Accessibility of local amenities to reduce car dependency: Obsolete concept or change yet to come? The Prague case.

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Abstract

This paper aims to present a novel interdisciplinary framework investigating the phenomenon of urban transport based on behavioural aspects of mobility interaction with the built environment in the Czech-specific context. The central research question lies in testing the influence of the accessibility of local amenities on car dependency within the suburbs of Prague. The work utilises an activity-based modelling technique, quantifying individual travel behaviour using geolocated travel diaries. The method is based on two regression models, measuring (i) PKT (person kilometres travelled) and (ii) the number of regular car / PT users. Local amenities accessibility constitutes independent variables, whereas personal socio-economic background plus built environment characteristics control variables. The sample comprises suburban residents who are parents of at least one child aged 0-15 and state their home geolocation.

Keywords

Built Environment, Travel Behaviour, Suburbs, Amenities, Education

Introduction

The sudden transition from central planning to a free market in Eastern Bloc countries caused uncoordinated and deregulated growth followed by sheer car ownership. Extensive suburban areas heavily dependent on cars exploded around larger cities (Stanilov and Sýkora 2014). Nowadays, ongoing climate changes, technological revolution, and planned energetic transition bring entirely new challenges to urban transport planning (Shakibamanesh et al. 2020). Such challenges also draw attention to the question of car dependency in the Czech planning practice. In response, Czech local plans started working with various planning practices to reduce car dependency in suburban areas. One of the most widespread practices constitutes retrofitting local amenities in suburban residential areas. Since such practice is part of various well-established global urban concepts (New Urbanism, low-traffic neighbourhoods, TOD, 15-minute city, etc.), the relationship between amenities and transport has been well-researched for decades in the USA and Western Europe (Ewing and Cervero 2010; Næss 2022). Whereas solid evidence from various backgrounds supports Western urban transport planning, Czech planning remains hovering “in the dark” without empirical findings concerning specific central European contexts. This paper brings the first insights into measuring amenities' influence on travel behaviour.

Most of the contemporary planning concepts mentioned above work with amenities accessibility; however, there are plenty of lapses and issues in applying such an attitude to real practice. As stated by (Næss, 2006), “the dog is buried” in the matter of personal choice. People do not go to the nearest cinema because of its proximity. Nor do university students go to the nearest university. On the other hand, things may work differently on a more local level. Parents may choose the closest kindergarten or primary school due to walking time. The same could work for recreational facilities (going to the closest gym) or primary health care (visiting the closest GP), etc. However, also local amenity selection by proximity works with vague assumptions which are not always met. Such assumptions are that there are no competing facilities (e.g. two schools within a similar distance), facilities do not vary in quality (one school is significantly better) or other hidden motivations (school proximity to parent's workplace).

Nevertheless, the distinction between higher and local facilities in the previous paragraph merely captures the real-world complexity – often influenced by various personal socioeconomic backgrounds (Ortúzar et al., 2011). On top of that, people have different motivations and preferences, often socially bound, limited by institutions, etc. (Neutens et al., 2007). This makes travel behaviour a complex discipline in its gritty attempts to predict individual choices. To take at least some of this complexity into account, three decisions were made when designing this research: (i) only local amenities accessibility is considered, (ii) facilities must not significantly vary in their quality, and (iii) socio-economical aspects must be included in the model. Considering the first and second points, local educational facilities were found to fit the criteria best. Firstly, Czech lower educational facilities are considered even, mostly run by local municipalities. Secondly, in the suburbs, primary educational facilities are often distributed individually (one school per municipality). Thirdly, lower education is governed by municipal governments, including planning and spatial distribution of new ones. On top of that, accessible educational amenities are considered to spread wider benefits (e.g. in matters of social cohesion) (Hickman et al., 2017), so their positive influence on residential travel behaviour may join to “the club” of benefits.

Method and Data

Travel behaviour modelling is a sub-group of activity-based modelling (ABM) (Hensher, 2008; Ortúzar et al., 2011). To gain a disaggregated form of person-trip data, travel survey diaries are mostly employed. The surveys include the socio-economic characteristics of every respondent and his/her travel behaviour, including the number of vehicles owned, frequency of car/PT usage, etc. Based on respondent address (self-geolocated), built environment characteristics such as residential density, urban centres and facility accessibility are derived by GIS analysis. In the case of this research, suburban zones and their centre's definition were adopted by the work of (Ouředníček, 2018).

In the case of this paper, questionaries were collected by the Prague Technical Road Administration Authority (TSK) by November 2021 and focused on residents of Prague's inner city (N = 1000) and the wider metropolitan area (N = 1000). The final population sample was filtered from the TSK data by the following parameters: adults (age 15+), suburban residents (zone 1-4) (Ouředníček, 2018), having at least one child in their household (age 0-14), and not being a student. The final sample size (N = 151) is spatially spread across the region (see Figure 1 below).

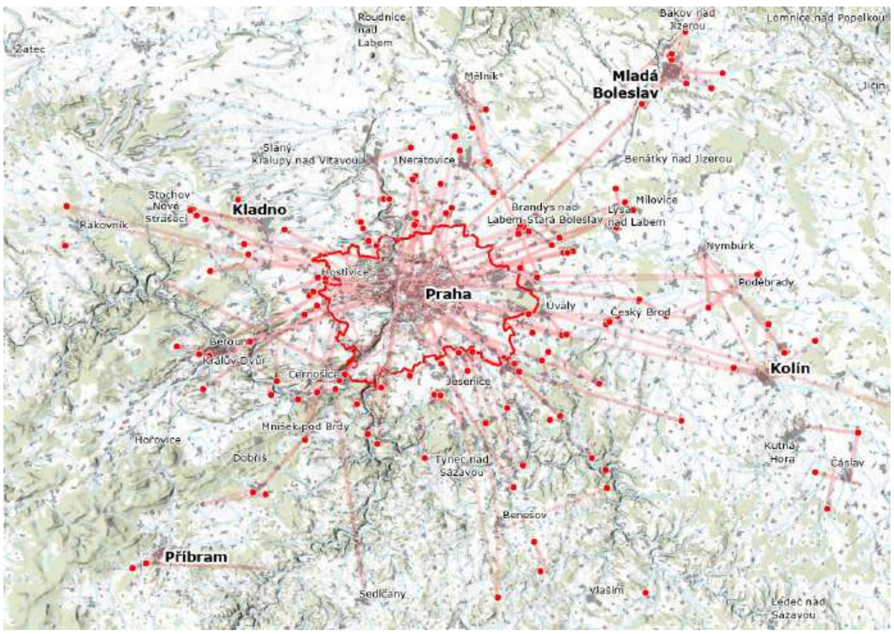

Figure 1 Respondent's home and their trips within one day

Socio-economic characteristics

The sample comprises parents mostly around in their 30s, roughly balanced between women and men (F 77, M74). The most frequent households contain three or four members. Both variables (age and household occupation) meet similar group characteristics to the Czech National Census 2021 (Ryšavý and Fiedor, 2023).

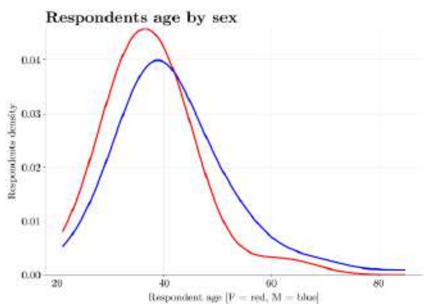

Figure 2 Respondents age by sex

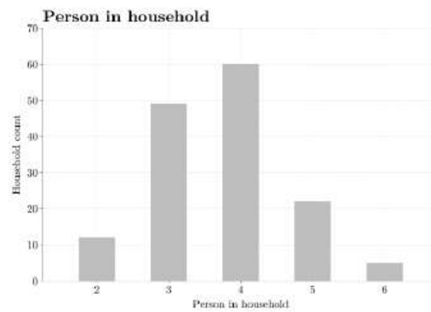

Figure 3 Persons in houshold

The primary survey data contains two children sub-categories: pre-school (age 0-5) and school (age 6-14). As shown in the charts below, the most common are households with one or two children and two adults. Comparing children sub-categories, one preschool and one school child is the most common, however, other combinations are also evenly spread across.

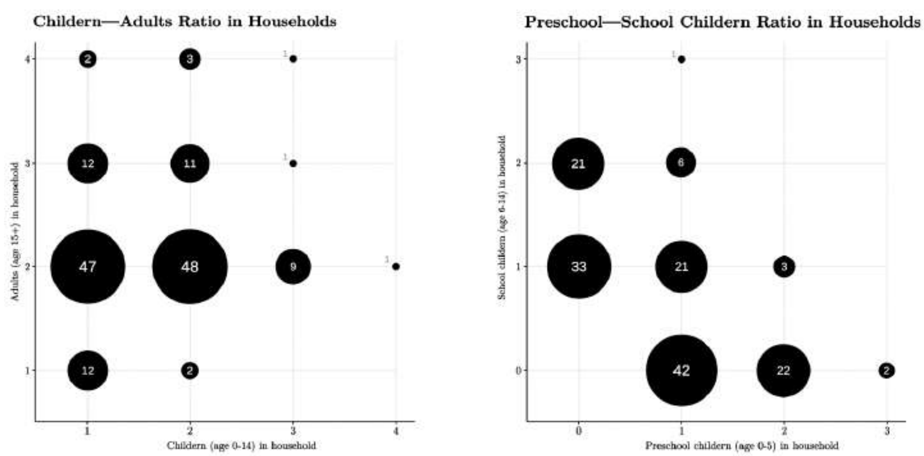

Figure 4 Adults-children and children sub-groups proportion

Other followed socio-economical characterstics are household income (normalised per adult person) and respondent education. The respondent's household income seems to be quite low (survey median CZK 22k compared to nationwide median CZK 34k (ČSÚ, 2022). However, distortion is assumed by the fact that most households with children (age 0-5) have one member on maternity/parental leave. On top of that, some other adults (age 15+) in the household may not be economically active (students). Unlike income discussed above, education distribution seems to follow common suburban patterns of an educated population, mostly diploma (secondary) and masters.

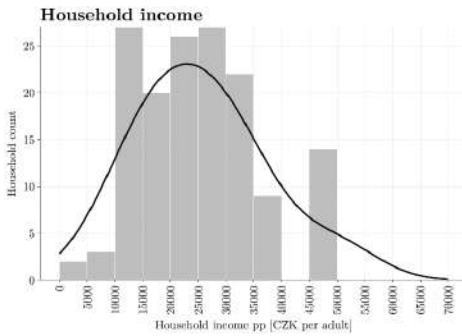

Figure 6 Household income pp

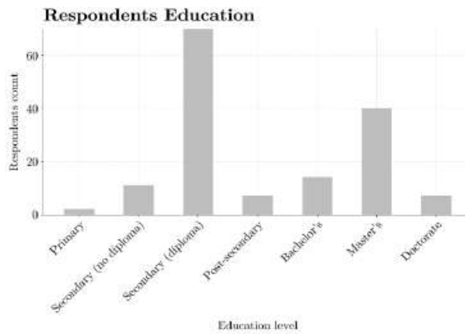

Figure 5 Respondents education

<u>Travel Behaviour</u>

The second group of data collected in the survey covers the travel behaviour of each respondent. The travel behaviour survey may be divided into two sections: general knowledge and trip-specific knowledge.

The first section, general knowledge, describes personal travel characteristics and habits, such as the number of vehicles in the household, PT ticket subscription or travel mode use frequency for an "ordinary weekday". Travel mode use frequency is depicted below (see Figure 7), comparing car and PT use within uneven time periods. The most obvious pattern is that respondents, unsurprisingly, tend to use cars much more frequently than PT. Over one hundred respondents use the car more than three times per week, whereas the most common frequency of PT use is less than once per month. Putting frequencies of both categories together, the car use frequency dominates across all PT use frequency categories. Thus, the sample meets the assumption of car-dependent suburban residents.

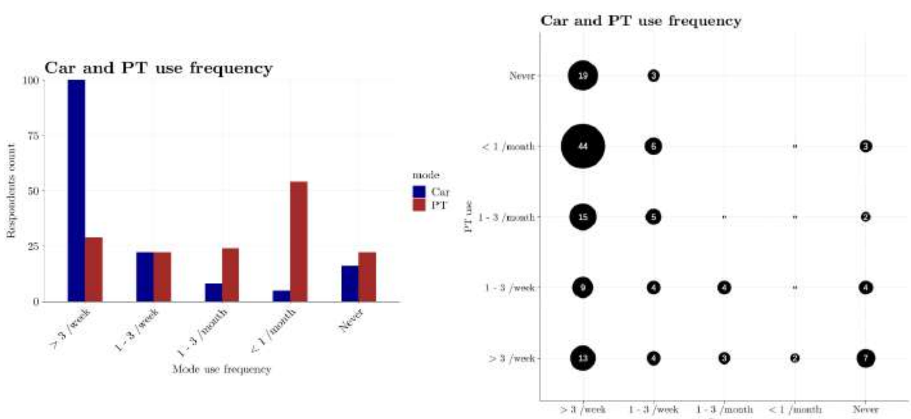

Figure 7 Car and PT frequency

The second section, trip-specific knowledge, utilises data from the personal trip inventory. Mostly, home and work locations are gained, and VTM distances are summed up. The researched sample shows sharply skewed distributions to the first interval (especially in the case of distance travelled by other transport means than a car). This may show the proportion of respondents working from home (the survey was collected between Corona epidemic waves, however, well apart from previous lockdowns). Secondly, the distribution may show a trend in combining more transport modes, especially car and PT or walking. The specific data distribution is reflected in generalised linear regression models (GLM) in the following chapter, where negative quasi-Poisson distribution is utilised.

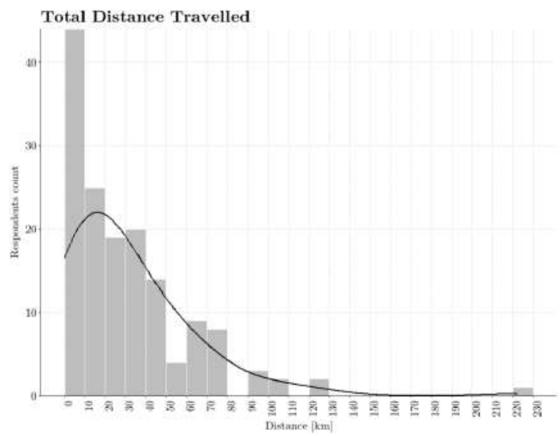

Figure 8 Distance travelled distribution

<u>Built environment</u>
Unlike the first and second groups, data in this third group are entirely created by secondary GIS analysis, mostly focused on home location and municipality. There is a "standard protocol" of which variables to use in order to control built environment influence – 5Ds (Ewing and Cervero, 2010). The bold lines below indicate the variable used in regression models presented later.

Density	**Household/population density**
	Job density
Diversity	Land use mix
	Job-housing balance
Design	**Intersection/street density**
	% 4-way intersection
Destination accessibility	Job accessibility by car
	Job accessibility by PT
	Distance to downtown
Distance to transit	**Distance to the nearest transit stop**

Table 1 Built environment controls – 5Ds (Ewing and Cervero, 2010)

The residential density constitutes a "traditional" challenge in terms of its definition; which places are considered to be residential and which are not? How to find out where these places are inhabited? And what to do with mixed-use? (Mees, 2010) Considering the poor quality of Czech geospatial data, built-up areas in all researched municipalities (over 100) were created by manual editing of digital zoning plans. Industrial and other obvious non-residential functions were filtered out (see Figure 9 – left). In the case of extensive recreational neighbourhoods, where some houses are residential and some are not, only locations with a majority of objects with postal addresses were included (see Figure 9 – right: the east bank of the river is considered a residential area, whereas the west bank remains recreational, thus blank).

Figure 9 Built-up residential area – definition

The output residential density shows a shallow distribution between 10 and 30 inhabitants per ha, with a spike between 12.5 and 15. These numbers correspond to the general residential density of the Czech suburbs. Job-residents balance gained from The Czech Ministry of Treasury (MF, 2020) unsurprisingly, it indicates that most suburbs offer 0.1 to 0.3 jobs per inhabitant. This finding also meets prior assumptions.

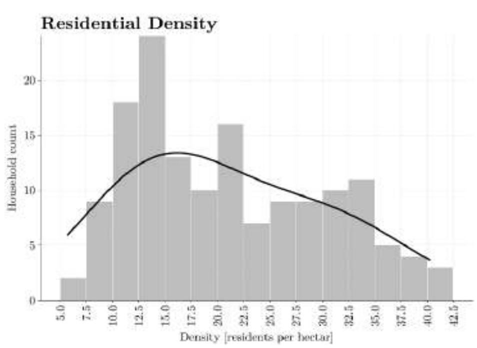

Figure 10 Residential density

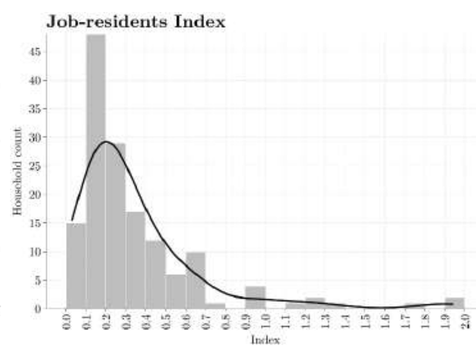

Figure 11 Job-residents index

Destination accessibility also shows unsurprising results for suburban locations – good, stable accessibility of urban centres by car and largely differing accessibility by PT across municipalities (see Figure 12 – left). Whereas car accessibility median time is 21 minutes with 8.9 minutes SD, PT accessibility offers a median of 57 minutes with 24.6 minutes SD! The ratio between car and PT accessibility is later used to determine municipality accessibility by PT compared to a car (see Figure 12 – right). On average, sample suburbs are 2.5 times better accessible by car than PT.

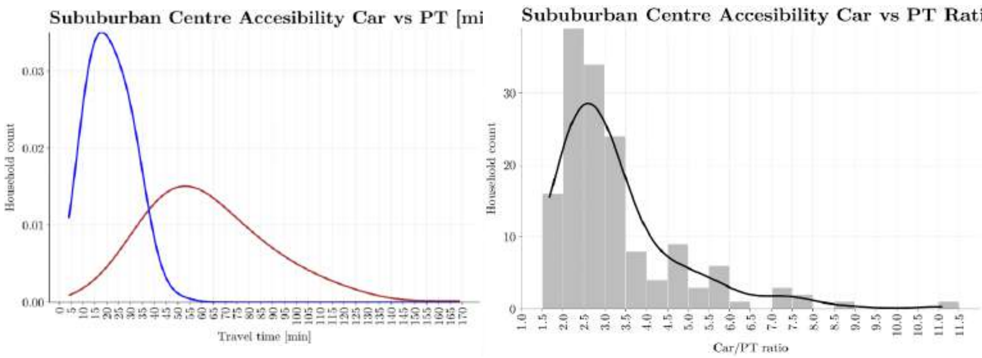

Figure 12 Urban centre accessibility car vs PT (blue: car, red: PT)

Last but the most important variable from the built environment group is accessibility to the educational facilities. Since the survey distinguishes between preschool and school children, accessibility to both kindergarten and primary school was measured (red and blue lines in Figure 13 – left). However, for parents of preschool children, only kindergarten accessibility is relevant and vice versa. Thus, a new variable, "Accessibility to the relevant ed. facility", was created, taking into account only relevant facilities (see Figure 13 – right). In the case of parents of both children groups (pre- and school), the average school and kindergarten accessibility was counted.

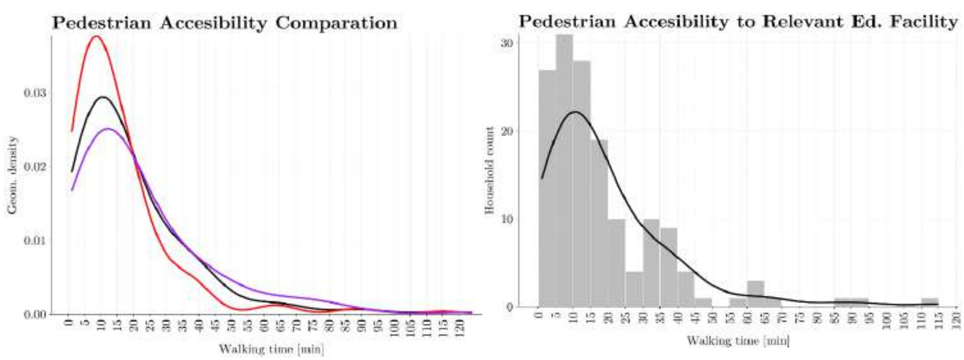

Figure 13 Pedestrian accessibility to educational amenities (red: kindergarten, violet: school, black: relevant education facility)

In summary, most input data individually behave as expected. Most distributions show Gaussian patterns, although in many cases skewed. In the case of the mentioned specifics and anomalies, findings were reflected in regression models presented in the next chapter.

Results

Data presented in the previous chapter includes: (i) personal kilometres travelled (PKT) and (ii) frequency of car and PT use. Those two variables are used as dependent (predicted) in two presented regression model sets to denote individual travel behaviour. In both sets, the researched independent variable is pedestrian accessibility to relevant educational facilities. Other variables, such as socioeconomic and built environment, are considered as controls.
Before commencing the description of the results, it is necessary to declare that certain built environment variables exhibit a strong correlation. Typically, residential density, municipal size, street density, household size and household type. The listed variables, mostly representing the built environment, also correlate to the researched independent variable – pedestrian accessibility to the relevant education facility. On the one hand, this indicates that more populous and dense suburbs are already fitted with educational amenities. On top of that, the correlation may signal a stronger connection between education and other amenities, typically concentrated together.

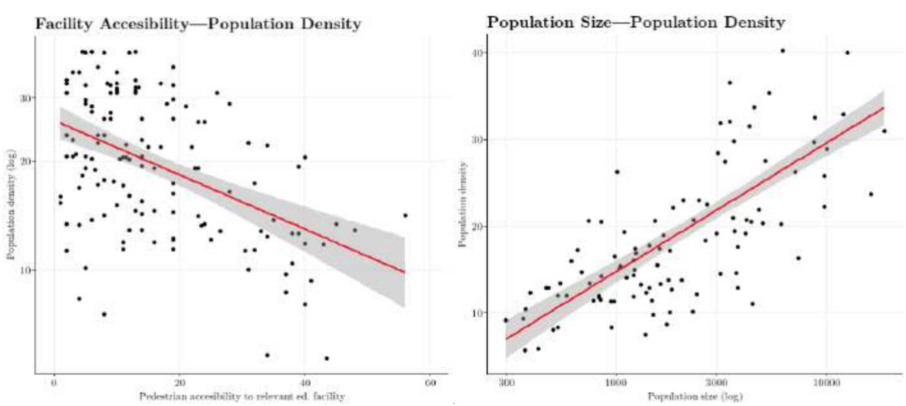

Figure 14 Variables correlation

<u>Set one: personal kilometres travelled (PKT)</u>
The first set of models consists of three GMLs predicting (i) total PKT travelled by the respondent, (ii) car-only PKT travelled by respondent, and (iii) PKT by other means than a car (PT, biking, walking, etc.) – see table 2.

variable	estimate			std.error			statistic			p.value		
PKT (N = 150)	total	car-only	no-car	total	car-only	no-car	total	car-only	no-car	total	car-only	no-car
(Intercept)	2.556	*insig.*	*insig.*	0.334	*insig.*	*insig.*	7.517	*insig.*	*insig.*	<0.001***	*insig.*	*insig.*
Living in detached house	0.464	*insig.*	*insig.*	0.225	*insig.*	*insig.*	2.066	*insig.*	*insig.*	<0.05*	*insig.*	*insig.*
Respondent economically active	0.543	*insig.*	1.320	0.216	*insig.*	0.580	2.515	*insig.*	2.269	<0.05*	*insig.*	<0.05*
Ed Facility < 20 min walking	0.437	*insig.*	0.871	0.190	*insig.*	0.443	2.300	*insig.*	1.963	<0.05*	*insig.*	<0.1 .

Table 2 Set one: GLM quasi-Poisson: PKT estimates – only PKT total significant variables selected

variable	odds ratios		CI		p.value	
N = 150	model 1	model 2	model 1	model 2	model 1	model 2
(Intercept)	*insig.*	0.08	*insig.*	0.00 – 1.11	insig.	<0.1 .
Respondent economically active	3.82	3.64	1.56 – 9.97	1.49 – 9.50	<0.01 **	<0.01 **
Cars in household	2.01	2.23	1.30 – 3.31	1.42 – 3.73	<0.01 **	<0.01 **
Respondent sex	0.28	0.29	0.13 – 0.60	0.13 – 0.63	<0.01 **	<0.01 **
Car/PT urban centre accessibility ratio	1.91	1.96	1.37 – 2.84	1.42 – 2.86	<0.001***	<0.001***
Residential density	0.96	–	0.92 – 1.00	–	<0.05 *	–
Ed Facility Accessible < 20 min walking	–	0.37	–	0.16 – 0.83	–	<0.05 *

Table 3 Set two: GLM binomial: Probability of regular car use (more than 3 times a week)

The initial finding shows that the car-only PKT vastly varies. Thus, none of the predictors of car-only PKT did not show significance. On the other hand, total PKT and no-car PKT work better. Perhaps the most surprising result lies in the increment of total PKT when the educational facility is accessible by walking (< 20 min). This may be caused by the fact that total PKT comprises car-only and no-car PKT, including activities like walking with children to school. To support this claim, unlike total PTK and no car PKT, car PKT indignancy may overall indicate that car use is far more complex and influenced by various hidden factors. Due to the high correlation with other built environment variables, especially residential density, only accessibility to education facilities was used (the accessibility variable also indicated the best statistical performance).
Due to the small sample (N = 150), the estimated magnitude of variables may not be accurate. However, their significance clearly declares trends. To improve overall model reliability, the sample shall be extended, and more continuous variables like dwelling size, household income, and persons in the household should be included.

<u>Set two: car and PT use frequency</u>
Regarding the focus of this research and the limited size of the sample (N = 150), categorical variables of car and PT use frequency were combined into dummy variables. To create the dummy variable, original survey intervals (see Figure 7) were binomially split by thresholds: using a car more than three times a week is considered regular usage, and vice versa; less than three times a week is irregular. In the case of PT, the threshold was set to at least once a week due to the broader distribution of counts in categories (see Figure 7). Created groups of "regular" and "irregular" users of car and PT are visualised below in the context of residential density. The distribution between regular PT users / irregular car users and irregular PT users / regular car users share very similar patterns. This may show that most commuters using a car regularly do not go by PT, and conversely, regular PT users don't drive. The spike in regular PT users / irregular car users, around 30 inhabitants/ha, shows better PT accessibility in more populated and, thus, bigger municipalities (see Figure 14). On the other hand, regular car users are spread across residential densities, starting at 12 (1st quantile) along to 22 (3rd quantile). Overall, all groups of users significantly differ in the context of residential density (ANOVA test).

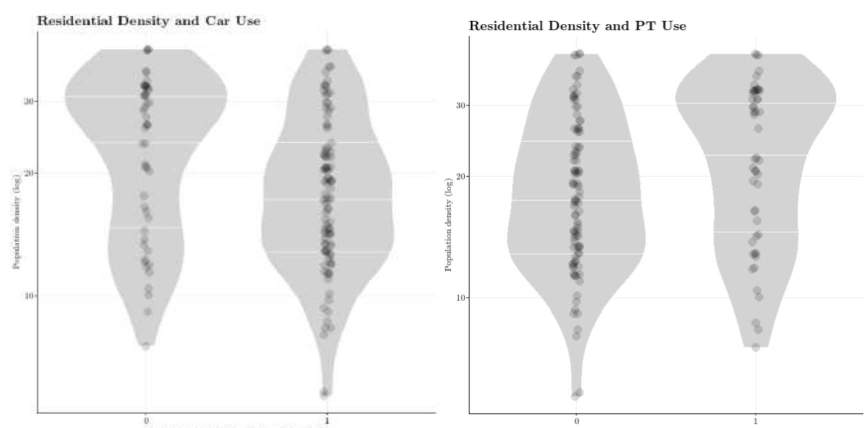

Figure 15: car and PT regular users distribution according to residential density

The GLM binomial regression is made on two models – the first using residential density (model 1) and the second replacing the density with educational facility accessibility (model 2). The reason for the isolation of these two variables is to avoid strong multicollinearity due to high mutual correlation. Due to unbalanced group sizes (regular cars are approximately two times bigger), irregular car users were weighted by two.
The model results (see Table 3) show that being economically active increases the probability of frequent car use. The same works for the number of cars owned. The other variable increasing car use probability is the ratio of car/PT urban centre accessibility – weaker PT accessibility, higher probability of regular car use. All three findings listed above are unsurprising and may confirm assumed trends. A bit surprising is the fact that being a woman strongly decreases the chance of regular car use (by 72%). This may show that women use PT instead of cars or stay home. Now, to the model's merit: residential density and educational facilities accessibility. Both variables in the corresponding model show expected trends – the increment of each person per hectare reduces the chance of regular car use by 4% in model one, and the educational facility accessible within 20 minutes reduces the chance of regular car use by 63%. Although educational facility accessibility may be connected with other close amenities, such as shops, sports centres, etc., the trend indicates a general connection between amenities accessibility and respondents' regular modal choices.
To conclude, both binomial regression models showed robust and significant results of educational facility accessibility (or residential density) influence on regular car use. Although the influence in the case of educational facilities may be indirect (correlation, not causation), the trend shows a positive tendency to be further scrutinised by employing a bigger sample and collecting geolocations of other facilities.

Discussion and Conclusion

To address the conference mobility track theme, this paper tried to shed the first rays of light onto the issue of car dependency – an issue resonating especially in the age of ecological and energetic transitions. Although the global academic discourse recognises suburban car dependency as a serious problem with ecological, social, or health consequences, Czech (and other Eastern European) research focuses only on transport supply – mostly transport systems effectivity. This paper provided a pioneering insight into the travel behaviour of Prague suburban residents and its connection to the built environment. The final focus was set on local educational facilities and their influence on residential travel behaviour. Compared to similar global research papers, this paper worked with a rather small sample of 150 respondents, sometimes methodically hitting limits – especially in the case of predicting distance travelled by respondents (PKT). The models in the first section predict PKT only by a few dummy variables that turned out to be significant. In this case, expectations were initially higher. On the other hand, the second set of models – probability prediction of regular car use – turned out to be fruitful, indicating strong results, including respondents' socio-economic characteristics. Although there is no way to prove causality between educational facilities accessibility and travel behaviour by a single set of travel dairies, the ultimate goal of this paper – to prove a connection between – was achieved. To move such research forward, further modelling is required, especially with a bigger sample and including a wider spectrum of amenities such as sport and recreation, culture, social care, healthcare, or public transport. Overall, the presented results show clear trends, thus worthy to continue working on.

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