Modelling of door-to-door commuting on the sample of chosen companies in the Moravian-Silesian Region

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Abstract. This paper would like to present the results of a bigger project named "Modelling of door-to-door commuting on the sample of chosen companies in the Moravian-Silesian Region". Main goal of this project is to analyze three main types of commuting and to calculate advantages of particular transport types - individual transport, public transport and car-pooling. The main benefit of this project is in the spatial level. All calculation count with all stops in the region and with all populated houses in the region - door-to-door approach is used. It means that it was counted with walking distance to the most useful stop (not necessary the nearest) near houses of potential commuters and with walking distance from the best stop near the chosen employer in the region. Similar approach was used by individual transport - walking time from house to the parking and from the parking to the workplace or delay of the commuting, if somebody has to pick up another co-worker (from one to three) by his journey to work. All results offer very detailed view on the public transport accessibility in the region for the case of commuting as well as the general transport accessibility by public transport from uncommon aspects of view.

Keywords: commuting, public transport, individual transport, carpooling, door-to-door, stop

1 Introduction

Spatial mobility of people can be divided ([2]) in migration movements and commuting. Migration is not so regular movement like commuting; there are people, who did not migrate during the lifetime. In contrast commuting belongs to irregular daily movements – almost everybody take some journeys to shop, to have fun or regular movements mainly to work. More than 90% of the population in the Czech Republic have different place of living and working and that is why they have to commute daily and travel a long distance to reach the workplace many times ([2]). Two basic principles for study of commuting exist - first one is the macro-approach and the second is micro-approach. The macro-measure brings a lot of inaccuracies and generalizations; it works with census data, so not with individual factors. In this paper, is worked on the micro-level with focusing in individuals. Three main aspects have to be consider – the selection of the target of travel, the time for the travel and the way how to reach the target. Whole project is focused in the commuting to chosen employers in regions of the Moravian-Silesian Region in the northeast of the Czech Republic – this defines the target of commuting. The type of mobility – commuting – defines the second aspect as well. Employee has to reach the place of work in time before the start of working shift – it can be morning, afternoon or night shift. The third aspect is the way of travelling. Here can be distinguished two main types – public transport and individual transport. In the Ministry of transport's year-book ([13]) is counted the ratio of people who use public transport to commute. There were 56% of people who use public transport in the Czech Republic in 2007. Although this ratio has decreased about 3.5% since 2000 and this decrease will probably continue, it is still more than a half of all commuters. Just this commuting via public transport plays the main part in this project.
Results of the European survey ([1]) suggest that situation is similar in other post-communist countries in the European Union. The survey covered all 27 Member States of the European Union on a randomly selected sample of over 25767 individuals of at least 15 years of age. Graph above (Figure 1) shows selection of answers for one question of survey – "What is the main mode of transport that you use for your daily activities?" Values for Czech Republic are different from that in the transport's year-book ([13]). This is caused by different data source. In reality should be the public transport usage a little bit more popular. Public transportation is notably more popular in the New Member States than in the EU15bloc. Definite exceptions from this are Cyprus and Slovenia. Using public transportation is most popular in Latvia (45%) and Slovakia (37%), and is the least popular in the Netherlands and Slovenia (both 11%).

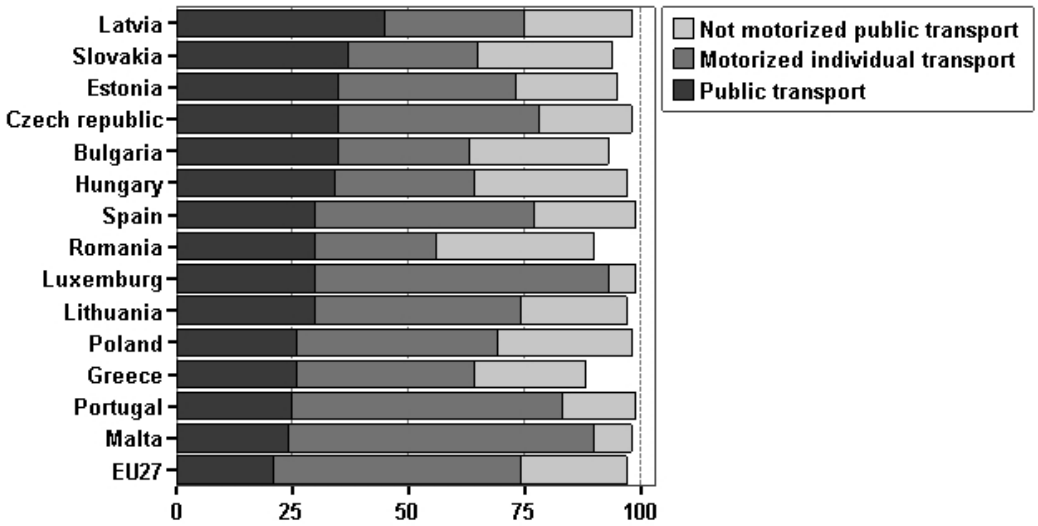

Figure 1. Main mode of transport for daily activities in countries of EU (selection) [1]
In %, Base: all respondents

Not only by public transport way of travelling is very necessary the travel time and the travel distance (from the stop near home to the stop near workplace), but here is very important the walking time or the walking distance from home to near stop and from stop near workplace to target of whole journey as well. In many studies is this walk to stop not a part of analysis although can have a big influence on overall results in time or in distance component of commuting. This approach of analysis is called as door-to-door (more in [10]). We try to count, how big can this influence be and how much longer is the journey to work in time-space. But the other possibilities of travelling were analyzed although – individual transport by car and carpooling. Carpooling is the shared use of a car by the driver and one or more passengers (in this paper it is maximally 3 passengers = 3stops during the journey), usually for commuting. Carpooling is going to be very popular in the world, because of saving money. The more people commuter carpools the more money he saves. Similar term to carpooling is vanpooling, in this case are used rented vans (more information in [14]). In the United States were the proportion of driving alone to work about 80% in 2000 and the proportion of carpooling decreased from 20% in 1980 to 12% in 2000 [5].

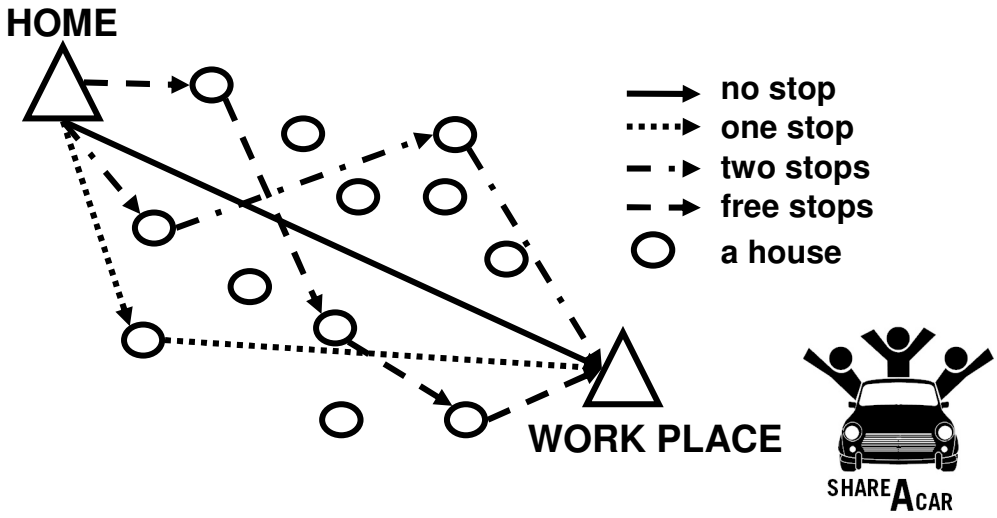

Figure 2. Schema of carpooling

2 Service areas of public transport stops

Firstly was analyzed the spatial distribution of all stops in the Region. There are 3898 public transport stops in the Moravian-Silesian Region in 2008. From this number belongs 170 to train and 3728 to bus transport system. Localizations and names about stops are offered by CHAPS Ltd. and dated to June 2008. The spatial distribution of these stops can be analyzed in many ways. One of these is the construction of regions, whose boundaries define the area that is closest to particular catchment stop – Thiessen polygons can be built above layer of public transport stops. Average surface of these service areas is 2.4 square kilometers, but median is much smaller – only 1.5 square kilometers. This situation indicates big number of smaller regions. This is understandable, in Moravian-Silesian region is a lot of bigger cities, the whole region is the most populated in the Czech Republic (1 249 897 people in 31/12/2007). Because of this the need for bigger number of stops exists in this region and for bigger density of stops. More than 30% of all areas are smaller than 1 square kilometer and more than half of all areas have the surface less than 2 square kilometers. But there are some regions (more then 10%), that are bigger than 5 square kilometers. Bigger service areas are situated in highland around Jeseníky Mountains, Beskydy Mountains but so around city Bruntál or Vítkov (more in [11]).

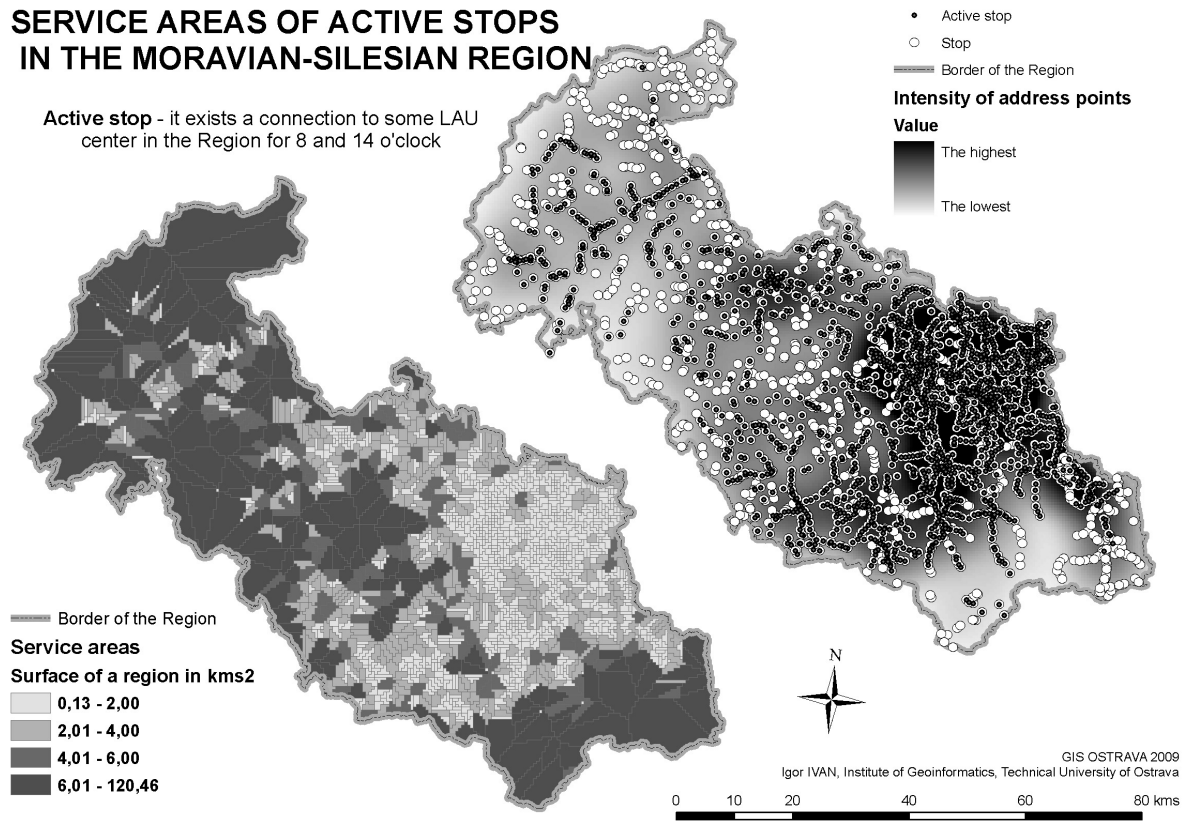

Figure 3. Service areas of public transport stops (for 8 and 14 o'clock)

The other problem is in these service areas the fact, that some of stops are irrelevant for transport accessibility. This irrelevance practically means that only a few traffic links stop here or they stop here in some unusable hours for commuting. Some condition for all stops had to be stated, which can eliminate these local stops. Most of the commuting targets are situated in bigger important cities and there are some preferred hours, when to commute. The most important hours for commuting are in the morning times. Most of employers start to work between six and eight o'clock in the morning. So the scholars should be in their schools before eight o'clock as well as most of all services open at 8 o'clock in the Czech Republic. So the first connection time is eight o'clock. The second connection time was stated as 14 o'clock, because in this time starts the afternoon shift and people start to travel to bigger cities for some other services after morning shift. The maximal duration of travelling is one and half hour and the earliest arrival to target stop should be one hour before (between 7 and 8

o'clock or between 13 and 14 o'clock), in agreement with methodology ([5] or [8]). Traffic order is actual to September 2008.

The whole conditions were stated as: there must be possible to reach one of the chosen stop in some LAU centre in the Region for 8 and for 14 o'clock or only for 8 o'clock, the duration of that connection cannot be longer than 90 minutes and the arrival cannot be earlier than one hour before. Every stop, which fulfils these conditions, will be called as active stop.

Table 1. Basic statistic of service areas

Value	All stops	Active stops (8 o'clock)	Active stops (8 and 14 o'clock)
Arithmetic mean	2.4 km^2	2.6 km^2	3.1 km^2
Median	1.5 km^2	1.5 km^2	1.6 km^2
Standard deviation	2.6 km^2	4.6 km^2	6.8 km^2
Minimum	0.01 km^2	0.01 km^2	0.01 km^2
Maximum	33.0 km^2	102.6 km^2	120.5 km^2

In comparison of results for all stops and results only for active stops is obvious bigger average surface for service areas around active stops. Standard deviation is bigger as well, what is explained with more scattered values of area sizes. This idea is supported by very big maximum. The biggest service area has over 120 square kilometers and is located in northwest part of the Region near the Osoblaha city. The results of all statistical values for the second condition (connection for 8 o'clock) are between results for all stops and for results for active stops with connection for 8 and 14 o'clock.

In the map above are in the right map field displayed with white points all public transport stops in the Moravian-Silesian Region. Above some of these white points lie smaller black points which correspond to the active stops (connection for 8 and 14 o'clock). There are obvious some stops with micro regional meaning. The biggest occurrence of these local stops is in northwest part of the Region – Osoblaha region, in southwest part, middle part and southeast part of the region – Jablunkov region and Beskydy Mountains. Below these stops is displayed intensity of address points in the Region. In most settled parts of the Moravian-Silesian Region is the biggest density of active stops as well. But we can find some exceptions, for example in the east part near the city Třinec or Jablunkov or in the central part of the Region (more in [11]).

3 Walking accessibility of stops via street network in the Region

From all results above is clear, that in the Region exist some areas, where the service areas are very large and so the people have to walk for some time. We try to reply in this chapter to the main questions – how important is the walking distance to stop in the whole process of commuting? Is the door-to-door approach really necessary? This influence was analyzed firstly in this chapter only for the nearest stops.

The distance from stop was divided in 5 intervals up to 500 meters, between 500 and 1000 meters, between 1000 and 2500 meters, between 2500 to 5000 meters and over 5000 meters. Distance was measured via street network from DMU25. The average walking speed was 4 kph. Most of the Region is in distance up to 2.5 kilometers from the nearest stop. But there are some areas, which are quite remote from the nearest public transport stop. In these remote parts are mostly some cottages or weekend houses, but even there we can find some inhabited house as is shown in detail preview in the map below.

If we focus in buildings and their flats inside in particular distances from stop, we can evaluate more precisely the average walking time to the nearest stop. As data source for coordinates of buildings and number of flats inside was based on the Register of buildings (Czech Statistical Office) actual to 1/7/2008.

Table 2. Weighted average walking time from houses to stops in the Moravian-Silesian Region

Space distance	**Weighted average walking time from flats***	**Weighted average walking time from houses***

to 500	2.12	1.93
500 - 1000	2.65	2.60
1000 - 2500	1.48	2.40
2500 - 5000	0.11	0.41
more than 5000	0.002	0.02
average walking time	**6.36**	**7.36**

* in minutes

In table are displayed results for weighted average walking time from all flats and from all houses in the Region to the nearest public transport stop. The weight is equal to percentage of flats in the space distance from nearest stop. More than 55% of all flats are up to 500 meters from the stop and people from here walk more than 2 minutes to the stop. About 10% of flats are farther than 1 kilometer. Generally people in the Moravian-Silesian Region have to walk more than 6 minutes to the nearest stop. Commuters have to walk twice – firstly from home to stop and than from stop to work place, so the totally walking time can take more than 12 and half minutes. This number can be even higher, if we count only with active stops instead of all stops. Walking time from all houses in the Region is about 1 minute higher than in previous case.

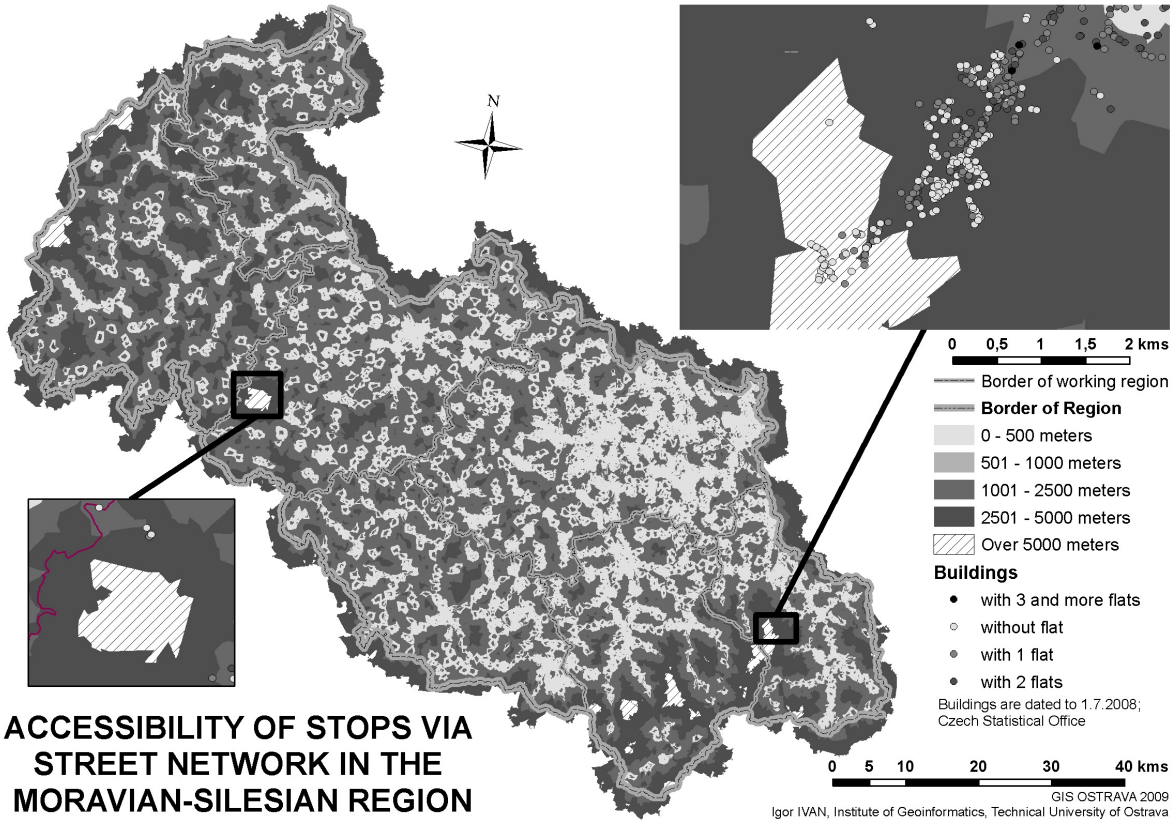

Figure 4. Accessibility of stops via street network

4 Door-to-door commuting to chosen employers via public transport

In previous chapter was calculated with connection between all houses or only with houses with some flat. But what is the situation in some practical case – in commuting to real employers. This walking situation was analyzed in special regions of the Moravian-Silesian Region. These special regions were calculated according to methodology from professor Hampl ([4] or [12]). The Region was divided in seven regions based on the commuting data from census in 2001. These can be named as working regions with one working center. The center was stated according to value of coefficient of functional

size and the municipality in regions according to the most significant commuting flow from the municipality of origin to the municipality with work place. All seven working regions are relatively workingly closed and most of commuters commute to the regional center. It was chosen five employers in each working region, so totally 35 of them. Localizations (addresses) of particular employer were taken from Albertina - Company Monitor, dated to February 2008. It was tried to choose the biggest employers and the location of them should be more scattered, so the result is displayed in figure below (Figure 5). The main goal is to compute the average walking time to stop of origin, walking time from target stop, time of journey and prize of journey from all houses in working region to all 5 employers. First of all was calculated the distance matrix between all stops in the Region with some overlap to surrounding Regions (5 kilometers behind the border, totally 4344 stops). Particular distances were taken from actual traffic order (September 2008) with utilization of NewDOK ([7]). The matrix is not complete, because between some of stops cannot be found any reasonable connection. Now we have computed the middle part of door-to-door commuting via public transport. The next stop is to calculate walking distances between houses and stops. Like it is written above, the commuter should have the possibility of choice, which stop he will use. But some condition had to be stated, so each commuter can choose from five closest stops which are maximally 5 kilometers from house via street network (data source again DMU25). After this step was calculated other distance matrix – between all houses and five closest stops (if those exist within 5 kilometers) – and we have the first and the last component for door-to-door commuting calculation. Then we can choose minimal values of travel distance between all houses and 35 buildings as work places.

4.1 Walking time to and from the most useable stop

In chapter above were computed the walking times to the closest stop. Now this evaluation can be upgraded and these times can be evaluated to the best stop to use for commuting to one of five employers in each working region. In table below are results. If the situation with walking time on previous case was about 7 minutes, now is this situation in average about 14 minutes. This is caused by usage other than the closest stop. The longest is the walk to stop in Bruntál region (more than 16 minutes) and the smallest in Ostrava region (less than 12 minutes). In all regions is the walking time less in case of walk from stop to work place then from home to stop. This can be explained with better location of these big employers considering to location of stops. Even more evident is this situation in maximum, where is the difference about 40 minutes.

Table 3. Average walking time to and from the most useable stop

Working region	Mean*		Std. Deviation*		Maximum*	
	to stop	from stop	to stop	from stop	to stop	from stop
Bruntál region	16.17	14.50	12.73	8.13	62.43	26.73
Frýdek-Místek region	15.52	13.00	9.91	8.63	62.49	26.89
Třinec region	15.85	12.50	11.57	4.59	62.42	18.89
Krnov region	12.85	12.17	9.90	5.57	62.19	23.94
Nový Jičín region	13.25	9.36	8.58	3.00	60.57	22.99
Opava region	12.01	10.66	9.77	3.76	62.01	16.05
Ostrava region	11.68	6.10	7.58	3.02	53.73	13.35

*In minutes

4.2 Influence of walking times on door-to-door journey via public transport

In the table below are displayed values for each employer. In first column are names of employers. The second column contains average walking times to home stop. The longest walk to home stop is by Město Třinec in Třinec region, Osram Bruntál, RD Rýmařov a AL Inv. Břidličná (all in Bruntál region). The walking time here is bigger than 16 minutes. The smallest walking time (about 12 minutes) time is by commuting to ArcelorMittal in Ostrava region or Brano in Opava region. The bigest walking times from target stop to work place are in cases of KVS Ekodivize or Osram Bruntál, both in

Bruntál region with more than 20 minutes of walk. It is naturally, that the longest journey to work will be in the largest regions – Bruntál, Ostrava or Opava region. Better for understanding of door-to-door approach importance is the influence of both walking times on the whole journey to work. In some cases (8 employers from 35) the walking process doubles the whole journey. Commuters who want to commute to companies Osram Bruntál or Slezan Frýdek-Místek have to commute thanks to walking to stop and from stop about more than 130% longer time. The commuting time will be extended about less than 50% by walking times in case of 10 companies. At least than in case of Biocel Paskov, Jäkl Karviná or ŽDB Group Bohumín, where is the extension caused by door-to-door approach only 35%. The column with prizes is only orientation, because not every transporter got the prize rates to traffic order provider.

Table 7. Average walking time and influence of walking times on journey to each employer

Employer***	Walking time to home stop*	Time of travel*	Walking time from work stop*	Influence of walking times on journey	Time of door-to-door travel*	Prize **
Slezan	15.58	23.91	17.45	138.12%	56.94	22
Osram	16.59	28.57	21.69	134.00%	66.85	23
Finidr	15.74	24.38	15.30	127.36%	55.42	11
Vúhž	15.53	27.87	19.55	125.85%	62.95	24
Dakon	12.57	23.57	16.09	121.57%	52.22	22
Nem. Třinec	15.91	27.61	17.44	120.76%	60.96	12
Pega	12.51	20.92	11.22	113.41%	44.65	21
SZZ	12.22	20.09	9.94	110.26%	42.25	19
Tiskárna	15.55	26.83	10.55	97.26%	52.93	11
KVS	15.52	41.02	23.34	94.75%	79.88	27
Technomont	15.57	41.62	20.26	86.09%	77.44	29
Strojírny	15.91	27.98	7.76	84.60%	51.64	8
KOaS	12.92	27.42	9.90	83.22%	50.24	21
Brano	12.33	29.72	12.06	82.06%	54.11	23
AL Invest	16.47	38.50	11.95	73.79%	66.92	25
Primus	12.83	33.73	11.90	73.33%	58.46	27
Třine	18.32	33.11	3.76	66.70%	55.19	14
Iktus	14.06	44.92	13.78	61.96%	72.76	29
Tatra	13.21	33.62	7.56	61.78%	54.39	27
Adv. Plastics	15.50	41.95	9.82	60.36%	67.27	32
MSA	11.62	43.43	13.81	58.54%	68.86	29
Msem	15.52	38.31	6.36	57.13%	60.19	27
Lanex.	10.73	37.09	9.97	55.81%	57.79	24
RD	16.54	39.11	5.06	55.21%	60.71	26
Ivax	11.95	37.93	8.16	53.04%	58.04	23
Nem. FM	15.40	34.25	1.48	49.26%	51.12	27
Mittal	11.32	34.14	5.07	48.01%	50.53	19
Autopal	13.38	48.18	9.25	46.95%	70.81	25
FNP	11.16	45.28	8.41	43.22%	64.85	24
GDX	13.34	58.66	11.03	41.55%	83.03	32
Nem. Opava	16.11	55.00	5.91	40.03%	77.02	29
Siemens	13.53	52.82	7.44	39.71%	73.79	37
Biocel	12.09	48.79	5.41	35.87%	66.29	27
Jäkl	11.43	56.19	8.55	35.56%	76.18	33
ŽDB	12.23	45.27	3.64	35.07%	61.15	26

*In minutes

**In CZK

***Ad. Plastics = Advanced Plastics, s.r.o., AL Invest = AL Invest Břidličná, a.s., Mittal = ArcelorMittal Ostrava a.s., Biocel = Biocel Paskov, a.s., Brano = Brano, a.s., Dakon = Dakon, s.r.o., FNP = Fakultní nemocnice s poliklinikou, Finidr = Finidr, s.r.o., GDX = GDX Automotive, s.r.o., Iktus = Iktus, s. r. o., Ivax = Ivax Pharmaceuticals, s.r.o., Jäkl = Jäkl Karviná, a.s., KOaS = Krnovské opravny a strojírny, s.r.o., KVS = KVS Ekodivize, a.s., Lanex = Lanex, a.s., Třinec = Město Třinec, Technomont = Milan Masný Technomont, MSA = MSA, a.s., MSEM = Msem, a.s., Nem. Třinec = Nemocnice Třinec, přísp.org., Nem. FM = Nemocnice ve Frýdku - Místku, přísp.org., Osram = Osram Bruntál, s.r.o., Pega = POO OS TOK Pega, Primus = Primus CE, s.r.o., RD = RD Rýmařov s. r. o., SZZ = Sdružené zdravotnické zařízení Krnov, Siemens = Siemens Automobilové systémy, s.r.o., Slezan = Slezan Frýdek - Místek a. s., Nem. Opava = Slezská nemocnice v Opavě, přísp.org., Strojírny = Strojírny Třinec, a.s., Tatra = Tatra, a.s., Tiskárna = Těšínská tiskárna, a. s., Autopal = Visteon - Autopal, s.r.o., VÚHŽ = Vúhž, a.s., ŽDB = ŽDB Group, a.s.

5 Door-to-door commuting to chosen employers via individual transport

In the previous chapter were calculated the times of journeys to chosen employers via public transport with usage of door-to-door approach. What is the situation with usage of individual transport? It was calculated a distance matrix with distances between all houses in the Moravian-Silesian Region and 35 chosen employers. All parts of the street network were scored with the average speed. The other possibility is usage of the time accessibility model via individual transport from Hudeček [9] but because of the used spatial micro-level and street network was used this methodology. From matrix were then removed houses, which are closer than one kilometer to the employer, because they can pass this distance by bicycle or by foot. If these results should be comparable to public transport results, it must be counted with door-to-door approach and so added some time foe walking to car from home and from car to the work place. These times were set as 6 minutes.
In the table below are displayed results for all 35 companies. In the first column are numbers of houses up to one kilometer from the employer. This corresponds with location and area of particular employer. Most houses in one kilometer, around 800 houses, have Lanex or the Třinec Hospital. Osram, MSEM or Slezan Frýdek-Místek have only around 10 houses within one kilometer distance. The second column shows times via street network without walking times and in the third column are walking times. In next 3 columns are the minimal, maximal and average times of journeys. All these times contain walking time. Minimal time from the closest house (but more than 1 kilometer) is very similar in all cases around 7.5 minutes. In maximal times are evident more different numbers. The range is from 80 minutes in case of Siemens or MSA to 44 minutes in case of Třinec Hospital or Třinec Authority. On the average are the times of journey highest in case of GDX or Jäkl with almou 40 minutes and lowest in case of Třinec Hospital or Třinec Authority or Strojírny Třinec. From these results is obvious that results are influenced by the location in the working region, if the location is nearer to boundaries, results are higher than in case of central location. But in comparison to other transport possibilities is this inaccuracy or influence equal. Prize of journey is counted as 3.9 CZK per kilometer (2 CZK for fuel and 1.9 CZK for amortization, this is a half of prize for amortization of official journey with private car).

Table 8. Time and prize of journey by individual transport

Employer ***	Houses up to 1 km	Time of travel*	Walking time*	Minimal time time of journey *	Maximal time of journey *	Average time of journey*	Prize**
GDX	74	33.14	6.00	7.66	74.13	39.14	93
Jäkl	419	32.90	6.00	7.54	75.95	38.90	103
Ad. Plastics	260	31.92	6.00	7.21	67.60	37.92	87
KVS	26	30.93	6.00	7.35	66.87	36.93	90
MSA	344	29.30	6.00	7.43	77.84	35.30	81
Siemens	406	27.18	6.00	7.17	80.14	33.18	78
Biocel	64	26.50	6.00	7.72	60.27	32.50	79
Lanex	814	26.40	6.00	7.47	75.16	32.40	76
RD	214	24.43	6.00	7.48	59.13	30.43	70
AL Invest	377	24.16	6.00	7.50	61.61	30.16	68

ŽDB	304	23.82	6.00	7.51	63.79	29.82	67
Iktus	138	22.91	6.00	7.52	60.46	28.91	68
FNP	505	22.78	6.00	7.59	59.96	28.78	69
Osram	12	22.11	6.00	8.02	54.21	28.11	61
Primus	397	21.20	6.00	7.54	66.28	27.20	63
Tatra	546	20.76	6.00	7.53	68.90	26.76	59
Tiskárna	729	20.13	6.00	7.45	55.02	26.13	61
Finidr	192	19.91	6.00	7.55	55.39	25.91	60
ArcelorMittal	107	19.70	6.00	7.86	50.77	25.70	59
Ivax	44	18.55	6.00	7.78	60.79	24.55	52
Dakon	166	18.19	6.00	7.75	54.76	24.19	51
Autopal	689	17.94	6.00	7.55	53.30	23.94	51
Brano	319	17.86	6.00	6.91	48.13	23.86	53
Pega	593	17.16	6.00	7.53	52.72	23.16	49
Nem. FM	774	17.09	6.00	7.54	62.35	23.09	49
MSEM	11	16.95	6.00	7.53	60.88	22.95	49
VÚHŽ	36	16.89	6.00	7.40	63.04	22.89	47
Slezan	8	16.69	6.00	7.79	61.49	22.69	47
SZZ	754	16.57	6.00	7.52	50.53	22.57	48
Nem. Opava	580	16.36	6.00	7.21	53.48	22.36	46
Technomont	225	16.29	6.00	7.50	55.35	22.29	43
KOaS	629	16.07	6.00	7.51	49.83	22.07	46
Strojírny	57	15.36	6.00	7.60	46.65	21.36	42
Nem. Třinec	36	15.06	6.00	7.56	44.28	21.06	43
Třinec	620	14.11	6.00	7.50	43.79	20.11	41

*In minutes

**In CZK

***Ad. Plastics = Advanced Plastics, s.r.o., AL Invest = AL Invest Břidličná, a.s., Mittal = ArcelorMittal Ostrava a.s., Biocel = Biocel Paskov, a.s., Brano = Brano, a.s., Dakon = Dakon, s.r.o., FNP = Fakultní nemocnice s poliklinikou, Finidr = Finidr, s.r.o., GDX = GDX Automotive, s.r.o., Iktus = Iktus, s. r. o., Ivax = Ivax Pharmaceuticals, s.r.o., Jäkl = Jäkl Karviná, a.s., KOaS = Krnovské opravny a strojírny, s.r.o., KVS = KVS Ekodivize, a.s., Lanex = Lanex, a.s., Třinec = Město Třinec, Technomont = Milan Masný Technomont, MSA = MSA, a.s., MSEM = Msem, a.s., Nem. Třinec = Nemocnice Třinec, přísp.org., Nem. FM = Nemocnice ve Frýdku - Místku, přísp.org., Osram = Osram Bruntál, s.r.o., Pega = POO OS TOK Pega, Primus = Primus CE, s.r.o., RD = RD Rýmařov s. r. o., SZZ = Sdružené zdravotnické zařízení Krnov, Siemens = Siemens Automobilové systémy, s.r.o., Slezan = Slezan Frýdek - Místek a. s., Nem. Opava = Slezská nemocnice v Opavě, přísp.org., Strojírny = Strojírny Třinec, a.s., Tatra = Tatra, a.s., Tiskárna = Těšínská tiskárna, a. s., Autopal = Visteon - Autopal, s.r.o., VÚHŽ = Vúhž, a.s., ŽDB = ŽDB Group, a.s.

6 Door-to-door commuting to chosen employers via carpooling

Carpooling as written in the introduction is special way of individual transport, where the car is shared (for this case) by one, two or three passengers. For need of this project was developed extension for OpenJUMP utility by Martin Prager. With this utility can be calculated lengths of journeys with some number of stops in buffer area with some distance from the shortest journey. As inputs should be used layer of buildings and layer of street network.

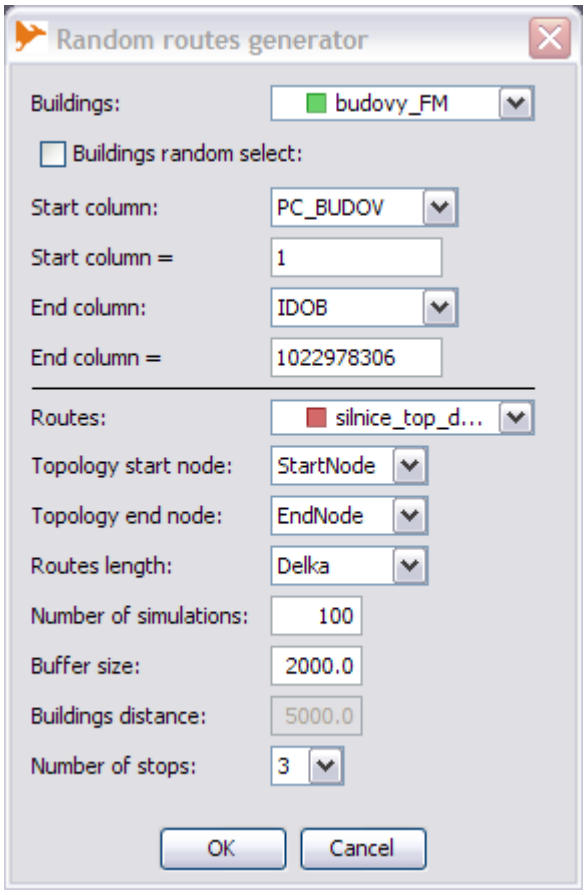

Figure 5. Random routes generator extension

There can be chosen a random selection or a value of some attribute as start of journey. The same process is in case of end of journey. In this project were chosen PC_BUDOV as the start attribute, because it contains only one value in all cases (equal to 1), so every building can be part of simulation. As the final point was chosen IDOB attribute with values of particularly employers. Start and final node of each line, as well as length of each line, have to be other inputs for street network. Followings factors are number of simulations, so how many calculations should be calculated, for this project it is 100 simulations (100 houses for each employer). Buffer size defines the area in meters around the shortest journey and for all simulations it is 2 kilometers. Finally the number of stops is equal to the number of passengers (in case, that 1 passenger = 1 stop). For this project are calculated 100 simulations for each employer and for 1, 2 or 3 stops.

In this table are displayed results for each of all 35 employers in the Moravian-Silesian Region. In first three columns are values of the average distances between home and employer with one, two or three stops. There are evident the rising numbers with more stops, what is logical, but interesting is the size of this increase, that is mostly not so high. The prize was counted from results and based on methodology in previous chapter. For case of one stop during the journey is the prize counted as half of individual journey prize. For case of two stops is the prize a third of individual journey prize etc.

Table 9. Time and prize of journey by carpooling

Employer**	Mean*			Prize		
	1 stop	2 stops	3 stops	1 stop	2 stops	3 stops
Adv. Plastics	21.97	24.45	25.17	43	32	25
AL Invest	18.04	18.72	19.09	35	24	19
Autopal	12.99	15.03	16.80	25	20	16
Biocel	20.57	21.51	24.08	40	28	23
Brano	14.84	15.64	17.42	29	20	17

Dakon	13.56	14.51	15.19	26	19	15
Finidr	16.89	17.90	18.30	33	23	18
FNP	17.70	17.76	19.08	35	23	19
GDX	24.21	25.42	25.73	47	33	25
Iktus	17.47	17.68	18.62	34	23	18
Ivax	13.88	14.87	15.72	27	19	15
Jäkl	26.74	27.45	27.81	52	36	27
KOaS	11.76	14.53	15.35	23	19	15
KVS	23.42	24.46	26.51	46	32	26
Lanex.	19.48	19.53	21.24	38	25	21
Mittal	15.77	17.49	17.82	31	23	17
MSA	21.00	22.05	22.15	41	29	22
Msem	13.31	15.11	15.70	26	20	15
Nem. FM	13.86	14.61	15.85	27	19	15
Nem. Opava	12.50	15.53	15.78	24	20	15
Nem. Třinec	12.35	14.33	16.09	24	19	16
Osram	17.00	16.94	18.98	33	22	19
Pega	13.36	14.25	14.52	26	19	14
Primus	16.66	17.90	18.15	32	23	18
RD	19.77	19.94	22.18	39	26	22
Siemens	19.99	21.75	24.57	39	28	24
Slezan	13.49	15.83	16.71	26	21	16
Strojírny	13.26	14.20	14.32	26	18	14
SZZ	13.18	14.33	15.40	26	19	15
Tatra	16.23	16.98	17.05	32	22	17
Technomont	12.63	13.81	15.58	25	18	15
Tiskárna	16.95	18.74	18.94	33	24	18
Třinec	11.24	13.58	15.45	22	18	15
Vúhž	12.68	14.90	15.73	25	19	15
ŽDB	17.67	19.28	19.72	34	25	19

*in kilometers

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7 Conclusions

In all previous chapters is evident the existence of areas with longer walking distance in case of usage public transport. So what is the situation in comparison of all types of transport vehicles? Chapters 5 and 6 were not been described because the size of average journey to particular employers depends on area of working regions and on location of employer. Because of these problems cannot be results for employers compared mutually. Only way of comparison is the difference based on type of transport vehicle for each employer. In figure 6 are displayed results of commuting distances comparison. In case of three employers is the distance by public transport less than by individual transport, what is

caused by more general results which are from time orders (that are rounded to whole kilometers). The longest journeys are traveled mostly by carpooling with three stops, than by carpooling with two stops, by public transport, by carpooling with one stop and finally by individual transport without any stop.

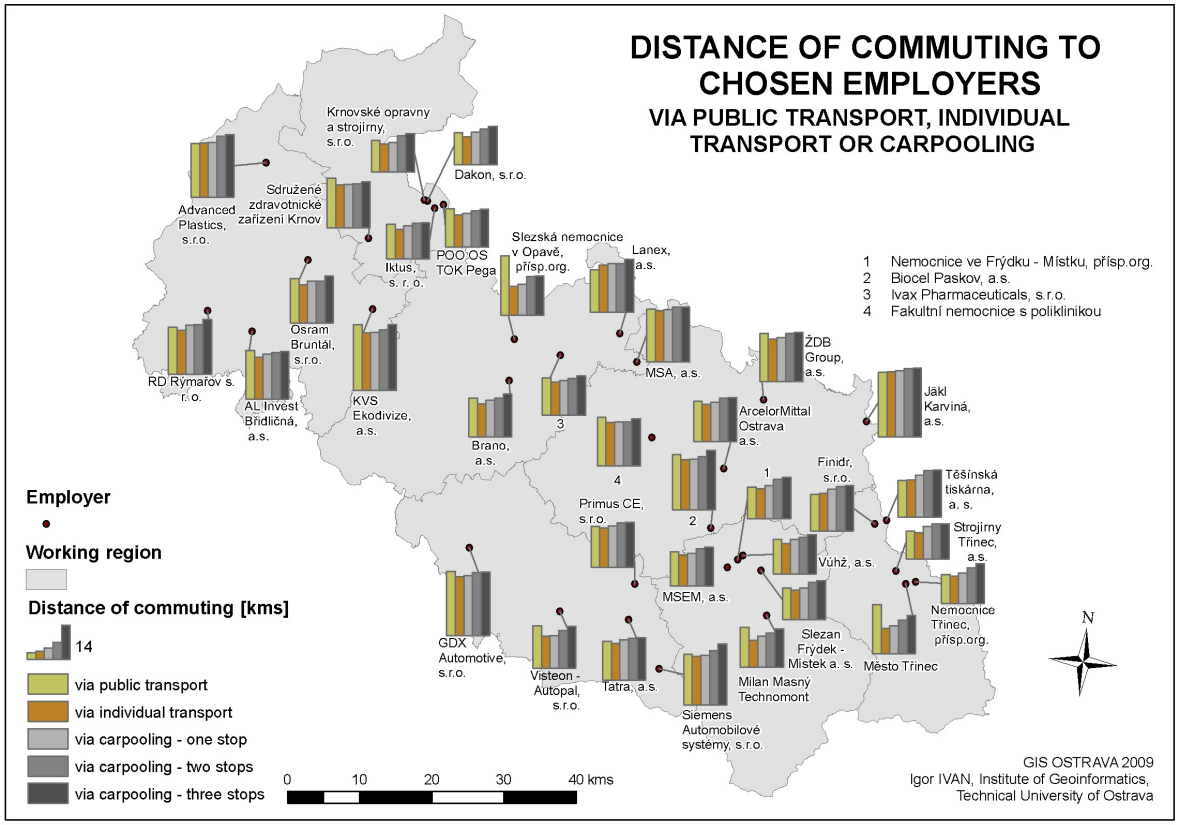

Figure 6. Comparison of commuting distances

In general can be said some results. If the percentage distance increases between particular transport vehicles and individual transport are compared, results will confirm the order of particular transport vehicles. The carpooling with three stops will enlarged the shortest journey in the average about 23%. The carpooling with two stops is almost equal to public transport and the increase is in the average 16% and in case of carpooling with one stop is the increase only about 7%. Median shows bigger differences between carpooling with 2 stops and public transport. In two cases (Třinec Authority and Opava Hospital) is the percentage increase of public transport distance about 100%, so the journey by car without stop is half-length.

Table 10. Percentage distance increase to individual transport

	Mean	Median	Std. Deviation	Maximum
Public transport x individual transport	15.33	10.59	23.19	103.68
Carpolling (1 stop) x individual transport	7.08	5.67	5.38	22.34
Carpolling (2 stops) x individual transport	16.35	14.82	9.50	32.98
Carpolling (3 stops) x individual transport	23.31	21.62	11.63	51.36

The prize of commuting is very important for a lot of people because the commuting is daily movement. The figure below shows the prizes for all analyzed types of transport vehicles for all 35 employers. In all cases is the most expansive way of travelling the individual transport. This superiority is very strength. Then is public transport and carpooling with one stop. The decrease continues with increase of stops by carpooling.

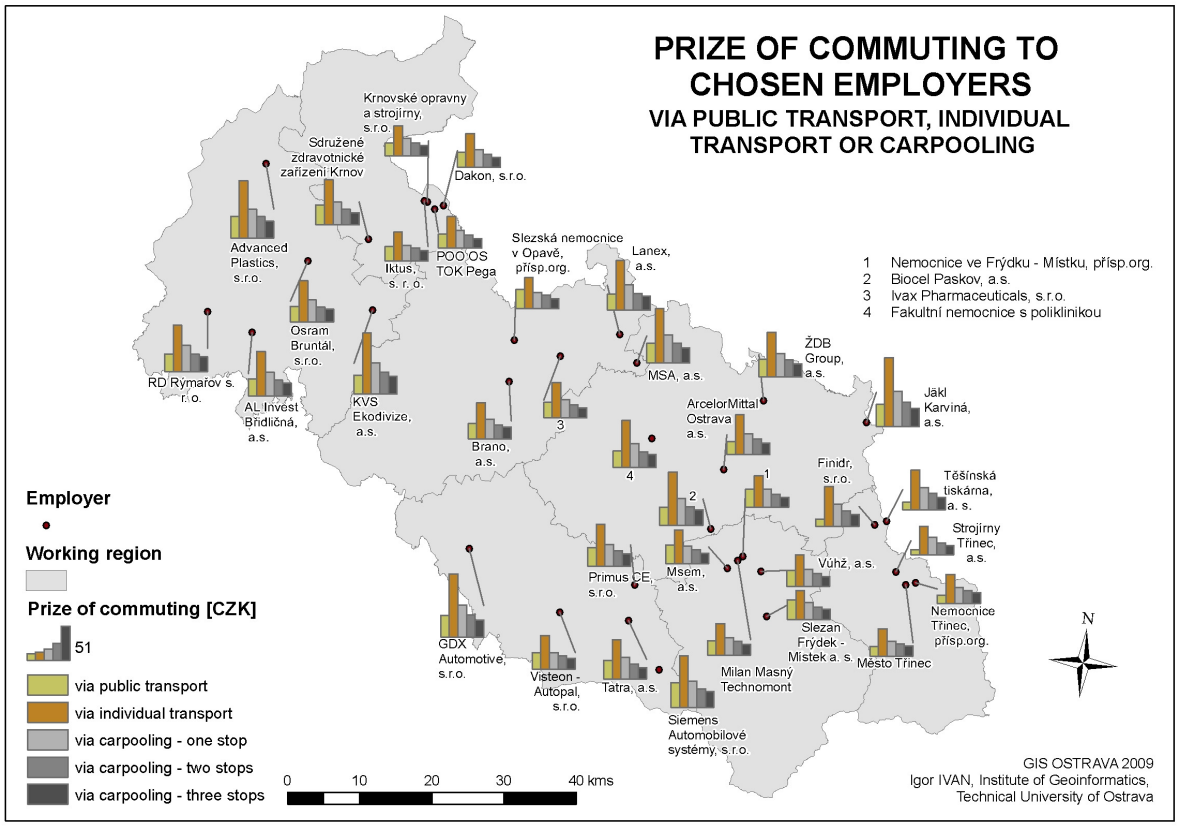

Figure 7. Comparison of commuting prizes

In previous case was obvious the increase of all transport vehicles but in case of prizes are obvious only decreases. The smallest decrease is by carpooling with one stop but the decrease is almost 46.5% what is quite big. Public transport and carpooling with two stops is again very similar and the decrease here is around 60%. The highest decrease is by carpooling with three stops -69%. Median is very similar to arithmetic mean. The minimums show the maximal savings of money. The biggest saving is in case of public transport and then with rising number of stops raises the savings as well.

Table 11. Percentage prize increase to individual transport

	Mean	Median	Std. Deviation	Minimum
Public transport x individual transport	-59.52	-60.61	11.23	-81.36
Carpolling (1 stop) x individual transport	-46.47	-47.02	2.71	-49.98
Carpolling (2 stops) x individual transport	-61.22	-61.94	3.18	-66.54
Carpolling (3 stops) x individual transport	-69.18	-69.76	2.90	-73.41

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