pedestrian patterns (such as the Christmas season or the pre-Easter "Holy Week"). The companies involved deployed the same number of trucks and routes and visited more or less the same number of stores. There was a notable difference in the number of deliveries taking place, with more deliveries in the July period. This is due to the higher temperatures in July as compared to April, and subsequent elevated consumption of water, juices, and beer (three of our suppliers involved in the study). In the data processing, we normalize for the increased number of deliveries.

We collect the following data during both the control period and the treatment period: (1) GPS movements per vehicle to identify different last-mile delivery patterns (in particular the location of stops, and the time present at stops and in the area), (2) Geospatial data of the area under study (specifically the store locations and the locations of the freight unloading bays) and (3) Delivery data per store (delivery dates and quantities). The strength of this experimental set-up allows us to do a quasi-controlled experimental comparison. In this way, by changing one specific control – namely the availability of unloading bays – we can compare the resulting dependent variables fairly and methodologically sound, in particular relating to the efficiency of the route and the use of public space. There are however also disadvantages to our method. An important one is the limited scope. We only consider one square kilometer, and only one week of control period and one week of treatment period. This relates to the effort of making the experiment work. These efforts are very significant. First, there is the preparation effort, which we discussed above. Second, We had to equip all vehicles with the same GPS devices, to allow the data to be comparable. Different GPS devices provide different types of errors in the measurement; a standardized device allows us to compare the data of the different delivery vehicles in a standardized manner. A limited area limits the number of devices that we had to obtain [1] Finally, the effort in the experimentation itself, in particular, the deployment of 20 traffic police compared to (normally) at maximum three in the area. If the area were larger, the extent of these efforts would become prohibitive. A second disadvantage is that, partly due to the limited scope in area and time, other factors (covariates) with potential effect could be quite different between the control period and the treatment period since we cannot control for this. In our specific case, a major issue turned out to be that the number of deliveries between the control period and the treatment period were substantially different. We will come back on this issue in the analysis. We believe other potential effects, such as the traffic situation, should not have much effect as the periods were in the same season of the year and sufficiently close to one another, without public holidays during the week. Econometrically we cannot fully control for this, since the number of observations is limited due to the limited size of the experimental area and the limited duration of the experiment.

[1] The devices were made available by one of the sponsors of the study

However, this experimental setup allows us to estimate real-life-size effects taking into account the complex urban reality, and the behavior of the drivers and other agents. Such human behavior cannot be captured in a (simulation) model unless this is pre-specified or hypothesized. Hence, our results provide valuable input to improve the external validity of future modeling efforts. As such, our results should be considered exploratory and a contribution to the development of a more comprehensive and multidimensional theory on parking, rather than a formal theory-testing experiment.

3 Analysis and Results

3.1 Data Processing and Descriptives

Data have been collected over six days in both the control period and the treatment period, with a total of 49 routes in each of the periods. A vehicle conducts one route per day. Eleven vehicles were part of the sample, across the four participating companies. Note that a route also included deliveries outside of the experimental area. Hence, we also track the total time of the route specifically spent within the area. We converted the GPS traces into data describing the total time traveled and the total time parked. To identify whether a vehicle was parked, a threshold stopping time was used of 90 seconds, i.e., if a vehicle was not moving for more than 90 seconds, it was labelled in our data as "parked". Since there are no traffic lights in the area, this seems a reasonable threshold. It is unlikely that a vehicle would park without a delivery taking place. Parking the vehicle, getting out, taking the goods onto a handtruck, delivering at the store, collecting the cash, and finalizing the paperwork typically requires at least 3-4 minutes in the nanostore setting (Fransoo et al., 2017) The GPS trace, as is common in these type of studies, also shows inaccuracies. To decide on whether a vehicle was parked in an unloading bay, we took an error of 50 meters into account, so if the GPS trace indicated that the vehicle was parked, and in addition indicated that it was within 50 meters of an unloading bay, it was labelled as the vehicle being parked in an unloading bay. It turned out that the total number of deliveries in the treatment period was substantially higher than in the control period, so for our results analysis, we need to normalize a number of the results per delivery made. Table 1 contains the data for both the control period and the treatment period, as well as a comparison percentage where this is appropriate.

3.2 Results

We limit our analysis to the descriptive statistics collected during the control period and the treatment period. This analysis demonstrates a significant efficiency gain in the distribution process, and a significant reduction in the total time parked and driven in the square kilometer. The latter implies a significant societal benefit. Note that due to the type of data, we cannot do a more detailed analysis.

Table 1: Results

Variable	*control period*	*treatment period*	*Difference*
Number of observations			
Total number of deliveries	326	435	
Total number of routes	49	49	
Total number of stops within bays	34	54	
Total number of stops outside bays	121	158	
Total number of stops	155	212	
Parking statistics			
Total time parked (hours)	84.2	70.0	-16.8%
Parking time per delivery (minutes)	15.5	9.7	- 37.7%
Parking time per stop (minutes)	32.6	19.8	- 39.2%
Share of bay parking by number of stops	21.9%	25.5%	+16.1%
Total time parked in a bay (hours)	14.8	25.8	+74.3%
Share of bay parking by time	17.6%	36.9%	+109.7%
Number of deliveries / stop	4.99	5.03	+0.94%
Movement statistics			
Total time moving in the area (hours)	55.8	34.01	-39.1%
Total time moving in the km2 area per delivery (minutes)	10.3	4.7	- 54.3%
Percentage that vehicle is moving	39.9%	32.7%	- 18.0%
Presence statistics			
Total time spent within the km2 area (hours)	140	104	-25.7%
Total time spent in the km2 area per route (hours)	2.9	2.1	-27.6%
Total time spent in the km2 area per delivery (minutes)	25.8	14.3	- 44.3%

For instance, due to the difference in the number of deliveries, we need to normalize the duration per delivery, and cannot do a one-by-one comparison of deliveries. Hence, we remain cautious with the implication of the specific numbers in our study. However, since the effect size is very large, we are confident that the difference between the control period and the treatment period are substantial and due to the intervention.

We observe a number of interesting effects. First, the drivers reduce their parking time by 17% and their travel time duration within the square kilometer decreases by 39%.This is illustrated in Figure 2. Note that the average number of stops per route (normalized per delivery) remains unchanged. We expect a shift in the balance, though, with the number of stores delivered from a bay having increased, and the number of stores delivered from a street parking (i.e., outside of an unloading bay) place having decreased. Since we do not have tracking data on the drivers and helpers while they are walking to do the final meters of the delivery, we are unable to demonstrate this effect. However, the share of the total time parked that vehicles were within an unloading bay increased substantially from 18 to 37%. This suggests that a much larger share of the deliveries were conducted from the unloading bay. In order

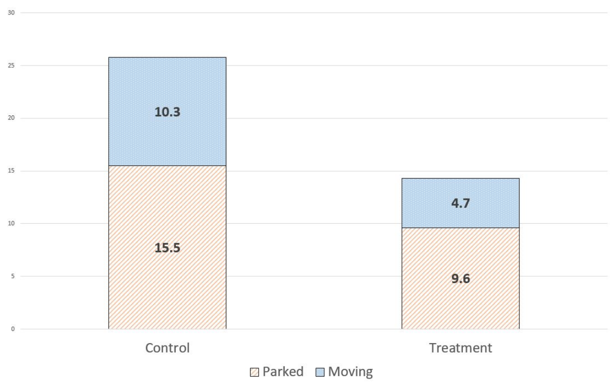

Figure 2: Comparison of time parked and time moving in the area (in minutes), normalized per delivery, between the treatment and control periods

to investigate this further, we computed the share of deliveries that are located within 70 meters of an unloading bay. This number only increased marginally (from 35 to 39%; not in Table). We believe this can be explained by the fact that drivers, once they have found a safe and secure parking spot in an unloading bay, leave the vehicle there for a longer amount of time, and walk more. On the other side, the implication would be that for the street-parking stops, fewer stores would be delivered per stop, and drivers would move from store to store, possibly increasing the number of short and illegal stops. We currently have only the following indication for that: the total number of deliveries per stop is not different between the control period and the treatment period, while – as mentioned, the vehicles spent much more time in the unloading bay during the treatment period than they do in the control period. While the reduction in travel time might have been expected based on a simulation or a model, the reduction of total parking time is more difficult to anticipate, since the drivers may do more walking if they use an unloading bay. Apparently, in certain parts of the area of study, walking is faster than driving. Further, each stop incurs a "fixed time" component: searching or waiting for a parking space, parking the vehicle, getting out of the vehicle, and opening the truck door. Furthermore, if multiple stores are delivered from one stop, the picking time in the truck per delivery is likely to be less. These factors could explain why the total parking time has reduced despite the driver walking more.

As a consequence of the reduction in parking time, the increase in the last 50 meter efficiency due to more walking, and the fact that less time is spent driving around, the total time per delivery went down by 44%. This is a very large number, and obviously needs to be qualified given the small sample and area. However, it does indicate that the potential gain is substantial.

4 Conclusions

Our results reveal that making available unloading bays in areas of high store density leads to more efficiency in the routes, as drivers move between delivery bays that they can rely on to likely be available upon arrival. Somewhat counterintuitive, a higher availability of delivery bays also leads to less time parked in total. This suggests that if bays are available, more stores are served per stop, implying that drivers and helpers are organizing their delivery more efficiently in a multi-tier manner, adding more walking within their operational delivery strategy. We believe this conjecture warrants more empirical research, for instance by separately tracking the drivers and helpers while off the truck. For instance, it could be demonstrated that within shorter distances, walking is faster than moving by vehicle, and this could further inform the proper design of delivery bay policies. Further optimizing the routes with this knowledge may also further reduce the costs of the supplier and the needs for freight vehicle parking.

Our results also support the premise that more research is needed focusing on the last 50 meters (or even 50 feet, as argued by Goodchild and Ivanov (2017)), in addition to the work focusing on the stereotypical "last mile". In nanostore deliveries, much of the time that vehicles spend on the route, are spent while the vehicle is parked. Hence, also improvements may need to be sought more on the parking time than on trying to further optimize the routes and reduce traveling time. While our study focuses on nanostores delivery in Latin America, we believe our insights can be generalized to any area where many stops are included in a dense route in an urban environment. For instance, we believe our insights are also valuable for parcel delivery in highly dense parts of European or some North-American cities.

It should be noted explicitly that the benefits identified in our study do not only end up with the distributing manufacturers. Effectively, we show that if a city allocates space to unloading bays, the overall space used for parking may reduce. Even if the utilization of a bay would be only 75% while the bay is open for a limited amount of time (for instance during 4 hours in the morning), our results suggest that a net gain in public space would be feasible. Moreover, we know from queuing theory that with such a utilization, it is highly likely that vehicles will find a space to park in a bay (Abhishek et al., 2021), so more advanced systems requiring booking the bay may not be needed to make the system as a whole more efficient. Our data furthermore show that by providing unloading bays, cities furthermore benefit by vehicles cruising around less, and leaving dense commercial areas more quickly than without those bays.

5 Acknowledgements

The authors dedicate this work to our co-author Karla Gámez-Pérez who was critical in processing and analyzing the collected field data, but could not complete it due her untimely death.

This study was financially and organizationally supported by the Embassy of the Kingdom of the Netherlands in Mexico. We thank former Ambassador Margriet Leemhuis for her support over an extended period of time, and Irasema Mendoza-Martinez for the extensive help in bringing multiple parties together. *Webfleet Solutions* made available the GPS devices for our study. We thank Joel Ramirez-Yescas for his support. We thank managers and drivers of the participating companies Heineken, Jumex, Bimbo, and Bonafont for their support of and participation in the project. We would like to thank Fausto Marquez, former director of IMPLAN Querétaro, for managing the entire process of involving the city authorities in the project. We acknowledge the support of Paloma Santos and Montserrat Gaytán Gutiérrez for their help in processing the data.

References

Abhishek, Legros, B., and Fransoo, J. C. (2021). Performance evaluation of stochastic systems with dedicated delivery bays and general on-street parking. *Transportation Science*.

Alho, A., Silva, J., Sousa, J. d., et al. (2014). A state-of-the-art modeling framework to improve congestion by changing the configuration/enforcement of urban logistics loading/unloading bays. *Procedia-Social and Behavioral Sciences*, 111:360–369.

Alho, A. R., e Silva, J. d. A., de Sousa, J. P., and Blanco, E. (2018). Improving mobility by optimizing the number, location and usage of loading/unloading bays for urban freight vehicles. *Transportation Research Part D: Transport and Environment*, 61:3–18.

Boulaksil, Y., Fransoo, J. C., Blanco, E. E., and Koubida, S. (2019). Understanding the fragmented demand for transportation–small traditional retailers in emerging markets. *Transportation Research Part A: Policy and Practice*, 130:65–81.

Dalla Chiara, G. and Goodchild, A. (2020). Do commercial vehicles cruise for parking? empirical evidence from seattle. *Transport Policy*, 97:26–36.

Fransoo, J. C., Blanco, E. E., and Mejia-Argueta, C. (2017). *Reaching 50 million nanostores: retail distribution in emerging megacities*. CreateSpace Independent Publishing Platform.

Girón-Valderrama, G. d. C., Machado-Leon, J. L., and Goodchild, A. (2019). Commercial vehicle parking in downtown seattle: Insights on the battle for the curb. *Transportation Research Record*, 2673(10):770–780.

Goodchild, A. and Ivanov, B. (2017). The final 50 feet of the urban goods delivery system. Technical report, University of Washington.

Iwan, S., Kijewska, K., Johansen, B. G., Eidhammer, O., Małecki, K., Konicki, W., and Thompson, R. G. (2018). Analysis of the environmental impacts of unloading bays based on cellular automata simulation. *Transportation Research Part D: Transport and Environment*, 61:104–117.

Jaller, M., Holguín-Veras, J., and Hodge, S. D. (2013). Parking in the city: Challenges for freight traffic. *Transportation research record*, 2379(1):46–56.

Jashami, H., Cobb, D., Hurwitz, D. S., McCormack, E., Goodchild, A., and Sheth, M. (2020). The impact of commercial parking utilization on cyclist behavior in urban environments. *Transportation Research Part F: Traffic Psychology and Behaviour*, 74:67–80.

Marcucci, E. and Gatta, V. (2014). Behavioral modeling of urban freight transport. In *Sustainable urban logistics: Concepts, methods and information systems*, pages 227–243. Springer.

Mareï, N. and Savy, M. (2020). Global south countries: The dark side of city logistics dualisation vs bipolarisation. *Transport Policy*.

Muñuzuri, J., Cuberos, M., Abaurrea, F., and Escudero, A. (2017). Improving the design of urban loading zone systems. *Journal of transport geography*, 59:1–13.

Nourinejad, M., Wenneman, A., Habib, K. N., and Roorda, M. J. (2014). Truck parking in urban areas: Application of choice modelling within traffic microsimulation. *Transportation Research Part A: Policy and Practice*, 64:54–64.

Savelsbergh, M. and Van Woensel, T. (2016). 50th anniversary invited article —- city logistics: Challenges and opportunities. *Transportation Science*, 50(2):579–590.

Thompson, R. G. and Taniguchi, E. (2017). City logistics and freight transport. In Brewer, A. M., Button, K. J., and Hensher, D. A., editors, *Handbook of logistics and supply-chain management*. Emerald Group Publishing Limited.