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Evaluating freight loading/unloading parking zones characteristics, usage and performance in Southern Europe

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Abstract

Loading/unloading parking zones represent the most widespread parking system for B2B urban freight pickup/deliveries. However, guidelines related to the provision, management and use of these systems are scarce, just as ex-post performance evaluations. Our objective is twofold: 1) to determine whether the infrastructure in a case study meets the needs of freight vehicles; and 2) to compare existing infrastructure with that suggested by existing guidelines.

For four highly commercial streets in the city of Seville (Spain) we assess: a) business establishment coverage; b) delivery arrival patterns; c) loading/unloading parking zone occupation patterns; d) freight vehicles' double parking and e) level of service. Moreover, we carry out a comparison with data from other Southern European cities to identify commonalities/differences between findings.

Current freight-reserved periods are mismatched with the freight vehicle parking demand, which results in a low usage of the infrastructure. Double parking events are comparatively short in the sample of observed pickup/deliveries, but might affect a considerable number of vehicles. The application of the CERTU method results in a potentially under-sized system but the existing system in Seville might be over-dimensioned and have an inadequate spatial distribution. Delivery arrival patterns and weekly frequencies show both similarities and discrepancies with those in other cities.

We can conclude that the existing system is unsuitable for the current demand patterns. Moreover, the discrepancy between case-studies illustrates the challenge of generalizing freight operations patterns and of deriving adequate solutions to deal with freight parking demand.

*Keywords:*urban freight; loading zones; level of service.

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1. Introduction

Loading/unloading parking zones constitute the most widely used type of public infrastructure to facilitate the pickup/delivery of goods in urban environments. These zones are curbside parking spaces reserved for vehicles performing freight

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loading/unloading activities. As drivers are time sensitive, when parking options are not available close to their destination they frequently double-park vehicles. This has subsequent negative impacts on tour performance (e.g. fine costs) and traffic fluidity, as well as supply-chain economic implications (Chatterjee, 2004). Loading/unloading parking zones provide drivers with a place to park the vehicles at a moderate distance from their destination, with the goal of avoiding having to look for a parking space. Regular parking spaces are typically too small to accommodate freight trucks or make difficult the process of loading/unloading goods.

Large shopping malls located in the outskirts of cities usually have their own delivery areas, but research on loading/unloading parking zone usage is particularly important when targeting the central areas of European cities. These areas are characterized by narrower streets and high commercial densities, making this type of public infrastructure most needed. Loading/unloading parking zones do not require relevant investments or maintenance costs, and are reasonably flexible when it comes to installation and removal in response to the varying requirements of the neighbouring retailers. Despite this, loading/unloading parking zone deployment should be carefully planned as a way to neither compromise public space usage and regular parking nor to incentivize parking of freight vehicles for a long term (Pivo et al., 2002). For example, by limiting its use to time windows and allowing all vehicles to park outside the reserved period. Time-windows should be aligned with the demand for parking.

The usual regulations for this type of infrastructure seek to make them egalitarian, forcing delivery vehicles to continue their route after a maximum standing time. This allows for an adequate rotation of vehicles and shared use of the infrastructure. However, there are challenges to accommodating the variability in urban freight transport (e.g., own-account and third-party transport) when the solution has a single-purpose common regulatory framework. Different users might want to use the parking zones differently.

We hypothesize scarcity of information available for local authorities in the decision-making process for the creation/restructuring of a loading/unloading system. One of the main reasons is having loading zones provided at the retailers' request (e.g. Seville, Lisbon). This is linked with the inexistence of: a) an ex-ante understanding on the number, size or location of the spaces to provide; nor b) an ex-post analysis on the use, performance or adequacy of the spaces provided. A single resource was found providing a general rule of thumb: the CERTU (2009) guide suggests to divide the number of weekly pickup/deliveries in a given street by 90 in order to obtain the number of loading/unloading parking zones needed in that street. It comes to no surprise that loading zone systems often end up being obsolete and poorly dimensioned (Dezi et al., 2010; Alho and de Abreu e Silva, 2014; Alho et al., 2015).

To illustrate the points made above, we will present here a detailed analysis of different streets in the city of Seville, in the South of Spain. We assess the existing infrastructure in terms of quantity, location and coverage. We also analyse the use of that infrastructure, in terms of number of deliveries, stop durations and double parking. Finally, we estimate the level of service provided by load zones, comparing our observations with the results provided by CERTU in a *deductive* fashion (Gillham, 2000).To frame the results of our case study in a wider context, we compare our results with those published to the date in Europe. We focus on the cities of Bologna (Dezi et al, 2010), Lisbon (Alho and de Abreu e Silva, 2014), Bordeaux and Lyon (Gardrat and Serouge, 2016). Finally, we derive different policy implications to help researchers and local authorities understand the difficulty of designing and managing loading zone systems, and formulate recommendations that could be considered in the process.

2. Case study

Our analysis was carried out in four streets with high commercial and residential density in Seville (Spain). Seville is a city with one million inhabitants in its metropolitan area. It has a medieval downtown district, typical in most European cities, with narrow streets, high commercial density and mismatch between parking demand and supply. The four streets in the analysis were chosen for their commercial activity, with multiple retail establishments, and also due to their different characteristics, which are hypothesized to result in different delivery patterns and practices, even though the focus of this paper was not on testing this hypothesis. The selected streets were:

- Feria is the main exit gate in the historical city center.
- León XIII is the main arterial in a densely populated district close to the historical area.
- José Luis de Casso links two avenues with high traffic flow levels in the newer part of the city.
- Virgen de Luján is an urban avenue crossing a high-income neighborhood.

Together they add up to 120 retail premises of different types. Congestion was observed in all of them, including passenger cars, freight vehicles and, in two of them, public transport. Table 1 summarizes the characteristics of these four streets, and Figure 1 shows their locations on the city map.

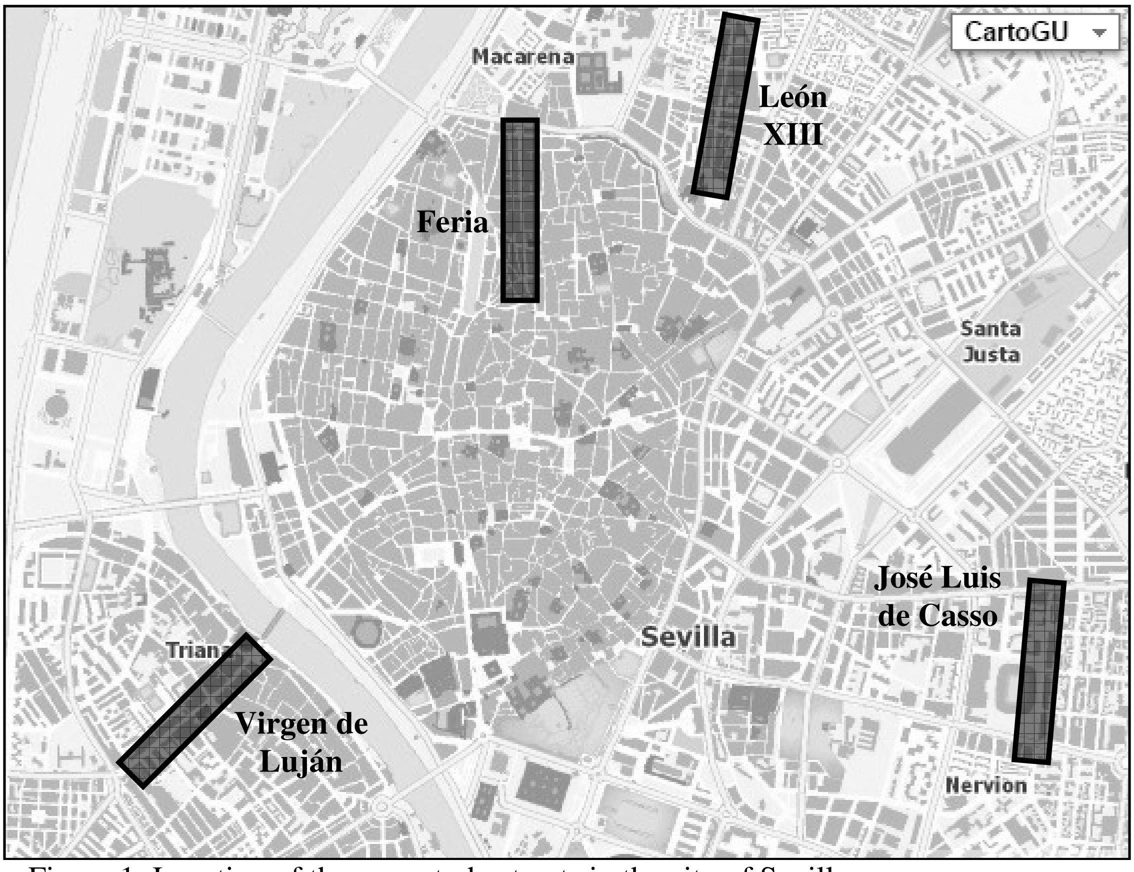

Figure 1: Location of the case-study streets in the city of Seville.
Source: authors' own.

The four streets contain a total number of 13 loading/unloading parking zones, with real capacity (i.e., number of vehicles that can simultaneous park, not by design but from a real usage point of view) and freight-reserved periods as described in Table 2. These periods are not necessarily aligned with the needs of receivers (Muñuzuri et al., 2012), and outside these periods the loading/unloading parking zones can be occupied by any type of vehicle.

Table 1: General characteristics of the four streets included in the case study analysis.

Street	*Characteristics*	*Directions*	*Lanes*	*Public transport (bus)*
Feria	Historical center	One way	Single lane	Yes
León XIII	District arterial	One way	Single lane	No
José Luis de Casso	High-density, connects two avenues	One way	Single lane	No
Virgen de Luján	Avenue	Two ways	Double lane	Yes

Source: authors' own.

Table 2: Loading/unloading parking zones capacity and freight-reserved periods in the four analyzed streets.

Street	*Zone*	*Capacity*	*Freight-reserved period*
Feria	1	7	7.00 to 11.00 and 15.00 to 17.00
	2	8	7.00 to 11.00 and 15.00 to 17.00
	3	1	7.00 to 11.00 and 15.00 to 17.00
	4	7	8.00 to 12.00 and 16.00 to 18.00
	5	1	7.00 to 11.00 and 15.00 to 17.00
León XIII	6	1	8.00 to 18.00
	7	8	7.00 to 11.00 and 15.00 to 17.00
	8	8	7.00 to 11.00 and 15.00 to 17.00
José Luis de Casso	9	2	7.00 to 11.00 and 15.00 to 17.00
	10	3	7.00 to 11.00 and 15.00 to 17.00
Virgen de Luján	11	3	7.00 to 11.00 and 15.00 to 17.00
	12	2	7.00 to 11.00 and 15.00 to 17.00
	13	4	7.00 to 11.00 and 15.00 to 17.00

Source: authors' own.

3. Methodology

The analysis process consisted in the following steps:

1. Assess the loading/unloading parking zone coverage of business establishments in each street.
2. Observe and record stops for pickup/deliveries within and outside the loading/unloading parking zones during a working day for each street.
3. Derive loading/unloading parking zone occupation and double parking statistics.
4. Carry out establishment surveys, to obtain delivery frequency data.
5. Calculate the level of service provided by each loading/unloading parking zone and compare it with the CERTU (2009) recommendations for designing the system.

The field work required in steps (1), (2) and (4), was carried out on the four selected streets during the working days of march, one week for each street. In (3) we used the Welch test to assess double-parking behavior differences between streets, vehicle types and time of the day. With respect to carrier surveys, they were discarded due to the lack of willingness of drivers to provide information regarding their activities; carrier operations were described through direct on-street observations.

The estimation of an indicator for the level of service provided by load zones on a given street seeks to determine to what extent the existing loading/unloading parking zone infrastructure covers the needs of the operating delivery vehicles. In (5) the level of service indicator measures to what extent the existing infrastructure covers requirements, and is calculated by the following formula: *Level of Service = Capacity / Demand* [1]. *Capacity* corresponds to the total amount of parking time that can be granted to delivery vehicles by the load zone system, calculated by the following formula: *Capacity = Freight-dedicated available time* (minutes) * *Total no of zones* [2].

However, due to the discrepancy between the freight peak periods and allocated freight-exclusive periods in the loading/unloading parking zones, we have distinguished two variants of loading/unloading parking zone capacity:

- Ideal capacity: calculated considering 6 available hours per day (typically from 7.00 to 11.00 and from 15.00 to 17.00, see Table 2), while assuming that it would be possible to match parking availability with freight demand peaks. This assumption implies that delivery times can be to a certain extent accommodated to the availability of parking spaces, since the other option would be to provide enough loading zones to accommodate peak demand, resulting in higher percentages of empty loading zone time.
- Real capacity: calculated for only 3 hours, taking into account that retailers are not open during the entire availability period, and further reducing this value as it was frequently observed on the field that vehicles cannot use the design capacity due to poor parking practices. Our observation has shown that the use of loading/unloading parking zones capacity by freight vehicles is usually imperfect, typically with 3 vehicles often occupying entirely a loading/unloading parking zone designed for 4 vehicles. This situation has also been reported in Alho and de Abreu e Silva (2014). To consider this, we multiplied the obtained 3-hour capacity values by 0.75.

Finally, *Demand* is the total amount of parking time required daily by delivery vehicles on a given street. It is calculated as follows while assuming non-simultaneous arrivals of freight vehicles (again, this implies that average parking demand will be compared with average loading zone capacity, instead of comparing peak values): *Demand = pickup/deliveries completed each day * average time required for each delivery* (minutes) [3].

4. Data gathered through direct observation

This section provides details of the information collected regarding the use of the existing loading zones and the subsequent level of service they provide to urban freight carriers.

4.1 Business establishments coverage

The business establishments' coverage provided by the loading/unloading parking zones is depicted in Figure 2 and Figure 3. Figure 2 illustrates the overall coverage of business establishments considering the closest loading/unloading parking zone. Taking the four streets into account, 45% of the establishments have a loading/unloading parking zone at 50 m or less and 55% have one at 75 m or less. These coverage values are consistent with the ones obtained in similar cities like Lisbon, where the typical loading/unloading parking zone coverage ranges between 28% (25m) and 51% (50m) (Alho and de Abreu e Silva, 2014). In Bologna (Dezi et al., 2010), the average degree of coverage is 24% although it is unclear whether a 50m or 70m radius was used. Furthermore, these calculations appear to have considered a homogeneous distribution of establishments, without taking into account actual retailer locations.

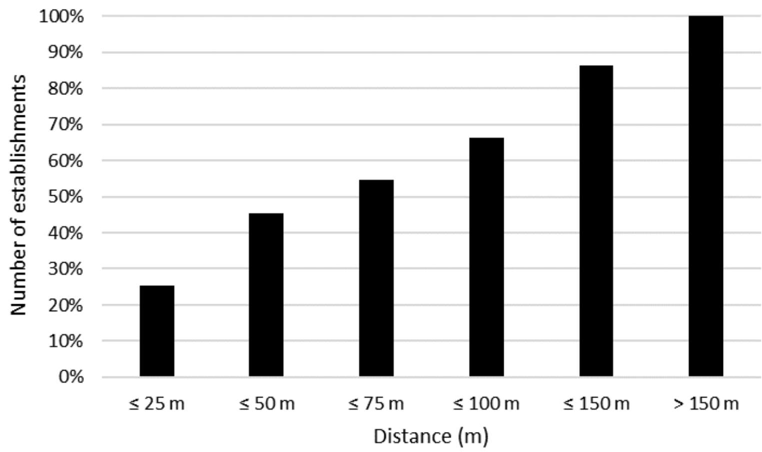

Figure 2: (Overall) Coverage of business establishments considering the closest loading/unloading parking zone.
Source: authors' own.

Figure 3 illustrates the percentage of businesses covered by each zone. It should be noted that some overlapping might exist between the coverage figures, i.e. some zones might cover the same business under the same threshold distance. The focus is that only a small share of business establishments is covered within what is considered as acceptable thresholds of walking distance. We chose a threshold coverage radius of 50 m, which is comparable to the value considered by Alho and de Abreu e Silva (2014) and Dezi et al. (2010), and smaller than the values of 100 m accepted by McLeod and Cherrett (2011) or the 75 m used by Pinto et al. (2019). It can be argued that the premises within the coverage radius might be the ones with higher frequency of pickup/deliveries but situations like Zone 1 for León XIII and José Luis de Casso, demonstrate that these zones are likely to be unappealing to staff performing loading/unloading operations. The establishment coverage results for the four analyzed streets are not homogeneous, with the best coverage in the case of Feria street, and worst for Virgen de Luján.

4.2 Delivery arrival patterns

It is worth contrasting the freight-dedicated schedules of the loading/unloading parking zones, against the delivery patterns revealed by the retailer surveys carried out in the four analyzed streets (Figure 4). Except for fresh food retailers, supermarkets and "other" activities, most commercial premises open their doors at 10:00, stop for lunch between 14:00 and 17:00 and finish their day around 20:30. This discrepancy between the opening hours of the freight-receiving retailers and the freight-reserved period in loading/unloading parking zones is significant (overlapping only 42% of the demand) and has represented a burden on freight delivery activities for a long time (Muñuzuri et al, 2012). The arrival times of delivery vehicles are not decided by the receivers but by carriers, who are in any case sensitive to the desire to receive the goods during the morning or the afternoon period. It can only be curious that the reserved periods are more aligned with the patterns revealed in the French (Gardrat and Serouge, 2016) and

Lisbon data (Alho and de Abreu e Silva, 2014), that have comparatively displaced peaks. The Italian case, in Bologna (Dezi et al, 2010), has a notably different pattern from the others.

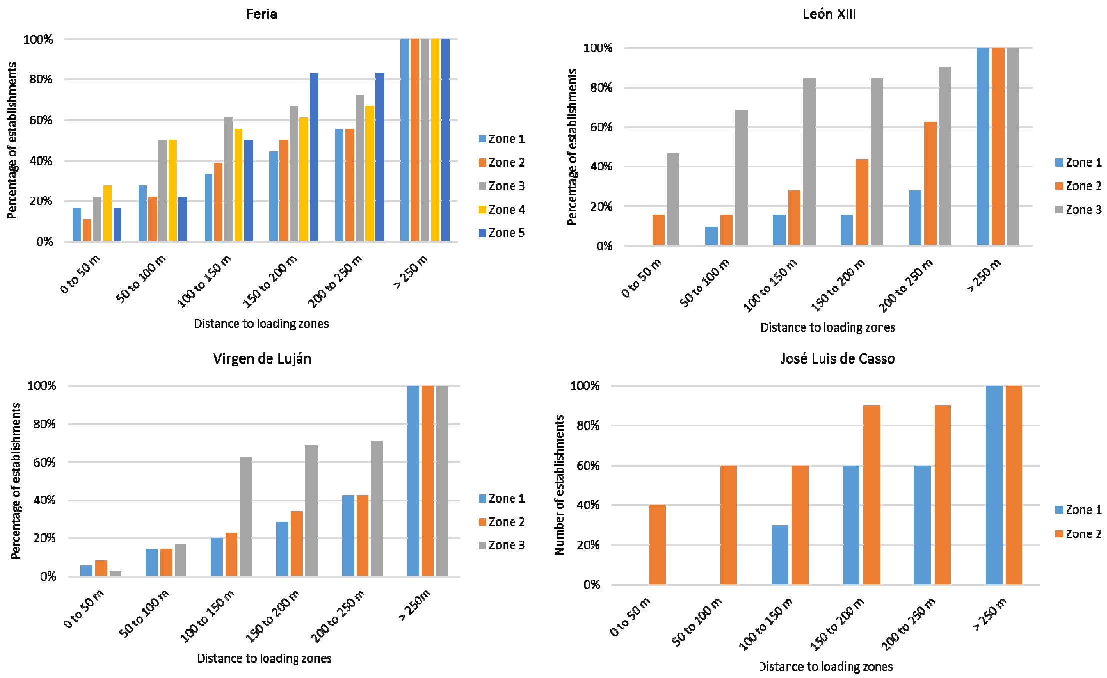

Figure 3: Percentage coverage of business establishments by each loading/unloading parking zone in the selected streets.
Source: authors' own.

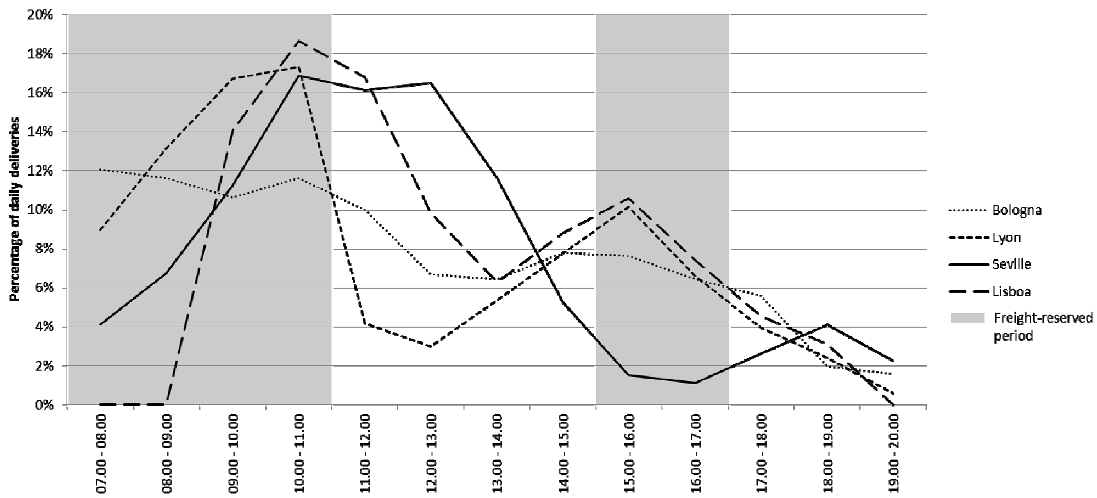

Figure 4: Comparison of freight vehicle arrival patterns for Bologna, Lyon, Lisbon and Seville.
Source: authors' own.

4.3 Loading/unloading parking zone occupation patterns

Data reflecting the occupation pattern in the 13 loading/unloading parking zones of our case study is shown in Table 3. Notably, the loading/unloading parking zone capacity (per space) is empty almost half of the available time, and illegal parking by passenger vehicles accounts for an average of 17% from total available time. This contrasts with the 58% measured in Bologna (Dezi et al, 2010), but this figure appears to be for a snapshot of the system occupation.

Table 3: Occupation data for the loading/unloading parking zones in the four analyzed streets.

Street	*Zone*	*Occupation*		
		Empty	*Delivery*	*Cars*
Feria	1	42%	43%	15%
	2	3%	97%	-
	3	-	100%	-
	4	52%	14%	34%
	5	31%	69%	-
León XIII	6	9%	91%	-
	7	70%	9%	21%
	8	64%	15%	21%
José Luis de Casso	9	3%	71%	26%
	10	45%	34%	21%
Virgen de Luján	11	70%	12%	18%
	12	50%	35%	15%
	13	48%	35%	19%
	Average	44%	39%	17%
	Standard Deviation	25%	35%	6%

Source: authors' own.

Our observations are coincident with the French case. In Bordeaux and Lyon, between 47 and 69% of the time the delivery space is not used for delivery operations, which accounts both for illegal use of the space by other types of vehicles and for the fact that transport operators do not use them. In Lisbon (Alho and de Abreu e Silva, 2014), the surveyed areas also revealed 63% of empty capacity and 16% of non-freight vehicles occupation (i.e., passenger, services, etc), where non-freight occupation included situations of simultaneous occupation with freight vehicles. This analysis highlights:

- One of the main problems related to the use of loading/unloading parking zones in the city, namely their use by passenger vehicles or service vehicles not carrying out loading/unloading operations.
- The challenge of comparing statistics across case-studies due to the difference in some of the selected metrics (e.g. arrival patterns).
- The assumption of considering non-simultaneous arrivals of delivery vehicles is sound, since loading zone capacity is seldom saturated.

It is also interesting to look at the variations in the duration of delivery stops within loading/unloading parking zones. Alho and de Abreu e Silva (2014) report an average of 19 minutes for delivery stops, with a high standard deviation of ±32 minutes, whereas the observations n Seville result in an average of 40-minute stops with a ±42 minutes standard deviation (Figure 5). One should note that this is relevant as the local regulations in Seville establish a maximum stop duration of 30 minutes, implying that 44% of the observed stops are illegally long. Some of these stops correspond to the whole morning period, meaning that some drivers (particularly those doing own-account transport) are using the loading/unloading parking zones as permanent parking spaces for their vehicles (Muñuzuri et al, 2015). The same situation has been reported by the researchers performing the observations in Lisbon but to a much smaller extent (Alho and de Abreu e Silva, 2014).

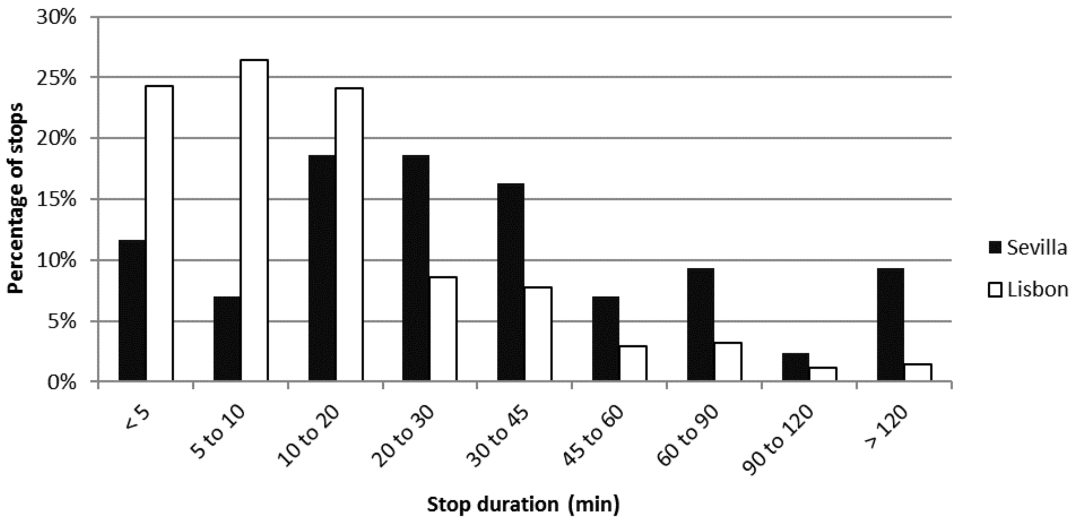

Figure 5: Distribution of stop durations in the four analyzed streets for Seville, and for a single street in Lisbon.
Source: authors' own.

Our parking observation also revealed many irregular practices in the use of loading/unloading parking zones. In the case of own-account transport, the driver often uses the loading/unloading parking zone to unload the vehicle but then, not having a route with other stops to make, leaves the vehicle parked at the same spot sometimes during the whole morning, illegally occupying a space needed by other drivers to complete their pickups/deliveries. This is the case of loading zones 2 and 3 in Feria street, located next to a large fresh food market where most shop owners carry their own goods (Muñuzuri et al, 2015). Own-account vehicles occupy these loading zones without moving during the entire business period, which explains their high degree of occupation. On the other hand, in the case of third-party deliveries, each retailer receives multiple small-size deliveries, each one of them carried out by a different transport company, resulting in higher vehicle density and loading/unloading parking zone scarcity, due to the lack of coordination between these companies.

4.4 Double parking assessment

Double parking events have been observed for three of the four analyzed streets (Feria, José Luis de Casso and Virgen de Luján; the single lane of León XIII is too narrow to double-park), resulting in 136 records over the course of 1 day. 30% of double parking events occurred while having a loading/unloading parking zone nearby (<50 meters).

Concerning differences in patterns of this phenomena, the Welch test revealed that different vehicle types (8 in total, including several sizes of trucks vans and cars) did not result in significantly different parking durations (0.91, p-value > 0.05). Similar results were revealed for the time of the day (AM/PM; p-value = 0.24). However, regarding parking duration in each street the results were borderline (p-value ~ 0.05). Further analysis led us to conclude that the mean duration is slightly higher in José Luis de

Casso. At this point we can only hypothesize that higher retailer density might be related to the same vehicle being used for deliveries at multiple establishments, which would increase parking duration.

The distribution of double parking durations is shown in Figure 6, demonstrating that over half of the double parking events are related to relatively “short” stops. Despite being “short”, their impact on traffic might not be negligible, though. The observation of traffic has showed that on average 120 vehicles cross Feria (std. dev. = 23), 366 vehicles in José Luis de Casso (std. dev. = 44) and 582 in Virgen de Luján (std. dev. = 58). Respectively, there are on average the following double parking vehicles per hour (excluding the lunch period): 4 vehicles in Feria (std. dev. = 3), 4 vehicles in José Luis de Casso (std. dev. = 1) and 7 in Virgen de Luján (std. dev. = 3). These double parking events are likely to have an effect on traffic, as shown by Han et al. (2005) for freight-related double parking and by Kladeftiras and Antoniou (2013) for general double parking.

Figure 7 demonstrates that arrivals are relatively constant thought the day, with a dip from 13:00 to 16:00. This is mostly aligned with the fact that shops are closed for lunch between 14:00 and 16:30/17:00.

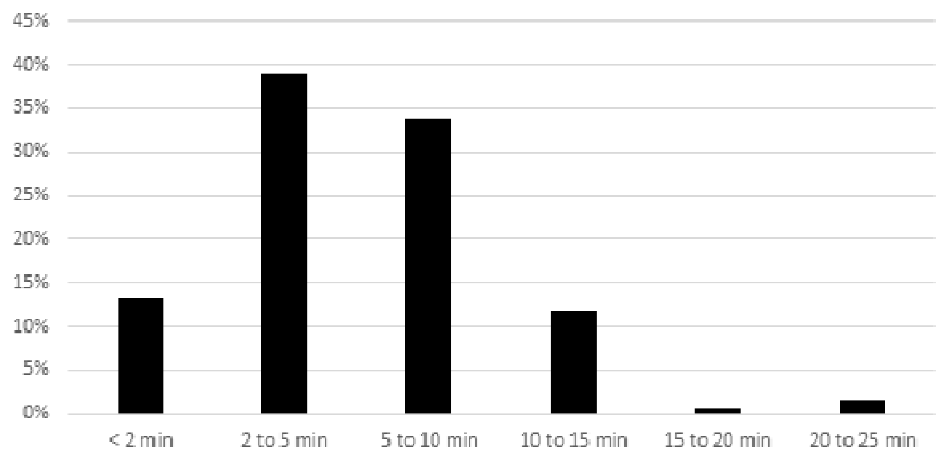

Figure 6: Distribution of double parking durations in three of the four selected streets (all except León XIII).

Source: authors’ own.

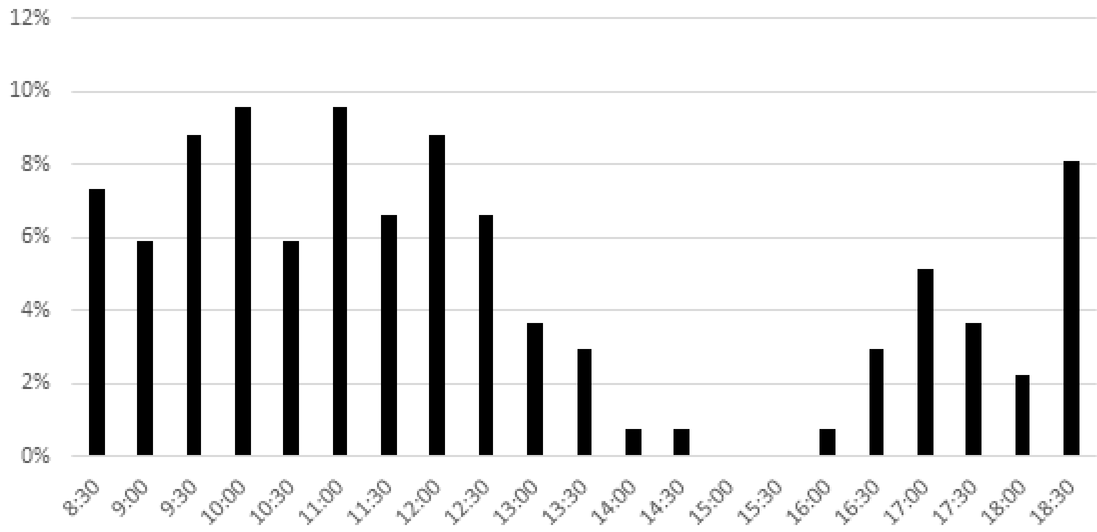

Figure 7: Distribution of double parking arrivals in three of the four selected streets (all except León XIII).
Source: authors' own.

Table 4: Aggregated delivery details of the four analyzed streets.

Type	*Sub-type*	*Sample*	*Weekly Deliveries*	*Average Duration (minutes)*
	Restaurants	3	6	20
Food service	Bars & cafés	17	6	10
	Takeaway	1	6	10
	Frozen food	1	6	10
	Bakery	7	6	10
	Herbs	2	1.2	5
	Deli	1	30	10
Specialized food store	Liquors	1	1.2	15
	Fruit & vegs	8	6	45
	Butchers	6	6	15
	Pork	3	6	5
	Fishmonger	7	6	30
Minimarket	Minimarket	3	24	15
	Books	2	3	15
	Stationery	2	1.2	10
Culture and Stationary	Tobacco	1	0.6	5
	Press	4	12	5
	Lottery	1	1.2	5
	Music	1	4.8	10
	Dry cleaner	1	1	10
	Hardware	2	1.2	10
	Frames	1	6	10
	Pets	1	1.2	5
Various	Florist	2	1.8	15
	Videogames	1	1.8	5
	Computer	2	1.8	10
	Telephones	2	6	5
	Veterinary	1	6	5
	Ink & toner	1	3	10
	Accessories	2	3	15
Personal usage items	Shoes	2	1.2	10
	Perfumes	1	6	30

	Sunshades	1	6	10
	Boutiques	2	1.8	10
	Baby	1	6	10
	Toys	1	6	10
	Clothes	5	1	10
Furniture	Furniture	1	0.6	10
Health and Hygiene	Drugs	1	6	15
	Pharmacy	4	18	5
	Dentist	1	6	15
	Health care	1	30	5
	Hairdressers	4	2	10
	Orthopedist	1	6	5
	Optometrist	3	24	5
Repairs	Bike repair	1	3	5
	Mechanic	2	6	5

Source: authors' own.

4.2 Weekly delivery frequency

Table 4 contains the delivery data collected by interviewing all the retailers in the four case study streets, including the number and business of retailers, the delivery frequency and the average delivery time. Business types were grouped in two levels, to allow a direct comparison with the results of the surveys performed in France and Portugal. Considerably differences can be noted in weekly deliveries and average duration of the loading/unloading activities for the different industry categories. Even for the hypothesized category equivalencies, when comparing delivery frequencies with the French and Portuguese data (Table 5) some values are similar and some show remarkable discrepancies.

While the direct comparison is difficult to make due to the different categories contemplated in each case, we believe that our attempt to match the business categories is a worthy effort. Data heterogeneity in different geographical locations is typical of urban freight, as shown by several comparative studies at European level (Ambrosini and Routhier, 2004). As a result, it is difficult to establish quantitative comparisons related to urban freight operations between different countries. Qualitative analyses supported on empirical data need to take these differences into account. The reader needs to be aware of this fact when we derive and compare level of service indicators.

Table 5: Delivery frequency data reported for two French cities (Bordeaux and Lyon), Lisbon and Seville.

French data (Gardrat and Serouge, 2016)		*Lisbon data (Alho and de Abreu e Silva, 2014)*		*Seville data*	
Type	Weekly Deliveries	Type	Weekly Deliveries	Type	Weekly Deliveries
Cafés, hotels, restaurants	6	Food and drinks	15	Food service	6
Bakeries	8	Specialized Foodstuffs	12	Specialized food store	6
Butchers, delicatessen	11				
General grocery store	10	Non-specialized Foodstuffs	13	Minimarket	24
Bookshops, stationery	14	Culture and leisure	6	Culture and Stationary	6
Other retail businesses	8	Various	9	Various	3

Clothing retail shop	3	Personal usage articles	3	Personal usage items	3
Furniture stores	8	Home appliances	8	Furniture	1
-	-	Health and hygiene	16	Health and hygiene	13
-	-	Repairs	8	Repairs	5
-	-	Non-specialized	5	-	-
Large stores (>400m2)	84	-	-	-	-
Wholesalers	22	-	-	-	-
Tertiary sector	2	-	-	-	-
Small-scale businesses	8	-	-	-	-

Source: authors' own except where specified.

5. Results and policy implications

Using the data collected for the four case study streets, we present the estimation of the level of service provided by load zones in each one of them, through the application of the methodology described in section 3. The results obtained provide an interesting insight on the provision of this type of infrastructure.

5.1 Level of Service analysis

This section presents our estimations of the level of service provided by the current loading/unloading parking zones in the four streets, according to the CERTU methodology. The available loading/unloading parking zone capacity (Ideal and Real) and the parking demand, for each street, calculated using the methodology described in section 3 and the data in Table 4, is shown in Table 6.

Table 6: Available capacity and demand for the four analyzed streets (the values are expressed in minutes per day).

Street	*Idealcapacity*	*Realcapacity*	*Parking Demand*
Feria	8640	2880	672
León XIII	6120	2040	513
José Luis de Casso	1800	600	230
Virgen de Luján	3240	1080	285
Total	19800	6600	1700

Source: authors' own.

Dividing the Real Capacity by the Demand, we obtain an average service level of 388%, meaning that the existing capacity is almost 4 times higher than the requirements. It cannot be ignored that the excess capacity would even be higher if we eliminated the excessive freight vehicle parking durations (Figure 5). However, this parking demand was only calculated for freight vehicles and if non-freight capacity is not eliminated, it is demand that must be accounted for. This highlights the methods' weaknesses in providing an adequate picture of the loading/unloading parking zone performance. This value is quite different when compared with the 21.4% service level reported by Dezi et al (2010) but we cannot foresee a justification for such discrepancy. One of the contributing factors might be the high occupation of freight parking zones by non-freight vehicles in Bologna and potentially some variation in the application of the methodology.

We have applied the CERTU method to our case study streets as a way to calculate the ideal number of loading/unloading parking zones. The CERTU method assumes that pickup/delivery staff are willing to walk any distance from the loading/unloading parking zones to the business establishments. Results are shown in Table 7, surprisingly showing that the required number of loading/unloading parking zones is overall 4 times lower than the existing one (8 times in the case of Feria street).

Table 7: Application of the CERTU method to the four streets.

Street	*Weekly deliveries*	*Loading/unloading parking zones needed (CERTU Method)*	*Existing loading/unloading parking zones*	*CERTU capacity (6 hours, adequate design)*	*Demand*
Feria	276	3	24	1104	672
León XIII	235	3	17	940	513
José Luis de Casso	101	1	5	404	230
Virgen de Luján	185	2	9	740	285

Source: authors' own.

The results show that overall capacity exceeds demand, which is consistent with the occupation data contained in Table 3. Nevertheless, a reduction in infrastructure might be too restrictive in cases like street José Luis de Casso, where a single loading zone would not allow for simultaneous occupation. If only one zone was located, it should be designed with capacity for more than one vehicle. The assumptions of the CERTU method also result in fewer zones, since it is assumed that pickup/delivery staff would always be willing to walk any distance to their destination. Infrastructure dimensioning might be under-estimated except for streets where the distance from its mid-point to ends is smaller than the maximum distance pickup/delivery staff is willing to walk. The results show clearly the need for re-assessing the techniques that help determine the number and location of loading/unloading parking zones, in line with the conclusions obtained in other European cities (Alho and de Abreu e Silva, 2014).

5.2 Policy implications

The provision of loading zones corresponds to local authorities, who are in charge of finding the balance between the needs of the different stakeholder groups (carriers, but also residents, workers and shoppers) competing for the often scarce space available in the central areas of many cities. Our analysis provides some insights for city planners, directly applicable to Seville but also transferable to other similar urban areas, as highlighted by the comparisons with the French, Italian and Portuguese scenarios. These insights are the following:

- According to the existing correlations and guidelines, the number of loading zones provided in commercially dense streets seems to be excessive. In Spain, loading zones are often provided at the request of receivers and carriers, which often results in an overestimation of the required capacity.
- The existing guidelines and methodologies apply the criterion of area coverage when selecting the location of loading zones, assuming that this infrastructure "covers" the area located within a given radius, which typically ranges between 25 and 100 m. However, this coverage is often not clear, as drivers prefer to double

park in front of their destination to make the delivery rather than using a loading zone 50 meters away (Muñuzuri et al, 2012).

- The need to overestimate the number of loading zones required often results from the insufficient rotation of vehicles in loading zones. The variability of delivery times is enormous, as shown in Figure 5, with vehicles making fast deliveries in less than 5 minutes having to share the same infrastructure with other vehicles that stop for more than one hour. The fact that all the variability inherent to urban freight deliveries (in terms of frequency, size and duration) needs to accommodate to the same regulations and facilities requires further investigations, with the introduction in the same street of different types of loading zones depending on the rotation requirements remaining a possibility.
- In any case, the inability of local authorities to control loading zone rotation remains a problem, as shown by the 20% of stops in Figure 5 lasting for more than one hour (half of them longer than two hours), when local regulations establish a maximum standing period of 30 minutes. In practice, the impact of this is larger than 20%, since a delivery vehicle occupying a loading zone for two hours is equivalent to 12 vehicles using that same space for 10 minutes each. Each one of these long-stop vehicles is taking one loading zone away from the system, and local authorities should pay special attention to avoiding this type of practice.
- The booking of loading zones (González-Feliu et al, 2013; Patier et al, 2014) constitutes the main technological approach to improve the management of this type of infrastructure, guaranteeing vehicle rotation and allowing the local authorities to establish different booking patterns for different loading zones, thus adapting the infrastructure to the specific needs of deliveries in the area.

6. Conclusions

We have presented an in-depth analysis of freight operations for four streets in the Spanish city of Seville from the point of view of loading/unloading parking zone usage patterns and performance. We hypothesize that the existing system results from a planning process carried out by local authorities without sufficient information, and without a clear understanding of the ideal characteristics of the system. Despite this, we acknowledge the difficulties in defining guidelines since a) scarce guidelines were found regarding methods to define the number, location and management of loading/unloading parking zones on a given street, and b) considerable differences were found in the way freight pickup/delivery operations occur across European cities (e.g., peak hours, delivery durations, weekly frequency).

The only set of official guidelines available in Europe is the French guide CERTU. We have applied this procedure to the four streets analysed in Seville, and found that the existing load zone infrastructure is over-dimensioned, a result also found in other European cities, which validates our results and constitutes one of the main contributions of this paper. Occupation ratios and vehicle arrival rates show that the demand for parking space could be accommodated with fewer load zones, as long as appropriate management and enforcement tools were put into practice to ensure an adequate rotation. In terms of the efficiency of the loading zone system, enforcement actions are likely to increase it, reducing the number of times that vehicles have to revisit the area due to the lack of parking spaces. However, it also represents a higher direct cost for the municipality, in the form of monitoring staff, which explains the typical inaction found on the streets.

The results obtained prove the soundness of the CERTU methodology.We put forward that at least city planners must attempt to align the freight-dedicated schedule of loading/unloading parking zones with the retailers opening hours or work together with the retailers to achieve changes in their requests for pickups/deliveries (e.g., Holguín-Veras and Aros-Vera, 2015). Loading/unloading parking zones dimensions and undue occupation by freight and non-freight vehicles should also not be ignored as it has a direct effect on the level of service these zones can provide, and on general traffic in the area (Alho and de Abreu e Silva, 2016). With loading/unloading parking zones being used in several cities around the world, the definition of a general application methodology appears to be a promising field of analysis for further research.

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