Tools for regulation of travel behaviour in small and medium towns

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Abstract. The subject of this paper is to analyse traffic-sociological surveys focused on the attitudes of citizens living in small and medium-sized towns to solve selected traffic problems. The basis for the following research is the data obtained through questionnaire surveys carried out in selected Czech and Moravian towns. Applications are for example a tool for optimal setting of the price for parking in historic centres of towns as well as the suitability of closure of these centres for vehicles or the regulation of entry through its charging.

1. Introduction
There is a fundamental difference between possibilities to solve traffic capacity problems in urban areas and outside them. In interurban areas there are usually much fewer barriers that would disable road modifications to increase capacity e.g. to build additional lanes or adjust intersections. On the other hand the area for transport infrastructure is nearly always limited by surrounding properties in urban areas. This problem is most evident in historical centres of cities and towns, which have been formed in the conditions of the Czech Republic (and Europe in general) since the Middle Ages. It is obvious that the road network in such centres, (designed for horse-drawn carriages and pedestrian traffic), cannot currently meet the demands of modern car traffic. Construction work such as additional lanes is in historical centres impossible, because the medieval core of the city is often protected as an urban conservation area or even as a UNESCO site. Due to the complexity of the construction modifications, the only possible solution is to use measures of traffic-organizational and regulatory character. These include excellent parking management (charged parking, parking zones), urban road toll system or urban access regulations. These measures should be supported by other measures that would drive people away from cars towards more sustainable means of transport such as urban public transport or bicycles. Modern solutions are also implementing intelligent technologies within the so-called Smart City concept.

The research described in this paper focuses on traffic in small and medium towns (from 10,000 to 50,000 inhabitants). Although, according to the data of the Czech Statistical Office, more than 3.25 million inhabitants lived in such settlements at the date January 1, 2017, which represents almost one third of the total population of the Czech Republic, there is still no research that would systematically deal with traffic in this category of settlements.

The International Statistics Conference in 1887 defined different sizes of settlements, based on their population size, as follows:

- country town (under 5,000 inhabitants);
- small town (5,000 to under 20,000 inhabitants);
- middle town (between 20,000 and 100,000 inhabitants);
- city (over 100,000 inhabitants).

This definition could be in the context of Europe and the Czech Republic considered being valid. This paper will further focus on towns with population between 10,000 and 50,000 inhabitants. There are 256 towns in the Czech Republic.

The social changes after year 1989 meant literally also a revolution in transportation. The ever-accelerating lifestyle and perception of the car as an indicator of social status leads to the fact that the movement between even very close destinations is carried out by cars, which negatively affects the road network, especially in the central areas of the cities, where the traffic often reaches the capacity limits. This needless traffic increases the road capacity demands and also causes the high parking pressure in centres of municipalities. Last, but not least, it also affects the environment with exhalations, noise and dust. As the number of cars increases (in 25 years it has more than doubled) the phenomenon of so-called cruising for parking has been becoming more crucial. Cruising for parking happens as drivers circle an area looking for a parking space. This phenomenon is caused by free and under-priced curb parking in locations with high demand for parking. Cruising for parking annoys drivers, increases traffic congestion and air pollution, and wastes gasoline and time. According to German [1] and American [2] research, this particular kind of traffic accounts for 20-30% of all traffic in a town.

In last few years some local authorities realized that transport cannot grow infinitely. Hence they are currently working on sustainable urban mobility plans. Sustainability in transportation, defined along economic, environmental and equity dimensions [3], can be achieved only with sustainable means of transport together with sustainable travel behaviour. Individual car transport is generally not considered to be sustainable whereas public transport and non-motorized transport are.

2. Background research

2.1. Parking in the Czech Republic

On-street parking is generally free of charge in the Czech Republic and is permitted wherever it does not conflict with the provisions mentioned in the law. Unregulated free parking, especially in historic city centres, has proven to be a very inefficient and appropriate solution over the last 25 years. Because of enormous increase of vehicles in the streets, it seems to be necessary to take certain measures to not only regulate, but also to enforce the observance of the parking rules at least in the historic town centres.

Czech legislation allows municipalities to introduce paid on-street parking within parking zones. For purposes of traffic organization, the municipality may define areas where streets or their designated sections can be used as subject to a charge according to pricing regulations. The purpose of introducing paid parking zones is to ensure a more efficient and equitable sharing of public space for parking. Parking zones are divided into resident (long-term parking for residents, institutions and property owners), visitor (short-term parking most often for 3 hours) and mixed (mix of resident and visitor). For easier differentiation of various types of zones there are used different colours – blue for resident, orange for visitor and purple for mixed.

2.2. How to set parking prices?

As it was stated above, free or under-priced curb parking in locations with high demand for parking causes that cruising for parking became quite negative phenomenon. Therefore the price setting is very important. But how should municipalities set on-street parking prices correctly? What criteria should they use? And which approaches are the best to serve parking success without parking excess?

Paid parking is usually introduced to reach various targets – to maximize vehicles turnover (short-term parking only), to maximize the revenue, to make shift from private to public transport or to reach occupancy of 80% to 90%. Experts agree that 10 to 20% of parking spaces (1 or 2 places) in a parking...
block (street) should be vacant for most of the day to avoid cruising for parking. This can be achieved by setting the parking price correctly.

In terms of constancy, the price can be fixed, variable and increasing. Fixed price is the oldest and most basic method of charging. The price is fixed and does not change. The advantage is the simplicity of the system, no additional equipment is needed. Variable price means that price changes in several dimensions. One should be geographic since some places in the city have higher parking demands than others. The price should be different according to the daily time – higher in peak hours, lower in off-peak hours and overnight parking could be free. The price may also vary for different week days since some areas have a higher need for parking on weekdays and other on weekends. A special (and a bit controversial) case is a changing the price in a real time depending on the actual occupancy of parking spaces. Increasing price is often used for off-street parking. The longer a vehicle parks, the higher price is. The purpose is to deter the drivers from long-term parking, to increase vehicle turnover and parking spaces availability. This type of charging is often used at airports.

The publication "On-Street Parking Management: An International Toolkit" [4] shows 11 approaches of price setting for on-street parking. As a best option the author recommends the last stated approach “Occupancy targeting with simple zones”. Price setting in this method is based on a target range for the average on-street parking occupancy (or vacancy) rate. Price zones cover several streets or blocks, but usually not more than about 1 km across. Price is re-set regularly, but usually much less often than monthly. Certain examples have some time-of-day pricing but most have a single price for all priced hours. This method is used in Auckland, Calgary, Rotterdam and Seattle.

2.3. How does on-street parking influences the road capacity?

The results of several studies show a serious correlation between parking regime and the capacity of roads [5] and intersections [6]. As it was described above, one of the targets of parking management could be the maximization of vehicle turnover. This could paradoxically worsen the traffic fluency, as many vehicles maneuver from or to a parking lot. It results into queues and start-stop traffic flow. From this point of view the on-street parking reduces the road capacity. It is important not to set the parking price and time limitation taken out of context but to set them as a part of comprehensive and integrated transport management, which is the only way to sustainability.

2.4. Urban road charging

Due to increasing number of vehicles and impossibility of further increase of capacity of urban roads, some municipalities decided to charge or limit the entrance of cars to their centres. Something similar can also be found in the Czech Republic. The Czech legislation allows municipalities to charge a fee for permission to drive a vehicle to selected locations and parts of cities. The maximum toll is set legally at US$ 9 for each day.

2.4.1. Czech examples.

Some Czech municipalities introduced a form of urban road toll. Entrance permission to the centre can be paid either for one day, usually at the price of US$ 1 (until June 30, 2017 the maximum daily charge, from July 1, 2017 raised to US$ 9) or there is a possibility to prepay the toll for longer period, usually for 30, 90 and 365 days. Charges vary considerably in each municipality. For example, annual charge in Bruntál is US$ 18 while in Český Krumlov it is US$ 327. The driver receives against payment an entry permit, which must be visibly located behind his windscreen all the time the vehicle is in a charged area. Administration of charging including the issue of permits is mostly handled by the Municipal Police. Urban access regulations are introduced for example in these municipalities: Český Krumlov, Znojmo (over 3,5 t), Františkovy Lázně, Pardubice, Malá Úpa, Janské Lázně, Pec pod Sněžkou, Karlovy Vary, Bruntál, Mariánské Lázně.
2.4.2. Foreign examples.
Many foreign municipalities currently have some urban road toll system. For example: Great Britain: London, Durham (43,000 inhabitants); Sweden: Stockholm, Göteborg; Norway: Oslo, Bergen, Trondheim, Haugesund (36,500 inhabitants), Kristiansand, Namsos (13,000 inhabitants), Stavanger, Tonsberg (41,000 inhabitants); Malta: Valletta (6,500 inhabitants); Singapur. It is clear from previous examples that urban road toll is not introduced only in large cities such as London or Singapur, but also in small and medium towns. A slightly different approach is the closure of the historic centre for vehicles either only during high pedestrian traffic or for all day. The ban could stand for all vehicles or just for goods vehicles. Supply is usually allowed only for a limited time, e.g. morning. Such limited access to the town centre is usually accompanied by a significant reduction of parking capacity or prohibition of parking in the whole area. This measure is very popular in Italy. These ZTLs (it. Zona a Traffico Limitato) are not only introduced in larger cities, such as Rome, Brescia, Bologna, Naples or Turin, but also in small and medium towns such as Mantua (48,000 inhabitants), Pinerolo (36,000 inhabitants), Chivasso (26,000 inhabitants), Castellanza (17,000 inhabitants) and Urbino (16,000 inhabitants).

2.4.3. Successful implementations.
In contrast to tolls on motorway where the aim is to raise funds, the aim of urban road toll should always be to reduce the traffic volumes, congestions and other related factors which negatively affect the population and the environment such as emissions and noise. The following examples prove that usage of above described method leads to established target. Research from the city of Durham, England, where the congestion charge scheme was introduced in October 2002 (a few months earlier than in London), shows, that there was a reduction of 85% of traffic volumes in charged area as well as an increase in pedestrian activity by 10% [7]. A similar, though not so significant, drop in traffic volumes was also observed in the Maltese capital of Valletta after the introduction of the charging system from May 2007. The number of vehicles entering the city dropped from 10,000 to 7,900 per day (circa 22%) [8]. After the introduction of London Congestion Charge the number of vehicles entering the charged area decreased by 30%, while the number of taxis, buses and especially bicycles increased. Total traffic within the charged area dropped by 10% [9].

3. Available data
Obtaining data which describe the travel behaviour is in the Czech Republic complicated. While in Germany there is a national survey of travel behaviour called Mobilität in Deutschland (MiD) carried out by the Federal Ministry of Transport every five years, there is no such thing at national level in the Czech Republic. There are several surveys only at the level of cities as a part of their sustainable mobility plans.

In general, travel behaviour surveys are among the worst-performing transport surveys. Unlike many other data in transportation sciences, travel behaviour data cannot be collected without direct interaction with the travellers.

4. Performed surveys
Questionnaire surveys focused on attitudes and opinions of citizens on some problematic transport themes were carried out in selected 17 Czech towns. The towns were: Česká Lípa, Děčín, Hlinsko, Jeseník, Kolín, Kroměříž, Kyjov, Mělník, Náchod, Nymburk, Ostrov, Poděbrady, Přerov, Příbram, Strakonice, Šumperk and Uherské Hradiště. Figure 1 shows the location of the aforementioned towns within the Czech Republic. The smallest town Hlinsko has population of 9,759 inhabitants and the largest town Děčín has population of 49,521 inhabitants.

The survey was conducted in a contact way and responses were recorded into prepared forms. The form contained 8 closed and opened questions of which 7 were focused on traffic and mobility and eight focused on personal information about the interviewee.
The first two questions were focused on parking solution in historic centres and the amount of its possible charging. In first question respondents were asked what the best way to regulate parking in the historic centre of their town in their opinion is. They were given five answers, of which only one should be marked. In the second question the respondents were asked to quote the highest acceptable price for an hour and a day of parking in case of its charging. The third question looked at the respondents’ view of a possible pick-up parking site outside the town centre, including the price of charge and acceptable distance from the centre. Three possible answers were given and only one should be marked. In the fourth question the respondents should mark one of the offered solutions of access regulations of theirs town historic centre for vehicles. The fifth question regards the respondent’s opinion of a possibility of charging the entrance to the historic centre and if so, the acceptable price of 1 entrance and monthly subscription. The sixth question concerned the optimal availability of public transport stops (in metres and minutes, in and outside the centre), its price and acceptable intervals in peak and off-peak hours. Respondents were also questioned about lining urban public transport in context of historic centre. They had to choose whether they prefer lining public transport within the historic centre or on the edge. The seventh question was focused on travel behaviour. The respondents had to state how often they use each mean of transport, what distances they travelled with each mean of transport and to what purpose they travel with each mean of transport. Four means of transport were distinguished in this question: walk, bicycle, public transport and car. Any number of answers could be marked for each mean of transport. The purposes of the trips were offered as follows: employment or school, shopping, offices, visits, culture, recreation and sport. The eighth question identified personal data (gender, age, social status and car and bicycle ownership) about the respondents, which would be key for further research. A total of 1851 completed questionnaires were obtained in 17 towns, on average 100 per town.

5. Preliminary evaluation
Based on obtained data can be stated that citizens prefer to regulate parking in historic centres (see Figure 2).
Most of the respondents opted for paid parking with time limit. Free parking without time limit and paid parking without time limit has the same share. Almost the same share has the option of parking for residents only. The prohibited parking option has the smallest share of all responses. As the highest acceptable price per hour of parking, respondents quoted an average of 80¢. The median of the data file is 60¢. The major value is 45¢. The highest acceptable price per day of parking in the historic centre was evaluated in a similar way. The citizens are willing to pay for parking in historic centre at average of US$ 4.90. Median of the data file is US$ 3.60. The most value is US$ 4.50.

Compared to parking in the city centre, there is a significantly lower willingness to pay for parking outside the centre (see Figure 3).

More than half of respondents said that parking on the outskirts of the city centre should be free of charge without a time limit. 29.2% of citizens are willing to pay for this parking, but it should be without a time limit. Significantly fewer people, namely 19.6%, would take a time limit. The lower willingness to pay for parking at the outskirts of the historic centre is also reflected in the amount that citizens are willing to pay. For an hour of parking it is at average 54¢. The Median of the data file and the most value is 45¢. For the whole day the people are willing to pay an average of US$ 3.20. The Median of the data file is and the most value US$ 2.30.
Regarding the solution of vehicle entrance to the historic centres the answers are not quite explicit (see Figure 4). Almost 60% of respondents want to regulate in some way access to the historic centres for vehicles. However, the ways of regulation are almost balanced.

![Figure 4. Priorities for solution of vehicle entry to the historic centres [author].](image)

People, who responded to the fourth question concerning the solution of vehicle entry to the historic centre in a way that they wish to retain the possibility of access, had to answer an additional question regarding the time limit of the access. Almost 60% of respondents do not wish to limit the access to city centres at any time. On the other hand, only 40% would like to limit the access by time. Forbidden access could be for example in time of high pedestrian traffic.

Interesting is that exactly half of respondents wishes some form of access charging, the other half wishes an access free of charge without any time limits (see Figure 5). Most of those who want a certain charge for access to the centre chose to charge only in selected period. Only 17.5% of respondents would prefer full-day charging.

![Figure 5. Priorities for solution of vehicle entry to the historic centres [author].](image)

As the highest acceptable price for entry to the centre the respondents quoted at average US$ 1. The Median of the data file and the most value is 45 ¢. People are willing to pay at average US$ 15.45 for a month. Median of the data file is US$ 9. The most value is US$ 4.50. There is no clear-cut opinion on the possibility of time subscription. 49% would support this option, 51% would oppose.
If cities are to take various measures to reduce the attractiveness of individual car transport, it is important to offer the people some alternative modes of transport. This could be primarily urban public transport with attractive parameters.

According to the survey, an average journey to the nearest public transport stop in historic centre should take 7.2 minutes. The distance should be up to 368 metres. Outside the historic centre people are generally more willing to walk a longer distance. An average journey to the stop should take 13.2 minutes. The average distance should be 462 metres. There are no uniform urban transport quality standards in the Czech Republic which the observed values can be easily compared with. The walking distance for bus stops is generally set between 400 and 500 metres. The willingness to walk depends not only on the quality and type of public transport, but may also vary for different cities. If public transport does not offer an acceptable interval of service, it cannot be attractive for passengers. The survey showed that people accept 12 minutes at peak hours and 30 minutes in off-peak hours.

The last important parameter of public transport attractiveness is the price. As the highest acceptable price for one way ticket the respondents quoted at average 40 ¢. For a monthly time ticket they would be willing to pay at average $ 8.20. The prices of one way ticket in the towns of surveys vary from 40 ¢ to 70 ¢. Prepaid monthly ticket costs from $ 9 to $ 15. Absolute majority of respondents would prefer lining urban public transport only around the perimeter of the historic city centre, while 36% would prefer lining it through that area.

The interpretation of travel behavior is quite interesting (see Figure 6). An important notice for figure 6 – the total, i. e. 100%, represents the number of acquired questionnaires. It is because the respondents could mark more than one answer for each mean of transport. People use individual car transport mainly for trips to shops, offices and visits. A little bit surprisingly the least used mean of transport is a bicycle. The exception is recreation and sport, for which the bicycle is the most used mean of transport.

Walking is mainly used for shopping trips and for visits. Urban public transport is used for all destinations except recreation and sport.

In term of age structure, all distinguished categories are more or less equally represented in obtained data. In terms of gender the data is balanced as well. Both distinguished means of transport, car and bicycle, is owned by 44% of respondents, 14% of respondents own only a car, 27% of respondents own only a bicycle and 15% of respondents own neither car nor bicycle.
6. Conclusion, direction of further research

Preliminary evaluation, described in previous chapter, discovered some interesting differences between questionnaires collected from different towns and from different socioeconomic categories of respondents. The aim of further research is to reveal correlation between travel behaviour, used means of transport and socio-demographic data.

The conclusion is to create an instrument that could serve as basis to decide the optimum level of parking charges and eventually the access regulation charges, depending on what effect the municipality wants to achieve.

Furthermore, the usage of the optimal means of transport would be investigated depending on the purpose of the journey. On the basis of this municipalities there will be able to take specific measures to support specific means of transport in certain areas or to certain objects of civic amenities.

Last but not least, on the basis of the obtained data, the suitability of closure of historic centres in small and medium towns for vehicles will be analysed in comparison with the mere regulation of it by measures such as introducing charged parking or even charged access.

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