AGGLOMERATION EFFECTS OF THE BRNO CITY (CZECH REPUBLIC) AS EXEMPLIFIED BY THE POPULATION LABOUR MOBILITY

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ABSTRACT:
Labour mobility (or, formally, travels to work) is the most significant region-shaping process creating agglomeration hinterlands of all larger cities. The South-Moravian Region and the city of Brno, which, with the population of 400,000, is its natural centre, represent the model region for this article. Based on performed research work the article would like to introduce and verify the potential of labour mobility of the region's inhabitants in relation to the expected potential salary/wage, transport time and distance from the centre - these belong among the principal economic motivators for travelling to work. Agglomeration effects of the Brno City are therefore perceived in the context of space and time while emphasizing transport costs, transport facilities and the effect of labour mobility itself.

Key-words: *Agglomeration effect**,** Transport, Travels to work, Mobility, accessibility, Regional development, City of Brno, South Moravian Region, Czech Republic.*

1. INTRODUCTION

The concept of agglomeration effects, or advantages, was established in the late 1900s when the English economist Alfred Marshall identified the mechanisms (principles) used by individual businesses to agglomerate or create mutual bonds. The concept explains concentration of activities at a place, through which they are provided an added value, extra profit, simplification of activities or cost saving (Rosenthal & Strange, 2008). These mechanisms can be classified in various ways. Kitchin and Thrift (2009) divide them into agglomeration advantages focused on flexibility and dynamics (sharing of services and infrastructure, transport cost reduction, proximity of the labour force source) and agglomeration advantages focused on innovation (sharing of know-how, experience). Rosenthal and Strange (2004) divide agglomeration advantages according to their dimensions into geographical (spatial), temporal and industrial (process ones).

Despite the fact that the term "agglomeration advantage" is rather old and there are many studies monitoring the impacts of these agglomeration advantages (most frequently in the form of localization determinants within a regional scope), Fujita and Thisse (2000) nevertheless consider the issue of agglomeration advantages to be an inadequately studied field. These issues seem to be inspirational within the context of theoretical concepts referring to the ever decreasing transport costs in the economy of the city or the region and the relationship between the city size and its performance (provision) for further improvements in city and suburban transport systems (e.g. Venables, 2004; Glaeser & Kohlhase, 2005; Graham, 2007; Rodrigue, Comtois & Slack, 2009 and others).

The latest studies of the Czech geographical community do not focus strictly on agglomeration effects - they rather strive to define nodal regions or hinterlands of cities according to transport flows (Seidenglanz, 2010; Kraft, Halás & Vančura, 2014; Kraft, Marada & Popjaková, 2014) without any regard for an economic motivation of the

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inhabitants to travel to the centre of the region. Kunc et al., (2012) study travels to shop as a part of the daily urban system of the Brno agglomeration; for similar evaluations from Slovakia see Fertaľová (2006) analyzing the hinterlands of large eastern Slovakian cities Prešov and Košice. Ivan (2010) compares the advantages of carpooling with the individual and public transport while emphasizing the travel distance and transport costs in the Ostrava agglomeration. Horňák, Pšenka and Križan (2013) provide an interesting comparison of the possibilities of the individual and public transport with, besides others, the economic interests of the public transport services providers to acquire customers (passengers) within the context of interconnecting the key regional centres of Slovakia.

Our article shall focus on the agglomeration effects connected with space and time with an emphasis on transport costs, transport infrastructure and labour mobility of the inhabitants in the South-Moravian Region, for which the city of Brno, with its population of 400,000, is the natural centre. The article would like to point out the potential of labour mobility of the inhabitants of the model region and its centre while considering the transport time and distance from the centre and to analyze the economic motivation of the inhabitants to travel to work. This economic motivation is expressed by the expected growth in wage/salary when travelling to the economic centre of the region. To preserve the consistency and logical framework of the text, the methodological starting points and approaches based on Viturka et al. (2014) are described together with the performed analyses and their results in the following paragraphs.

2. METHODS AND RESULTS

2.1. Labour Mobility Potential

Clarification of the population's motivation to travel to work is based on the concept of manufacturing resources, or rather labour force marginal rate of mobility (Viturka & Pařil, 2013). The South-Moravian Region has become the studied space and there was studied the potential mobility of all inhabitants from all municipalities (673) to the gravity centre of Brno. Three main information sources related to both public and individual transport were used to study the labour force mobility potential: www.maps.google.cz for data about the time of transport and distances for individual car transport (according to: http://jizdnirady.idnes.cz/idsjmk/spojeni/) for data about the distances and transport time for the public transport and IDS-JMK (2013) for data about the public transport zoning within the South-Moravian Region.

Information about transport costs is one more significant input for labour force mobility analyses. The Integrated Transport System of the South-Moravian Region (IDS JMK), which determines the price according to the number of zones the passenger passes through to reach his/her destination location was used to acquire the public transport prices (see IDS JMK, 2013). The prices of the nine tariffs in the South-Moravian Region range according to the tariff zone and the means of purchase from 830 CZK to 31,560 CZK (29.92 EUR to 1,137.71 EUR, (The Czech National Bank exchange rate for September 1, 2014 of 27.74 CZK/EUR was used in all cases to convert Czech Crowns to Euros) for an annual pass. Individual car transport costs were calculated from the average fuel price of 36.65 CZK/l (1.32 EUR/l) (CSO, 2014), (according to Czech Statistical Office), the average fuel consumption of 7 l/100km and it also includes the so-called base rate defined in the Labour Code, which takes into account the car depreciation for each driven kilometer at the rate of 3.80 CZK/km (0.137 EUR/km) (Section 157 par. 3 and par. 4 of the Labour Code).

The total number of days in 2013 (252) multiplied by two was used to define the frequency of travels to work, i.e. the total number of driven kilometers per year (to compare with the public transport annual tariff rate).

The labour mobility potential can essentially be analyzed by two elementary methods. These methods represent two different models studying the labour mobility potential from the distance from centre viewpoint and from the transport time viewpoint. Within the first model, reflecting the aspect of a municipality distance from the centre, there were identified, within the catchment area of Brno, the total of seven concentric zones, see Table 2; the determining distance was the shortest possible route to the main transport node of the regional centre - i.e. to the area of the Nádražní - Úzká streets (the centres for railway and bus transport) achievable by public transport or by car (in most cases these are distances achievable by passenger cars). Individual municipalities were then classified into particular zones regardless of the IDS JMK tariff zones. To calculate the average annual cost of transport it was necessary to define the structure of use for the main types of transport used to travel to work, see the following table. Values in the following table are the percentage representations of the individual transport modes according to the distances of travels to work. Zones starting from 6km were considered since the distance is not shorter from any of the analyzed municipalities (travels to work from the municipal districts of the regional centre naturally feature shorter distances but there are correspondingly higher shares of public, bicycle and pedestrian transport).

Table 1 Usages of the individual transport modes while travelling to work

Distance (km)	Usage of the specific transport mode (%)					
	Passenger Cars	Railway	Bus	Public Transport	Bicycle	Pedestrian
6.1-9.0	18	1	5	71	5	0
9.1-12.0	25	1	30	43	1	0
12.1-15.0	40	6	54	0	0	0
15.1-20.0	40	6	54	0	0	0
20.0-25.0	39	6	55	0	0	0
25.1-30.0	34	12	54	0	0	0
30.1-35.0	29	24	47	0	0	0
over 35	30	21	49	0	0	0

Source: Čarský (2007); Own survey and processing.

The Marginal Rate of Mobility (travel distance) is determined by the following equation (Viturka & Pařil, 2013):

$$M_m = \frac{G_I}{G_C}, \qquad (1)$$

Where M_m = Marginal Rate of Mobility, G_I= Income Growth, G_C = Costs Growth, which can be further defined as follows:

$$G_C = \frac{C_P(S_P) + C_I(S_I)}{S_P + S_I}, \qquad (2)$$

Where C_P = Average Growth of Cost for Public Transport, S_P = Public Transport Share in the Zone, C_I= Average Growth of Cost for Individual Car Transport and S_I= Individual Car Transport Share in the Zone.

The following **Table 2** presents a general overview of the results of the performed analysis of the Marginal Rate of Mobility for the individual zones, or rather for the distances of residences of the persons travelling to Brno to work. It applies to M_m that if $M_m > 1$, there is a precondition for achieving the economic motivation of the inhabitants for travelling to the centre of attraction. Vice versa, if $M_m < 1$, it is not worthwhile for economically active inhabitants to travel to work to the centre of the studied centre of attraction. If $M_m = 1$, or in case of values approaching 1 (between 0.9 and 1.1), we are talking about a transitional zone, where additional factors, especially sociological and psychological aspects of the person travelling to work, would have to be taken into account when considering travels to the centre. The table calculates the Marginal Rate of Labour Mobility for five different situations according to the potential growth in income of the person travelling to work (values from 2,000 to 10,000 CZK are considered).[2]

Table 2.Marginal Rate of Mobility – Concentric Zone Model

Zone (km) / G_C (CZK/EUR)	2,000/ 72.1	2,500/ 90.12	3,700/ 133.38	5,000/ 180.25	10,000/ 360.49
0.0 – 10.0	1.87	2.34	3.46	4.68	9.36
10.1 – 20.0	0.92	1.15	1.70	2.29	4.59
20.1 – 30.0	0.61	0.76	1.13	1.53	3.06
30.1 – 40.0	0.52	0.66	0.97	1.31	2.62
40.1 – 50.0	0.42	0.52	0.78	1.05	2.10
50.1 – 60.0	0.35	0.44	0.65	0.87	1.75
60.1 and above	0.25	0.31	0.46	0.62	1.25

Note: The "value of time spent in transport" is not considered due to its high variability - see HEATCO (IER, 2006). *Source: CSO (2014), IDS-JMK (2013), MPSV (2013); www.maps.google.cz; own survey and processing.*

Table 2 implies that when considering the likeliest pay increase from median pay to average pay in the South-Moravian Region, listed in the column with the gross income growth (G_I) at the amount of 3,700 CZK/month (rounded up to hundreds of CZK) then economic motivation for travelling to work in Brno is demonstrated for distances within 30 km from Brno. The distances between 30 and 40 km represent the transitional zone where individual factors will play an important role in the decision-making processes of individual workers. These results are summarized in **Fig.1**, where you can see three zones: the zone of economic advantage ($M_m > 1.1$), the transitional zone ($1.1 > M_m > 0.9$) and the economic disadvantage zone ($M_m < 0.9$).

Fig.1 presents the results of the labour mobility potential analysis according to the distance priority along with the backbone infrastructure, which is closely associated with the transport accessibility. The second used model, reflecting the time aspects of transport to the centre, identified the total of seven isochronous zones with boundary values of time distances from Brno of 20, 30, 40, 50, 60 and 90 minutes, see **Table 3**. Formulas from the previous section have been used to calculate the Marginal Mobility Rate but the individual

[2] The value of 3,700 CZK (133.38 EUR) represents the gross difference between the average pay (25,592 CZK – 922.57 EURO) and median pay (21,905 CZK – 789.65 EURO) in the South-Moravian Region in 2013, rounded to hundreds of CZK. The model example assumes that it is possible to achieve the median pay on average in the Brno attraction area while it is possible to achieve at least the average pay in Brno.

municipalities were categorized into zones not according to the distance from the centre but according to the time needed to travel to Brno to work. The resulting minimum times for the public and individual modes of transport were weighed according to the representations of the individual modes of transport according to the distance of travelling to work as listed in **Table 1**; bicycle transport has not been considered and the categories of railway, bus and public transport were merged into the Public Transport category (for the zone of nine kilometers there is considered the ratio between the public and individual transports as 81:19, in the zone within 12 km it is 75:25, farther away 60:40, etc.).

Fig. 1 (and the following figures) includes the border of the Brno hinterland for easier orientation. This hinterland was defined according to the data on daily travels to work coming from the 2011 census; a municipality was assigned either to Brno or to one of the microregional centres depending on the direction orientation of the main outgoing flow while preserving the principle of hinterland territorial continuity (suppression of enclaves/exclaves). A municipality is considered a microregional centre when, based on travels to work, it has its own hinterland composed of a contiguous territory of at least 5 municipalities and the whole microregion must include at least 10,000 inhabitants (Hrušovany nad Jevišovkou is an exception since the number of inhabitants living in the microregion is only 7,500 due to the location close to the country border).

The following **Table 3** implies that when considering the likeliest income growth, which was established identically with the previous case to be 3,700 CZK (133.38 EUR) per month, the economic motivation for the population to travel to work is within 40 minutes of travel into the corresponding labour centre. The subsequent zone is then considered to be the transitional zone. The basic tree resulting zones of economic advantageousness, the transitional zone and the zone of economic disadvantageousness are defined in **Fig. 2**.

Table No. 3 Marginal Rate of Mobility – Isochronal Zone Model

Zone (minutes) / G_C (CZK/EUR)	2000/ 72.10	2,500/ 90.12	3,700/ 133.38	5,000/ 180.25	10,000/ 360.49
10.0 – 20.0	1.21	1.51	2.23	3.01	6.03
20.1 – 30.0	0.88	1.09	1.62	2.19	4.38
30.1 – 40.0	0.63	0.79	1.17	1.58	3.16
40.1 – 50.0	0.54	0.68	1.00	1.35	2.70
50.1 – 60.0	0.47	0.59	0.88	1.19	2.37
60.1 – 90.0	0.35	0.44	0.65	0.88	1.77
90.1 and above	0.24	0.31	0.45	0.61	1.22

Source: CSO (2014), IDS-JMK (2013), MPSV (2013); www.maps.google.cz; own survey and processing.

In general, it is possible to claim that a positive potential for labour mobility was identified in the first model to be within 30 kilometers from the Brno centre and in the second model to be within 40 minutes of the total travel time. A transitional zone is represented by the distance within 40 kilometers and 50 minutes of travel. These values correlate closely (reflecting the fact that travels to work occur mainly at the rush hours) and they can be regarded as a significant limiting factor for labour force availability in the South-Moravian metropolis.

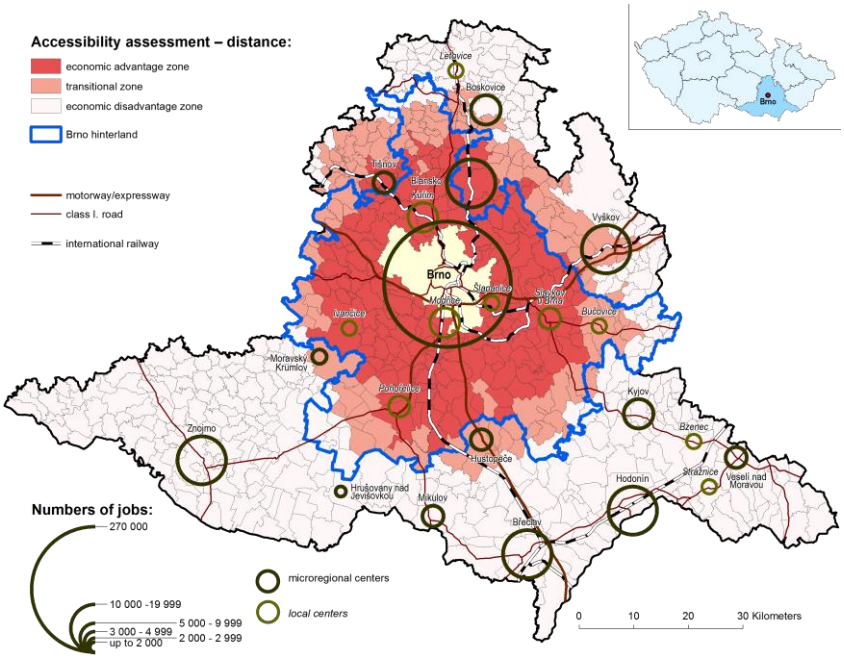

Fig. 1 Labour mobility potential according to the distance from the centre

Source: CSO (2014), IDS-JMK (2013), MPSV (2013); www.maps.google.cz; own survey and processing.

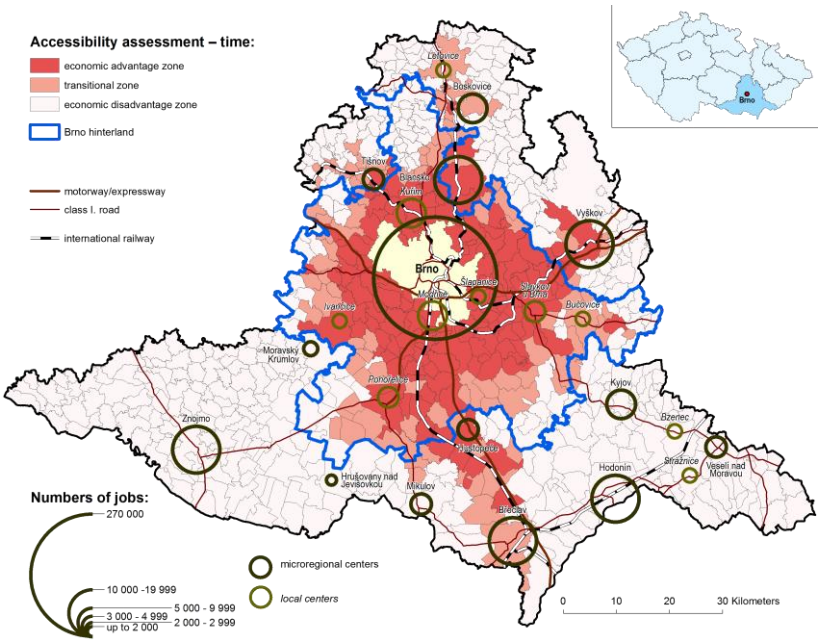

Fig. 2 Labour mobility potential according to the travel time to the centre

Source: CSO (2014), IDS-JMK (2013), MPSV (2013); www.maps.google.cz; own survey and

processing.

Table 4 summarizes the synthetic assessment of municipalities according to both temporal and distance accessibility. Three situations when considering temporal accessibility and three cases when considering distance from centre can occur for each municipality. In the first case the municipality is located within the 40 minute transport time zone (economic advantage), within the 40-50 minute zone (transitional zone) and in the zone with over 50 minutes of travel time (economic disadvantage). Three situations can occur also when considering the distance: within 30 km, 30-40 km and over 40 km from the centre. For graphical representation of the synthetic model see **Fig. 3**.

Table No. 4 Synthetic model of the labour mobility potential

Model / Economic (Dis)Advantage	Concentric Zone Model	Isochronal Zone Model	Marginal Rate of Mobility (Mm)	Mm Evaluation	Synthetic Model			
	Zone (km)	Zone (minutes)			Assessment in the Concentric Zone Model	Assessment in the Isochronal Zone Model	Assessment Sum	Resulting Zone
Economic Advantage Zone	0.0 – 10.0	10.0 – 20.0	> 1.1	1	1	1	2	1
	10.1 – 20.0	20.1 – 30.0	> 1.1	1	2	2	3	2
	20.1 – 30.0	30.1 – 40.0	> 1.1	1	3	3	4	3
Transitional Zone	30.1 – 40.0	40.1 – 50.0	<0.9 -1.1>	2			5	4
Economic Disadvantage Zone	40.1 – 50.0	50.1 – 60.0	< 0.9	3			6	5
	50.1 – 60.0	60.1 – 90.0	< 0.9	3				
	60.1 and above	90.1 and above	< 0.9	3				

Source: Own survey and processing.

2.2. Verification of the Labour Mobility Potential According to Travels to Work

The following section presents a verification of the above-mentioned model of economic motivation for travelling to the regional centre with the expectation of obtaining higher wage/salary with regards to the temporal and distance accessibility of this natural centre. This verification is based on the comparison of the results of the above-mentioned model with real-life processes of travel flows of the South-Moravian Region's inhabitants. It describes to what extent Brno, as the economic centre of the region, is able to absorb the travels to work in competition with the less significant district centres or employment centres (e.g. Znojmo, Břeclav, Hodonín, and Blansko) or in competition with microregional centres, such as Tišnov, Hustopeče, Moravský Krumlov, etc.

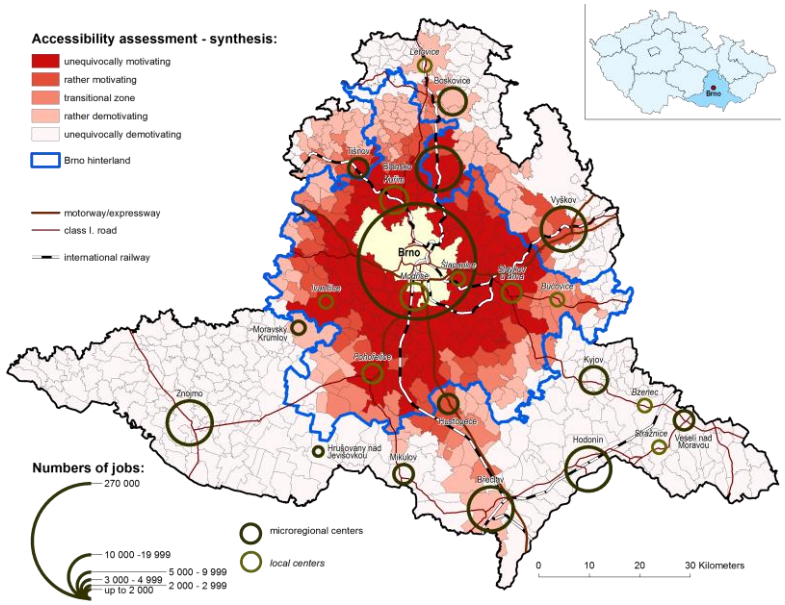

Fig. 3 Synthetic model of the labour mobility potential

Source: CSO (2014), IDS-JMK (2013), MPSV (2013); www.maps.google.cz; own survey and processing.

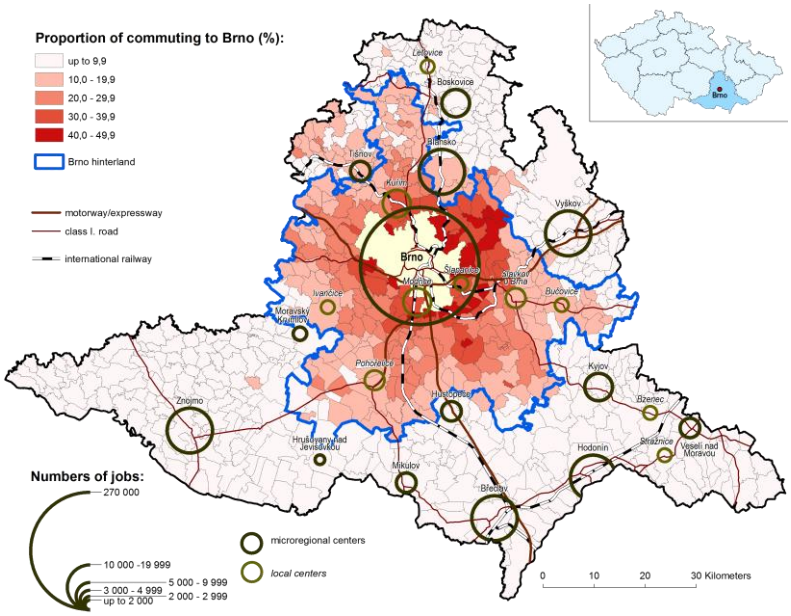

Fig. 4 Proportion of employed people travelling to Brno to work from individual municipalities

Source: CSO 2013, own survey and processing.

Table 5. Correlation coefficients in the labour mobility potential verification.

Model	Concentric Zone Model	Isochronal Zone Model	Synthetic Model
Correlation Coefficient	-0.84	-0.82	-0.83

Source: Own survey and processing.

The results of the correlation analysis presented in **Table 5** imply a statistically significant correlation relationship between the travels to work and the labour mobility potential assessment in all three models presented above. Correlation with a proportion of people travelling from a municipality to the centre of the region, i.e. to Brno, was analyzed. Seven zones from **Table 2** were the starting point for the correlation between travels to work and the concentric zone model (distance) - here you can logically observe high indirect dependence since motivation for travelling to work to the centre declines with increasing distance. Zones specified in **Table 3** were the starting point for the correlation relationship with the isochronal zone model (time) and the five-point scale from **Table 4** (**Fig. 3**) was the starting point for the synthetic model. The following **Fig. 5** depicts the graphical distribution of the correlation relationship (the problem of relationship between commuter's interaction and distance has been further discussed in Halás, Klapka & Kladivo (2014).

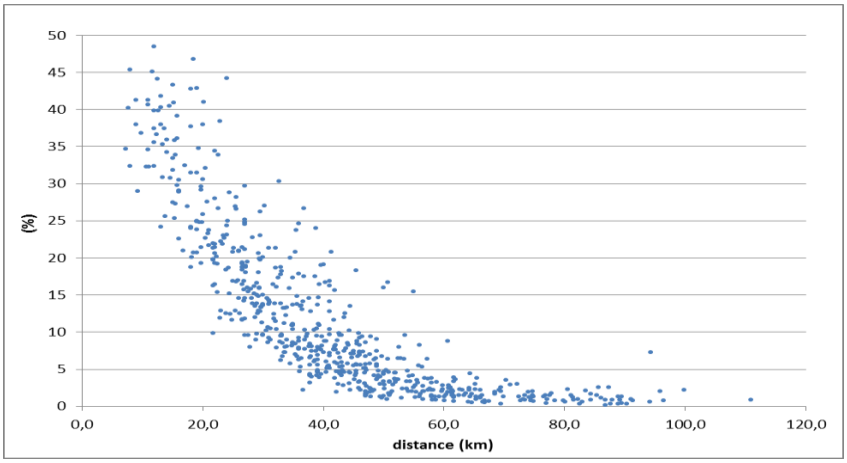

Fig. 5 Commuter percentage dependence on the municipality's distance from Brno
Source: CSO 2013; own survey and processing.

3. DISCUSSION AND CONCLUSION

The above-mentioned models analyzed the influence of the South-Moravian regional centre on the labour market from the viewpoint of transport accessibility and economic motivation of the surrounding municipalities' inhabitants to travel to the centre with the purpose of achieving higher wage/salary. There was studied the influence of the centre on the complete regional labour market in the South-Moravian Region regardless of any other local labour markets depicted in figures above. Description of agglomeration effects in the labour market with regional dimension - at the example of the Brno City - was the key topic and goal of this article.

The results of the performed correlation analysis cannot predict any causation between the studied processes but the mutual interdependence between travelling to work and the

labour mobility potential based on distance and time was unequivocally demonstrated. Zones of municipalities with positive economic motivation for travelling to work into the regional centre (Brno), transitional zones and zones with negative economic motivation (with a lack of economic motivation) were identified in the studied region using the distance and temporal models. The results imply that in the positive economic motivation zone (within 30 km) and in the transitional zone (30-40 km) and within the travel time of 40 minutes (within 50 minutes) distance is the key factor for the commuters (the most significant correlation relationship from all the three models described above). This can be interpreted by means of a directly proportional relationship between distance and potential costs of travelling to work. Decrease in the distance from the centre by 5 km is therefore more significant for a commuter than transport time decrease by 5 minutes (increase in the speed of transport, in general). This could be taken into consideration when defining the zones of the South-Moravian Integrated Transport System since by establishing adequate prices for the individual zones this distance preference could be adequately lowered and this would support the development of sustainable public transport. It is necessary to take into account, though, that with increased distance cars are still strong competitive mode of transport to public transport system.

Significance of car transport in the regional centre accessibility analysis is indisputable. The above-mentioned models, though, implicate certain influences, which are worth considering from the infrastructural point of view. Besides the significant influence of motorways and limited-access highways on the accessibility improvement it is advisable to mention the effect manifested in the southern direction - the international railway corridor towards Wien extends the economic motivation zone farther south than the parallel D2 motorway and this has been confirmed by actual proportions of commuters. This is where you can see the effect of well-performed zoning of the public transport and its interconnection with fast railway service. Another interesting influence can be observed northwestward of the centre where you can see a railway corridor of regional-national significance in combination with a 2nd class regional road - and despite this the economic motivation zone (once again confirmed by actual proportions of commuters) is extended in this direction comparably with motorway effects. This fact further supports the significance of regional infrastructure for suburban public transport.

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