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On-street illegal parking costs in urban areas

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Abstract

Private transport represents more than a third of all the journeys carried out in large cities urban areas. The high amount of traffic in metropolitan zones implies the appearance of congestion that is one of the most important complications transport engineers must fight against. Bottle necks are one of the most common reasons of congestion effect and on-street illegal parking (double parked or driving lane parked) implies the creation of a (or successive) bottle neck. This paper is focused on to evaluate the costs that appear when on-street illegal parking is detected.

To achieve the paper's goal, first of all, the different costs of the journey have been defined and formulated; next, the effect of illegal parking has been considered and the cost related to that has been formulated for each of the different types of cost. In order to use the formulation obtained two real scenarios have been evaluated. The results obtained in real scenarios have demonstrated that the economic cost due to car parking indiscipline to the whole city is significant; also it is worth to remark that unit cost (cost provoked for a single vehicle) differs depending on the location of the violation and the affected vehicle.

On-street illegal parking cost is significantly outstanding. According to data, on street illegal parking reduction has to be one basic pillar of mobility policies. This reduction would allow a higher road capacity and, consequently, greater traffic fluidity

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1. Introduction

The total amount of daily trips carried out in a town is outstanding due to urban areas are the most important poles of economic activity in a region and, therefore, where most of the trips end.

The trips made by private vehicles carried out through the city represent around 30% and a 50% of all trips are done in the metropolitan area; however, important variations are registered depending on the city (for example, referred only to the tips made through the city, private vehicles represents almost 60% in Brussels but nearly 15% in Barcelona).

Regarding to this, all journeys, including private vehicles public transport and soft mode, are made, obviously, to achieve a concrete destination, most of the times predefined before the beginning of the trip.

In private vehicle journeys, it is worthy to remark that almost all trips carried out begin without a parking lot secured (only people who made a reservation or own/rent a car park lot have it). This problem only appears with private transport because public transport as well as soft modes requires no parking lot to finalize the journey.

The lack of secured space to park in destination in most of the cases implies that the driver must search for an on street lot or off street lot when arrives to the end of the trip, commonly known as cruising for parking.

In the case of two-wheel vehicles, this lack of secured space does not represent, actually, an important problem to local administration because this kind of vehicle is allowed to park on the sidewalk - completely free (except some cases as Westminster – United Kingdom – where a fixed rate is required to park on sidewalk - permitting an offer considerably greater than demand.

Despite the problem related to two-wheel vehicles is not significative, problems appear when 4-wheel vehicles are considered due to they need a greater amount of space to park. This requirement implies that, often, the offer does not suit the demand due to multiple reasons such as lack of physical space, economic cost of a parking lot, location of the lot, need of cruising for parking, etc. implying the appearance of on-street illegal parking whether it is on the sidewalk or on the side of the road.

2. Objective

The main objective of the study is to calculate the cost that implies to all the actors and consequently to the whole city the appearance of on-street illegal parking. To obtain the total amount of the economic impact, most common illegal on-street urban parking typologies are evaluated and, next, the economic cost of them is calculated.

Table 1. Illegal parking typologies considered in the paper.

Typology	Description
Double parking	Vehicle parked on the road parallel to a legal curb car park
Road	Vehicle parked on the road with no curb parking area next to it
Bus Lane	Vehicle parked on a reserved lane for public transport
Loading/Unloading	Non authorized vehicle parked in loading and unloading area
Pedestrian crossing	Vehicle parked in a pedestrian crossing

The illegal parking typologies described in table 1 have been considered because they are the most common and expensive to society.

3. Calculation methodology

3.1. Journey Cost

The direct cost of a journey in private vehicle is related to a set of variables such as:

$$C_{jour} = f\left(l_{ij}, v_{ij}, IMD_{ij}, P_i\right) \quad (1)$$

Where l_{ij} is the length between origin and destination, v_{ij} is the average travel speed, IMD_{ij} the daily average vehicle intensity and P_i the price associated to each of the consumables (petrol, lubricant, tyres, etc.).

Cost formula related to each element is, according with Spanish Public Works Ministry (MOPU 1990, MOPT 1992), as follows:

Petrol consumption:

$$C_{pet} = 0.0865 * P_{pet} * IMD_{ij} * \left(0.804 + \frac{12.66}{v_{ij}}\right) * l_{ij} \quad (2)$$

Where P_{pet} is the price of petrol

Lubricant consumption:

$$C_{\text{lub}} = 0.001211 * P_{\text{lub}} * IMD_{ij} * \left(0.804 + \frac{12.66}{v_{ij}}\right) * l_{ij} \quad (3)$$

Where P_{lub} is the price of lubricant

Tyre wear:

$$C_{neum} = \frac{P_{tyre}}{V_u} * IMD_{ij} * \left(0.804 + \frac{12.66}{v_{ij}}\right) * l_{ij} \quad (4)$$

Where P_{tyre} and V_u are the price of the tyres and their useful life, respectively.

In addition to direct cost associated to a journey, external costs derived from it must also be considered.

External costs are those costs even not noticed directly by the customer. Those costs have an impact to the whole society. External costs include a wide variety of impacts, from accident cost to landscape effect or noise.

Table 2. Marginal cost referred to externalities; External costs of transport in Europe, INFRAS/IWW, 2004

Marginal Cost [$/1000 pkm tkm]		Car	MC	Bus	LDV	HDV
Accidents	Marginal	10-90	36-629	1-7	10-110	0.7-11.8
	Average	30.9	188.6	2.4	35.0	4.8
Noise	Marginal	0.07-13	0.25-33	0.05-4.6	2.4-307	0.25-32
	Average	5.2	16.0	1.3	32.4	4.9
Air pollution	Marginal	5.7-44.9	3.2	12-18	15-100	33.5
	Average	10.1	3.3	16.9	77.6	34.0
Climate Change	Marginal	1.7-27	1.7-11.7	0.7-9.5	8.2-57.4	1.8-12.8
	Average	17.6	11.7	8.3	57.4	12.8
Nature & Landscape	Marginal	0-2.1	1.9	0-1.3	10.9	0.8
	Average	2.87	2.07	0.69	10.9	2.03
Urban Effects	Marginal	1.1-9.6	0.7-7.1	0.1-2.2	3.0-32.3	0.9-7.1
	Average	1.6	1.1	0.4	5.2	1.1
Upstream Process	Marginal	2.0-4.1	1.3-2.7	2.6-6.0	13.0-23.4	3.6-7.4
	Average	5.2	3.0	4.0	22.4	7.4

The cost of each of these typologies is calculated for unit of length as it can be seen in the table 2.

Finally, once direct and external costs are described, temporary cost is introduced. This type of journey cost can be expressed as follows:

$$C_t = P_t \sum \frac{l_{ij}}{v_{ij}} \quad (5)$$

Where P_t is the time marginal cost, l_{ij} is the existing length between origin and destination and v_{ij} is the average speed between both places, as it has been defined previously.

It is worthy to remark that time marginal cost has been evaluated in previous studies and it will be used to adjust the marginal cost related to the present document.

According to usual methodology, time marginal cost is valued depending on different journey purposes and associating each purpose to a correction factor of the average salary wage.

$$\overline{\alpha} = \sum_{m=1}^{n} P_m f_m R \quad (6)$$

Where P_m is the users' percentage of users travel for purpose m, f_m is the correction factor referred to m and R is the average salary wage.

Next, marginal cost of time depending on journey purpose is described:

Table 3. Marginal time cost depending on journey purpose

Journey purpose	Percentage related to average wage		
	Minimum	Maximum	Average
Formalities	64%	100%	82%
Work	27%	69%	48%
Shopping	15%	59%	37%
Leisure	35%	47%	41%

Most of journeys are carried out due to work purposes (either on a way to or from work or during the working hours).

Table 4. Journey distribution depending on work purposes

Journey purpose	Trip distribution
Formalities	21.5%
Work	40.5%
Shopping	9.3%
Leisure	28.7%

3.2. Cost increase of journey related to on-street parking violation

Once trip economic impacts are described, the cost increase of a trip due to on street parking violation is studied. To achieve it, the costs mentioned in table 5 are considered but only the most remarkable are evaluated in the present paper.

These costs imply increases of the total trip expenditure due to the trips are affected by the mentioned parking indiscipline.

Table 5. Violation parking main costs

Violation parking main costs		
Type		Evaluated
Temporal		√
Direct	Petrol	√
	Lubricant	√
	Tyres	√
	Maintenance	X
Externalities	Accidents	X
	Noise	X
	Pollution	√
	Climate Change	X
	Landscape effect	X
	Upstream process	X

Related to direct costs, effects that appear when illegal parking is detected vary in function of each component. Formulas to obtain these costs are described next.

Petrol consumption:

$$\Delta C_{pet} = 0.0865 * P_{pet} * (IMD_{ind} * l_{iind} * \left(0.804 + \frac{12.66}{v_{ind}} \right) - l_{ij} * IMD_{ij} * \left(0.804 + \frac{12.66}{v_{ij}} \right)) \quad (7)$$

Where IMD_{ind}, v_{ind} and l_{ind} are the daily average vehicle intensity, average speed and the length of the stretch where illegal parking affects to traffic, respectively.

Lubricant consumption:

$$\Delta C_{\text{lub}} = 0.001211 * P_{\text{lub}} * (IMD_{ind} * \left(0.804 + \frac{12.66}{v_{ind}} \right) * l_{ind} - IMD_{ij} * \left(0.804 + \frac{12.66}{v_{ij}} \right) * l_{ij}) \quad (8)$$

Tyre wear:

$$\Delta C_{tyre} = \frac{P_{tyre}}{V_u} * (IMD_{ind} * \left(0.804 + \frac{12.66}{v_{ind}} \right) * l_{ind} - IMD_{ij} * \left(0.804 + \frac{12.66}{v_{ij}} \right) * l_{ij}) \quad (9)$$

External costs increase due to on-street parking violation as follows (formula is only presented for the ones that data is enough strong):

Air pollution:

$$\Delta C_{pol} = C_{pollutant} * (E_{ind} - E_{ij}) \quad (10)$$

Where $C_{pollutant}$ is the cost per tonne of the pollutant considered, E_{ind} and E_{ij} the pollutant emissions in a scenario with illegal parking and the optimal scenario.

Finally, the formula related to time costs is:

$$\Delta C_{time} = P_{time} \sum l_{ij} * \left[\frac{\left(1 - p^{ind}\right)}{v_{ij}} + \frac{p^{ind}}{v_{ind}} \right] - \sum \frac{l_{ij}}{v_{ij}} = \left(\sum l_{ij} \right) * \left(\frac{1}{v_{ind}} - \frac{1}{v_{ij}} \right) * p^{ind} \quad (11)$$

Where p^{ind} is the percentage of length that illegal parking is detected and v_{ind} is average speed of the vehicle in this stretches.

4. Illegal parking cost – case studies

Having been defined the different typologies of illegal parking evaluated as well as the cost referred to the trips and how they change depending on the level of parking violation, two case studies have been carried out: Barcelona and New York City.

For Barcelona, a global study has been performed, evaluating not just the city center but also the outlying districts.

By contrast, for New York City, only the neighborhood of Murray Hill in Midtown Manhattan has been studied.

In both studied cases, previous field works has been carried out and the data has been processed in order to show the results referred to illegal parking costs.

4.1. Field Works

To obtain the necessary data to achieve the goals of this study, a set of registers has been developedin order 1) to determinate the existing illegal parking level in urban areas as well as 2) to determinate the effect of the on-street parking violation to the environment have been performed.

4.1.1. Data referred to on-street illegal parking level

The field works to obtain data referred to on-street illegal parking level were done as follows.

First of all, the total length required to obtain a representative sample of the on-street illegal parking level of the case study has been defined.

In the case study of Barcelona, a set of subitineraries have been also determined referred each one to a specific area of the town. Each subitinerary has been divided in a set of stretches (the total amount of stretches varies depending on the itinerary).

By contrast, for the case study of New York, the itineraries have been done randomly.

To record all data obtained, a pattern has been created to write down for each stretch the presence of an illegal parked vehicle with the typology of the violation and, also, some additional characteristics (bus lane, cycle lane, etc.)

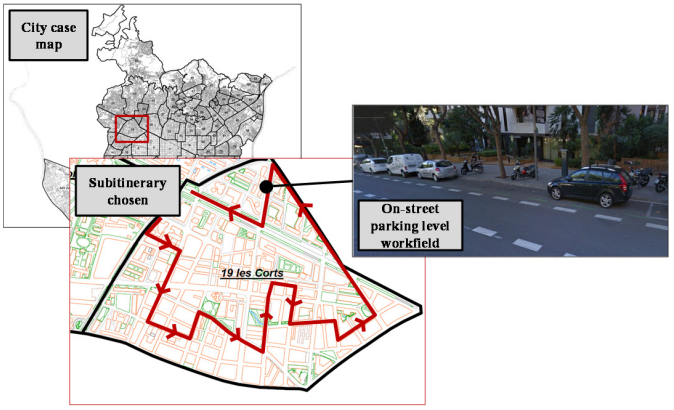

Fig. 1. Example of data obtaining referred to on-street illegal parking level

The Field Works referred to parking violation level had been carried out during the year 2011. The procedure used for the Barcelona case study was as related next:

- Day one of data collection begins recording the first stretch of the sub-itinerary one and it goes on until all stretches are recorded
- The following sub-itineraries are done exactly as the previous

- Every time an illegal parked vehicle is detected on the itinerary, stretch and typology are recorded (as well as if exists an additional characteristic)
- It is important to mention that all the itineraries had been carried out evaluating the on-street illegal parking existing in both sidewalks
- The schedule time was from 8:30AM to 2PM and 3:30PM to 8PM obtaining data for the whole working day. It is worthy to remark that the recordings began in the same place where left the previous day
- Although all the stretches were not evaluated the same day, data collection were adjusted to obtain data balanced for each time slot
- The data was only collected on working days (Monday to Friday)

On the other hand, for New York City working day collection and time slot equity were the same, however itineraries were not predefined.

4.1.2. Data collection referred to cost of on-street illegal parking

The Field Works referred to this chapter were developed to obtain the time increase (temporary cost) from vehicles driving around the illegal parked car due to its presence.

It is worth it to take into account that this data collection has been developed only for the city of Barcelona and its results have been used for all case studies

Fig. 2. Example of data obtaining referred to on-street illegal parking cost effect

To obtain the temporary cost, different parameters referred to the illegal parked cars and around them have been calculated:

- Average amount of vehicles (distinguishing between cars and buses) affected per each illegal parked car and unit of time
- Average temporary cost referred to vehicles affected by an illegal parked car

To achieve those goals, the procedure chosen was:

- Day one of data collection begins recording the first stretch of the subitinerary one and it goes on until all stretches are recorded
- The following subitineraries are done exactly as the previous
- Every time an illegal parked vehicle is detected on the itinerary, stretch and typology are recorded (as well as if exists an additional characteristic) as well as the amount of vehicles affected (in terms of temporary cost) and the time lost for each one due to the effects of parking violation.
- The schedule time was from 8:30AM to 2PM and 3:30PM to 8PM obtaining data for the whole working day. Recordings began in the same place where left the previous day

It is worth it that the itineraries chosen were identically the ones carried out in the previous field works

4.2. Field Works data processing

Once data from field works was available, it was processed in order to obtain the results.

4.2.1. On-Street illegal parking level

First of all, Barcelona case study is shown and, next, New York City case is described.

Barcelona

For Barcelona, the data collected shows an average of 1.32 illegally parked vehicles have been registered for each 100 meters of road.

It is important to mention these values are slightly greater in the outlying districts where no comprehensive parking regulation have been introduced.

An important outcome from data collected is that illegal parking is greater on low-traffic streets than in high-traffic streets.

New York City

In the case study of New York City –Murray Hill Midtown Manhattan – the result obtained is 0.28 vehicles for each 100 meters.

4.2.2. On-Street illegal parking effects to vehicles located around

The data collected during the field works – referred to Barcelona – have permitted to be acquainted with the average amount of vehicles affected by illegal parking and the temporary cost referred to them.

To show the results, data has been distinguished for each illegality typology due to the results varies significantly depending on them.

Table 6. Average number of vehicles affected by indiscipline typology and temporary cost related to it

Typology		Affected vehicles (vh/minute)		Temporary Cost (seconds)
		Buses	Cars	
Road	Overtake	0.15	2.84	1.95
	Yield	0.00	0.09	2.33
Double Parking	Overtake	0.05	2.81	1.69
	Yield	0.00	0.11	2.06
Pedestrian crossing	Vehicle stopped in crossing	0.00	0.13	2.00
	Vehicle complicates turn	0.00	0.91	2.12
Bus Lane	Bus Lane: overtake	1.33	0.33	3.00
	Bus Stop: stop access	1.67	1.33	3.83
	Bus Stop: access time	0.67	0.33	3.00
Loading / Unloading	Additional Manoevres	0.00	0.11	10.00
	Access time increasing	0.00	2.22	5.33

4.3. Cost of on-street illegal parking – Final results

Using the previous data as well as the one related with direct costs and externalities, we can obtain the results of economic cost of on-street illegal parking in urban areas, the goal of the present study.

To calculate the final results, the following inputs have been reckoned:

- Additional direct cost (difference between illegal park car and normal scenarios) referred to a vehicle affected by a car parked illegally on-street
- Lost time referred to the presence of a car parked illegally on-street
- Externalities referred to indiscipline (in the present paper only pollution has been considered)

In both studied cases, level of on-street illegal parking obtained on field works has been used as starting point to calculate economic impact.

It is important to mention temporary cost has been calculated according to the marginal value and referred to average city wage.

Also, emphasize that direct costs have been evaluated according to the current price of the consumables in the area evaluated (prices vary between Barcelona and New York City).

Taking into account these items, the total amount referred to on-street illegal parking has been calculated by unit of length; in the case of Barcelona, the value is 0.0325$ per 100 meters and 1 minute, in other words, in Barcelona, for 100 meters of road, the economic cost each minute is greater than 3 cents per minute. In New York City, the value is slightly lower, 0.0251$ for 100 meters and minute.

Table 7. Cost per unit of length (100 meters) and 1 minute in the studied cases

Type of cost	Cost / 100 linear meters	
	Barcelona	Murray Hill
Temporal	0.0317 $	0.0249 $
Direct	0.0003 $	0.0001 $
Externality	0.0005 $	0.0001 $
Total	0.0325 $	0.0251 $

In Barcelona, due to the high amount of data collected, it has been calculated also the cost of illegal parking for each typology. It can be observed that most outstanding cost is the one referred to vehicles located on reserved lanes for public transport, with a huge difference with the rest of typologies evaluated.

Table 8. Illegal parking costs per each 100 meters of road and 1 minute depending on parking typology in Barcelona

Illegal parking typology		Total cost
Double parking	Parallel to the curb	0.0096 $
	Chamfered streets corner	0.0539 $
Road	Parallel to the curb	0.0328 $
	Chamfered streets corner	0.0023 $
Pedestrian Crossing		0.0218 $
Bus Lane		0.2530 $
Loading / Unloading		0.0155 $

Finally, an extrapolation to the whole area studied and for a whole year has been performed; according to data is worthy to remark that the cost of illegal parking in Barcelona is about 432$/minute and more than 80,000,000$ per year.

For Murray Hill (New York City), the economic impact is slightly greater than 14$/minute and the annual cost is about 2,500,000$. It is necessary to take in account that the area considered is just a small part of one of the 5 districts of New York City.

Table 9. Estimation of illegal parking costs in the studied cases

Case	Cost per each 100 meters		Total Cost	
	Per minute	Per year	Per minute	Per year
Barcelona	0.033 $	6,098 $	432 $	80,941,221 $
Murray Hill	0.025 $	3,603 $	14 $	2,588,803 $

5. Main conclusions

Once evaluated the most important illegal parking typologies and its economic impact, it can be seen on-street illegal parking cost is significantly outstanding – in Barcelona, the value is slightly greater than 80,000,000$ per year-. According to data, on street illegal parking reduction has to be one basic pillar of mobility policies. This reduction would allow a higher road capacity and, consequently, greater traffic fluidity.

Referred to the cost typologies, it is important to mention that most of economic impact is associated to temporary costs (more than 95% of total amount) while the remaining factors, direct costs and externalities have a lower effect.

If different illegal parking typologies are taking into account, it is worthy to remark the typology of illegality that represents the higher economic impact is the one referred to bus lanes due to the elevated time costs related to them – the occupancy of buses is, on average, greater than any other vehicle and, consequently, the total amount of time lost is higher than any other vehicle.

This higher cost referred to illegality on bus lanes can be verified with the comparison between the two studied cases in the paper. In Barcelona, with an average on-street violation parking of 1.32 vehicles per each 100 meters, the cost is 0.0325$ / 100 meters while in New York City with a noticeably lower violation level (0.28 vehicles) the cost per 100 meters is almost the same (0.0251$). The reason is because in Murray Hill illegality in bus lanes is more frequent than in Barcelona.

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