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Ειδικό τεύχος – Αφιέρωμα

Πολεοδομία, Χωροταξία, Περιφερειακή Ανάπτυξη: Νέοι Επιστήμονες, Σύγχρονες Τάσεις

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Περιεχόμενα

Illegal Parking in Urban Streets: connection with the geometric characteristics and its mitigation through traffic calming measures

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Abstract

This article studies the Greek interregional commuting network (GRN) by using measures and methods of complex network analysis and empirical techniques. The study aims to detect structural characteristics of the commuting phenomenon, which are configured by the functionality of the land transport infrastructures, and to interpret how this network serves and promotes regional development. In the empirical analysis, a multiple linear regression model for the number of commuters is constructed, which is based on the conceptual framework of the term "network", in effort to promote the interdisciplinary dialogue. The analysis highlights the effect of the spatial constraints on the network's structure, provides information on the major road transport infrastructure projects that constructed recently and influenced the country capacity and outlines a gravity pattern describing the commuting phenomenon, which expresses that cities of high population attract large volumes of commuting activity within their boundaries, a fact that contributes to the reduction of their outgoing commuting and consequently to the increase of their inbound productivity. Overall, this paper highlights the effectiveness of complex network analysis in the modelling of spatial and particularly of transportation network, and promotes the use of the network paradigm in spatial and regional research.

Keywords
illegal parking, geometry, traffic calming, urban streets, problem mitigationία

Παράνομη Στάθμευση σε Αστικές Οδούς: σύνδεση με τα γεωμετρικά χαρακτηριστικά και άμβλυνση του μέσα από μέτρα ήπιας κυκλοφορίας

Περίληψη

Σκοπός της παρούσας εργασίας είναι να εξετάσει την ύπαρξη μιας σύνδεσης μεταξύ της παράνομης στάθμευσης και των γεωμετρικών χαρακτηριστικών των αστικών οδών. Επιπλέον, επιλέγονται κάποια μέτρα ήπιας κυκλοφορίας, τα οποία αμβλύνουν το πρόβλημα. Επιλέγονται τρεις εμπορικές οδοί με μια λωρίδα ανά κατεύθυνση στο Ναύπλιο, αυτές είναι: οδός Χαρ. Τρικούπη («πλατιά περίπτωση»), οδός Άργους («στενή περίπτωση») και η οδός 25ης Μαρτίου (περίπτωση με νησίδα). Ένα πείραμα οδήγησης (driving experiment) εκτελείται από τρεις οδηγούς εθελοντές, οι οποίοι οδηγούν και μετρούν τον αριθμό των παράνομων σταθμευμένων οχημάτων. Το εύρημα αυτών των παρατηρήσεων είναι ότι οι οδοί με μεγάλο πλάτος και χαμηλό φόρτο έλκουν γεγονότα "διπλο-παρκαρίσματος" και οι στενότερες λωρίδες κυκλοφορίας δεν επιλύουν το πρόβλημα αντίθετα αυξάνουν τον αριθμό των αναγκαίων ελιγμών προσπέρασης στην αντίθετη κατεύθυνση. Συνεπώς, η κατασκευή μιας κρίνεται νησίδας προτιμότερη. Για την άμβλυνση του παράνομου παρκαρίσματος, μέτρα ήπιας κυκλοφορίας μπορούν να εφαρμοστούν σε τέσσερα (4) διαφορετικά επίπεδα: δίκτυο αστικών οδών, σχεδιασμός αστικής οδού, αστικός εξοπλισμός και διαχείριση στάθμευσης.

Λέξεις κλειδιά
παράνομη στάθμευση, γεωμετρία, ήπια κυκλοφορία, αστικές οδοί, άμβλυνση προβλήματος

1. INTRODUCTION

The illegal parking problem, mostly in the form of double-parking, is tremendous in Greece. Indeed, Kladeftiras and Antoniou (2012) have estimated that 8000 vehicles park illegally on a daily basis in Athens. This negative phenomenon will be more crucial in the future, since in Great Britain, for instance, the number of vehicles will increase from 27,000,000 to 39,000,000 in 2030 and the 2,800,000 of them will be parked on the street (Marsden, 2006).

Previous studies have examined some of the potential causes of illegal parking. According to Spiliopoulou and Antoniou (2012), in Greece, double-parking is a significant problem, since the enforcement system is almost non-existent, creating in this way a

tendency to disrespect the system's regulations and even park illegally since no fine will be given. Furthermore, there is a huge connection with the culture of drivers. Stamouli (2017) wrote in an article in Wall Street Journal that Greeks respect more the "basket in the street" signal, which can be used by a neighbour for saving parking space than the parking regulations. In addition, Gao and Ozbay (2017) attempted to model double-parking in the city of New York and they found that high commercial usage, more hotel rooms, and longer block length increases the likelihood of double-parking. Despite the fact that the lane width and the bicycle lane existence had a statistically significant correlation with the study problem, they were less important in comparison with the other factors.

Regarding the impacts of the problem, Gao and Ozbay (2016) referred that obstructions of traffic, like double parking, cause traffic delays and safety risks. They proved that the hourly average travel time raise by 3.1%, 13.6%, 20.5%, and 27.6% when there is a rise of double-parking situations frequency by 1, 2, 3, and 4 vehicles per 15 minutes, respectively. Also, Kladeftiras and Antoniou (2012) expressed that limiting the illegal parking could result in an increase in speeds of about 10-15% and a decrease of about 15% and 20% for delay and stopped time respectively. Lastly, according to Edquist et al. (2012), legal and illegal on-street parking increases dramatically the workload of the driver and the reaction time, when he/she interacts with an unexpected pedestrian.

The plethora of negative effects caused by the illegal parking phenomenon in urban shopping streets motivated the authors to find a correlation between the geometric characteristics of this type of streets and the illegal parking events. Therefore, this objective drives us to formulate the main research question: How the geometrical characteristics of commercial urban streets influence illegal parking events? If there is an actual connection between the geometric characteristics of these streets and the illegal parking events, urban/transport planners should consider this issue when designing commercial urban streets in cities. Therefore, a second research question arises at this point: Which are suitable street designs in terms of geometry and distribution of street elements that may yield to a reduction of illegal parking events?

The geometric characteristics of urban streets can be modified with the use of traffic calming measures that are able to reduce the number of illegal parking events among other functions. Hence, the answer of the second research question drives us to formulate the following sub-question: Which are the traffic calming measures that should be implemented in commercial urban streets to achieve an actual reduction of illegal parking events? In addition, traffic calming measures can also lead to better use of the space available in urban streets. Nowadays, we can see an important amount of road space used by legal and illegal parking vehicles, which could be rather used for designing friendly urban streets in cities.

This idea drives us to formulate a second sub-question: Could space, which is occupied by illegally parked vehicles, be used for creating friendly urban streets that boost the share of active modes (e.g. cycling and walking) yielding to an improvement of sustainable mobility of cities?

The aforementioned questions will be answered in this study to ensure that the research objective is fulfilled. In the beginning, a driving experiment in three different (in terms of cross-section design) commercial streets of Nafplio, namely: Char. Trikoupi, Argous and 25th Martiou, will be conducted. In this experiment, the counts of illegally parked vehicles will allow the authors to determine the volume of illegal parking in each street. From this experiment, the correlation between the geometric characteristics and the illegal parking events can be established. Afterwards, this correlation is utilized in the development of a framework for the implementation of traffic calming measures that lead to a reduction in the number of illegal parking events in those streets. These traffic calming measures are implemented following a framework composed of four levels, namely: 1) urban road network, 2) urban road design, 3) street equipment and 4) management. In the conclusions, answers to the research questions and some recommendations will be provided.

2. DRIVING EXPERIMENT

As we have referred, a driving experiment was conducted in order to find out the connection between the illegal parking and the geometric characteristics. The second chapter has been divided into 3 subchapters. In the first one, a methodology description will be provided, afterwards, the geometrical characteristic of the study cases will be presented and in the last chapter the results of this experiment will be given.

2.1 Methodology Description

The empirical data related to the volume of the illegal parking in the study streets are collected by a driving experiment. According to Glendon (2007), the validity of the in-vehicle observations is quite high, since the measured number describe absolutely the observed reality. Yet, in some cases, the cost, in terms of time and money, is very high and a significant number of volunteers is required. This is the reason why we just focused on three popular design of urban streets. Nevertheless, it is important to note that, although this study does not cover the whole variety of design streets, it provides some primary insights in the general process of modelling the illegal parking and double-parking behaviour.

Three volunteers/drivers are used in this driving experiment. In every street, one section of 350 m was identified by the authors and crossed 40 times (at least) by the drivers.

They were counting illegally parked vehicles and the necessary overtaking manoeuvres in each cross. The overtaking manoeuveres can be distinguished in the dangerous ones, in which drivers are forced to use the oncoming vehicles lane, and in the safe ones, in which drivers do not use it. These total numbers have to be divided by the total covered length in each street, since a single rate of illegally parked vehicles per km allows comparisons. The accuracy of this indicator was selected to be lower than 3 vehicles per km for a confidence interval of 95%· therefore, the number of driven kilometres (or the number of crosses) in each road was related to the standard deviation of the measurements. In addition, the traffic flow measurements took place in the last hour of the driving experiment in each road and the saturation flow was estimated using the well-known formula, which was recommended in the Highway Capacity Manual (TRB, 2000). According to it, factors, that influence mainly the saturation flow of a cross-section without left/right turn streams, are the number of lanes, width, gradient, the fraction of HGV, type of area and number of parked vehicles. The fraction of the heavy good vehicles was recorded by additional observations. Lastly, after the experiment, we interviewed the three drivers in order to describe their experiences from this procedure. Two questions were added, namely 1) in which spots of each street did you observe a repetition of illegal parking events (identify the most important ones) and 2) have you experienced dangerous situations during the driving experiment, if yes, can you describe these situations to us?

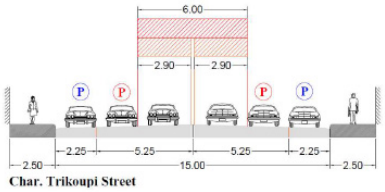
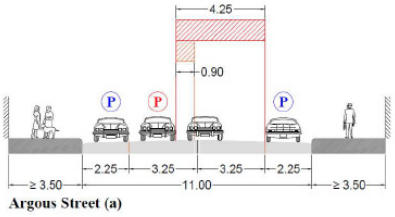
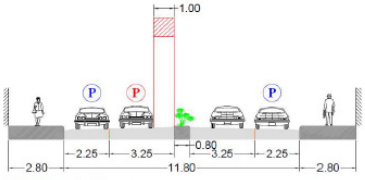
As it is previously mentioned, three urban streets of Nafplio were selected for the driving experiment, namely: Argous, Char. Trikoupi and 25th Martiou. From the previous studies, we know that the legal enforcement and the culture influence more significantly the illegal parking events than the geometrical characteristics. The selection of three study cases from one country, i.e. Greece and from one city, i.e. Nafplio, ensures that the cultural conditions will be the same. Another factor is the number of commercial uses in an urban street. Argous has much more shops and super/mini markets than 25th Martiou. To balance it, the driving experiment in the last street was accomplished during the days on which the central food market took place in an area, that is located approximately 50 meters away. In addition, all of them are located in the centre of Nafplio and the difference in the block sizes are negligible. Hence, the main difference between them is the design of the cross-sections.

Regarding the time period of the experiment, a non-touristic period, namely: November and December 2018, was selected, since tourists and visitors may have different habits that can influence aggregate parking behaviour. Also, for the measurements, the peak hour 13:00-14:00 was preferable since shops and mini/super-markets are open during this hour and many citizens stop in order to buy goods before returning back home.

2.2 Geometrical Characteristics Analysis

The selected urban streets have one traffic lane and one parking lane per direction. However, the widths of their lanes differ much (Table 1). These three designs can be characterized as representative and common in many regional cities of Greece and in some districts in Athens.

Table 1. Presentation of the geometrical characteristics of the selected streets

	Present Situation (2017)	Cross-Section
Char. Trikoupi		 Char. Trikoupi Street
Argous		 Argous Street (a)
25th Martiou		 25th Martiou Street

Source: Ministry for the Environment, Physical Planning and Public Works, 2001· Own Elaboration, 2018.

Char. Trikoupi is a wide urban street since the traffic lane is around 5.25 m. This road was constructed in 2012 by the municipality of Nafplio and the main purpose of this construction was the reduction of the load of trucks inside the city centre. Hence, the designers conceded too much space to the heavy vehicles for their 'safe' movements.

Argous is a busy street in Nafplio since the shopping centre of the city is located in this street. In 2004, there was an extension of the sidewalks and today their widths are greater than 3.50 m. This urban regeneration project reduced the on-street parking spaces in some specific spots of Argous street. The urban road of 25th Martiou is located in the historical neighbourhood of Pronoia. It has a median island and its traffic lanes is 3.25 m wide.

In Table 1, we can see with the red symbol (red P) the illegally parked vehicles, and with the blue symbol (blue P) the legally parked vehicles. These illegal parking situations, which are represented in the drawings, are typical and common in these streets, but they do not describe the big variety of illegal parking events. It is clear that in the first street the free space is 2.90 m (in each direction). Then, the overtaking manoeuvre is unnecessary in Char. Trikoupi, but in Argous street, drivers actually use the opposite direction to avoid double-parked vehicles. The free space (both directions) is approximately 4.25 m in the second street. In 25th Martiou, vehicle drivers cannot use the opposite direction, since there is a median island that blocks this movement. Therefore, if someone parks his or her vehicle illegally in this street, the traffic will be stuck and then, congestion problems will appear.

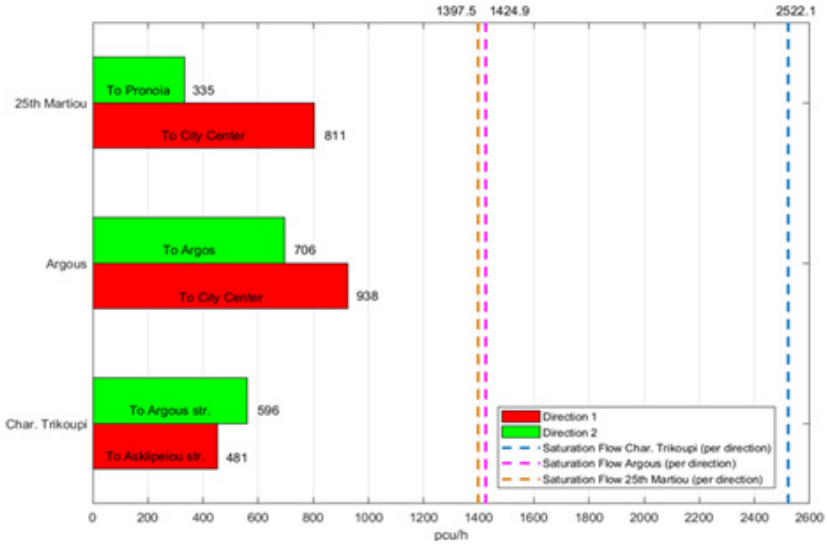
2.3 Results Presentation

The obtained results can be divided into three main parts. The first part is related to the traffic conditions observed during the driving experiment. In the second part, the computation of the main indicator 'illegal parking per km', is accomplished. The final picture about the volume of illegal parking in each street can be obtained by the use of the previous indicator together with the answers collected in the volunteers' interviews.

Figure 1 presents the peak hour flows of each direction and of each street. The estimation of them was achieved by selecting the quarter with the maximum flow and extrapolating the results to obtain hourly measurements. According to Antoniou and Spiropoulou (2015), the quarter of an hour is the minimum time period, at which the traffic conditions are stable. As we can observe in Figure 1, Argous had the highest traffic flow by 938 and 706 pcu/h in direction 1 and 2 respectively. The saturation flow in each direction of this street is 1424.9 pcu/h. Double parking in Argous is able to reduce the saturation flow of this road since the width of the lane is decreased due to parked vehicles. This is the reason why congested spots were observed during the driving experiment. Char. Trikoupi had the lowest traffic flow of approximately 540 pcu/h/direction and the highest share of HGV by 6.4%. Nevertheless, the saturation flow of this street is much bigger, 2522.1 pcu/h/direction, due to the large widths of the traffic lanes. Thus, there is enough available space that can attract significantly double-parking events. The street of 25th Martiou had

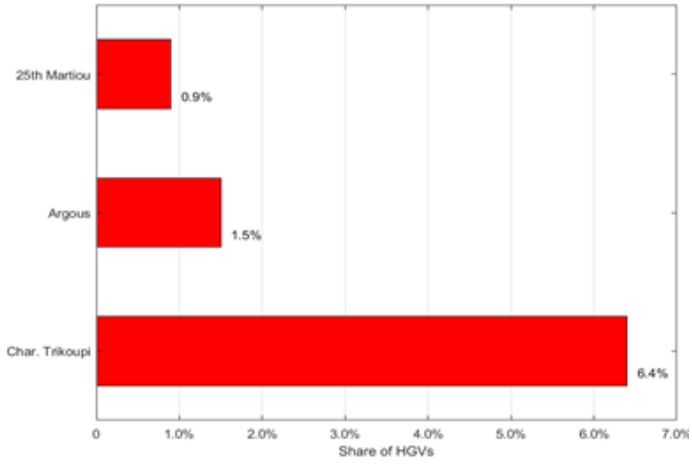
the lowest saturation flow by 1397.5 pcu/h/direction due to the existence of a slope of approximately 5%. In the direction from Pronoia to Nafplio, the traffic flow was quite high, 811 pcu/h since the central food market took place on that day. The share of trucks was the lowest in this road by 0.9%.

Figure 1. Traffic flows in the study streets



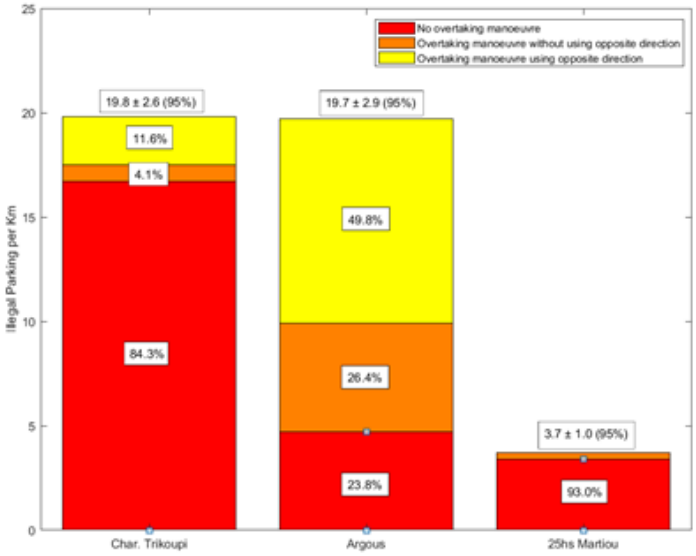
Source: Own elaboration, 2018.

Figure 2. Share of HGVs in the study streets.



Source: Own elaboration, 2018.

Figure 3. Illegal parking per km in the study streets.



Source: Own elaboration, 2018.

Volunteers covered 30.54 km, 42.16 km and 15.6 km in Char. Trikoupi, Argous and 25th Martiou, respectively. The outcome of this procedure is the histogram of Figure 3. We can observe that the 'wide street' Char. Trikoupi has the highest rate of illegally parked vehicles per km. Nevertheless, volunteers did not accomplish an overtaking manoeuvre in 84.3% of the illegal parking events. In Argous (the street with the highest flow) the same levels of illegal parking were observed by 19.7 veh/km. Overtaking manoeuvres are necessary for this street and 65.4% of them was achieved using some meters of the opposite direction lane. Therefore, the illegal parking events in the second street influenced significantly the road safety. In 25th Martiou street, we observed a relatively low illegal parking phenomenon of 3.7 veh/km. Despite the fact that the central food market increased the demand for parking in this street during the hours of the experiment, the number of illegal parking did not expand dramatically. Lastly, it has to be noticed that the difference between the rate of Argous Street ('narrow street') and 25th Martiou (with median island) is around 16.0 veh/km.

From the discussion with the volunteers, we found that high levels of illegal parking create chaos in the flow of vehicles. Volunteer 2 observed a triple-parking event in Char. Trikoupi. She tried to avoid the parked vehicles by an overtaking manoeuvre using the opposite direction. Unfortunately, the driver of the opposite direction did not reduce the speed since he did not consider the overtaking movement. Volunteer 1 expressed that illegal parking using emergency lights is quite common in Argous near the bins and near the two supermarkets. According to the third volunteer, safety problems also exist in 25th Martiou Street because of the illegal parking issue. Pick-up vans usually park in some spots in the middle of the road, where the alignment of the median island stops due to the existence of a junction (see Table 1). In the driving experiment, there was a case in which one car from the opposite direction tried to turn left and volunteer 3 could not see the car since it was behind of the illegally parked vehicle.

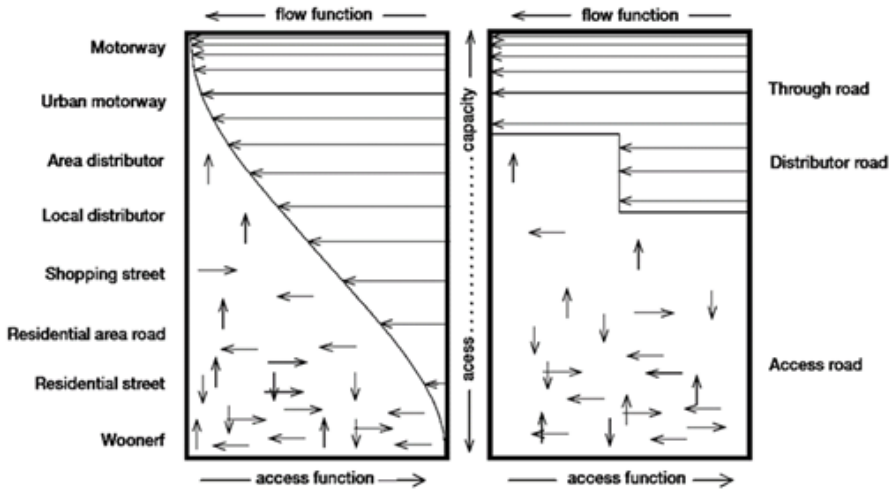
3. TRAFFIC CALMING MEASURES

In the third chapter, we will introduce a variety of traffic calming measures that are able to mitigate the illegal parking events in Greek cities. The recommended strategies can be divided into 4 main levels, which create a pyramid (see Figure). Starting from the top to the bottom, these levels are a) the urban road network level, b) the urban road design level, c) the street equipment level and d) finally the management level. presents the previous levels in a pyramid and points out the sequence of these required steps. The second section study aims to develop a primary strategy, that can be followed by cities in order to reduce the illegal parking events in the main links of the urban network. In addition, this study will attempt to present some paradigms from the study case about how traffic calming measures that are included in each level of the pyramid can be implemented.

3.1. Urban Road Network Level

According to Wegman and Aarts (2006), the function of the roads should be clearly expressed as a part of traffic policy plan of each city. Then, according to the selected functionality, the cross-section of the street is designed by the road designer. In the end, the selected geometry of the street influences the behaviour of the drivers. Therefore, it can be said that a mistaken road categorization can lead to an increase in illegal-parking events from the beginning of the planning process. A typical example from Nafplio is the Char. Trikoupi street.

Figure 4. Road functionality graph.



Source: Wegman and Aarts, 2006.

The traffic function of roads can be distinguished in two main sub-functions, namely: flow function and access function (Wegman and Aarts, 2006). Distributors are roads that can connect both aforementioned categories. A residential street or a shopping street has access function, while a motorway has a flow function (Figure 4). Ring roads are a typical example of area distributors, which can control the motorization in the cities (Buchanan, 2015) and protect the commercial and business centres from the local and supra-local traffic (Bakogiannis et al., 2017). The reduction of through traffic by the previous strategy results to a high decrease of traffic flow within the city centres (Van Schagen, 2003). In addition, the ring road can limit the flow of HGV in the urban roads. Hence, the road designer is able to apply changes in the capacities of these roads, such as lane narrowing, creation of median islands, bike lanes, etc.

Figure 5. Current and recommend HGV paths

Source: Own elaboration, 2018.

As we mentioned before, the functionality of Char. Trikoupi street was wrongly established. HGVs, that comes from Argos or Athens, cross this street to avoid passing by Endekati intersection. Nevertheless, Char. Trikoupi is a road located in the urban fabric of the city, characterized by the presence of many residences and shops. Hence, if we take into account the urban environment around it, then, the most reasonable category for this road would be a shopping road. Planners permitted the high fraction of trucks in this street (Figure 2) by keeping traffic lanes with large widths, 5.25 m. However, there is an alternative route for trucks, such as the peripheral road of Nafplio, which was constructed to protect the city from the through traffic (from Argos/Athens to Kranidi). The establishment of additional restrictions for trucks will increase the use of this ring road and decrease the fraction of trucks within the city centre. With a lower fraction of HGVs, traffic calming designs, such as lane narrowing, are more feasible. As a result, the double-parking spaces in Char. Trikoupi will be reduced.

3.2. Urban Road Design Level

From the results of the driving experiment, we realized that the establishment of a median island is an effective measure in order to decrease the illegal parking events. According to the Department of Transport of the UK (2007), median islands can be used for a variety of purposes, such as controlling vehicle speeds and facilitating movements of pedestrians. Moreover, it is a design that reduces the width of the lane and adds extra green spaces in the urban street. Furthermore, according to Ewing (1999), median islands or refuge islands are able to minimize the lane changes of the car and improve the homogeneity of the traffic flow. Therefore, the dangerous overtaking manoeuvres by using the opposite direction will disappear by the construction of a median island. Then, double-parking events will be reduced, since there will not be any available space to overtake the double-parked vehicle, like in 25th Martiou street.

Figure 6. Recommended traffic calming designs.

Source: NACTO, 2016

Lane narrowing can be an effective measure for problem mitigation in Argous. One ideal strategy is cut off completely the parking lanes and use this available space for a bus lane or pedestrian/cycle facilities (NACTO, 2016). According to NACTO (2016), the minimum width of a traffic lane shared by cars and bikes is 3.00 m, yet the Greek guidelines for traffic calming areas (Ministry of Infrastructure, Transport and Networks, 2013) propose 3.25 m and 5.50 m as the minimums for streets with one and two directions,

respectively. Thus, in Argous and Char. Trikoupi, there is enough available space, which can be "taken" from legal and illegal parking vehicles and delivered to pedestrians. In the end, this measurement will increase the pedestrian comfort and safety (Ewing, 1999), so that these streets will be more attractive for walking and shopping.

It is true that cutting off the parking lanes is a rational strategy for the Greek reality. Bulb-outs are an alternative traffic calming measure. In some spots, the sidewalk can be extended into the parking lane. By designing them, the urban street becomes narrower in some points, which makes it unattractive for double-parking events due to the lack of space. In addition, this design contributes to the clear identification of the parking spaces in a narrow street. Also, sheltered parking is able to increase the visibility of pedestrians, so that they can be seen beyond the parked vehicles (DfT, 2007). Another design is the pitch points at which designers reduce the width of the street in pedestrian crossing spots. Furthermore, with this measure, we can limit the number of vehicles, which park illegally there. Especially in Argous, this strategy is necessary, since the number of parked vehicles in pedestrian crossings was extremely high.

Volunteers expressed many complaints related to the reduced visibility in the junctions of Argous and Char. Trikoupi. In the majority of cases, illegally parked vehicles in the corner spots blocked their visibility. To solve this problem, an effective measure could be to decrease the radius of the corners at intersection areas. The result of this choice is the extension of the sidewalk and the minimization of the available space for illegal parking. Moreover, the sidewalk can be extended even further in an intersection to alert drivers that they are entering a slower area (NACTO, 2016). This design measure is called gateway treatments and it also reduces the crossing distance of pedestrians (Ewing, 1999).

3.3. Street Equipment Level

Improvements in the road marking may lead to an important reduction of illegal parking events. According to DfT (2007), central hatched road marking can be utilized in order to discourage drivers from overtaking and can also give the impression that the road is narrower in comparison with reality. Therefore, this false impression may result in less double-parked vehicles in streets like Argous since drivers will start realizing that they could block the traffic lane creating congestion problems.

As we see in Figure 6b, in some spots of the parking lane, green infrastructure, like trees, can be added. Green infrastructure can provide physical barriers, which are able to limit the illegal parking phenomenon. In addition, it provides natural relief to the built environment, improves the street aesthetic and delivers benefits to the community (NACTO, 2016).

Bollards can restrict the access of the vehicles in certain areas, like the sidewalks (NACTO, 2016). The phenomenon of illegally parked vehicles on the sidewalks is quite common in Greece. The solution to this problem is the establishment of short bollards, that do not reduce the accessibility of pedestrians/cyclists. Plastic bollards can be added in some areas in which illegal parking may occur. One example is the area around the waste collection containers, where drivers prefer to leave their vehicles for a short time using emergency lights. In the majority of cases, they do not consider that heavier vehicles, like busses or trucks, cannot pass through the remaining space. Also, in 25th Martiou street, we observed vehicles, which had parked in the gaps of median island alignments. Plastic bollards can be utilized in this case too so that the available space will be sufficient for the left turns of the vehicles and insufficient for parking purposes.

3.4. Management Level

In the last level, management measurements are necessary in order to effectively face the illegal parking problem. During the working hours, freight vehicles enlarge significantly the study problem since truck drivers are willing to park near the shop or the mini/super -market for picking up or dropping off the goods.

In the narrow Greek streets, parking facilities dedicated to the urban freight do not exist; thus, trucks share the parking space with passenger cars. This negative situation can be changed by loading bays. According to NACTO (2016), loading bays facilitate the efficient pick-up and drop-off of goods from local businesses and they have to be located strategically near shops and markets and away from intersections in order not to add new conflicts (NACTO, 2016). The availability of these parking positions in the city centres can be controlled by the municipalities. For the daily picking up and dropping off activities, they can develop a time schedule, which should be restricted in a specific period of the day. An alternative and more innovative idea is the use of real-time parking control systems, which will be able to indicate available positions to the drivers of the trucks. If the capacity of the loading bays is not enough, then loading zones in urban areas, which are some kilometres away from the city centres, are recommend. Loading zones allow freight vehicle to load or unload goods in designated spaces without blocking through motor vehicles and transit traffic (NACTO, 2016). Cities with many pedestrian zones, like Nafplio, can distribute the goods from the aforementioned zones to the shops/markets by the use of mini freight vehicles, cargo cycles and hand carts.

Regarding the parking management of passenger cars, the replacement of the parking lanes in streets by positions in specific parking areas nearby the city centres is recommended. Although the high availability of parking positions may reduce the illegal

parking events, it could also cause an increase of the number of car trips towards the city centres. Therefore, these new positions have to be connected with a parking cost, which is able to create an additional disutility. Then, more people will be encouraged to cycle or walk in the city centre of Nafplio. Lastly, parking spaces dedicated to the inhabitants of the city centre should be determined by the local municipality.

All the aforementioned designs limit the accessibility of emergency vehicles, like ambulances, fire trucks, etc. To face this negative phenomenon, access on the sidewalks or on the cycle lanes should be provided for the emergency vehicles. This access can be achieved by the construction of large ramps in specific points of the street. In addition, wide sidewalks not with many obstacles are able to facilitate the movements of the emergency vehicles.

Figure 7. Representation of the suggested framework in a pyramid.

Source: Own elaboration, 2018.

4. CONCLUSIONS

The first important conclusion from this research is that the geometrical characteristics of an urban street affect the illegal parking phenomenon. Wide streets with low traffic loads attract illegal parking events. Narrow traffic lanes do not solve the problem of double-parking in Greek roads, yet they increase the number of dangerous overtaking manoeuvres in the opposite direction. As we observed in the results of the driving experiment, the existence of a median island in a street is decisive in the reduction of illegal parking. Potential illegal parking spots usually located in the corners of an intersection, near super/mini markets, bins and in the gaps of the median island alignment. Lastly, freight transport modes, like pick-up vans and trucks increase the illegal parking events since there is not infrastructure dedicated to their operations.

For the reduction of illegal parking, we realized that urban/transport planners should start from the strategic macroscopic level in which the functionality of each road of the network is determined. Traffic calming design measures implemented in just one street may lead to new illegal parking events in other streets within the city network. Besides, some designs such as lane narrowing and median islands, are able to decrease dramatically the potential illegal parking positions. However, in the regenerated urban street, there will be some spots, which may remain "uncovered". Bollards or green infrastructure, like trees, can reduce significantly the existence of them. Regarding the illegal parking events that are related to the freight transport operations, city parking management is the key answer.

Following the aforementioned strategies, municipalities will improve the quality of the urban environment and the accessibility of pedestrians/cyclists. It is true that in Greek streets, like Char. Trikoupi in Nafplio, there is enough available space for double even triple-parking events but not enough for cycle lanes and sidewalks. This paradox proves that there is an opportunity to boost sustainable mobility in Greece by reducing the illegal parking phenomenon in the Greek streets. This opportunity should not be dismissed by the local municipalities.

Illegal parking in Greece is a mass phenomenon and planners should take into account the previous conclusions when they design urban streets with commercial uses. Their designs/plans could change the parking behaviours of drivers in a more efficient and peaceful way than legal enforcement. In this process, statistical models that are able to predict the hotspots in each street design and describe the illegal parking behaviour will contribute significantly. At the same time, the discussion regarding the development of a strategy to mitigate illegal parking in Greek streets should be opened among policy-makers and stakeholders. Lastly, further research has to be conducted regarding the relationship of double-parking events and local market profits.

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