THE PARKING GENERATION AT SUPERMARKETS AND ITS INFLUENCE ON PLANNING

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Abstract

The paper is focused on a parking generation in "full-assortment shops" usually called supermarkets. It tries to address an issue taken as dogma in retail i.e. „no parking, no business". The paper presents results of traffic and questionnaire surveys carried out at 31 supermarkets with the identical assortment and similar gross building square (GBS). All traffic surveys were organised on Fridays at peak hours. The aim of the concurrent questionnaire survey was to find out data about customers' origin-destination distances, used traffic mode and other information. The results obtained show low strength linear correlation R^2 for dependence of parking lots' size and capacity on GBS. Dependence with higher strength was established among the number of parking spaces and parking lots' square (R^2=0.6822); i.e. parking lots are rationally explored, but differences can be seen in area types. Intensities of in/out coming cars ranged from 175 to 575 per three hours (I_{3H}); maximal one hour intensity (I_H) ranged from 66 to 215 in all supermarkets. Dependence of both the intensities on population density or intensity of the nearest important road was determined and was assessed by R^2 with a low strength. Supermarkets' parking generation rates and their dependence on 100m^2 of GBS with the R^2 = 0.0039 presenting low strength. There were determined parking turnovers and parking turnover's dependence on number of parking spaces for different area types. The final results did not prove dependence of financial annual turnover on the offer of parking capacity. In conclusion, parking generation is influenced by many other factors – the question remains if the spatial planning process is able to take into account all these factors with appropriate measures in time.

Key words: parking generation, parking turnover, supermarkets' financial turnover.

INTRODUCTION

Spatial planning of parking lots surrounding retail facilities encounters two main issues. These issues are: what parking capacity (e.g. lot's square and number of parking spaces) would sufficiently supply a supermarket's need (or retail area, shopping mall etc.) and what type of parking policy should take place there (i.e. paid parking or time restriction and some others). It is possible to say that especially among shop owners, retail managers and branch organisations, there is a widespread belief that parking plays a fundamental role in the performance of shopping. Local authorities are under the pressure to increase parking capacity or reduce parking fees around shopping areas and even in the downtown. It is evident that to determine parking capacity is the ultimate goal.

The procedure to determine area parking demand (not only retail areas but with every various functions) is generally carried out in these three basic ways. The first one is the usage of standards (e.g. ČSN EN 73 6056, ČSN 73 6110), the second one is through zoning regulations (e.g. PSP, 2014, Building codes etc.) and the third one is modelling (BOSSERHOFF, 2009; CHENG TIEXINA ET AL., 2012; MARTALOS, 2013 ETC.). The principle of all these accesses is based on squares called e.g. gross building square (GBS), gross floor area (GFA) or sale floor surface etc. Consequently different square quantities (square units) are taken as the generator of the number of customers, of students, of clerks, of transit frequency, of passenger cars per time (trip generation rate), parking generation rate and other information according to experience supported by traffic surveys. The results are often further modified and particularised by different influences (coefficients) e.g. areas type (urban, suburban, rural) of shopping, density of population, transit accessibility, offer of different goods, discount actions, the growth factor of motor vehicles etc. SHOUP (1999) has discussed these procedures and has pointed out several discrepancies in e.g. number, place and duration of the traffic surveys carried out, the relation validity between generation rates and GFA and accepting conclusions based on these presumptions. He proposed to plan spatial development with the support of pricing of parking lots ("pricing of curb parking rather than requiring off-street parking will improve urban design", but "cities should establish Parking Benefit Districts" as well).

MINGARDO (2012) reviewed the literature on the relationship between parking and retail and divided the topic into two groups: those suggesting that parking is important for retail activities and those arguing the opposite. The first group's authors perceive the topic thus: "'the consumer choice of supermarkets is influenced by store characteristics and by parking characteristics" (WAERDEN VAN DER ET AL., 1998), "retailers' perception that the provision of parking facilities for shoppers is positively related to the vitality of retail centres" (STILL - SIMMONDS, 2000) or 40% drivers find parking "too expensive and too difficult to find" (RAC FOUNDATION, 2006). The second group's authors object that retailers have the wrong perception of the modal split of their customers, they overestimate the percentage of their customers using the car to reach the shop, which in reality is much lower (SUSTRANS, 2006). Further, authors are interested in the use of other transport modes – frequency of shopping by cyclists, pedestrians in comparison with drivers (VERHOEK, 2000; MINGARDO, 2009). TELLER (2008) found that retail tenant mix and atmosphere has the highest relative importance. He concludes also that parking does not seem ''to provide potential to change the attractiveness of the investigated agglomeration factors". MINGARDO (2012) concluded: "The main driver of the retail sector is the dogma that parking plays a crucial role in the success of shopping areas, often referred to with the motto 'no parking, no business'. This study shows that this dogma is mostly incorrect." and accordingly four implications for policy were recommended.

The second issue linked with the parking policy can also have significant spill-over effects on urban areas. For example, under-priced on-street parking (during peak periods) can exacerbate urban traffic congestion by inducing drivers to cruise for an inexpensive parking space. These phenomena have been modelled by ROWSE (1999), ARNOTT AND INCI (2006) AND SHOUP (2006). The topic is bound with curb-side parking within shopping areas' surroundings even when the private sector provides parking lots or garage parking (ARNOTT ET AL., 2015). HYMEL (2014) found that in both saturated and non-saturated parking environments, the evidence does not suggest that parking meters (fees) help increase retail sales, which hinge importantly on customer flow. But in comments on the study's validity he remarks that specific findings are somewhat limited: the results are based on observations from one location, and the discontinuity in enforcement occurs at only two points in time. Hence, the estimates can only be interpreted as local effects specific to two times of day at Belmont Shore. The complete literature overview of the economics of parking was published by INCI (2015).

The aims of this paper is to assess and evaluate under different area conditions (urban, suburban, rural) mainly these hypotheses: the dependence of number supermarket's parking places on GBS per 100 m^2, the dependence of parking generation rate characterised by passenger car intensities (I_{3H}, I_H) on a density of surrounding population, the dependence of these intensities (I_{3H}, I_H) on the intensity of the nearest important road, the dependence of higher number of parking places on a higher parking turnover and the dependence of the supermarket's financial turnover on the number of offered parking places per 100 m^2 GBS. Other obtained information is discussed there to specify their influence on the conclusion.

MATERIALS AND METHODS

31 supermarkets with free (not priced) parking lots were chosen, located throughout the Czech Republic. Every supermarket's offer i.e. food, drugstore and other basic consumer goods and management is identical in time therefore all shops belong to one retail chain. The supermarkets were located in Prague- city with app. 1.3 million inhabitants (10) and Prague's suburb (8). Other supermarkets (13) were located in municipalities and smaller cities with the number of inhabitants from 3,000 to 170,000. The mean number of inhabitants was 23,207. The density of population in Prague was taken from ČSÚ (2015) data. For the purpose of this study the density of city population was determined within a radius of 5 km from the supermarket's location i.e. a territory with a square 78.5 km^2 was taken into account. Population data about villages in this circle were derived from ČSU (2015), as well.

The traffic surveys were carried out on Friday from 3 to 6 p.m., in October 2014 and April 2015. They were carried out three times at every supermarket. The decision about the limited number of surveys is linked with the fact that half of the reported parking data by ITE are based on four or fewer surveys (SHOUP, 1999) – assuming that this number of surveys should provide similar results. The number of all incoming and outgoing vehicles was recorded at quarter of an hour intervals, together with vehicles' occupancy and vehicle types arriving at parking lots. The time of Friday's afternoon peak hours was chosen with regard to preliminary surveillance that proved the highest attendance of customers at this time and in this type of supermarkets.

Parking turnover is the rate of use of a facility. It is determined by dividing the number of available parking spaces into the number of vehicles parked in those spaces in a stated time period (SHOUP, 1999; KUMAR, 2016). Data processing of parking turnover per maximal hour intensity or per three hours intensity of passenger vehicles was determined i.e.

$$\tau = \frac{I_H}{P} \qquad (1)$$

where: τ - *parking turnover (1)*

I_H – *max. intensity of vehicles per 1 hour* [I_{3H} *per 3 hours] (number of cars)*

P – parking capacity or total number of parking lots (number of lots)

The maximal hour intensity of passenger vehicles was determined by cumulative means when the following four quarters of the hour during the survey were taken into account (sum up) and the maximal value selected. The presented three hour intensity is the arithmetical average of three traffic surveys.

Concurrent with the traffic survey, the questionnaire survey was carried out in the supermarkets. The customers were asked questions aimed to specify in more detail the surveyed topic e.g. the type of used transport (walk, cycling, public transit, passenger car), the distance of their journey to supermarkets i.e. origin-destination (OD), the main motivation for using alternative transport mode and others. The total number of incoming customers to the supermarket was recorded as well for the whole duration of the traffic survey.

It was necessary to determine the gross squares of buildings and the square of the whole parking. These squares were determined with the support of application ÚZK (2015). The capacity of the parking infrastructure (max. number of parking vehicles or total number of parking lots) was established on the spot.

The traffic surveys and further necessary data consist of further information such as the 24 hour intensity of passenger cars on the nearest important road (NIR) (source CSD, 2010), the accessibility and quality of public transit, the opportunities for parking in near surroundings (curb-side parking), competing nearby supermarkets etc. The owner of this retail chain provided information about yearly turnover of several supermarkets in relative values for the purpose of this study.

It is necessary to remark that coefficients of determination are used in other parts of this paper to point out none existing dependence. Their value is nearing to zero and it has not any practical meaning. It is supposed that the usage of other statistical methods would not bring any different conclusion under these specific and real conditions.

RESULTS AND DISCUSSION

The results of the questionnaire survey confirmed some expected presumptions but it is necessary to remark that the supermarkets' surrounding conditions differed significantly (e.g. one supermarket was accessible by passenger car only, the other one had good transit nearby etc.). That is why it is questionable to accept these results without objections as a generalisation of customers' behaviour. The total number of customers addressed was 263; 87% of them used passenger cars; transit was used by 4%; 8% used bicycles or walked. Customers came from OD distance: 35% up to 5 km; 67% up to 10 km (includes 5 km OD as well). The main reasons for using transit, bicycles or walk were as follows: I do not have a car (driving licence) 23%; good accessibility 32%; shortest way (in time) to get there 13%; I do not want to use a car 19% and walking is good for health 13%. Customers were asked to guess their time spent by shopping: 25% up to 10 minutes; 40% 10-20 minutes; 28% 20-30 minutes. It means that 93% of customers perceive half an hour as sufficient for their shopping in this type of shop. This shopping time corresponds with parking turnover (Fig. 6) where the majority of parking places were occupied app. twice.

The gross building squares (GBS) and parking squares (PS) were determined in all surveyed supermarkets i.e. GBS ranged from 1195 to 2488 m^2 (average GBS 1745 m^2), PS ranged from 1246 to 5802 m^2 (mean PS 3443 m^2). The smallest PS is the one exceptional case when the supermarket had a limited surrounding space and its parking lot was built on its building's roof. The PS's dependence on GBS was assessed; the coefficient of determination R^2 for linear correlation is equal to 0.3355.

The expected dependence with higher strength was established among the parking capacity (number of parking spaces) and PS that is proved by linear correlation R^2=0.6822; this value shows that parking lots are rationally explored. The total square of parking spaces covers on average 40% of PS (lowest 24%); it means that the layout of parking spaces is designed very similarly. The layout is done by standards (the space's dimensions), by shape of plot and by the designer's efforts to maximize number of parking spaces. Fig.1 shows dependence of PS on GBS according to their location. It is evident that the highest deviation occurs in the suburban area (standard deviation = 1243.2). Coefficient of determination R^2 = 0.5074 would be even higher (0.6793) without „roof parking" in Prague.

The number of parking spaces per 100 m^2 of GBS was determined to be from 1.93 to 8.29. The dependence of number parking places per 100 m^2 of GBS on total GBS is presented in Fig. 2 - where R^2 of 0.0022 shows low strength i.e. supermarkets with larger buildings do not have more parking places per 100 m^2 of GBS.

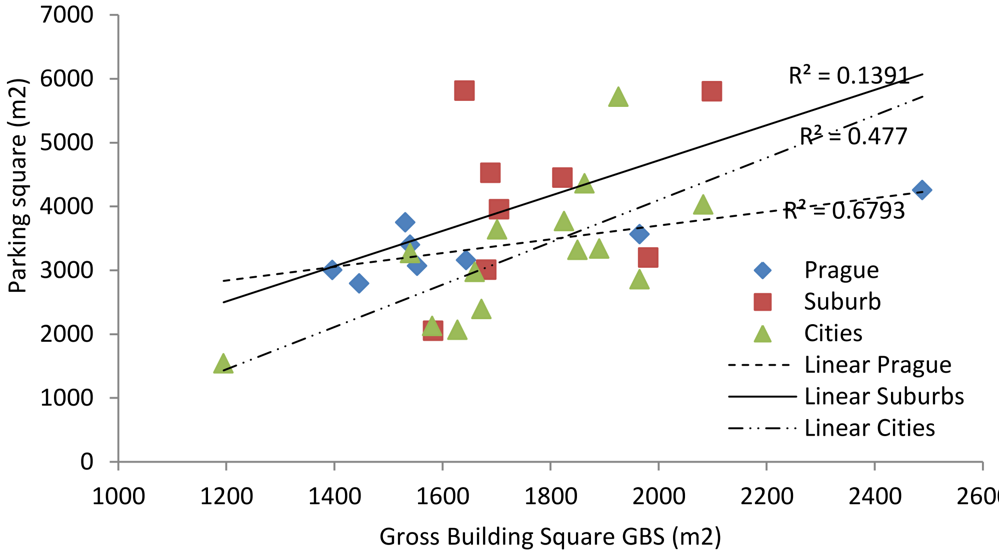

Fig. 1. – Parking squares' dependence on GBS and area

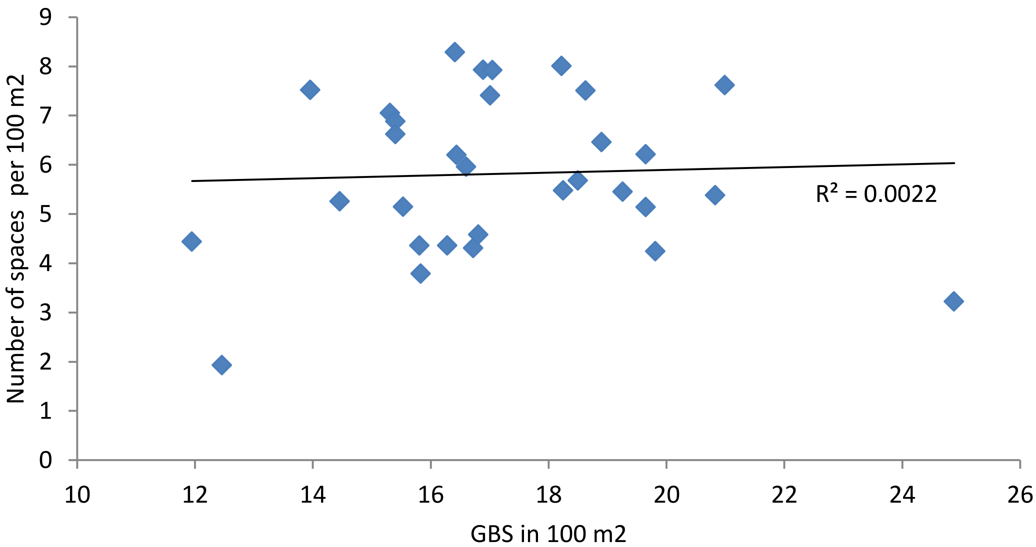

Fig. 2. – Number of parking spaces' dependence on 100 m^2 of GBS

The three traffic surveys carried out recorded the number of passenger cars (out/incoming parking lot) and their occupancy. The mean number of incoming passenger cars (I_{3H}) ranged from 175 to 575 during three hours (the exception was only 46 cars on the "roof parking lot") for all supermarkets. Maximal one hour intensity (I_H) was determined by 15 minute intervals and ranged from 66 to 215 for all supermarkets. 62% of supermarkets had I_H during time interval from 4 p.m. to 5:30 p.m. – this confirms an assumption for

Friday's peak hours. Only 10% of supermarkets had I_H in the last hour of survey. The average occupancy of passenger cars was determined as 1.5 persons per car (range from 1.29 to 2).

The dependence of intensities (I_{3H}, I_H) on density of population was determined. Both dependencies on population density was assessed with low strength, I_{3H} had R^2 = 0.0005 and I_H R^2=0.0021 for all supermarkets. Dependence of intensity I_{3H} on density of population and different areas proves low strength by R^2 (Fig. 3).

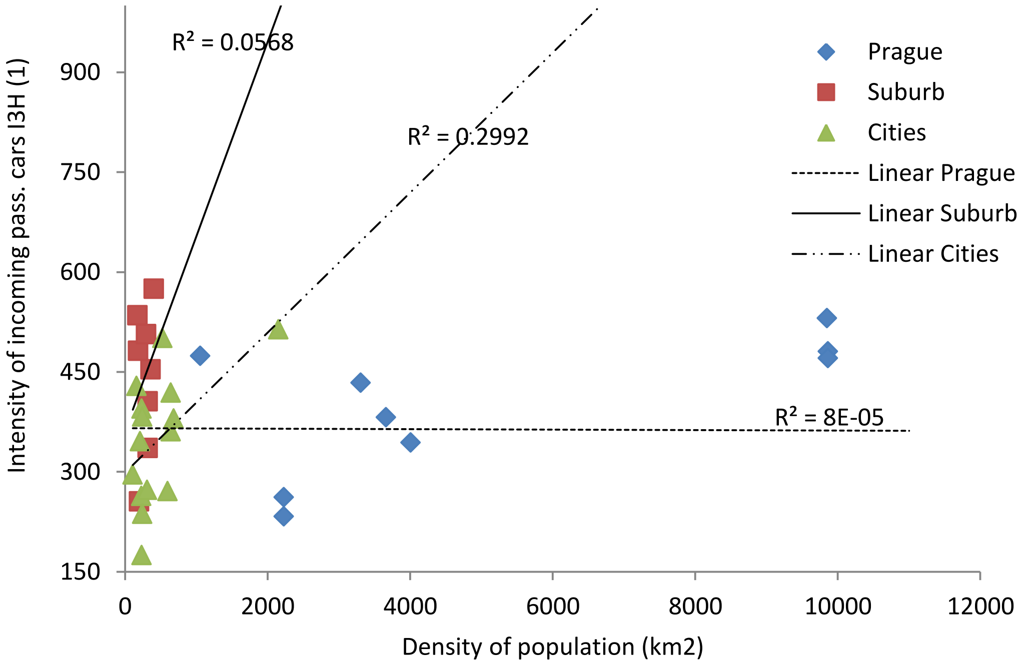

Fig. 3. – Dependence of I_{3H} on density of population

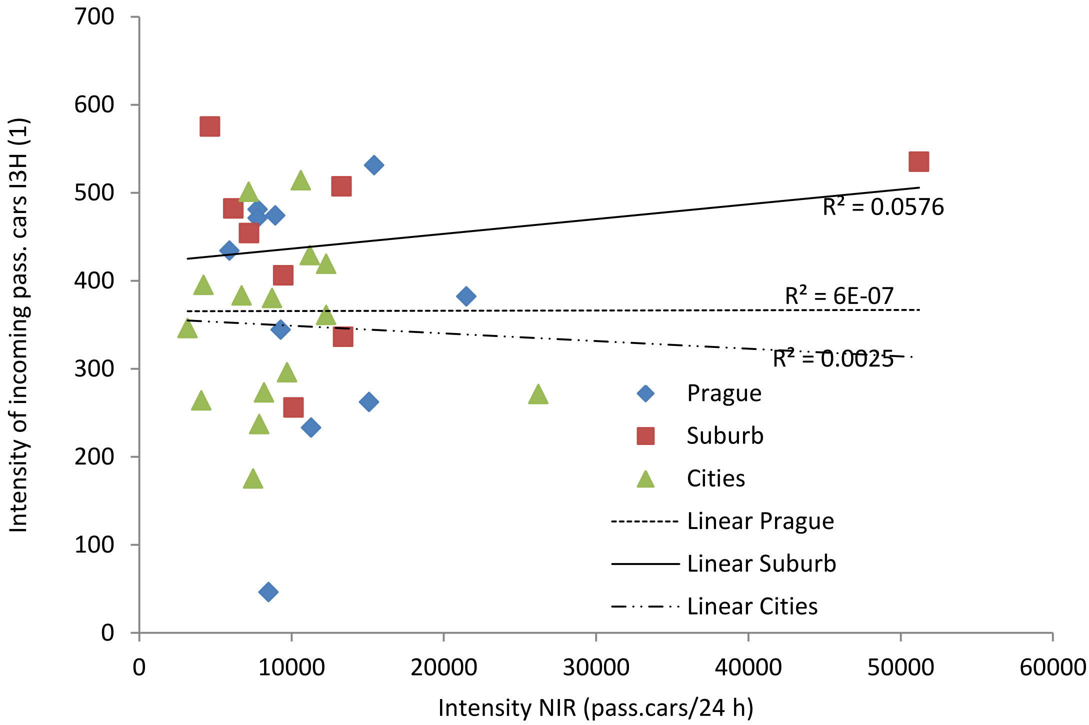

Fig. 4. – Dependence of I_{3H} on intensity of NIR

Dependence of intensities (I_{3H}, I_H) on intensity of passenger cars on the nearest important road (NIR) was determined. Both dependencies on NIR was assessed as low strength, I_{3H} had R^2 = 0.0218 and I_H R^2=0.019 for all supermarkets. Dependence of intensity I_{3H} on density of population and different areas proves low strength by R^2 (Fig. 4).

The parking generation rate defined as the peak parking occupancy (THE INSTITUTE OF TRANSPORTATION ENGINEERS, 1987,a) was determined for I_{3H} or I_H. The peak of occupancy was presumed for maximal one hour intensity (or three hours intensity was taken into account as well). The parking generation rate was stated in relation to the number of parking spaces per 100 m^2 of GBS. In other words, it states how many cars replaced themselves on one parking place during one hour or three hours i.e. how many parking spaces were theoretically needed for 100 m2 of GBS. Supermarkets' parking generation rates and their dependence on 100 m^2 GBS are shown on Fig. **1**. – the R^2 = 0.0039 presents low strength. Similar research was done with I_{3H} with the result of R^2 = 0.0174. The values of parking generation rates for I_H are in the range from 0.65 to 2.79 (I_{3H} from 1.72 to 7.47).

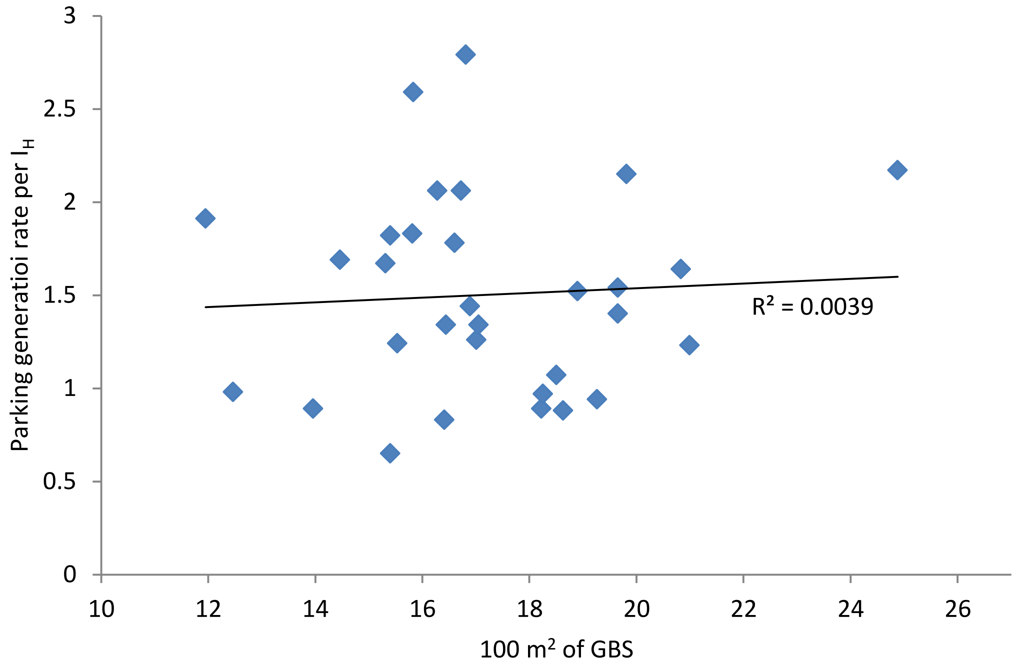

Fig. 1. – Parking generation per I_H and 100 m^2 of GBS

Parking turnover τ was determined at every supermarket for I_{3H} and I_H for the whole parking square. The τ for I_{3H} ranged from 1.7 to 7.5 (average 3.9); for I_H ranged from 0.6 to 2.8 (average 1.5). Linear correlation of parking places and parking turnover rate was determined for I_{3H} as R^2 = 0.2009, for I_H it was R^2 = 0.2747. Fig.6 presents parking turnover τ dependence on the number of parking spaces that are offered in different areas. The highest strength can be seen at Suburb's area R^2 = 0.8497, Cities' area had R= 0.4685 and Prague's area had the lowest strength R^2 = 0.0115.

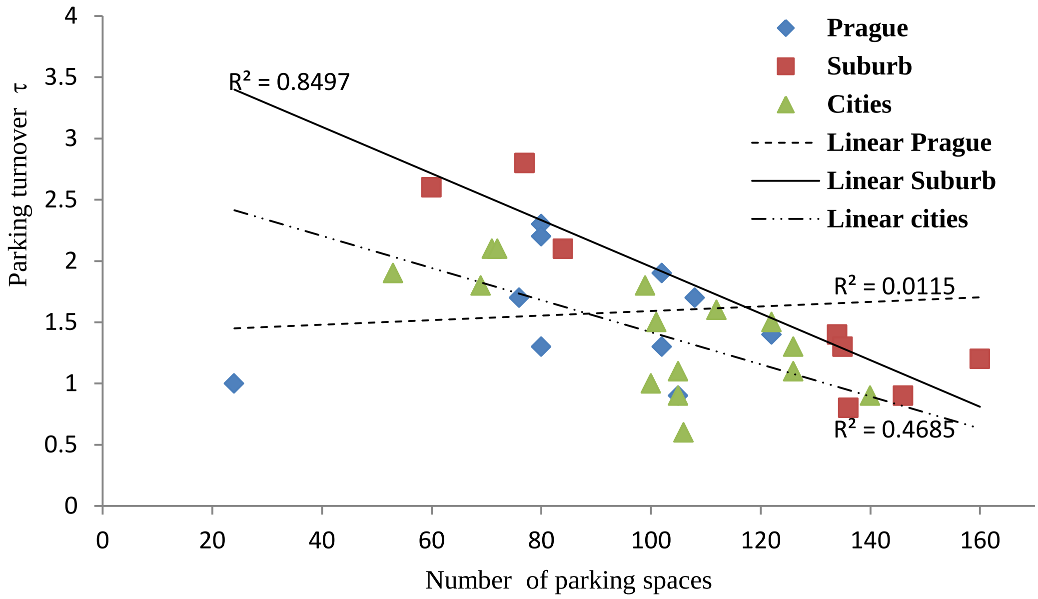

Fig. 6. – Dependence of parking turnover τ (I_H) on number of parking spaces and area

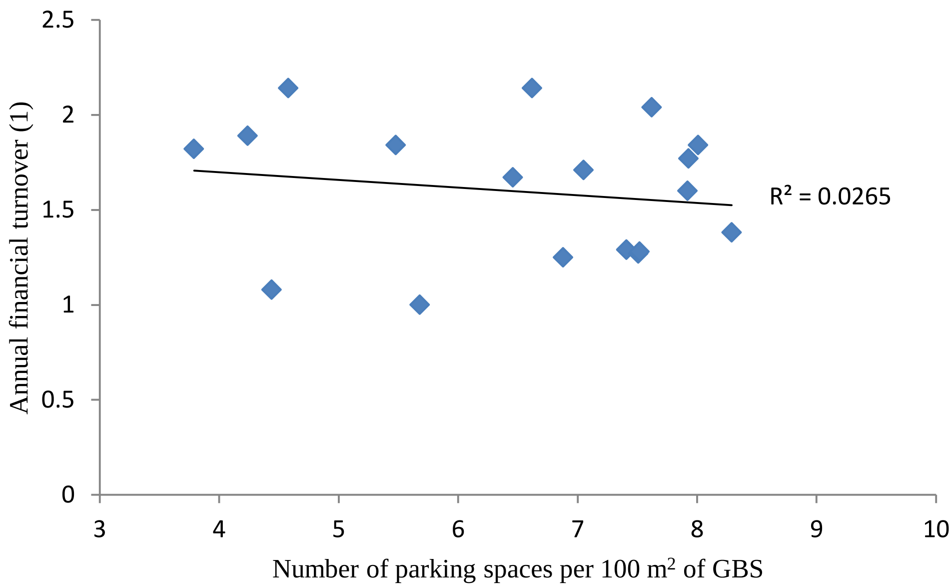

Fig. 7. – Dependence of shop's financial turnover on number of parking spaces

The annual financial turnover was provided by the owner of supermarket chain for 18 shops in relative values. Fig. 7 presents the dependence of the financial turnover on the number of parking places per 100 m^2 GBS. The presumption of a correlation between increased number parking places and a supermarket's turnover was not confirmed. The coefficient of determination R^2 = 0.0265 has a low strength. It would be possible to say that only 3% of supermarkets will have a higher turnover through the provision of more parking places per 100 m^2 of GBS.

CONCLUSIONS

In total, 31 supermarkets were surveyed during the year. They differed slightly in gross building square but they had an identical assortment and management. The strength of the coefficient R^2 between gross building square (GBS) and parking square (PS) was rather low in all supermarkets. It is possible to say that only 33% of the surveyed cases can be explained by the relation between GBS and PS. On the one hand, the dependence from the point of location had the higher strength (R^2=0.6793) in Prague (metropolis). This fact can be explained by the higher price of land (plots) in comparison with the other areas, or by limited space in higher density of buildings etc. But on the other hand, R^2 of Prague's suburban areas provide the evidence that PS was designed according to local possibilities regardless of any spatial planning rules or directives. The planners, designers and investors used their chance to obtain non-restricted land-take.

The number of parking places per 100 m^2 of GBS is in range from 1.93 to 8.29 (average 5.8). These values show that a parking lot's capacity or the number of parking spaces do not take into account the total GBS and even R^2 of 0.0022 shows the low strength i.e. supermarkets with larger GBS do not have more parking places per 100 m^2. It is evident that standards, regulations and models were not kept or even taken into account.

The determined intensities of incoming and outgoing passenger cars to parking places and the influence of population density or intensity of NIR on them was not proved. It can be explained by many different factors. One of the very important factors can be competition of nearby other supermarkets, retail areas or malls. The lowest R^2 strength was found out in Prague where the shopping conditions are the most accessible in comparison with other areas.

THE INSTITUTE OF TRANSPORTATION ENGINEERS, 1987A in SHOUP (1999) declares the parking generation rate equal to 2.9 per supermarket i.e. parking spaces per 1000 square feet of gross floor area (it is app. 93 m^2 , the difference of square is negligible, it means a difference of app.1 parking place). If these conditions are met, it is expected that 22 passenger cars will be on one parking place per day. The results of parking generation rates obtained exhibit a wide range, these values differ nearly 4 times. If the expected three hours' parking generation rate characterises one quarter of a supermarket's open hours (not supposed non-stop time) then the result can be from 7 to 30 passenger cars per place per day. It means high deviations from the declared standard. It supports the conclusion that parking generation is essentially unrelated to GBS in the surveyed cases and this confirms SHOUP'S (1999) conclusions with GFA (backed up by a traffic survey carried out at 18 fast-food restaurants). The generally accepted expectation that the higher is number of parking spaces the lower is parking turnover τ was confirmed in low strength. It is possible to say that only 23% (average of I_{3H} a I_H) of surveyed cases confirmed this dependence. During I_H seven supermarkets had the parking turnover $\tau \leq 1$. It means that these supermarkets provide overestimated the capacity of parking places; therefore, a majority of customers spend there then less 30 minutes (according to their own estimation obtained from questionnaire survey 93%). The R^2 in suburban areas proves that a higher supply of parking places really reduced parking turnover τ. The wide range of parking turnover proves that customers would like to accept a shorter shopping time in this type of supermarkets. It all depends on shopping management and customers' clearance. Even more, this access enables the supermarket to increase financial turnover more than higher parking capacity. Shop owners, retail managers and branch organisations often believe that parking plays a fundamental role in the performance of shopping. They try to persuade local authorities to increase parking capacity or reduce parking fees around retail areas and even in the downtown. Results of the research carried out did not confirm this dependence of shopping performance on parking capacity. The presumption that a higher number of parking places should lead to a higher turnover was not confirmed by this study. The coefficient of determination R^2 = 0.0265 has low strength. It would be possible to say that only 3% of supermarkets will have a higher turnover with a higher number of parking places offered per 100 m^2 of GBS. This fact confirms results of MINGARDO ET AL. (2012).

In conclusion, the research carried out proved in the case of 31 supermarkets that parking generation is influenced by many factors. It is very complicated to forecast future parking demands. The question remains if the spatial planning process is able to take into account all these factors with appropriate measures in time. The current access, i.e. minimum parking requirements and free parking, imposes hidden costs on spatial development and parking lots' construction which impede our progress toward important social, economic and environmental goals. Spatial planning and parking design deserves a new paradigm (SHOUP, 1999).

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