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Demand forecast for parking spaces and parking areas in Olomouc

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Abstract: The study focuses on the issue of parking in Olomouc and in two localities of this city: the Foerstrova and Hodolany areas. In the first part of the manuscript, general data, approaches, and methods regarding the process of designing parking areas as well as the demand forecasting for parking spaces, when explaining the principles of regression analysis itself, are presented. The second part of the article, which represents a crucial section of the conducted research study, discusses the very analysis of the parking situation and parking demand forecasting for both areas being investigated. As for major findings, an increasing trend related to the number of cars per 1,000 inhabitants in Olomouc can be observed. Furthermore, following the performed analyses and forecasts, it can be stated that there is a parking deficiency issue, which needs to be addressed in the future.

Keywords: parking management, parking areas, demand forecast

1 Introduction

We know from everyday experience that there are more than four million drivers in the Czech Republic, how difficult it is to find a free parking space in cities. The car is still more popular than other alternative means of individual transport or public transport in terms of daily mobility [1].

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In the Czech Republic, the purchasing power of the population has been growing for a long time while an increasing number of cars are being produced in the world. These facts lead to a long-term decline in the level of automobilisation in the Czech Republic. This phenomenon leads, especially in large cities, to increasing demand for parking spaces and areas. The resulting shortage of parking spaces can be resolved by increasing the number of parking spaces or by applying parking management measures [1].

A successful parking policy must consider the needs of residents, ensure a quality offer of different modes of transport, inform well about the benefits of parking management and measures taken, and cultivate public space and use it for functions other than transport [2].

The introduction of measures resulting from parking management means that everyone has the opportunity to park without looking for a long parking space. It considers the needs of businesses, shops and services (supply, shutdown), etc. [2].

Transport at rest is one of the most serious problems stemming from the accelerating growth of motorization, and in particular passenger carization, to which the transport infrastructure is not enough to adapt. Transport at peace includes parking and garage parking [1].

Standard applies to the design of new parking and parking areas, changes to completed buildings, changes in the use of buildings and the like for renovations (especially for passenger cars, as well as for trucks, buses, motorcycles, and bicycles), and appropriately applies to other categories of vehicles (construction machinery, etc.) [3,4].

“Standard applies to the design of local roads and publicly accessible purpose-built roads, both for new constructions and reconstructions, in built-up and undeveloped areas of municipalities; applies to transit sections of roads in the built-up area of municipalities, including buildable areas and zoning reserves defined in zoning plans. It also applies to the connection of traffic areas and traffic facilities.” [3].

Parking management is a set of tools and measures that support more efficient use of parking spaces, help

define the causes of many traffic problems, and achieve a greater variety of modes of transport used and improved living conditions. Parking management is part of mobility management [2].

By regression, we mean systematic changes of one quantity during changes of other quantities and the description of these changes by mathematical functions. We, therefore, try to balance the observed values with a suitable mathematical function. The whole construction of the regression model will have several phases. Which come from sources [5,6].

2 Approaches to parking area design

The first section deals with approaches to the parking issues in terms of parking area designing.

2.1 Standard ČSN 73 6056 parking spaces and parking areas for road vehicles

This standard applies to designing new parking spaces and areas, alterations to completed buildings, usage changes of buildings and similarly to refurbishments (mainly for cars, but also for trucks, buses, motorcycles, and bicycles) [7].

2.2 Standard ČSN 73 6110 local roads designing

This standard applies to designing local roads and publicly accessible special purpose roads, both for new buildings and conversions, in the built-up and non-built-up areas of municipalities; it applies to through sections of roads in the built-up area of municipalities, including built-up areas and zoning reserves defined in the zoning plans [8].

2.3 Parking management

Parking management represents a set of tools and measures that support more efficient use of parking areas; they help to define the reasons for most traffic troubles; and they help to achieve a wider range of used means of transport and improvement of life conditions. Parking management is a part of mobility management [9,10].

3 Demand forecasting using regression analysis

The section deals with regression analysis that helps us to predict the values of variable Y from the values of variable X with certain accuracy.

3.1 Regression

Regression is understood as the systematic change of one variable with changes in other variables and the description of these changes by mathematical functions [5].

3.2 Dependence of phenomena and variables

The functional dependence of variable Y on variable X as a formula $y = f(x)$, where the values of variable X are definitely assigned to values Y [5,11].

3.3 Dependent variable

A variable in a regression model whose behaviour we are trying to explain, or to describe by a mathematical curve. This variable appears in the model as a result of the action of so-called dependent variables.

3.4 Independent variables

Variables in a regression model whose behaviour explains the behaviour of the dependent variable. These variables act in the model as causal variables, that is, as a result of their change, the dependent variable changes.

3.5 General linear model

A general linear model is a model of the formula [12]:

$$Y = X\beta + e \tag{1}$$

where Y is a random vector n of values for dependent variables, X is a matrix of given values for independent variables, β is unknown parameter vector p, and e is random error vector n.

4 Demand forecasting for parking areas

In this section, previous presumptions for parking demand forecast in Olomouc will be applied [13].

The number of vehicles per 1,000 inhabitants has been increasing on a long-term basis. The following chart shows the prediction of this trend up to 2025.

According to the equation following Figure 1, it is possible to carry out a more accurate prediction of the assumed number of vehicles in Olomouc even for a longer period. When we substitute into the equation to calculate the value of vehicles number per 1,000 inhabitants in 2025, it is necessary to substitute "x" with the value of 15. The forecast for Olomouc for the year 2025 is 619 cars per 1,000 inhabitants.

4.1 Forecast for the Foerstrova area

The monitored area is located in the Nová Ulice urban area. Most of the streets in this area were built during the 1970s–1980s. The number of parking spaces, according to witnesses, was fully sufficient at that time. The area is predominantly a housing area with blocks of flats; there are few businesses and, therefore, few employment opportunities. There is a post office, a health centre and two pharmacies, shops, as well as several other smaller shops and service establishments. There is also a building in the area that is now used for renting office premises. This building has its own parking spaces inside the building. The location is well connected to its surroundings by bus transport, with a tram stop easily accessible on foot [14,15] (Figure 2).

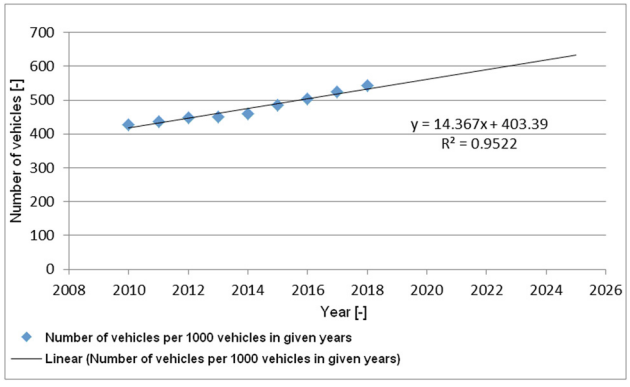

Figure 1: Automobilisation forecast in Olomouc since 2025.

4.1.1 Parking analysis in the Foerstrova area

Using the data available, it is possible to get the necessary data to calculate the present offer of parking spaces. The offer of parking spaces in this area can be calculated when we add up average values of properly parked vehicles and unoccupied parking spaces: 414.1 + 16.4 = 430.5. It can be stated that this area provides 430.5 parking spaces on average.

4.1.2 Demand forecast in the Foerstrova area for 1 year

Figure 3 shows the demand for parking after 1 year since the research started.

Figure 3 shows a regression equation that can be used to make predictions for the next period:

$$y = 0.121x + 457.57. \quad (2)$$

If we want to get a forecast for 1 year, it is necessary to substitute x with 365 in equation (2). The result is $y = 501.735$. This value expresses the future demand for parking spaces in 1 year.

The unmet demand for parking spaces in the area in 1 year is calculated by subtracting the actual parking spaces offer from the parking spaces demand: 501.7 – 430.5 = 71.2. The resulting value expresses the unmet parking spaces demand in the area in 1 year [9,17].

4.1.3 Demand forecast in the Foerstrova area for 5 years

Figure 4 shows the demand for parking after 5 years since the research started.

To obtain the forecast for a period of 5 years, x must be substituted with the value of 1825 in equation (3). The result equals $y = 678.395$. This value expresses the demand for parking spaces in 5 years' time.

The unmet demand for parking spaces in the area in 5 years' time is calculated by subtracting the actual parking spaces offer from the parking spaces demand: 678.4–430.5 = 274.9. The resulting value expresses the unmet parking spaces demand in the area in 5 years' time [9,13].

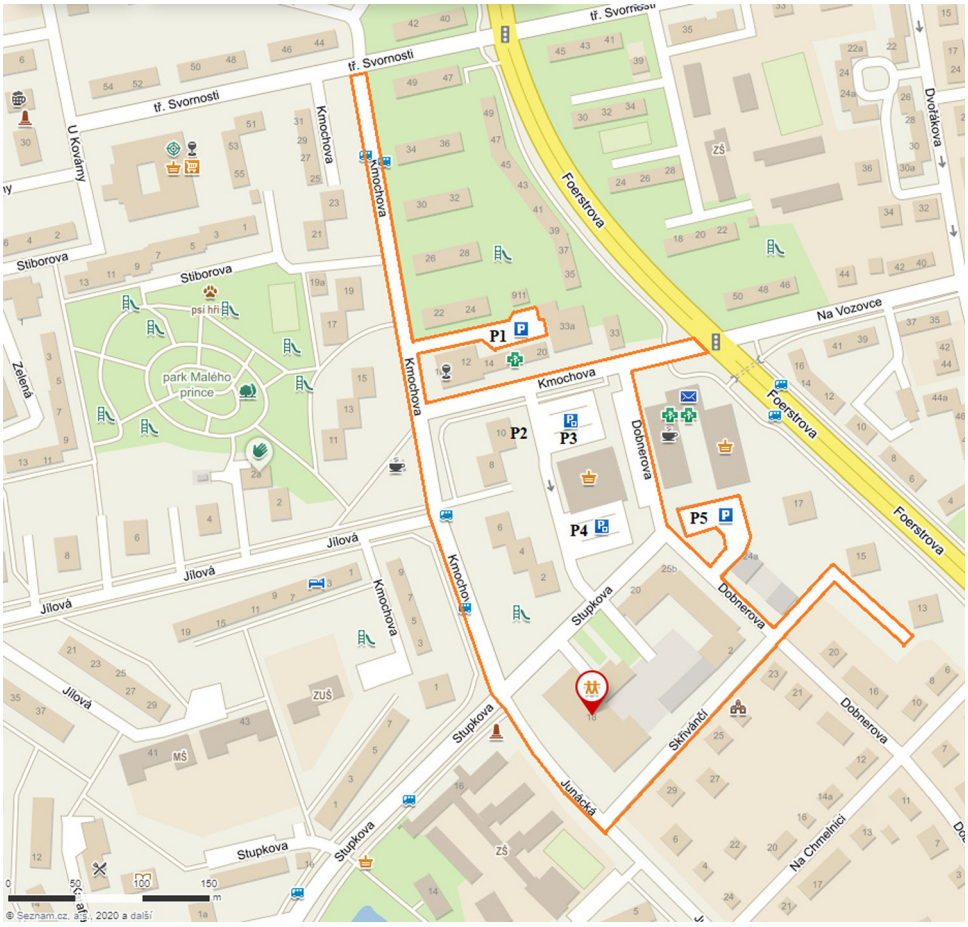

Figure 2: Map of the monitored Foerstrova area [16].

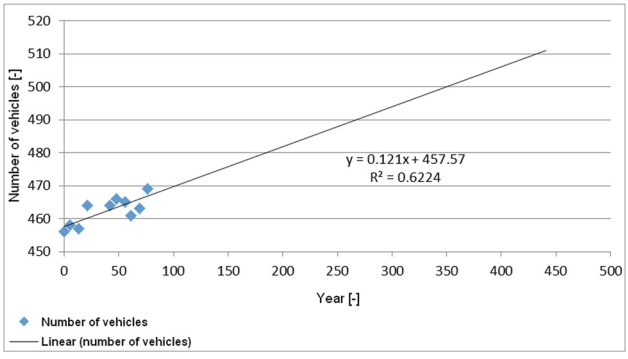

Figure 3: Parking demand forecast for 1 year.

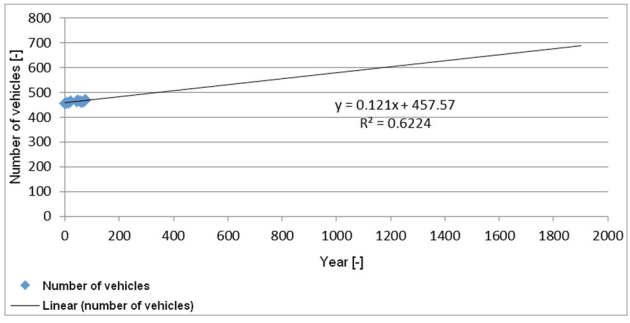

Figure 4: Parking demand forecast for 5 years.

4.2 Forecast for the Hodolany area

The monitored area is located in the Hodolany district. The area was originally a separate village, which has been absorbed by the surrounding town due to urbanisation. Therefore, the predominant building type is rural with narrow streets and terraced houses. There is a pharmacy, two convenience stores, an industrial laundry, a school and nursery, a church and several businesses with their own parking spaces (Figure 5).

4.2.1 Parking analysis in the Hodolany area

Using the data available, it is possible to get necessary data to calculate the present offer of parking spaces in the Hodolany area. The offer of parking spaces in this area

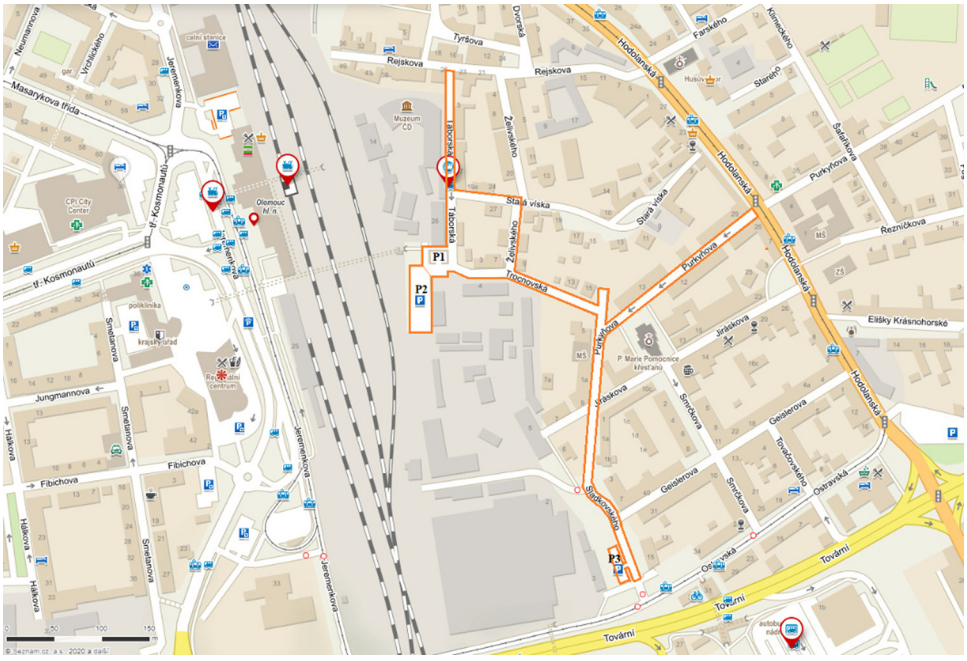

Figure 5: Map of the monitored area Hodolany [18].

can be calculated when we add up average values of properly parked vehicles and unoccupied parking spaces: 223.9 + 13.9 = 237.8. It can be stated that this area provides 237.8 parking spaces on average.

4.2.2 Demand forecast in the area of Hodolany for 1 year

Figure 6 shows the parking demand after 1 year since the beginning of the research.

Figure 6 shows a regression equation that can be used to make predictions for the next period:

$$y = 0.0872x + 256.59. \quad (3)$$

To obtain the forecast for 1 year period, x must be substituted with the value of 365 in equation (3). The result equals value y = 288.418. This value expresses the demand for parking spaces in 1 year.

The unmet demand for parking spaces in the area in 1 year is calculated by subtracting the actual parking spaces offer from the parking spaces demand: 288.4 – 237.8 = 50.6. The resulting value expresses the unmet parking spaces demand in the area in 1 year [13,19].

4.2.3 Demand forecast in the area of Hodolany for 5 years

Figure 7 shows the parking demand after 5 years since the beginning of the research.

If we want to get a prediction for 5 years' time, it is necessary to substitute x with 1,825 in equation (3). The

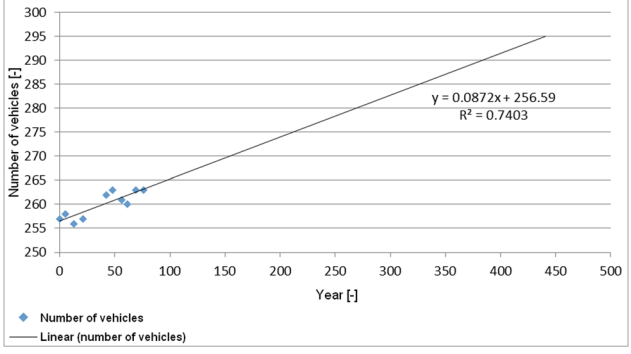

Figure 6: Parking demand forecast for 1 year.

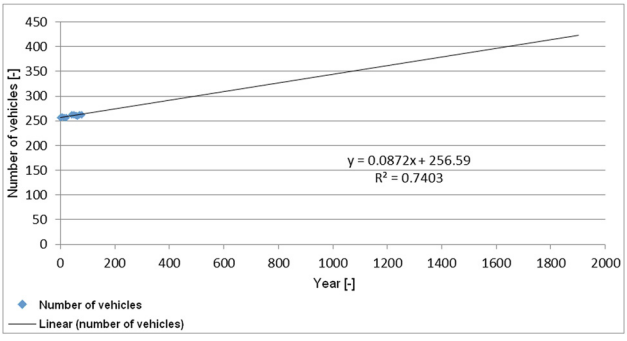

Figure 7: Parking demand forecast for 5 years.

result equals value y = 415.73. This value expresses the future demand for parking spaces in 5 years' time.

The unmet parking spaces demand in the area in 5 years' time is calculated when we subtract the actual parking spaces offer from the parking spaces demand: 415.7 – 237.8 = 177.9. The resulting value expresses the unmet parking spaces demand in the area in 5 years' time [20].

5 Conclusion

In the first part, the theoretical background for parking of road vehicles was elaborated. The issues of standards ČSN 73 6056 and ČSN 73 6110, which deal with the creation of parking areas, were explained. In addition, this section presented parking management issues. Finally, the principles of regression analysis were explained.

In the second part of the study, an analysis of the city in terms of parking was carried out. As a result, it was found that the number of cars per 1,000 inhabitants is increasing in Olomouc and that this trend can be expected in the future, with the estimated number of cars per 1,000 inhabitants in Olomouc in 2025 being 619. A parking analysis was done for the Foerstrova area. A regression analysis was then used to forecast the demand for parking spaces for a period of 1 year and 5 years, and it was found that the number of parking spaces in the area is already insufficient at present and that in 5 years' time, there will be a shortfall of 275 parking spaces in the area. A parking analysis was also carried out for the Hodolany area. A regression analysis was then used to forecast the demand for parking spaces for 1 year and 5 years, and it was found that the number of parking spaces in the area is already insufficient and that in 5 years' time the area will lack 178 parking spaces.

The analyses and forecasts for both areas indicated that there is a parking shortage problem and it is going to get worse in both areas and it needs to be resolved.

Conflict of interest: Authors state no conflict of interest.

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