MANAGING KERB CONFLICTS:
RELATIONSHIPS BETWEEN KERBSIDE ACTIVITIES AND FRONTAGE LAND USES

Martin Chan
Peter Jones
Paulo Anciaes
UCL (University College London)

ABSTRACT

Provision for kerbside activities is crucial for the functioning of economic and social activities, but space allocation for these activities is usually an afterthought, when compared to managing moving traffic. There is a lack of guidelines to assess demand for kerbside activities and allocating kerbside space. Strategies to manage the kerbside have had different degree of success.

This paper examines the relationships between the intensity of kerbside activities and the distribution of land use. Data on kerbside use in two high streets in London was analysed through regression and spatial analysis to determine how kerbside activities and the illegal use of spaces were related to the characteristics of premises and streets.

We found that the number and duration of parking and loading activities were associated with the presence of some types of businesses, such as supermarkets and takeaway shops. Floor area was related to the number of parking activities, duration of loading activities and, when interacted with specific types of businesses, with duration of parking activities. Illegal activities were frequent in both case studies and concentrated at loading bays and locations at the start and end of loading and parking bays.

The study provided fresh evidence that kerbside activities are related to frontage land uses and that illegal activities are prevalent when kerbside space is scarce or is inefficiently managed. The estimated models can be used predict the effects of changes in land uses on the number and duration of parking and loading activities.

ACKNOWLEDGEMENTS

The authors would like to thank Tom Becker (Transport for London (TfL)) and Chris Greenwood (Atkins Ltd) for kind provision of street survey data for the project.

1. INTRODUCTION

1.1. Background

Streets act both as places for social, economic and cultural exchanges and as a thoroughfare for the movement of people and goods. While city authorities strive for better street vibrancy and the smooth movement of traffic, the performance of each street is also influenced by the activities at the kerbside, i.e. the carriageway space adjacent to the footpath. Kerbside spaces are crucial for people's safe and efficient transition between being pedestrians and passengers/drivers, and for delivery of goods and services for the shops, residences, and offices along streets. Key kerbside activities include parking, loading/servicing, pick-up/drop-off, and waiting (Table 1).

Table 1: Key kerbside activities

Kerbside Activities	Function
Parking	Storage of vehicles (driver leaves the vehicle)
Loading/servicing	Delivery and collection of goods; provision of services
Pick-up/Drop-off	Access for people
Waiting	Short-term storage of vehicles (driver stays in the vehicle)
Other	Roadworks, maintenance, etc.

Source: International Transport Forum (2018), Meghan Mitman *et al.* (2018), Jones *et al.* (2009)

Highway authorities designate different stopping and/or loading restrictions for kerbside spaces to facilitate a smooth traffic flow, ensure safety, and other reasons (Butcher 2014). However, the overall allocation of these restrictions (referred henceforth as "kerbside allocation"), is not a quantitative science. Transport for London's "Streetscape Guidance" and "Kerbside Loading Guidance" manuals provide some examples of how kerbside provision relates to the adjoining land uses and character of the streets (TfL 2019). However, kerbside allocation is still largely a matter of judgement, as there is no statistical evidence on how the kerbside is currently being used, let alone a solid basis to guide efficient kerbside allocation. Yet, pressures on the limited kerbspace are growing. For example, in London, the absolute number of Penalty Charge Notices is growing, despite the decline in registered vehicles numbers

This paper helps to fill the knowledge gap concerning the use of kerbspace by:

1. Estimating relationships between kerbside activities and the characteristics of the adjacent land uses
2. Identifying conflicts in the usage, allocation, and management of kerbspace;
3. Discussing potential kerbside management solutions

2. DATA AND METHODS

The analyses reported here use data from a kerbside video survey in two streets in London (Acton High Street and Camden High Street) on 20-26 October 2014 and 3-9 November 2014, by Atkins Ltd for TfL. The two 7-day datasets covered 4.6 km of kerbspace and 412 premises on 36 street blocks across the two sites. 45,270 and 35,793 kerbside activities were recorded on Acton High Street and Camden High Street, respectively.

We used regression analysis to explore how the intensity of different kerbside activities relates to types of frontage, sizes of premises, and days of the week. Explanatory variables that were not significant at the 10% level were excluded from the final models.

The individual frontage destinations of parking and loading activities were identified, but not for pick-up/drop-off and waiting activities, for which only the stopping kerb zone could be identified. Hence, regressions for the four types of kerbside activities were performed at two levels of aggregation:

1. Premise-level models for parking and loading/servicing activities
2. Street block level models for pick-up/drop-off and waiting activities

We then mapped hot spots for illegal activities and analysed how those activities are spatially related with kerbside space allocations and adjacent premises. More detailed analysis were carried out for selected loading, bays to investigate their usage and determine causes of non-compliance and the impact on adjoining kerbside spaces. One loading-bay in Acton and two loading-bays in Camden were selected due to the frequently observed illegal activities.

3. MODEL RESULTS

3.1 Overview

On both high streets, the majority of the recorded stopping activities were pick-up/drop-offs by scheduled bus services (Table 2). Parking was the next most common activity, with around 20% of all kerbside activities at both sites, almost the same as servicing, pick-up/drop-off and waiting combined. It was noted that waiting vehicles accounted for about 10% of kerbside activities in Camden, but only 6% in Acton (which might be associated with the greater number of idling private hire vehicles in Camden).

Table 2: Breakdown of kerbside activities over the survey period

Trip Type	Camden		Acton	
	Number	**%**	**Number**	**%**
Bus pick-up/drop off	26,563	58.7%	20,511	57.3%
Parking	9,068	20.0%	8,216	23.0%
Servicing (including loading)	2,849	6.3%	2,122	5.9%
Pick-up/drop off (except buses)	2,423	5.4%	2,750	7.7%
Waiting	4,367	9.6%	2,194	6.1%
Total	**45,270**	**100.0%**	**35,793**	**100.0%**

There were more kerbside activities in general on Friday and Saturday, more so in Camden. The number of parking activities remained relatively steady over the week. However, there were substantial increases in drop-off/pick-up trips (>+100% in Camden and >+40% in Acton) on weekends. Both sites have the most and least loading/servicing activities on Friday (18%) and Sunday (<10%) respectively.

The overall fleet compositions of stopping vehicles were similar in Camden and Acton. Waiting and parking activities were dominated by cars (about 80%) and Light Goods Vehicles (about 17%); 40% of servicing vehicles were Light Goods Vehicles. The only major difference between the two sites was the composition of pick-up/drop-off activities – 29% of these activities are carried out by taxis in Camden compared to only 6% in Acton.

3.2 Parking activities

In the regression model of the number of parking activities (Table 3), floor area, and floor area squared were both significant predictors. The number of activities increases with floor area but the increase is progressively smaller. This could reflect a lack of proportionate increase of customers /visitors with size of premises. At larger premises, some of the space could be dedicated to amenities, storage or back offices, which would not directly translate to the more business. Supermarkets, fast food restaurants, bars, and take-away shops all shown significantly more parking activities compared to other types of premises. While day of the week was insignificant across all types of shops, restaurants and cafes have shown an increase in activity on Saturday and Sunday.

Over 50% of parking activities were completed within 15 minutes (Table 4). Visitors to Bars, offices, and residences generally parked longer. Visitors to financial/professional services parked for shorter durations.

Table 3: Model of number of parking activities

	Coefficient	Std. Error	t	sig.(p)
(Constant)	2.982	0.463	6.438	0.000
Floor area	0.008	0.005	1.741	0.082
Floor area ^{2}	-9.538E-06	0.000	-1.652	0.099
Type of premise				
Supermarkets	17.399	1.614	10.782	0.000
Fast Food Restaurants	33.520	1.783	18.797	0.000
Bars	1.794	1.017	1.764	0.078
Take-away shops	9.510	0.919	10.343	0.000
Restaurants/cafés (Saturday/Sunday)	4.068	1.387	2.933	0.003
R^2		0.255		
N		2016		

Table 4: Distribution of Parking Duration

Duration	Retail	Financial/ professional services	Restaurants	Bars	Take-away shops	Offices	Residential
0-15 min	60%	69%	64%	44%	59%	53%	54%
15-30 min	21%	16%	20%	19%	22%	16%	19%
30-45 min	7%	6%	6%	9%	9%	10%	8%
45-60 min	4%	3%	3%	7%	4%	6%	4%
>60 min	8%	6%	7%	21%	6%	16%	15%

Regression analysis found no significant relationship between size of premises and the parking duration, except in the case of larger supermarkets and restaurants.

3.3 Loading/servicing activities

Loading/servicing activities showed a less consistent picture across the two sites. Both have low percentages on Sunday. Over 75% of loading activities were carried out by Light Goods Vehicle and Ordinary Goods Vehicles Class 1, except for Take-away shops, where most of the loading activities were food deliveries by motorcycles. Floor area did not have a significant impact on the number of loading/servicing activities. The model (Table 5) provides an average estimate of 2-3 daily loading acts per premises, except for take-away shops and supermarkets, where the numbers are much higher. There was a significant relationship with percentage of legal kerbspace available for loading.

Table 5: Model of number of loading activities

	Coefficient	Std. Error	t	sig.(p)
Constant	0.255	0.368	0.694	0.488
Loading Space on Street Block (% of length)	2.083	0.726	2.869	0.004
Type of premise				
Supermarkets	7.249	0.499	14.539	0.000
Take-away shops	3.784	0.878	4.309	0.000
R^2		0.104		
N		2016		

Loading durations vary both across vehicle class and land use (Table 6). Ordinary Goods Vehicles Class 2 in general require more time for loading. Loading activities for retail and take-away shops generally took longer. The loading duration was not proportional to size of vehicle. For example, the average dwell times for motorcycles were almost the same as for cars and were longer than for Ordinary Goods Vehicles Class 1.

Table 6: Average loading duration by type of vehicle

Average Loading duration (minutes)	Retail	Financial/ professional services	Restaurants	Bars	Take-away shops	Office	Residential
Overall	17.86	14.29	14.73	18.28	16.15	10.74	14.56
Car	15.3	11.78	15.7		18.7		4.4
Light Goods Vehicles	16.8	15.5	18.2	18.6	15.2	10.5	14.5
Motorcycle	16.6		15.3		17.2		14.6
Ordinary Goods Vehicles 1	11.8	5.3	12.8	14.2	6.2		13.5
Ordinary Goods Vehicles 2	40.0		34.6	14.3			

The regression models found a significant relationship between loading duration and size of premises (Table 7). The relationship is stronger with the squared effect, which can be associated with a higher payload and with the longer time required to move within the shop as the size of premises increases.

Table 7: Model of average duration of loading activities

	Coefficient	Std. Error	t	sig.(p)
Constant	14.604	1.184	12.337	0.000
Gross Floor Area	-0.035	0.011	-3.333	0.001
Gross Floor Area^2	9.296E-05	0.000	7.470	0.000
Supermarket	4.465	2.320	1.924	0.055
Bars	-5.008	2.321	-2.158	0.031
Take-away shops	3.418	1.247	2.740	0.006
Monday	4.878	1.671	2.919	0.004
R^2	0.135			
N	1038			

The model of average size of loading vehicle (Table 8) showed a relationship between floor area and size of loading vehicles. This partly explains why the number of loading activities does not increase significantly with size of store due to consolidation of deliveries, which is more evident for supermarkets. The negative coefficients for restaurants and take-away shops implied that smaller vehicles, such as motorcycles, were used for loading for catering shops.

Table 8: Model of average size of loading vehicles

	Coefficient	Std. Error	t	sig.(p)
Constant	6.554	0.101	64.716	0.000
Gross Floor Area	0.001	0.001	2.335	0.020
Type of premise				
Bars	0.823	0.261	3.150	0.002
Take-away shops	-4.398	0.137	-32.051	0.000
Sunday	0.147	0.203	0.724	0.469
Restaurants	-1.208	0.359	-3.363	0.001
Gross Floor Area (supermarket)	0.007	0.001	6.563	0.000
Gross Floor Area (chain retail)	0.004	0.001	4.044	0.000
R^2	0.585			
N	1036			

3.4 Pick-up/drop-off

The majority of the pick-up/drop-off activities were completed within 5 minutes (83%). Although there were adequate spaces for pick-up/drop-off (such as on red route and double yellow lines), over 10% of these activities still occurred at illegal locations such as

bus stops and zig-zags/crossings. It is also surprising to see the average time of the activity to be much longer on zig-zags/crossings (Table 9).

Table 9: Location and duration of pick-up/drop-off activities

	% of pick-up/drop-off activities	average duration (minutes:seconds)
Zig-zags/crossing	9.6%	05:08
Double red lines	11.6%	02:43
Double yellow lines	1.4%	02:11
Restricted zone	3.0%	02:37
Bus stops	1.7%	01:31
Other	73%	03:40

The street-block regression model is reproduced in Table 10.

Table 10: Model of2 pick-up/drop-off activities per meter of street block

	Coefficient	Std. Error	t	sig.(p)
Constant	0.081	0.015	5.311	0.000
Gross Floor Area per metre of street	0.002	0.001	2.351	0.020
Type of premises				
Financial/professional services (%)	0.003	0.000	6.744	0.000
Bars (%)	-0.001	0.000	-2.766	0.006
Office (%)	0.002	0.000	3.399	0.001
Fast food restaurants (%)	0.006	0.001	5.969	0.000
Cafes (%)	-0.001	0.001	-2.041	0.042
Convenience stalls (%)	0.006	0.002	3.446	0.001
Personal services (%)	0.006	0.002	3.591	0.000
Individual retail (%)	-0.001	0.000	-3.102	0.002
Chain retail (%)	-0.002	0.000	-6.644	0.000
Estate agents (%)	-0.008	0.002	-4.937	0.000
Friday	0.074	0.014	5.134	0.000
Saturday	0.097	0.014	6.731	0.000
Sunday	0.071	0.018	4.053	0.000
R^2		0.531		
N		252		

This showed that floor area per meter of street had a significant positive relationship with the number of pick-up/drop-off activities. However, some land use percentages have negative coefficients, notably bars, cafes, individual retail, chain retail, and estate agents.

This implied a reduction in overall pick-up/drop-off rate per meter of street if there was a high proportion of these premises located within the street block. Proximity to train stations and bus stops on pick-up/drop-off activities were not significant. The model also revealed that Friday, Saturday and Sunday had more pick-up/drop-off activities.

3.5 Waiting Activities

Out of the 57% of waiting activities which were illegal (Table 11), over 13% were carried out on zig-zags/crossings and on double yellow lines. Albeit occupying less than 5% of the kerb allocation, dedicated bays such as car club bays, taxi stands were frequent spots for illegal waiting (8.1%).

Table 11: Location and duration of waiting activities

	% of waiting activities	average duration (minutes:seconds)
All legal	**42.7%**	**06:58**
Zig-zags/crossing	13.0%	05:27
Red route	9.8%	05:26
Double yellow lines	13.5%	02:39
Restricted zone	3.8%	04:51
Bus stops	8.8%	01:46
Other (car club bays, taxi stand, etc.)	8.1%	04:26
All Illegal	**57%**	**03:56**

The regression model found that the number of waiting activities increased significantly with parking supply (Table 12). They were higher in general on Saturday. The proximity to train station and bus stop did not have significant impact on the number of waiting activities. However, the site variable was significant, which implies there might be area characteristics that can help to explain the higher number of waiting activities at Camden.

Table 12: Model of 3number of waiting activities

	Coefficient	Std. Error	t	sig.(p)
Constant	0.054	0.018	2.952	0.003
Legal Parking Time (hrs) per m	0.007	0.001	7.115	0.000
Saturday	0.064	0.030	2.175	0.031
Camden	0.006	0.001	5.969	0.000
R^2		0.270		
N		252		

Five variables were tested to be significant in the model of waiting duration (Table 13). Waiting duration increased with the availability of legal parking time per metre of street. The duration was longer on Thursday, but not on Saturday, which had more activities. The waiting duration decreases with the density of development (Gross Floor Area per metre of street), but increases with the duration of loading activities on the same street.

Table 13: Model of waiting duration

	Coefficient	Std. Error	t	sig.(p)
Constant	3.458	0.583	5.934	0.000
Gross Floor Area per meter of street	-0.092	0.035	-2.651	0.009
Legal Parking Time (hrs) per m	0.059	0.018	3.272	0.001
Loading Duration per m on street block	6.070	2.950	2.058	0.041
Thursday	0.981	0.513	1.913	0.057
Camden	1.492	0.433	3.449	0.001
R^2		0.205		
N		252		

4. ILLEGAL KERBSIDE ACTIVITIES

Non-compliance was common at both sites (Table 14). The rate of non-compliance of pick-up/drop-off activities was much lower than other activities. This is because pick-up/drop-off activities were allowed on most of the kerbside allocations except for bus stops and zig-zags/crossings.

Table14: Percentage of illegal activities on Acton and Camden High Streets

	Acton	Camden
% parking illegal	57%	58%
% loading illegal	47%	66%
Illegal pick-up/drop off %	13%	29%
Illegal waiting %	60%	56%

In Acton, 910 of 4,667 observed illegal parking activities (19%) stayed beyond the permitted parking time (1 hour) in parking bays; 30% were parked illegally in loading bays. More illegal parking activities were observed near restaurants and supermarkets, regardless of the stopping restrictions. Drivers also tended to park illegally at locations with part-time restrictions (such as loading bays and single yellow lines) when there were no legal parking space available, or at locations immediately before or after legal loading

and parking spaces. Illegal waiting activities showed a similar trend. Illegal loading clustered around the edges of loading bays. Although no particular pick-up/drop-off hotspots were observed, there were many illegal pick-up/drop-off at all the bus stops despite the availability of adjacent legal spaces.

In Camden, 236 of 5,271 observed illegal parking activities (4.5%) stayed beyond the permitted parking time (30mins) on Red Routes; 2,306 (48%) and 1,163 (22%) vehicles respectively, parked in loading bays and red routes during operating hours. Similar to Acton, illegal parking clustered around key premises with high parking demand and in locations where part-time restrictions were applied.

The illegal loading activities were spread evenly along the street and had no obvious association. Unlike Acton, pick-up/drop-off activities were not common at bus stops, but generally happened at or adjacent to the end of street blocks and crossings. Waiting activities frequently happened in loading bays and parking bays.

5 KERBSIDE OCCUPANCY

5.1 General patterns of occupancy

To compare the legal capacity and the actual occupation of the kerbside, the number of vehicles stopped by the kerb was first converted into kerb length occupied. The occupied length is the sum of the length of the vehicle and the normal spacing between parked vehicles (Table 15).

Table 15: Occupied length of vehicles

Type of vehicle	Average vehicle length	Spacing between parked vehicles	Occupied length
Motorcycle	1.5	1.0	2.5
Car	4.5	1.0	5.5
Taxi	4.5	1.0	5.5
Light Goods Vehicles	5.2	1.0	6.2
Ordinary Goods Vehicles1	9.5	1.0	10.5
Ordinary Goods Vehicles2	16.5	1.0	16.5

Figure 1 shows the supply and demand for kerbside space on Friday in the Acton case study. The kerbside was busiest between 20:00 and 21:00, when 383 metres of kerbside were occupied, with parking making up 80% of the kerbside activities. The kerbside space

occupied by parked vehicles increased during the day and exceeded the legal parking supply between 09:00 and 19:00. 60% of illegal parking activities occurred at dedicated loading bays. However, on average there was a substantial buffer in available loading space during the busiest hours (over 100m of dedicated loading space). The total kerb occupied by pick-up/drop-off and waiting vehicles remained low at around 30m, due to their much shorter dwell time at the kerbside.

Figure 1: Kerbside activities on Friday (Acton)

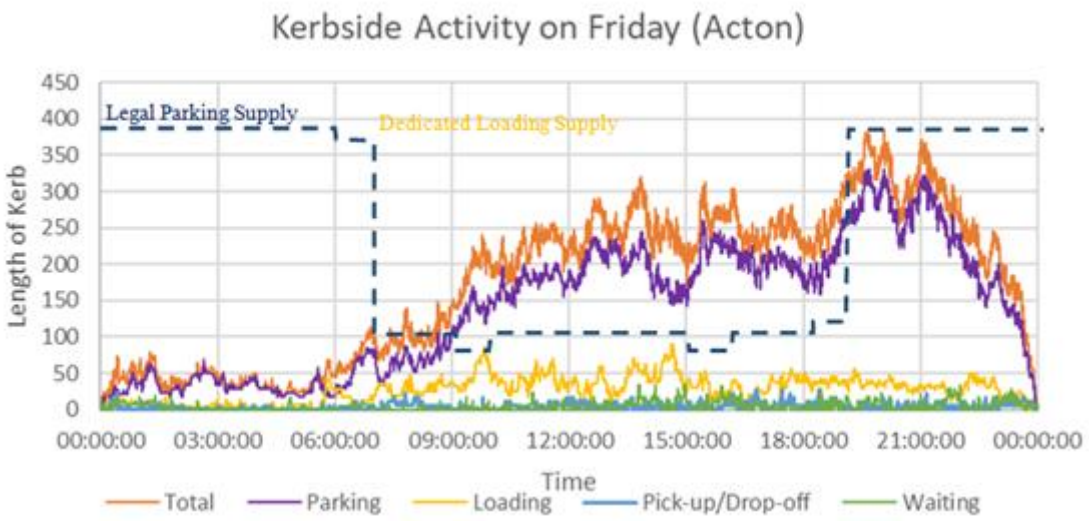
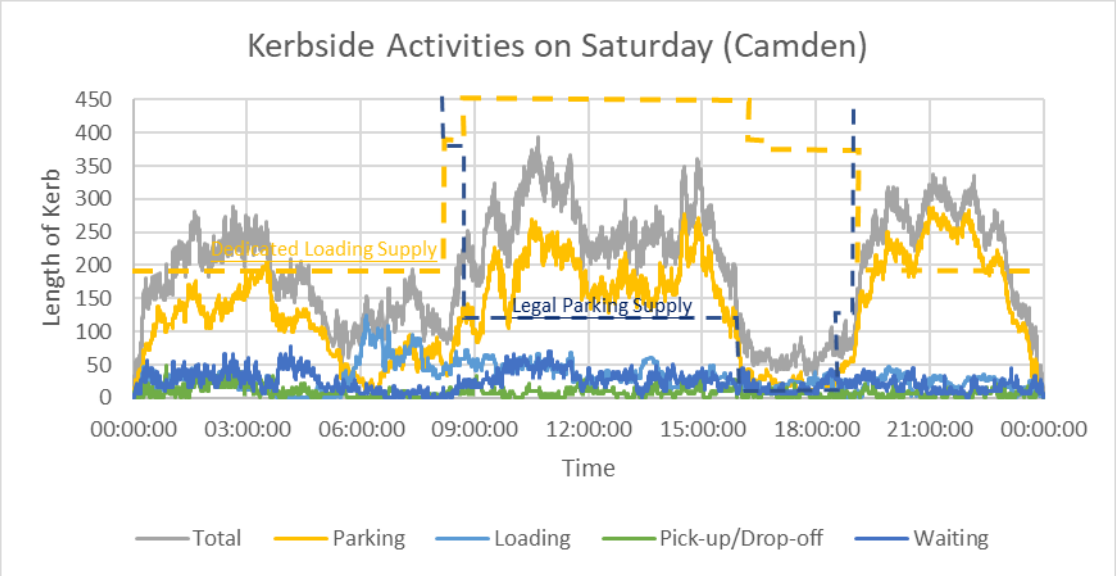


Figure 2 shows the supply and demand for kerbside space on Saturday in the Camden case study.

Figure 2: Kerbside activities on Saturday (Camden)



Peak usage of the kerbside occurred at 11:00, with 380m of kerbside being occupied. The loading peak was at 07:00, when there were fewest parking activities. Illegal parking was again commonplace during daytime, exceeding the provision by about 50-100m (about 20 cars). The drastic reduction in parking provision between 16:00 and 19L00 had a significant effect on reducing parking activities, which can be attributed to heightened enforcement along red route during those hours. This was not observed in Acton, where no red routes were designated.

5.2 Micro influences

When we look in detail at occupancy patterns along the high streets, we find a number of detailed factors that affect the outcomes.

For example, on one stretch of Acton High Street, a loading act was observed at four times on a weekday during the working day. A short loading bay was provided to accommodate this demand, but on three occasions the loading bay was occupied (in part or all) by illegally parked cars, so that the loading activity was displaced to adjacent double yellow lines. A similar problem was identified on Camden High Street, adjacent to a McDonalds take-way (Figure 3). Outside the premises was a 44m loading bay; during the restricted hours (07.00 – 19.00) there were 700 parking violations over the surveyed week, with 109 of them on Saturday. 60% of the occupants of the illegally parked vehicles visited McDonald's.

Figure 3: Illegal parking at the loading bay outside McDonald's in Camden

It was also observed that the intensities of parking and loading activities can show considerable variation within one land use category. For example, two fast food shops of similar size were located on the same street block on Camden High Street, but with very kerbside parking and loading activity rates (Table 16*)*. It is not evident how much these differences were due to different shop attraction factors, or to the stopping regulations in the immediate vicinity of the premises.

Table 16: Comparison of characteristics of different fast food shops

	Fast Food Shop I	**Fast Food Shop II**
GFA (m^2)	45	35
Max Daily Parking Trips	230	26
Max Daily Loading Trips	7	4
Kerb Side Restrictions	Loading Bay and Crossing	Double Red Line and Crossing
15-min visitors count	73	34
Opening Hours	0500 – 0200	0900 - 2300

6. CONCLUSIONS AND RECOMMENDATIONS

This paper has shown that patterns of kerbside activities vary across different types and sizes of premises. In addition, illegal parking activities erode the availability of loading facilities. The analysis has also shown a mismatch in distribution of bays among the different types of stopping activities at peak hours. Yet there is enough overall capacity to cater for all observed parking, loading and waiting acts, even at their combined peaks.

One possible response would be to reallocate the kerbspace in proportion to the number of activities at peak times, in conjunction with heightened enforcement to ensure compliance. In particular, this would benefit loading: although loading activities are not frequent compared to parking or waiting acts, they are essential to the operation of the high street. In view of the frequency of illegal waiting and parking in dedicated loading bays, authorities could consider if a higher penalty might be introduced for misusing/ blocking a loading bay.

Specific kerbside spaces could also be reallocated to fit the observed stopping patterns. Much of kerbspace at Camden and Acton High Streets is currently under-utilised, at different times of day and days of the week. With the increasing practice of pre-booking parking and loading spaces, it becomes possible to allocate kerbspace dynamically according to demand at that time. This could be signed either through a sign saying

'reserved space only' and displaying parking and loading symbols, or by dynamic signing and lining, using LED displays. The latter possibility is being explored with five cities in the EU MORE project (Multi-modal Optimisation of Road-space in Europe), both in relation to the allocation of carriageway space and footway space (Jones, 2019).

REFERENCES

Butcher, L. (2014) Roads: Traffic Regulation Orders. House of Commons Research Briefing SN06013., https://commonslibrary.parliament.uk/research-briefings/sn06013/

Jones, P. (2019). Optimising and future-proofing the design of major urban routes for all street users. Paper to the Transport Practitioners' Meeting Conference, Oxford.

TfL (Transport for London) (2019a) Streetscape Guidance., http://content.tfl.gov.uk/streetscape-guidance-.pdf

TfL (Transport for London) (2019b) Kerbside Guidance., http://content.tfl.gov.uk/kerbside-loading-guidance.pdf