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THE IMPACTS OF ILLEGAL PARKING ON THE URBAN AREAS' TRAFFIC AND ENVIRONMENTAL CONDITIONS: THE CASE OF THE CITY OF THESSALONIKI

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A combination of factors including an unattractive public transport offering a low level of service, the lack of parking facilities, an inadequate drivers' education and poor policing have led to illegal parking phenomena in many Greek cities, contributing in their aesthetic and cultural degradation, making them inaccessible for both vehicles and pedestrians. In the present study the phenomenon of illegal parking is investigated along selected road axes in the city of Thessaloniki, Greece. After the appropriate processing of the data collected, the impact of illegal parking on the reduction of road capacity was calculated. Moreover, it was attempted to relate illegal parking activity with the type of adjacent land uses. Conclusions regarding the degree of parking violations and the road capacity reduction in relation to road and adjacent land uses' characteristics are given and possible measures and policies towards the alleviation of the problem are proposed.

Key words: **Illegal parking, road capacity, traffic impact, urban traffic, urban degradation.**

INTRODUCTION

The economic development that occurred in western societies during the last decades of the previous century led to a rapid increase in private car ownership, which resulted to high traffic congestion in most city centers. A combination of factors including an unattractive public transport offering a low level of service, the lack of parking facilities for off-road parking, an inadequate drivers' education and poor policing may lead to illegal parking phenomena in central urban areas. Illegal parking has major impacts on everyday quality of life, such as increased travel times and slower movement of goods, due to the critical reduction in road capacity and may cause an increase in car emissions. In the framework of a research in the city of Athens by Frantzeskakis (1989) it was found that illegal parking at certain spaces, such as bus stops, can potentially increase emissions within the adjacent areas at up to five times as a result of the derived delays and increased fuel consumption. All these effects contribute in the aesthetic and environmental degradation of urban centers, making them inaccessible for both vehicles and pedestrians (Taxiltaris *et al.*, 2001). This fact, combined with the overall decentralization that is now observed in most cities through the appearance of new commercial activities in the suburbs, where a sufficient number of parking spaces is offered, can lead to the decline of urban centers. Furthermore, illegal parking can have negative effects on tourism since visitors are obliged to confront the daily traffic congestion in all affected city centers, which usually constitute the cultural generators of most tourist attractions. Land use and transport systems allocation and integration have played a major role in the context of urban planning. An optimal spatial organization of urban functions correlated in harmony with the transport systems is a prerequisite for a sustainable transportation planning urban development (Pozoukidou, 2014). Parking policies are considered to be one of the key links between transport and land use policy (Marsden, 2006) having an impact on transport mode choices and travel routes thus affecting the urban mobility, the environment and therefore the economic development (Feeney, 1989; Sisiopiku, 2001).

In the present study the phenomenon of illegal parking is investigated along selected road axes in the city of Thessaloniki, Greece since it is a more critical problem for the Greek city centers than other European cities where, apart from adequate and proper policing, the appropriate drivers' education exists. In addition, the non-integrated urban and transportation planning in Greece resulted to the current development of cities' form that is unable to

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support the soaring ownership of private cars and applies more pressure to the existing parking problems. Within this framework, parking measurements were conducted along selected road segments and a database including legal and illegal parking data was developed. After the appropriate statistical processing of the data collected, the impacts on the reduction of road capacity were calculated. In addition, the connection of existing land uses and illegal parking activity was investigated. Finally, some interesting conclusions regarding both the degree of parking violations and the road capacity reduction in relation to road and adjacent land uses' characteristics are given and possible measures and solutions to the problem are proposed.

METHODOLOGY

The proposed methodology used for this study comprises five stages: a) the selection of the road segments to be investigated, b) the collection of local urban data, including type of land use, road geometric and operational characteristics, c) the collection of local parking data concerning both legal and illegal parking, d) the analysis of the data collected and e) finally, the extraction of conclusions and the proposal of possible solutions. The stages of the methodology are presented in Figure 1.

Initially, the road segments to be investigated are selected within the study area. The primary data collection includes the recording of the adjacent land use data type and the characteristics of the selected roads (number of lanes, existence of bus lanes, traffic direction, existence of center island etc.). On-site measurements are conducted at the selected road segments; with those measurements the exact number of illegal parking, the parking supply (i.e. the number of offered legal parking spaces) and the percentage of each kind of deviant behavior was evaluated (i.e. parking on the sidewalk, not adequate distance from the junction, etc.). Then, a statistical analysis of the measurements is made followed by comments and descriptions of the current situation occurring in each street. In addition, with the help of spreadsheets, the calculation of the reduction of road capacity is made for each road at specific points at the midblock between traffic lights (Frantzeskakis *et al.*, 2008). The green times and the total cycle length of each traffic light are measured and then, with the use of the methodology for the calculation of traffic saturation flows deriving from the early studies of Webster and Cobbe (1966) and later of Kimber *et al.* (1986), the road capacity of each section is calculated. Aiming to estimate the impact of illegal parking on the reduction of road capacity the calculation of road capacity is made for two traffic situations, i.e. the existing one where illegal parking has been recorded and an 'ideal' one where there is complete compliance with the existing parking regulations. The comparison of the two situations results in the estimation of the road capacity reduction due to the illegal parking. Then, an attempt is made to establish a connection between the adjacent land uses and the main type of deviant behavior concerning parking that occurs at each road. Finally, based on the above results possible measures to tackle the problem of illegal parking are proposed.

CASE STUDY

Study Area

The study area includes selected road segments in the city of Thessaloniki. Thessaloniki is the second largest city in Greece and plays a major role as the administrative, financial and cultural center of the country's north but also contributing in the strategy of promoting spatial competitiveness and in the country's development in general, with a population of 1110312 and a density of 301.49 inhabitants per km^2 (Thoidou, 2013; Hellenic Statistical Authority, 2011). The use of private car is the citizens' first travel choice as 1800000 out of 2300000 or 78.26% of the trips made daily within the city are conducted using the private car, while the private car ownership index reaches a 45% (Organization of Urban Transportation of Thessaloniki, 2014). Public transport, currently including only buses, is run by the Thessaloniki Urban Transport Organization serving 167000000 passengers annually with a fleet of 618 vehicles serving 79 lines in the city center and its premises. Moreover, the city operates as a transportation node for southeastern Europe, by having an international seaport and airport as well as a railway terminal, supporting thus the transportation of people and goods at the urban, regional, national and international level. Nine major road axes of the city were included in this study in order to have a representative picture of the impacts of illegal parking in areas with different characteristics. The study area and its selected road segments are presented in Figure 2. Along these streets parking policy varies according to its type. Along main arteries parking is prohibited and only a few parking spaces exist. Along secondary arteries parking is allowed except for bus lanes and spaces reserved for special

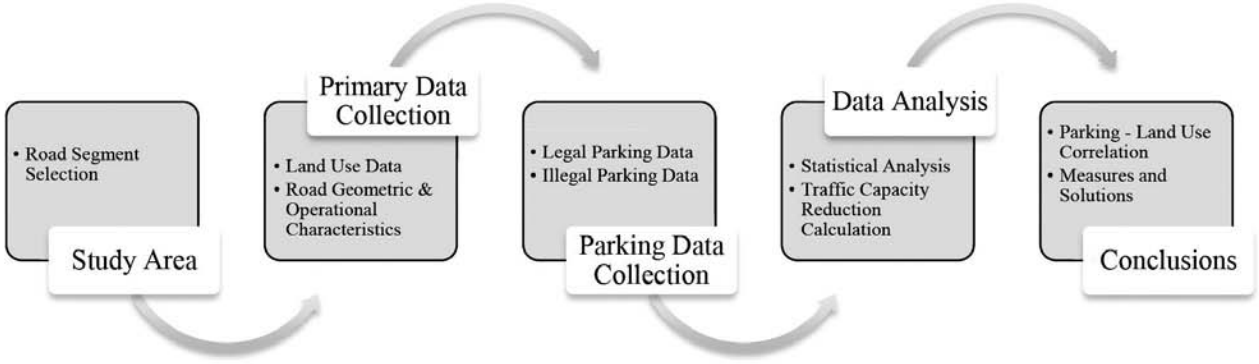

Figure 1. Methodology of the study

Figure 2. Study area and selected road segments

use (e.g. disabled people, loading/unloading of goods etc., while along collector roads parking is generally allowed with minor exceptions in cases of spaces reserved for special use. Along local roads parking is generally allowed on both sides of the road.

Application of the Methodology

The nine major road axes that were selected for the investigation include three main arteries, three secondary arteries and three main collector roads.

Field recordings were conducted separately for each of the nine road segments where the legal parking spaces, the total number of illegally parked vehicles and the type of delinquency were registered. Two recordings were made per route, one in the morning and one in the afternoon during 8:30-11:30 and 19:00-21:00 respectively, in order to capture a representative view of the parking conditions throughout the day. The days the recordings took place had to be typical working days when the commercial shops remain open during the afternoon (i.e. Tuesday, Thursday and Friday). With the assistance of spreadsheets, the reduction of road capacity for each route was calculated at points in the midblock between two successive signalized intersections. The calculation of road capacity was based on the geometric characteristics of the road (road width, number of lanes, lane width etc.), traffic characteristics (traffic volumes and traffic composition) and on the existing traffic regulations (existence of signalized intersections, one-way system). In addition, data concerning the green phase as well as the whole cycle of the signalization along the examined road segments were taken into consideration. Then, as it was mentioned above, the road capacity was estimated for the conditions that should normally exist if there was no illegal parking at all and also the capacity for the existing situation based on the type of delinquency recorded by the field measurements. Finally, the percentage of the capacity reduction caused by illegal parking on each road segment was calculated. The Transport Engineering Laboratory of the Aristotle University of Thessaloniki provided land use data for the study area; the nine areas of the study do not have common elements concerning the adjacent land uses (SRM-LIFE, 2006). More specifically, they include road segments with purely residential areas adjacent to them, such as Olympiados and Plastira Str. and road segments that are characterized by intense commercial activity and nightlife activities (recreation, restaurants etc.), such as Tsimiski and Mitropoleos Str. The various road segments also differ as far as the geometric characteristics are concerned, ranging from roads with four lanes and adequate width (i.e. Egnatia Str. with 16.00m) to roads with fairly limited width, such as Mpotsari Str. (6.00m). Thus, the analysis of data resulted to some interesting conclusions about the degree of delinquency and the reduction of road capacity in relation to the particular road characteristics.

RESULTS

For the analysis of illegal parking the following cases of violations are considered: parking on private spaces or spaces for special use (e.g. reserved for loading/unloading, reserved for disabled people), double-parking (illegal parking besides parked vehicles), parking on bus-lanes or bus stops, parking on pedestrian crossings, parking in close proximity to signalized intersections and parking on corners. The analysis of the data concerning parking behavior showed that the majority of drivers did not keep the minimum parking distances from intersections, pedestrian crossings, bus stops etc. (Frantzeskakis *et al.*, 2002). More specifically, in Plastira Str. there were very high percentages recorded near or inside an intersection (15.7%), near a bus-stop (7.5%) or near pedestrian crossings (9.0%), while in Olympiados Str. there was a high number of vehicles parked at a corner (29.7%). Nevertheless, the most significant illegal parking rates observed were those that referred to the violation of bus-lanes and of special parking places as well as those that referred to double-parking. Those types are

Table 1. Selected road segments and their characteristics

Road	Road Class	Directions	Lanes per Direction	Lane Width (m)	Bus-Lane	Center Island	Signalized Intersection
Egnatia Str.	Main Artery	Two	Three	2.75	Yes	No	Yes
Tsimiski Str.	Main Artery	One	Four	3.50	Yes	No	Yes
Olgas Ave.	Main Artery	One	Four	3.00	Yes	No	Yes
Mitropoleos Str.	Secondary Artery	One	Two	3.20	Yes	No	Yes
Papanastasiou Str.	Secondary Artery	Two	Two	3.00	Yes	Yes	Yes
N. Plastira Str.	Secondary Artery	Two	One	4.00	No	No	Yes
Aggelaki Str.	Main Collector Road	One	Three	4.00	Yes	No	Yes
M. Mpotsari Str.	Main Collector Road	Two	One	3.00	No	No	Yes
Olympiados	Main Collector Road	Two	One	3.00	No	Yes	No

the ones causing the most important problems contributing to the highest reductions in road capacity. The road segment with the highest percentage of illegal parking at special parking spaces (26%) and double-parking (65.4%) was that of Aggelaki Str. Concerning illegal parking along bus-lanes Egnatia Str. holds the highest percentage (37.4%), a type of illegal parking activity that affects the its road capacity with a reduction at least of 5%. Table 2 presents the examined nine road segments according to their adjacent land uses while the total number of illegal parked vehicles per 100m, as well as the percentages of illegal recordings per type are presented in Table 3 and 4 respectively.

Table 2. Road segments and distribution of adjacent land uses (SRM-LIFE, 2006)

Road	Residential	Commercial
Egnatia Str.	30%	70%
Olgas Ave.	30%	70%
Tsimiski Str.	30%	70%
Mitropoleos Str.	30%	70%
Papanastasiou Str.	30%	70%
Aggelaki Str.	50%	50%
M. Mpotsari Str.	50%	50%
Olympiados Str.	70%	30%
N. Plastira Str.	90%	10%

Table 3. Illegal recordings per 100m per hour

Road	Road Segment Length	Illegal Recordings per 100m per hour
Egnatia Str.	708	44
Olgas Ave.	537	61
Tsimiski Str.	562	50
Mitropoleos Str.	526	31
Papanastasiou Str.	726	43
Aggelaki Str.	490	47
M. Mpotsari Str.	644	44
Olympiados Str.	571	15
N. Plastira Str.	681	26

The estimation of the illegal parking impact on road capacity showed that there is a great variation in the capacity reduction rate according to the road geometric characteristics. Thus, along Egnatia Str. a small decrease in road capacity was observed (5 - 10.4%), due to the large width of the road, while in Olgas Ave. the capacity reduction remained constant (22.0%) throughout the study section, due to the same geometric and operational characteristics along the road.

The width of the road is critical concerning the effect of double-parking. Double-parking strongly affects roads with limited width in various ways i.e. reduction of the number of available lanes, restriction of existing turns at intersections and occupation of bus lanes. Moreover, the existence of center islands creates space, which in some cases can be used for illegal parking in the middle of the road having a negative impact on the road capacity. Therefore, a limited width of the road combined with double-parking and illegal parking on the center island can create severe problems in the effective operation of the traffic along the roads.

Special mention should be also made for special parking spaces, whose illegal occupation creates multiple problems to the proper functioning of the road. Particularly important is the seizure of cargo positions, leading trucks to double park or park farther away from the shops where the loading and unloading of goods should take place. It should be pointed out that throughout the duration of the in-situ survey no trucks were parked in special cargo spaces, a fact that requires more effective policing in order to keep the specific places free for the hours when loading and unloading is allowed by law. Regarding the taxi parking spaces the situation is different because the taxi drivers remain in their vehicles while they are on-duty and therefore they apply enforcement by themselves. Finally, the recorded spaces reserved for special vehicles were primarily places for school buses in front of schools and parking spaces for disabled people. Although most of these spaces were occupied, this did not lead to further problems in traffic; this phenomenon, however, should be evaluated by its social side.

The reduction of road capacity per road segment and the possible correlation between the size and type of illegal activity and adjacent land uses by processing the collected data is presented in Table 5.

Table 4. Distribution of illegal recordings per type

Road	Minimum Distance from Signalized Intersection	Parking on Corner	Minimum Distance from Bus Stop	Minimum Distance from Pedestrian Crossing	Parking on Bus-lane	Parking on Special Parking Space	Double-parking
Egnatia Str.	3.9%	1.5%	0.2%	3.8%	37.4%	6.3%	0.4%
Olgas Ave.	0.9%	1.7%	0.0%	0.7%	18.4%	17.6%	21.5%
Tsimiski Str.	1.6%	0.8%	0.0%	2.4%	5.5%	3.5%	7.2%
Mitropoleos Str.	0.2%	5.4%	0.0%	4.5%	2.5%	25.8%	56.7%
Papanastasiou Str.	8.4%	1.7%	2.0%	4.5%	0.0%	2.5%	2.4%
Aggelaki Str.	0.0	7.0%	0.0%	1.5%	0.1%	26.0%	65.4%
M. Mpotsari Str.	6.3%	1.1%	0.0%	5.9%	0.0%	2.9%	32.5%
Olympiados Str.	6.2%	27.9%	0.0%	0.7%	0.0%	24.0%	1.4%
N. Plastira Str.	15.7%	3.9%	7.5%	9.0%	0.0%	3.3%	0.3%

Table 5. Reduction of road capacity per road segment

Road	Residential Use	Commercial Use	Capacity Reduction Percentage	Main Type of Illegal Parking
Egnatia Str.	30%	70%	5.0-10.4%	Parking on Bus-lane
Olgas Ave.	30%	70%	22.0%	Double-parking
Tsimiski Str.	30%	70%	36.7-54.8%	Violation of parking prohibition
Mitropoleos Str.	30%	70%	47.2-64.8%	Double-parking
Papanastasiou Str.	30%	70%	26.6-85.1%	Violation of parking prohibition
Aggelaki Str.	50%	50%	26.5-47.2%	Double-parking
M. Mpotsari Str.	50%	50%	28.0-74.3%	Double-parking
Olympiados Str.	70%	30%	55.9-56.2%	Violation of parking prohibition
N. Plastira Str.	90%	10%	26.5-39.0%	Violation of parking prohibition

From the data of Table 5 it can be concluded that double-parking is observed when there is an intense adjacent land use i.e. commercial or multi-purpose, with the exception of Egnatia Str. where the existence of bus lanes limits illegal parking. Moreover, these results are confirmed by Table 3 where it can be seen that the roads with an intense land use present more illegal recordings.

Regarding the rate of road capacity reduction, this is mainly a function of the geometric characteristics of the road, as it has been mentioned previously, while the roads with mixed land uses adjacent to them, i.e. regions with 50% residential and 50% commercial uses (Mpotsari Str.), show the highest reduction rates of over 70%, as they attract or produce multi-purpose trips. It should be pointed out that the highest capacity reduction rates were observed along Papanastasiou Str. (85.1%) and Mpotsari Str. (74.3%), reflecting the bad actual traffic conditions at those road segments.

CONCLUSIONS

In recent decades an exponential increase in car sales took place leading to a large number of households with two or more private cars; this results in poor parking supply, unable to meet the actual parking requirements. In the framework of the present study it was found that capacity reductions due to illegal parking vary from 10% to 75% according to the road geometric characteristics. This means that there is a necessity to switch users from the use of private car to public transport by implementing bus priority measures i.e. extension of bus-lanes and bus priority in signalization.

Suitable parking policies should be also implemented in order to limit both car ownership and car use. Policies for the control of the growth of private car ownership usually include the control of car owners for households that already possess one or more vehicles i.e. higher taxes or higher traffic charges. Of course the prerequisite of such measures is the existence of a dense and well-organized urban transport network that will cover the population's needs for travel to all parts of a city, making the private car unnecessary for the majority of trips which is not valid for the case of most Greek cities, including the city of Thessaloniki. Concerning car use, the common parking policies applied are: the coordination of on and off-street parking management and charging, the charging for on-street parking in order to achieve the preferred occupancy rates and have the ideal performance rates, the design of parking facilities that are well-integrated with the surrounding urban environment and transport infrastructure and that increase the turnover in the existing parking spaces in order to serve more cars through the appropriate parking charging.

Of course, regarding the illegal parking, a very effective and direct way to address it, is the correct and adequate enforcement and the imposition of an appropriate penalty system. Regarding the city of Thessaloniki, enforcement could be limited to parts of the city with a significant problem of illegal parking if the resources available are not currently sufficient for traffic or municipal police to adequately cover all areas of the city. In addition, contemporary technology could be used in order to achieve a more effective policing. Traffic cameras can be installed for the real-time monitoring and recording of offenders' vehicles. This measure, however, is highly unpopular in many countries and installed cameras are often at risk by phenomena of vandalism.

Finally, other ways to deal with illegal parking beyond policing are the appropriate street-design interventions. These include the widening of the pavements at corners, leading to the limitation of the lane width, the placement of appropriate obstacles on sidewalks that will prevent the access of vehicles, the better marking of areas where parking is prohibited, warning the driver not to park at that point.

Above all these measures, a key condition for the elimination or reduction of illegal parking is an adequate traffic education of drivers, as its lack is the main cause of the problem in general. Concluding, it can be said that the improvement of parking conditions results to a better urban environment and to a higher quality of everyday life.

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