Considerations for an Outbound Direction Bus Lane in an Urban Area

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Abstract

This paper examines the feasibility of inserting a new exclusive bus lane in the public transport network of an urban area. It gives data and a case study example that demonstrate how a bus lane can be evaluated especially how a bus lane of a relatively limited length and of a relatively low bus frequency is worth being implemented – normally - in the case of a one-way street connecting the city center with the suburbs. The approach followed, analyses the findings from a case study in the eastern part of Thessaloniki, the second largest city in Greece with a population of approximately one million inhabitants. The bus lane used as the case study is focused on an outbound direction along a one-way street that connects the city center with the eastern suburbs of the city. This bus lane operates during part of the day according to the traffic conditions and the demand needs along the road corridor where it is located. The analysis includes field measurements of traffic data along the bus lane as well as a questionnaire-based survey that was mainly focused to investigate the quality of the service as perceived by the passengers. The paper shows that such bus lane can be fully justified (though with a reduced number of buses per hour), in terms of the travel time savings that it provides, the uninterrupted bus flow operation that it provides (that minimises the time they spend on the bus) and other characteristics. Parking restrictions and other traffic regulations enforcement is, however, necessary to prevent violations by drivers of private cars and minimise any adverse effects on the bus lane's operation.

1. Introduction

The environmental impact of traffic is a major problem globally. Authorities in the European Union (EU) are trying to reduce its impact through the design and implementation of sustainable urban mobility plans (SUMP). According to the New Urban Agenda, adopted at the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in Quito in 2016, there is a commitment (Goal 36) to "promoting appropriate measures in cities and human settlements that facilitate access for persons with disabilities, on an equal basis with others, to the physical environment of cities, in particular to public spaces, public transport" (United Nations, 2016). Another commitment (Goal 114) refers to "a significant increase in accessible, safe, efficient, affordable and sustainable infrastructure for public transport" among other actions. Clearly, the role of public transport is fundamental to achieve the UN goal of global sustainable urban development (United Nations, 2016).

Although an efficient transport system can reduce traffic congestion (Dirgahavani, 2013), air pollution, energy consumption (Liu et al., 2017), and carbon footprint (Aggarwal & Jain, 2016), a competitive public transport system is also needed to combat congestion (Dahlström, 2002). Accordingly, to reduce reliance on private vehicles, decision-makers attempt to promote environmentally friendly transport modes such as cycling, walking, and public transport systems. Rosenberg (1984) has noted that random movements in which "people form into lanes and as they are picked up by buses or cars, (…) their places may be taken by more people coming out of buildings". Given this microlevel congestion, establishing efficiencies in the smooth operation of urban public transport systems becomes imperative.

To increase public transport usage, priority measures should be implemented to make systems more attractive compared to the use of private cars (Basbas, 2009). The implementation of bus lanes is one efficiency measure to ensure bus priority which makes public transport more competitive (Kim, 2003). Bus lanes can be created at low cost and in a relatively short period of time. They are therefore considered to be a cost-effective way to make public transport more efficient (Deng & Nelson, 2011). Another measure to improve the bus system is to convert the conventional bus service into a Bus Rapid Transit (BRT) system. This option has been successfully implemented in many countries around the world (Vincent, 2010) (Tiwari & Jain, 2010). The operation of bus lanes and BRT systems provides multiple benefits and is therefore crucial for managing the urban environment. It must be mentioned, however, that the successful operation of a bus lane depends on effective enforcement to prevent disruption caused by violations such as unauthorized use or illegally parked vehicles (Basbas, 2007).

Bus lanes come in several types; kerbside unsegregated bus lanes, segregated bus lanes, offset unsegregated bus lanes, median unsegregated bus lanes (Mundy, Trompet, Cohen & Graham, 2017), contra-flow bus lanes (Stamos, Kitis & Basbas 2013), inbound direction and outbound direction bus lanes among others, and are usually characterized by their length. Often, local conditions require a shorter bus lane as the benefits outweigh the cost. This could be due to high levels of congestion in small road segments, for example. Local authorities must then implement bus lanes to enable buses to save valuable time. In many cases, planners must take measures to minimize delays experienced by users of the public transport system, even if these measures only apply specifically to a small area and are not part of a greater network plan.

This paper attempts to demonstrate how such bus lanes can be evaluated and in doing so, to answer the question of whether an outbound direction bus lane of a relatively limited length and of a relatively low bus frequency is worth being implemented in a one-way street connecting the city center with the suburbs. That is, we seek to answer the following question: Do passengers appreciate the small time gains from such arrangements?

Our approach is to analyse the findings from a case study that focused on an outbound direction bus lane implemented along a one-way street in the eastern part of Thessaloniki, the second largest city in Greece with a population of approximately one million inhabitants. Although a metro is currently under construction in the central and eastern part of the city, for the time being buses remain the only available public transport. The bus lane being studied connects the city center with the eastern suburbs of the city and only operates during certain hours of the day. The analysis was based on field counts along the bus lane in question. In addition, a questionnaire-based survey was used to investigate the quality of the service as perceived by the passengers.

2. Methodology

The kerbside unsegregated bus lane under consideration is located on the right side of Georgiou Papandreou Street, a one-way arterial street carrying traffic from the city center to the eastern suburbs. The bus lane is 644m long and operates for 9 hours on weekdays from 12:00 noon to 9:00 pm. There are three bus stops along its entire length. Since most bus lanes in the city are inbound, it was considered interesting to evaluate an outbound bus lane and explore whether such a measure is worth implementing more widely across the city. Another element worth examining, considering its short length, was its performance against other bus lanes in the city. Six bus lines utilize this bus lane (No.5, 6, 8, 30, 33, 78). Three out of the six lines (No.5, 6 and 8) are characterized by high demand. Nevertheless, it should be noted that the bus lane only serves 20 buses per hour; and while there are various recommended thresholds around the world, the Los Angeles Metropolitan Transportation Authority, for example, generally implements bus lanes which serve a minimum of 25 buses during peak hour period (Litman, 2016).

The field data collection occurred during the periods of March-May 2015, November 2015, and September-October 2016. Field work consisted of recordings (directions, number of lanes, horizontal and vertical traffic signs, location of traffic lights, etc.; field counts (bus travel time, passengers' waiting time at a bus stop,

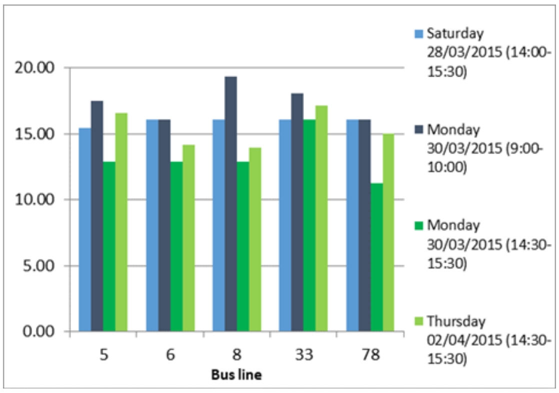

Fig. 1: Average speed (km/h) per bus line

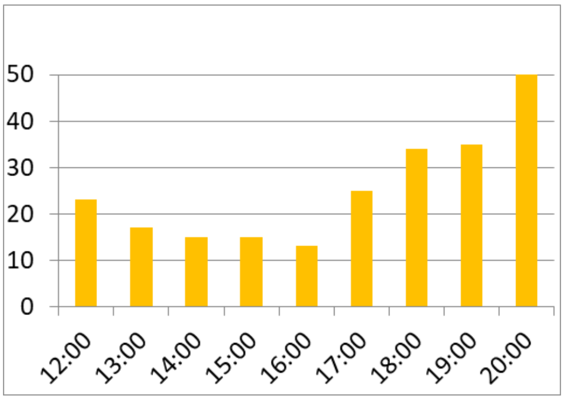

Fig. 2: Time period of illegal parking in the bus lane

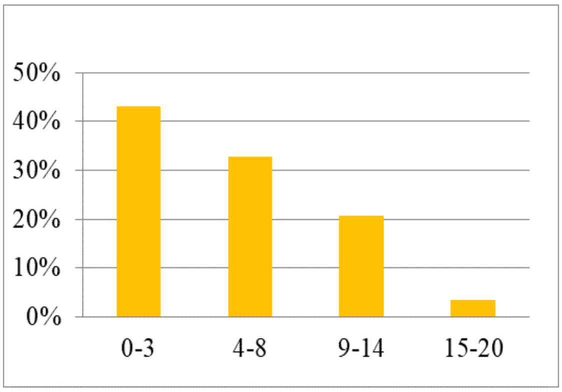

Fig. 3: Distribution of the passengers' observed waiting times (in minutes) at bus stops along the lane

traffic volume, parking supply and demand in the impact area of the bus, illegal parking on the bus lane etc.); and a questionnaire-based survey (300 interviewees) addressed to passengers at one of the three bus stops of the bus lane.

3. Results and Discussion

One of the gravest problems affecting the operational characteristics of the bus lane is illegal parking; especially when considered in relation to average bus speeds. In the impacted area of the bus lane, it was found that demand for parking exceeds supply: whereas demand was estimated to be 2717 parking spaces, the supply was calculated to be only 1727 spaces or approximately 63.5% of demand.

The average speed of the buses using the bus lane is shown in Fig. 1. On average, this speed is just below 15 km/h, which, when compared to the average speed observed in other bus lanes in the city is approximately 12-15% lower. More specifically and taking into consideration the total length of each bus route, the average speed of buses in bus lanes in other parts of the city is as follows: line 5-17.31 km/h, line 6-17.21 km/h, line 8-16.66 km/h, line 33-18.33 km/h and line 78-21.12 km/h (The Organization of Urban Transportation of Thessaloniki, 2016). The relatively higher speed of line 78 can be explained by the fact that it connects the city airport to the intercity bus station, and therefore has special operational characteristics. This detail notwithstanding, it should be noted that, following the implementation and operation of bus lanes in the city of Athens, the average speed of buses using bus lanes increased to 23km/h (Athens Public Transport Organization, 2020).

As regards the number of illegally parked cars along the bus lane, Fig. 2 shows the numbers found during the different hours of the day. Drivers tend to violate the bus lane more during the afternoon period, when they return home, something which was predicted due to the residential character of the area. Also, the passengers' observed waiting time (in minutes) was measured at the bus stops and this is presented in Fig. 3.

Table 1: Descriptive statistics of the bus lane's evaluation by the passengers

Description	Coding	Percentage (%)
Gender	0: Male,1: Female	0: 49, 1: 51
Age	0: 18-24, 1: 25-39, 2: 40-54, 3: 55-64, 4: ≥65	0: 20, 1: 20.7, 2: 27.3, 3: 18.3, 4: 13.7
Area resident	0: Yes, 1: No	0: 52.7, 1: 47.3
Car availability	0: Yes, 1: No	0: 72.3, 1: 27.7
Main user of the private car	0: Yes, 1: No, 2: Non-car holder	0: 42.7, 1: 29.7, 2: 27.7
Frequency of Public Transport use (minutes)	0: 0-10, 1: 11-20, 2: 21-40, 3: 41-60, 4: >60	0: 21.3, 1: 18, 2: 27, 3: 18.3, 4: 15.3
Knowledge of the existence of the bus lane	0: Yes, 1: No	0: 94.3, 1: 5.7
Bus usage in this road axis before the implementation of the bus lane	0: Yes, 1: No, 2: Ignore the existence of bus lane	0: 74.2, 1: 20.4, 2: 5.4
Perceived waiting time at the bus stop (minutes)	0: 0-3, 1: 4-7,2: 8-12, 3: 12-16, 4: >16	0: 4.3, 1: 26.7, 2: 42.3, 3: 18, 4: 8.7
Number of busstops along the on-board travel distance as stated by the interviewees	0: 1-5, 1: 6-10, 2: 11-17, 3: 18-24	0: 20.3, 1: 51.3, 2: 15, 3: 13.3
Improvement in travel time (minutes)	0: 0-3, 1: 4-7, 2: 8-12, 3: >12, 4: No improvement or ignore of existence of the bus lane.	0: 8.7, 1: 16.4, 2: 12.4, 3: 9.4, 4: 53.2
Walking time to the bus stop (minutes)	0: 0-3, 1: 4-6, 2: 7-10, 3: 11-15, 4: >15	0: 43, 1: 34.3, 2: 18, 3: 3.7, 4: 1
Optimum operating hours of the bus lane	0: 12:00-21:00, 1: 9:00-21:00, 2: 6:00-21:00, 3: other	0: 38.1, 1: 23.4, 2: 10, 3: 28.5

Other operational characteristics of the bus lane were gathered through the questionnaire-survey mentioned above. The majority of the interviewees were regular users of the specific bus lines. Most were aged between 40-54 years old (27.3%) and there was an equal distribution between males and females who participated. Over half of the interviewees were residents of the impact area of the bus lane and the majority had been using the specific bus lines before its implementation. The perceived average waiting time at the bus stops was mainly in the range of 8-12 minutes and most passengers used the buses for a length of up to 10 bus stops; meaning that they were on-board for a long period both before and after their bus entered and exited the bus lane section.

Notably, as the passengers' walking times to and from the bus stop was on average less than 10 minutes, this figure was used to determine the impact area of the specific bus lane. Assuming a walking speed of around 5km/h, the impact area can be defined by a buffer zone of 834 m around the bus lane (maximum value). Interestingly, most of the passengers interviewed experienced a total travel time gain following the

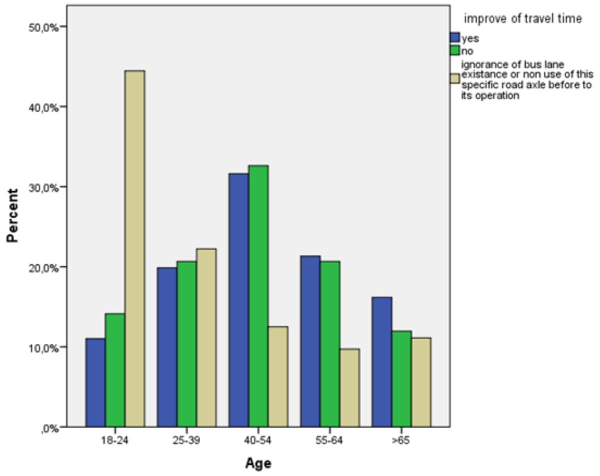

Fig. 4: Correlation between “age” and “travel time improvement after the implementation of the bus lane

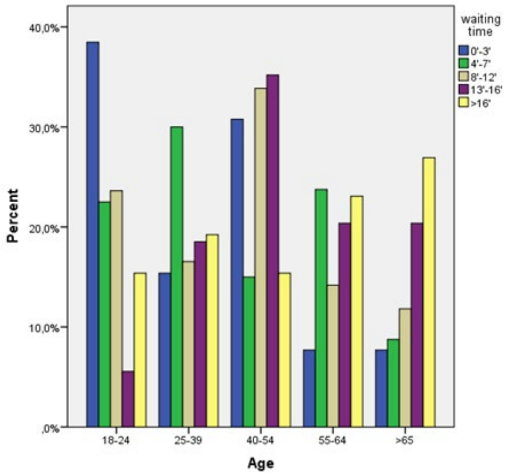

Fig. 5: Correlation between “age” and “passengers waiting time at a bus stop

implementation of the bus lane, with most of them stating time savings of between 4 and 7 minutes. Finally, the operating hours were considered satisfactory by most of the interviewees.

The collective results of the descriptive statistics for the bus lane studied are presented in Table 1.
Inferential statistical analysis was performed using the IBM Statistical Package for the Social Sciences (SPSS) Statistics 23. The first correlation refers to the variables “age” and the variable “time travel improvement after the implementation of the bus lane”. The test was performed using Kruskal-Wallis H test ($p < 0.05$). A strong correlation between those two variables existed. As shown in Fig. 4, when the age of the interviewers increases up to the age of 54 years old, the positive answers for the existence of time travel improvement increases. The next correlation refers to the variables “age” and “passengers waiting time at the bus stop”. The test used was the Spearman Rho test ($p > 0.05$). There is also a strong correlation between those two variables. As shown in Fig. 5, as age increases the perceived waiting time of the passengers waiting at the bus stop increases as well.

The key findings of this specific analysis include the following:

- Passengers' observed waiting time at the bus stop lies between 0-3 minutes. The respective perceived time is much higher.
- The average speed of buses is lower during bus lane operation hours than during the non-operation ones, something which was highly unexpected. This happens because of the bus lane violations made by the drivers of private cars.
- Parking demand exceeds parking supply in the impact area of the bus lane and therefore illegal parking along the bus lane seriously affects its efficiency.
- Perceived waiting time at the bus stop is increased along with the age of the interviewees.
- Perceived travel time in the bus (along the bus lane) is increased along with the age of the interviewees (up to the age of 54 years old).

4. Conclusions

This study provides support for decision-makers concerned with the design and operation of a short, low-cost outbound bus lane. A combination of field-counts and a questionnaire-based survey was used for the purposes of the evaluation.

Although the implementation of the bus lane cannot be fully justified in terms of the number of buses served per hour, it can still help passengers feel good about the travel time savings that it does provide. In general, this outbound bus lane can improve the travel time of the bus lines under certain conditions; parking enforcement is necessary to prevent violations by drivers of private cars that impact the bus lane’s efficacy. That is, in terms of the bus’s operation, the main objective must be to maximise uninterrupted bus flow. In terms of the passengers, perceived time gains are related to their age and the total time they spend on the bus.

The literature regarding bus lanes suggests that they should be of extensive length to justify their creation. The results of this study show, however, that short bus lanes can be beneficial as their implementation offers increased satisfaction to the users, over and above the time savings they provide.

Policy recommendations derived from this research can be summarized as follows:

a. Enforcement is very important since drivers are used to violating the outbound direction bus lane when they realize that bus frequency is not high.

b. Given that the pressure for parking spaces is high in residential areas where outbound bus lanes are mainly implemented, an effective parking policy should be in place before the implementation of the outbound direction bus lane.

c. Passengers must be informed well in advance of the potential benefits of the outbound direction bus (e.g., time reliability) to better appreciate and realize them.

d. Ongoing and constant evaluation of the benefits of the bus lane (especially less-common forms and schemes such as this one) is needed to enable local authorities and operators to make informed decisions about continuing or adjusting the operation of the bus lane.

e. Operating hours must allow for local conditions and the habits of the residents, employees, and visitors of the bus lane impact area so to minimize any negative effects.

One limitation of the research has to do with the fact that the perceived waiting time at bus stops cannot be directly compared to the actual waiting time since the interviewees are not the same passengers as the ones for whom the actual waiting time was observed. In addition, data concerning the performance of the bus system in the study area before the implementation of the bus lane is not available. Therefore, a "before" and "after" evaluation cannot be made. Finally, the use of video recording will be adopted in the next steps of this research to increase the reliability of bus passenger waiting time counts at bus stops

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