GEOGRAFIE – SBORNÍK ČESKÉ GEOGRAFICKÉ SPOLEČNOSTI
ROK 2006 • ČÍSLO 1 • ROČNÍK 111

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TRANSPORT ACCESSIBILITY EVALUATION

J. Horák: *Transport accessibility evaluation.* – Geografie–Sborník ČGS, 111, 1, pp. 115–132 (2006). – Theoretical means of accessibility measures are applied mainly for transport accessibility evaluation. Analyses of transport accessibility are usually based on data collected during census. Nevertheless its results for commuting are published with remarkable delays. Monitoring campaigns organised by specialised companies represents another possibility, but the cost of such a statistical campaign is relatively high. The other possibility is the application of network analysis in the environment of geographic information systems for the evaluation of non-public individual transport. For evaluation of transport accessibility using public transport means, the analysis of time schedules can be applied. It is possible to evaluate existing public transport connections, analyse selected conditions, evaluate real costs of commuting, conditions of commuting like number and waiting time for changing and apply a Monte Carlo simulation approach to evaluate not only average conditions but also the range of commuting conditions (which can be next utilized with a probabilistic approach). The selected presented methods were applied and tested for Bruntál district in Czechia. The transport accessibility was studied from the point of view of commuting to work and a comparison with the situation in the labour market was undertaken.
KEY WORDS: transport accessibility – GIS – network analyses – public transport – commuting.

1. Introduction

The description and analysis of transport accessibility have both a significant impact in decision making for new investments where the placement of a new facility depends on the relative advantageousness of the location as well as in the personal choices of migrating people. The transport accessibility of basic services (job, education, health, culture, administration) has to be assured to a satisfactory level and the local/central governments should support public transport in an appropriate way that is connected with non-neglected requests to their budgets. An insufficient level of transport accessibility of employers could be accompanied by a higher level of unemployment, notably in certain professions with low incomes. Special attention has been paid to the analysis of transport accessibility for the location of emergency services.

2. Measures of accessibility

The concept of accessibility of geographical objects has been studied since the 1950's. The accessibility is measured by specific indicators, which describe the position of a relevant object in the frame of spatial structure on the basis of connectivity and distance of this object to other objects. Thus, the accessibility is a geographical feature of the object. Its evaluation utilises distance measures inside a point or line pattern.

Measures of accessibility can be divided according applied metrics to: distance-based, time-based, topological, cost, others. The accessibility can be evaluated in relation to other criteria, e.g. proposed travel means. From this point of view the most significant variants to be studied are non-public individual transport and public collective transport.

The most frequent indicator of accessibility utilises the length calculation of the path in the graph (indicator of travel accessibility). The graph represents a model of a transport network; where accuracy depends on the scale and the level of generalisation. Thus, the result is certainly highly influenced by the model abstraction level and its quality. Usually network analyses for searching shortest path in GIS environment are applied.

The best travel accessibility has the location with the smallest value of indicator:

$$D_i^C = \sum_j d_{ij}^c$$

D_i^C indicator of travel accessibility in location i
d_{ij}^c length of the shortest path from the location i to j
i index of the source
j index of the target

Other variants of accessibility indicators can be obtained by substitution of usual metric distance by time evaluation of the path or by application of topological measures (number of connections etc.). Number of connections was used e.g. by Rölc (2001) for an evaluation of transport accessibility of regional centers. Some accessibility measures can also include human well-being indicators which trend to incorporate human properties and behaviour into the model (e.g. physiological index of weariness with respect to commuting described by Hůrský 1969).

Simple measures of accessibility (presented above) suppose all geographical objects (sources and targets) are equal and evaluated with the same weight in the model. The more advanced models applied different weights to targets (especially different attractiveness of the targets). Typical measures of attractiveness are based on population (resp. segment of population). The application of the attractiveness represents the first step in the change to apply a general gravitation model (models which maximise the entropy). The gravitation model is used for various purposes. The description of theoretical relationships among urban centres in Czechoslovakia based on such a model was provided by Řehák (1992). An adjusted gravity model was applied to test an influence of urban spatial structures to commuting patterns in Seoul Metropolitan Region (Sohn 2005).

3. The transport accessibility analyses

One of the many references to the practical application of accessibility analysis shows Bracken (1994), who describes the results of studying of general practitioners accessibility. Burrough et al. (1998) similarly documented the analysis of car ambulance accessibility (applied limit is 9 minutes), but also the working positions accessibility in the western part of the Netherlands expressed in transport time by means of individual automobile and also by public transport.

The comparison of public and individual transport accessibility associated with the critical assessment of the gravity model and the exploitation of a GIS environment was shown by Hansen (1996). The continuous need for theoretical and empirical research on relationships between accessibility, option values and non-user benefits, and the measurement of different components of accessibility was emphasised by Geurs and Wee (2004).

The role of public services in the transport model differs between countries. The relatively high level of bus transport density in countries of previous communist block was documented by Jordan (1995). Czechia can be characterised as one of the countries where the extent of public transport is still relatively high in spite of continuous increases in the use of individual transport. Thus, the evaluation of public transport accessibility cannot be neglected. Additionally, these analyses allow for the possibility to evaluate the geographical conditions of the territory.

The following main methods appropriate for transport accessibility studies can be applied:
– analysis of census results
– survey, territorial monitoring
– analysis of data collected by transport providers
– network analysis
– analysis of time schedule of public transport
– socio-economic models (e.g. gravity model, regression model).

Selected methods as well as their advantages and disadvantages are described in more detailed.

3. 1. Analysis of census results

The census represents an important source of information essential for various analyses and evaluations. Also analyses of transport accessibility usually benefit from the census results. The statistics are organised according gender, age, main economical sectors, frequency of commuting and time spent by commuting (in categories).

Nevertheless, censuses are organised with 10 year intervals and the results for commuting are published with substantial delays – e.g. in Czechia usually more than 2 years. If the evaluation of the current situation represents the objective, such postponing of data supply is evidently unsatisfactory. The data cannot reflect the changes of employment structure and commuting destinations in connection with the change of employers, whether it concerns their location change or orientation or even their existence. Such changes have been recorded quite often in the last decade and the constantly changing situation in the labour market typical for all market economies will always be responsible for a disparity between historical data from census and the actual situation.

The second issue of census utilisation is connected with the aggregation level of the published results. The results are processed usually to quite a rough form, the documented time of commuting are classified by 15–30 minutes steps and, in particular, this time does not distinguish between the walk time and transport time, commuting to work and commuting to education etc. Even more, persons with alternative accommodation fill in the questionnaire with the time of commuting from the alternative location instead of their residence (Horák et al. 2004). This fact complicates the evaluation of data processing. We cannot be sure that the stated time corresponds to the commuting from the present residence location (that is known) or from the alternative accommodation the location of which is unknown.

3. 2. Surveys and analysis of data collected by transport providers

Another possibility is represented by surveys organised by specialised companies, which can provide detailed results in one time slice. Generally, the frequency of customers in the personal public transport has been monitored (the number of transported persons, the number of persons getting on board at the individual pickup points etc.). Unfortunately, the cost of such a statistical campaign is relatively high and cannot cover large areas with full details. It is not possible to infer the share of commuting to work. Organizationally less demanding would be the theoretical possibility of ticket-sale data exploitation but the personal public transport companies do not want to provide such a data because of their competitors. There also remains the disadvantage of impossibility to distinguish the reason of travelling.

Also, it is possible to insert into this group of instruments, the experts' opinion on the situation in a certain location or alternatively to exploit the database of transport providers, generally available by non-private subjects providing the emergency services, e.g. fire brigade and ambulance. This information can be exploited not only for evaluation and improvement of a special transportation but also wider for evaluation of the local transport situation.

3. 3. Network analysis

The transport situation can be transformed into a topologically correct network (graph). It represents a model where every segment can be evaluated in an appropriate way (time, velocity, conditions, etc.) and utilised in network algorithms based on graph theory. Network analysis can be applied to find the best route between two nodes, to solve the "salesman problem", for location and allocation of facilities etc. Due to automation of processes in GIS it is able to calculate all transport combinations for commuting between nodes which cover all settlement and all destination locations in the area (application e.g. in Cometti et al. 1996). The resolution of node locations should be satisfactory in respect to acceptable walking distance. Then the evaluation of all routes and analysis of the transport accessibility for any location by individual transport means follows.

Usually, the algorithm for searching the shortest path (e.g. Dijkstr algorithm) is applied. The algorithm finds the shortest connection between 2 locations in the network (nodes), records the path and calculates the time needed to travel along this path. It is assumed that a person, who regularly commutes, selects the shortest path from all possible ones.

It is evident that the results of the analysis are not influenced by the algorithm type selection but above all by the adequacy of prepared network model. All of the significant transport flow lines have to be included in the model. It is not simple to designate which flow lines may have significant influence on the model above all in the case of towns and agglomerations. There it is necessary to define the connection restrictions (e.g. one way streets) and to set up the impedance of individual network segments properly (generally the time needed to go through the segment). The impedance is usually determined on the basis of time allocation according to the speed, assigned to the whole class of given type of communication. More advanced models also enable one to apply impedance of nodes, which can represent an average delaying at the crossing. The greatest deviation from reality happens here. It is possible to achieve better results by individual segments calibration according to the real travel time between 2 places. For calibration the analysis of time schedule or census results can be used. Of course there also remain certain model limits, given by the applied assumptions such as the constant speed of the given road segment, convenient meteorological conditions and stable traffic density.

4. Analysis of time schedule of public transport

For evaluation of transport accessibility using public transport means the analysis of time schedules can be applied. Due to the required extent of processing it is needed to find out an appropriate way to process and evaluate thousands of requests for commuting. Clearly, a digital form of time schedules and a special programme application have to be used here.

We utilised a DOK programme, which is tailored for searching in time schedule IDOS (application for travel connection searching). The programme operates in two time-separated steps. In the first step it opens the database, where the user inserts the input parameters of the searched connections. DOK reads the database and as soon as it reaches the demand that has not been searched yet it reads its input parameters that than inserts into users' interface of the IDOS application and starts the connection searching. As soon as the IDOS finds the connection, DOK lets the found connection to be saved into the text file. In the second step the DOK searches through the text file and identifies the parameters of found connection. It saves the results of this processing into the database. Results stored in the database can then be easily processed and evaluated.

The main advantages of automated processing can be seen in:

- evaluation of existing (or planned) public transport connections
- extended processing of thousands of commuting requests with automation of result evaluation
- analysis for selected conditions (e.g. commuting in the specific time)
- evaluation of real costs of commuting
- evaluation of conditions of commuting like number and waiting time for changing
- possibility to apply a Monte Carlo simulation approach to evaluate not only average conditions but also the range of commuting conditions (which can be next utilised with probabilistic approach or bulk service approach)
- low cost of analysis
- reiteration in any time.

The weakness of this method can be found in the need for an appropriate parameters setting (parameters for commuting like requested time of departure or arrival which can, however, be overcome by the mentioned simulation approach), appropriate evaluation of results (evaluation of different parameters of found connections), selection of probable commuting destinations (decreasing uncertainty connected with decision taking about commuting from a studied residential area).

4. Case study

The main objective was to evaluate transport accessibility in the pilot area with application of different methods, verify these methods, document their advantages and disadvantages, and compare results from different processing procedures. The second objective was the comparison of the level of accessibility with indicators of the unemployment situation. The initial assumption was the level of unemployment depends in an indirect way upon transport accessibility, thus the locations with good transport accessibility should show significantly lower levels of unemployment.

Also the motivation to commute was studied on the basis of calculation of real labour costs including travel costs.

The transport accessibility was evaluated for each part of the municipalities. The transport destinations were selected according to the main application, which is the evaluation of transport accessibility for commuting. In our case study, the assumption of the strongest influence of important employers was accepted. Thus, the locations of important employers represent the possible targets. This selection was verified by census results.

The transport accessibility was evaluated using network analysis and analysis of time schedule. The first method evaluates the situation for individual means of transport, while the second one provides the evaluation of public transport situation.

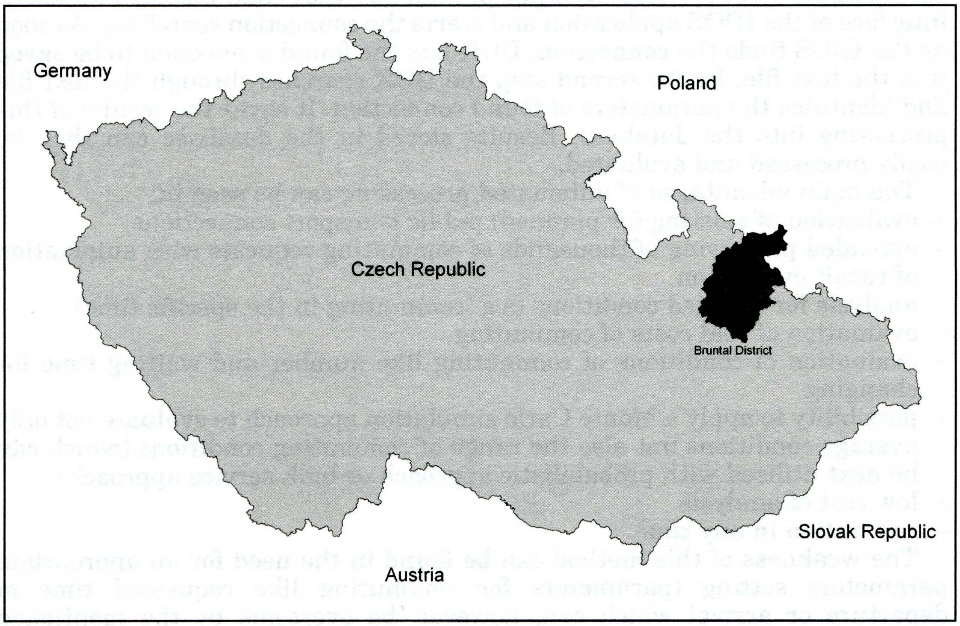

Fig. 1 – Location of the pilot area

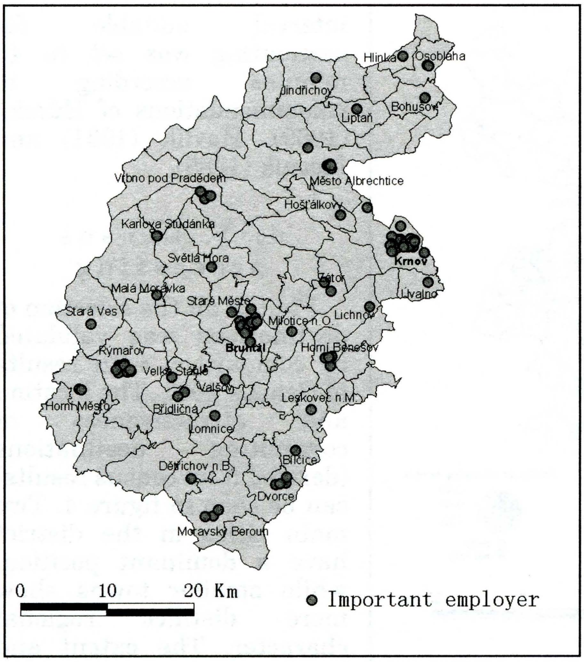

Fig. 2 – Distribution of important employers in Bruntál district (according to the Labour office)

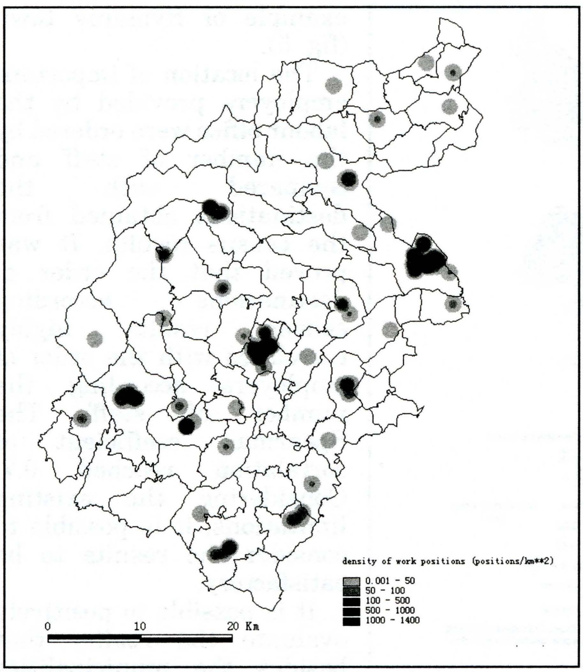

Fig. 3 – Density of work positions in Bruntál district (kernel estimation with a 1000 m wide band)

The study was applied to the territory of Bruntal district in Czechia (fig. 1). This area can be characterised as a problem region with tough geographical conditions (mountainous relief, larger distances and excentricity of transport network, more severe weather conditions, a peripheral position in the country, etc.). The geographical conditions are accompanied. with the high level of unemployment. The seriousness of the labour market situation, indicated relations to the transport accessibility and high interest of local labour offices were the main reasons for the selection.

Important employers were identified in collaboration with the local labour office. There the employers employing of 50 and more employees were chosen. The employers of the neighbouring regions were not included into the processing in this stage according to a recommendation of experts from the local labour office. The peripheral and mountainous character of the studied area are likely to decrease a possible bias.

The location of important employers can be seen in figure 2. A better image of distribution of work positions is obtained after kernel processing of employer's capacity (fig. 3). The resulting pattern indicates probable destinations of commuting and their attractiveness. Other parameters used for analysis can be found e.g. in Horak et al. (2005). The time

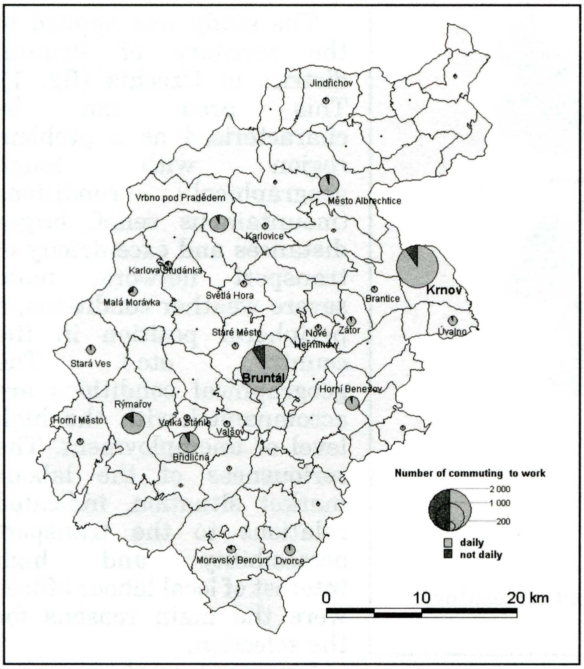

Fig. 4 – Number of persons commuting to work inside the Bruntál district (according to the Census 2001)

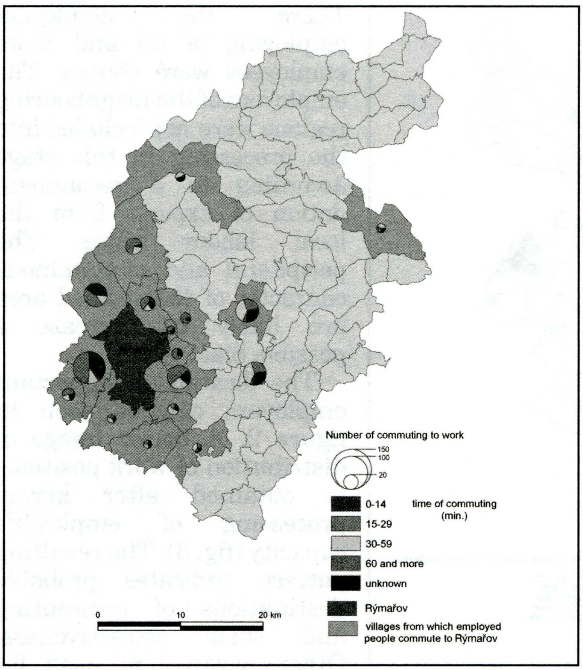

Fig. 5 – Commuting to work in Rýmařov town (according to the Census 2001)

interval suitable for commuting was set to 45 minutes according to recommendations of Hůrský (1969), Havlík (1981) and Líčeník (1985).

4. 1. Census processing

First of all the selection of destinations was validated by comparison with results of Census 2001. The location and attractiveness of commuting destinations (derived from census results) can be seen in figure 4. Two main cities in the district have a dominant position, while smaller towns show more distinct regional character. The extent and local character of the commuting catchment can be demonstrated on the example of Rymarov town (fig. 5).

The location of important employers provided by the labour office were ordered by the number of staff and compared with the destinations obtained from the census results. It was proved that the order of destinations according census results highly correlates with the order of employers according the number of staff. The Spearman coefficient of correlation reached 0.7. Considering the existing limitations, it is possible to consider the results to be satisfactory.

It is possible to positively evaluate the reality that besides the municipalities scheduled in the last and next to last place, all of the municipalities with the significant destination of the commuting to work from the evidences of the labour offices were identified.

We can conclude that the comparison of destinations approves the satisfactory utilisation of important employer's locations (from 50 and more employee) from the monitoring of labour offices. The determination of order for destination appears to be less valid.

4. 2. Network analysis

To evaluate the individual transport accessibility, network analysis of the studied territory was provided. The transport serviceability of the significant employers has been evaluated by means of number of municipalities from which it is possible to commute to the employers. This indicator controls the catchment area of the individual employers and documents their advantage in view of their accessibility for potential employees.

The road network model was constructed from the digital topographical map (based on a map with scale 1 : 25 000). Each line segment of the model was classified according to the communication category and then evaluated on the basis of recommended travel velocity for a common car. Next year, a more detailed subdivision of the last categories was undertaken (connected with appropriate travel velocity) and it resulted in improved behaviour of the model.

Next, the analysis of the shortest path between start and destination goal of the commuting, has to be processed as an automatic subroutine due to the extent of processing. The program searched the path between each part of the municipalities in the Bruntal district (165 locations). Together, 13 530 shortest paths were determined. The locations were read from the database and parameters of found paths (from, to, time, length) were also recorded to the database. Finally, results were summarised, visualised and evaluated (Peňáz 2005).

The analysis of available working positions did not bring us some new and unexpected results, due to relatively good connectivity (fig. 6).

The analyses were undertaken with the support of ArcGIS 8.2 Workstation, modules ARC, ARCPLOT, ARCEDIT a NETWORK, and partially ArcView GIS 3.2 for operative control and processing (tab. 1).

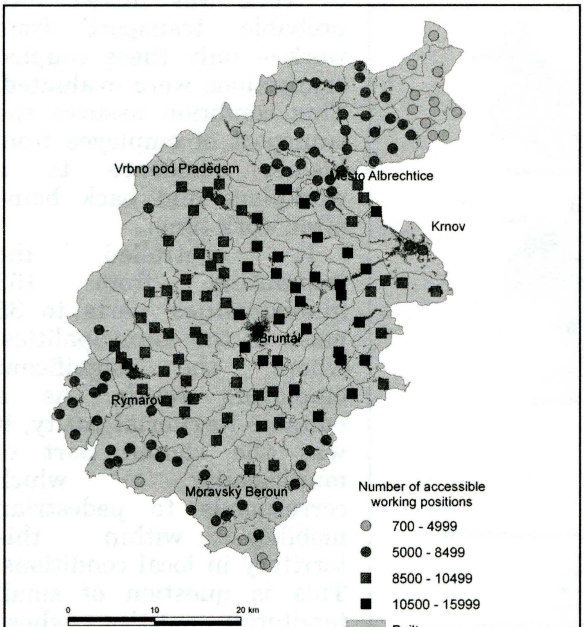

Fig. 6 – The number of working positions provided by the significant employers accessible by individual transport to 45 minutes

Table 1 – Average velocity for drive on these segments

Category of communication use	Parameters in 2003	Parameters in 2004
	Average velocity (km.hour^{-1})	Average velocity (km.hour^{-1})
Highway	85	85
Road 1st category	75	75
Road 2nd category	55	55
Main passage	40	40
Street	35	35
Purpose-built communication (including road 3rd category)		40
Consolidated path	30	20
Bridging of railways		30
Others		20

4. 3. Analysis of time schedule

The public transport in this region uses both the train and bus traffic. Both of the types of transport including the eventuality of transport means changes have been considered while searching the connections.

The analyses of time schedules were provided for various parameter settings and results were compared. Commuting for 3 work shifts were tested (1st work shift with 3 possible starting times). In all cases 15 minutes before the beginning of working time was the latest time of arrival. A similar appropriate time interval after finishing working time was set. Any transport to work was linked with probable transport from work – only these coupled connections were evaluated. This condition assures the transport of employee from his/her residence to a workplace and back home after work time.

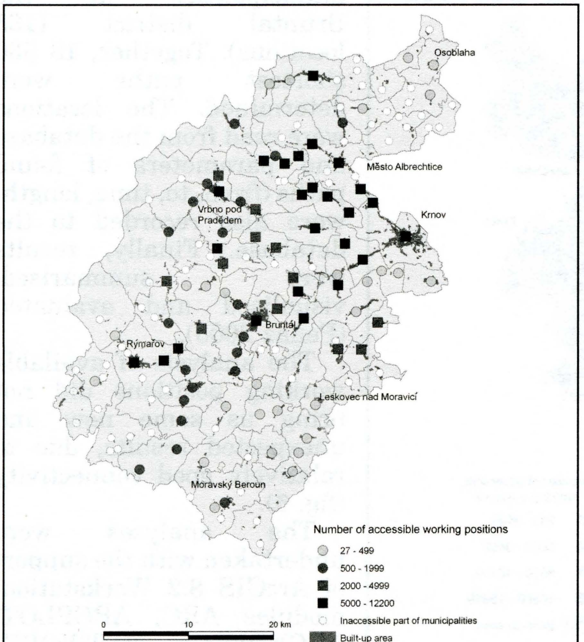

Fig. 7. – The number of work positions accessible the suitable way by public transport to the working hours beginning at 8:00 a.m.

It controlled the commuting from 153 municipalities' parts to 35 parts of the municipalities, where the significant employers reside. As a suitable territorial entity, it was the chosen part of municipality which corresponds to pedestrian mobility within this territory in local conditions. This is question of small territorial entities, whose distance is approximately 2 kilometres from each other. This decision appears as a suitable compromise among the municipality level and individual transport pick-up points. By each part of the municipality there has been chosen the representative public transport pick-up point from which is the public transport brought into effect.

The commuting has been controlled at two levels – as suitable commuting and theoretical commuting. In the case of theoretical commuting, there it is possible to apply a longer travel time and a sooner departure than in the case of suitable commuting. The result for suitable commuting at 8 a.m. is demonstrated in figure 7.

The following measures of accessibility were tested – the number of accessible municipal parts, the number of accessible important employers and the number of accessible work positions. Also the situations in different years were investigated to verify changes in the model between years.

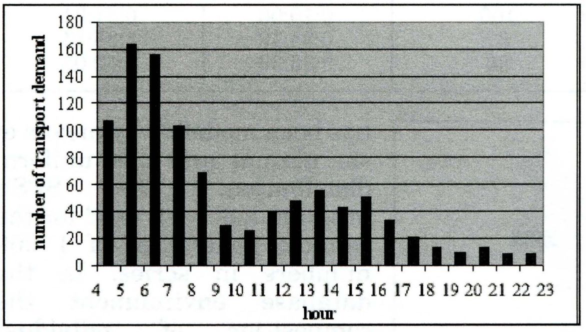

Fig. 8 – The simulated transport demands

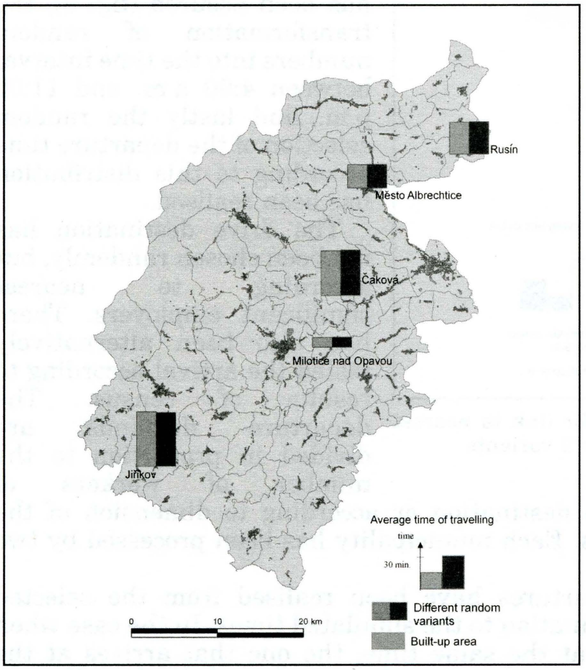

Fig. 9 – Average time of travelling to nearest significant employers calculated in 2 variants

4. 4. Simulation approach to improve analysis of time schedule

By the analysis of time schedules, there appears to be a problem with appropriate parameter settings, e.g. time of departure, arrival, and selected connection limitations. Such issues can be overcome by the simulation access applied for the connection selection.

The main goal of this evaluation was to evaluate the transport service of given municipal parts by means of public transport. The simulation of departure times from 5 selected municipal parts to the 5 nearest parts of municipalities, where the significant employers reside, was undertaken.

The transport demands distribution has been simulated according to the expert assessment of transport demands frequency. The histogram clearly shows the main morning rush hour and a secondary rush hour in the afternoon. The distribution

Table 2 – The selected municipal parts and corresponding number of successful links to given alternatives

Municipality name	No. of variant	Count of successful connection	Average travelling time	Average waiting time for the link
Čaková	11	98	0:48:07	0:54:39
Čaková	12	99	0:47:22	0:55:59
Jiříkov	9	93	0:57:06	3:50:50
Jiříkov	10	95	0:57:56	4:06:01
Město Albrechtice	1	100	0:24:50	0:21:44
Město Albrechtice	2	100	0:24:40	0:22:13
Město Albrechtice	3	100	0:20:41	0:19:55
Město Albrechtice	4	100	0:21:16	0:17:09
Milotice nad Opavou	7	100	0:10:47	0:27:02
Milotice nad Opavou	8	100	0:10:06	0:31:21
Rusín	5	87	0:34:12	1:35:14
Rusín	6	86	0:33:36	1:42:03

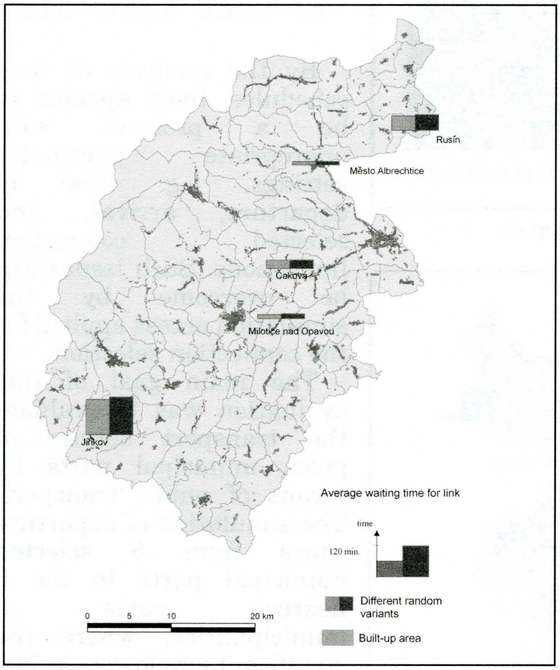

Fig. 10 – Average waiting time for link to nearest significant employers calculated in 2 variants

has been modelled by means of six normal and one uniform distribution. The SPSS program has been used for the random generation of 1 000 numbers in series. In the database environment the composition of individual distribution into the final one has been assured (fig. 8), the transformation of random numbers into the time interval between 4:00 a.m. and 11:00 p.m. and lastly the random selection of the departure time according to this distribution has been realised.

The drive destination has not been chosen randomly, but according to nearest significant employers. There has also been alternatively tested the arrival according to results of census. The departure demands are divided in proportion to the number of workers of significant employers in the destination or according to dimension of the arrival flow in case of census. Each municipality has been processed by two alternatives.

Nearby train or bus departures have been realised from the selected municipality to the final destination to the simulated times. In the case when two traffic channels depart at the same time, the one that arrives at the employer part of the municipality sooner will be preferred. In the following there were preferred links with minimum price.

The results have been simply evaluated. The number of successful found links, average travelling time (fig. 9) and average waiting time for the proper link (tab. 2, fig. 10) are the most interesting indicators.

5. Comparison to the labour market situation

The analyses of transport accessibility play an important role in the evaluation of social conditions. One of the main application areas of transport accessibility is the evaluation of the labour market situation.

An important question for the study of the labour market represents its spatial demarcation, especially for the regional labour market. According to Schubert et al. (1987) the regional labour market can be distinguished on the basis of administrative or functional limits. The administrative determination appears to be more advantageous from the point of view of available data sources. On the contrary, the main disadvantage is artificial way of regional subdivision.

The functional determination of the regional labour market mainly uses the level of commuting into the region core. E.g. according to Fischer and Nijkamp (1987) is the regional labour market defined as spatially delimited area whose borders fulfil the following demands:

- The daily commute to work across this border is inconsiderable
- The cost of commuting and the cost of migration within the region is strongly lower, than between this and another region
- The companies are situated so, that they gain more workforce within the region
- The price of searching a job within the region is much lower than searching in another region.

The concept of horizontal labour market segmentation leads to an assesment of accessibility impact to the employment structure and level. Recently, the study of relationships between accessibility and employment in developing countries was undertaken (Srinivasana S. and Rogersb P.), where the results indicate that differences in accessibility strongly affect travel behaviour.

The importance of commuting to the labour market situation was also emphasized in Czechia (e.g. Hůrský 1969 or with impact to land use planning e.g. Havlík 1981). It has been traditionally asserted that a dependency exists between unemployment situation and transport accessibility. That is why this relationship evaluation in the studied territory was done.

Spearman's correlation coefficient was used to test the relationship between the unemployment indicators and the number of work positions accessible by a suitable connection. 5 indicators of unemployment were used on the basis of previous factor and multiple criteria analysis to the labour market situation characteristics (Horak et al. 2004):

- The unemployment rate
- The proportion of long-term applicants (registered more than 12 months) from the total number of applicants
- The proportion of applicants with the primary education degree from the total number of applicants
- The proportion of applicants primarily demanding the less qualified job
- The proportion of 50 year olds and older- age group from the total number of applicants.

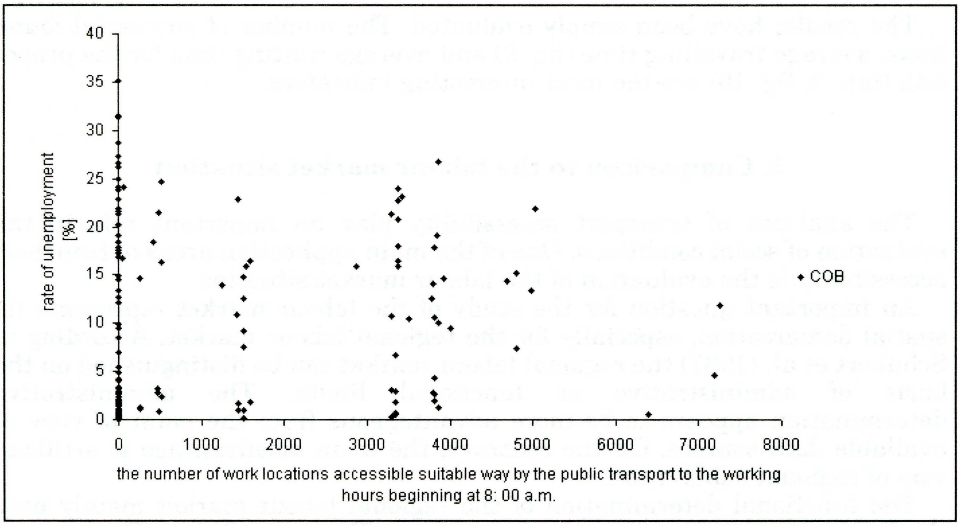

Fig. 11 – Relationship between unemployment rate (31.12.2002–30.9.2003) and number of suitable accessible work positions (important employers, work shift starts at 8 a.m.)

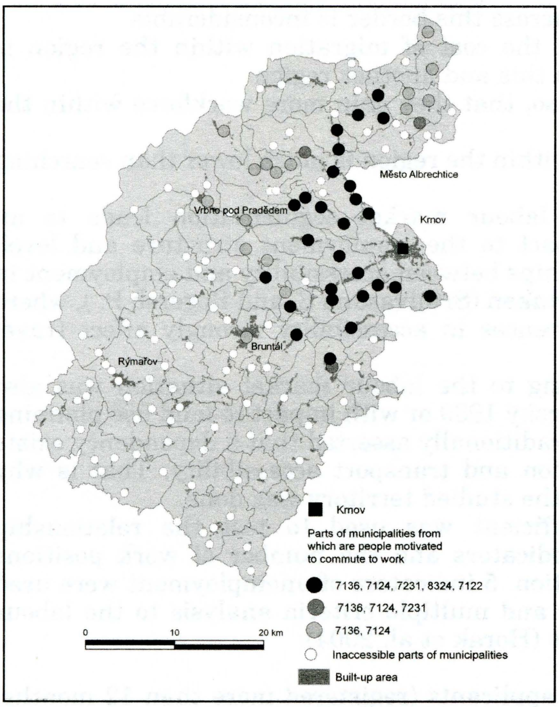

Fig. 12 – The accessibility of the Krnov town to the selected low-income professions. Explanation of professions' codes: 7 136 means fitters, locksmiths, plumbers; 7 124 means carpenters and joiners; 7 231 mechanists and car repair servicemen; 8 324 lorry and power unit drivers; 7 122 bricklayers, stonemasons, plasterers.

The value of correlation coefficient varies from 0.01 to -0.18 according to the indicator and time of commuting. Also the scatter plots did not show any dependency (fig. 11). All results of transport accessibility comparison of both the individual transport and public transport with the unemployment level show that there are no significant relationships to the situation on labour market in the existing transport situation of this area.

The analysis of wage levels provided by Trexima and information about job applicants from the labour office allow us to apply real labour costs in our analysis. Real possibilities of commuting to work in relation to labour cost including the costs connected with commuting were also evaluated. The connections searched from the analysis of timetables have been converted by using the discount information of each transport provider into the real prices of commuting per month.

Average levels of monthly wages were assigned to the individual professions, the gross wage has been by means of 2 alternatives (self-providers and the member of three-member family with the partner with average earnings and the six-year old child) converted into corresponding monthly disposable income. These professions have been further classified from the view of motivation to commute to work into selected locations (fig. 12). The results show the costs of commuting (using public transport) should have no significant effect to the behaviour of workers. It appeared, that limiting is above all the level of remuneration for work and conditions of commuting (in particular the existence of proper connection) (Horak and Sedenkova 2005).

6. Conclusion

The results show that it is possible to use the mentioned variants of employers' transport accessibility evaluation. Over the course of processing a whole range of recommendations to perform such analyses has been proposed.

After evaluation of many variants (various indicators, time schedules for 2 years, conditions for individual lower income professions etc.) following recommendations for parameters setting were proposed:

1. We do not recommend evaluating the theoretical commuting (that with the free conditions of arrival), but the suitable commuting, limited by certain settings (recommended parameters, see the tab. 3).
2. It is not needed to repeat the analysis for any possible starting time. It is enough to use only 1 or 2 times. As suitable we consider the testing of commuting to 6:00 a.m. and to 8:00 a.m. in our conditions, in relevant cases (shift operations demand) also to 2:00 p.m. and 10:00 p.m. (see the tab. 3)
3. We recommend as the most suitable indicator of controlling the accessibility of municipality from the view of commuting to work "the number of accessible work positions at significant employers by commuting to 6:00 a.m.". The important employers can be delimited as employers with average numbers of 50 employees or more. When the details of employee numbers are not available, we advise using "the number of significant employers by commuting to 6:00 a.m."
4. It is not advised to control the commuting price in individual locations and professions in detail, it is sufficient to divide the professions according to their incomes to the groups with no motivation, average and high motivation to commute. Probably, the commuting prices only influence persons' behaviour by choosing locations of their occupation slightly.
5. The inter-annual changes in public transport (PT) do not influence created model in principal that is why it is not evidently important to do the

Table 3 – Recommended parameters of suitable commuting between 2003 and 2004

Work shift starts at	6:00 a.m.	8:00 a.m.	2:00 p.m.	10:00 p.m.
Arrival	5:15 – 5:45a.m.	7:15 – 7:45a.m.	1:15 – 1:45p.m.	9:15 – 9:45p.m.
Departure	2:45 – 3:15p.m	4:45 – 5:15p.m.	10:15 – 10:45p.m.	6:15 – 6:45a.m.
Travelling time	max. 60 minutes			

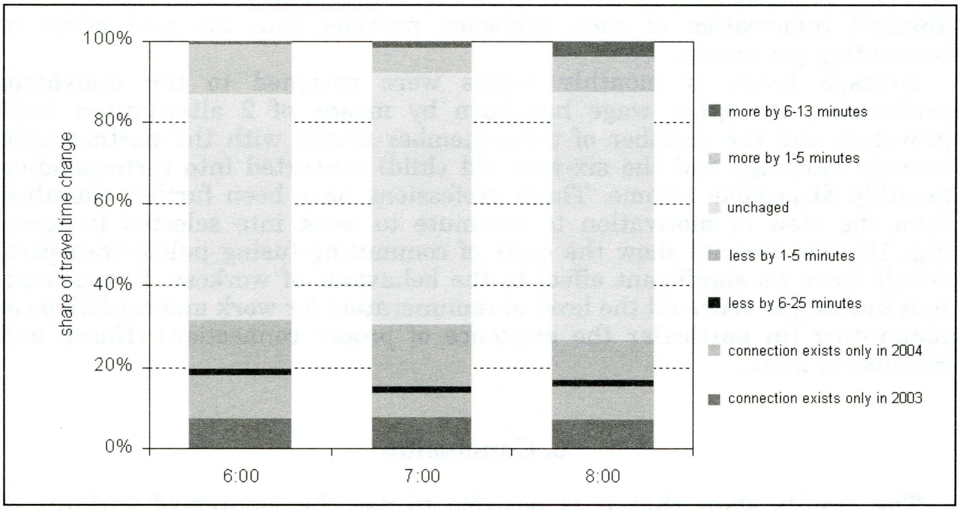

Fig. 13 – The change of travel time in selected departure time

analysis of accessibility of significant employers by means of PT repeatedly in case of slight changes of timetables (fig. 13).

We advise calibrating the models of individual connections (personal transport) by exploitation of relationships of available data from the census (if it is not too obsolete and the situation has not changed obviously) and data of public transport and connections.

The accessibility in the pilot area derived from the public transport differs from those obtained from the individual transport analysis. According to the public transport accessibility results, the part of the central region appears as inaccessible, serious difficulties can be distinguished also in the SW part of the district (differs to individual transport) and N part (similar to individual transport analysis, but strongly expressed). It appeared that the territory accessible by individual transport is larger - as it has been expected. If we would not count in the vehicle amortisation, the individual transport would be more suitable from the view of shorter distances travelling cost (app. 10 km). Of course the travelling time is in most of cases shorter (the exemption is e.g. train transport on a more suitable corridor).

The simulation approach to the link selection (on the basis of transport demands distribution) can be used to remove the problems with setting the parameters of searched connections (time of arrival/departure, limitation of selected connection by abnormal length or price).

The testing of transport accessibility with the unemployment level (described by 5 indicators) did not approve any significant relationship. The results may be used at labour offices by the assessment of commuting conditions and decision making of financial support of commuting to the employer, than by evaluating the level of transport service provision in individual municipalities with the consequences on decision making of support and transport service provision.

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S h r n u t í

VYHODNOCENÍ DOPRAVNÍ DOSTUPNOSTI

Teoretická opatření týkající se dostupnosti se používají zejména k vyhodnocení dopravní dostupnosti. Analýzy dopravní dostupnosti jsou obvykle založeny na údajích shromážděných při sčítání lidu. Ovšem výsledky týkají se dojíždění za prací jsou zveřejňovány se značným zpožděním. Monitorovací kampaně pořádané specializovanými společnostmi jsou dalším možným řešením, ale náklady na takovou statistickou kampaň jsou relativně vysoké. Další možností je použití síťové analýzy v prostředí geografických informačních systémů pro vyhodnocení neveřejné individuální dopravy. Pro vyhodnocení dopravní dostupnosti pomo-

cí veřejných dopravních prostředků lze použít analýzu jízdních řádů. Je možné vyhodnotit stávající spoje veřejné dopravy, analyzovat vybrané podmínky, vyhodnotit skutečné náklady na dojíždění do práce, vyhodnotit podmínky dojíždění do práce jako počet a čekací dobu při přesedání a využít simulační přístup Monte Carlo k vyhodnocení nejen průměrných podmínek, ale také škály podmínek dojíždění do práce (což může být dále využito s pravděpodobnostním přístupem či hromadným přístupem).

Vybrané uváděné metody byly použity a vyzkoušeny v okrese Bruntál v Česku. Dopravní dostupnost byla studována z pohledu dojíždění do práce a bylo provedeno srovnání se situací na pracovním trhu.

Doporučujeme kalibrování modelů spojení v individuální dopravě využitím vztahů dostupných údajů ze sčítání lidu (pokud nejsou příliš zastaralé a pokud se stav viditelně nezměnil) a údajů o veřejné dopravě a spojích.

V případě porovnání skutečných nákladů na dopravu a nákladů na pracovní sílu jsme dospěli k závěru, že dojíždění do práce je především limitováno úrovní výdělků, dále časovými ztrátami a problémy, které dojíždění do práce působí (doba cestování, čekání na spoje), daleko více než náklady na dojíždění do práce.

Simulační přístup k výběru spojení (na základě rozložení požadavků na dopravu) může být použit k odstranění potíží se stanovením parametrů vyhledávaných spojů (čas příjezdu/odjezdu, omezení vybraného spojení vzhledem k nadměrné délce či ceně).

Výsledky mohou být využity úřady práce při vyhodnocování podmínek dojíždění do práce a při rozhodování o finanční podpoře zaměstnavatelům zajišťujícím takovou dopravu, dále při vyhodnocování úrovně poskytování dopravních služeb v jednotlivých obcích s dopady na rozhodování o podpoře a poskytování dopravních služeb.

Obr. 1 – Lokalizace modelového území
Obr. 2 – Rozmístění důležitých zaměstnavatelů v okrese Bruntál (podle úřadu práce)
Obr. 3 – Hustota pracovních míst v okrese Bruntál (jádrový odhad s šířkou pásma 1 000 m)
Obr. 4 – Počty osob dojíždějících do zaměstnání v okrese Bruntál (podle Sčítání lidu z roku 2001)
Obr. 5 – Dojížďka do zaměstnání v Rýmařově (podle Sčítání lidu z roku 2001). Počet osob dojíždějících do zaměstnání. Doba dojíždění v minutách: 60 a více; není známo; vesnice, z nichž zaměstnanci dojíždějí do Rýmařova.
Obr. 6 – Počet pracovních míst poskytovaných důležitými zaměstnavateli dostupných individuální dopravou v době kratší než 45 minut. V legendě: počet dostupných pracovních míst, zastavěná oblast.
Obr. 7 – Počet pracovních míst vhodně dostupných veřejnou dopravou v případě pracovní doby začínající v 8,00 hod. V legendě: počet dostupných pracovních míst, nedostupné části obcí, zastavěná oblast.
Obr. 8 – Simulovaná poptávka po dopravě. Osa x – hodina, osy y – poptávka po dopravě
Obr. 9 – Průměrná doba cesty k nejbližším důležitým zaměstnavatelům kalkulovaná ve dvou variantách. V legendě: průměrná doba cestování, čas, různé náhodné varianty, zastavěná plocha.
Obr. 10 – Průměrná čekací doba na spoj k nejbližším důležitým zaměstnavatelům kalkulovaná ve dvou variantách. V legendě: průměrná čekací doba na spoj, různé náhodné varianty, zastavěná plocha.
Obr. 11 – Vztah mezi mírou nezaměstnanosti (31.12.2002 –30.9.2003, osa y) a počtem vhodně dostupných pracovních míst (důležití zaměstnavatelé, pracovní doba začínající v 8,00 hod; osa x)
Obr. 12 – Dostupnost města Krnova pro vybrané profese s nízkými příjmy (části obcí, ve kterých jsou lidé motivováni k dojíždění do zaměstnání). V legendě: nedostupné části obcí, zastavěné plochy.
Obr. 13 – Změna cestovní doby ve vybraných dobách odjezdu. Osa x – podíl změny doby cestování. Vpravo seshora dolů: o 6 –13 minut déle, o 1–5 minut déle, nezměněno, o 1–5 minut méně, o 6–25 minut méně, spojení existovalo pouze v roce 2004, spojení existovalo pouze v roce 2003.

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Arrived to the editorial board on November 4, 2005