Spatial and transport system differences of travel time as mode choice determinants

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Differences of accessibility within two subsystems of transport, individual travel and public transport, are analysed in this paper. The described data analyses are part of the author's doctoral thesis project which may confirm or disprove the hypothesis of competition between the transport modes of public transport and carpooling (i.e. ride-sharing in privately owned cars).

Based on spatial and modal differences of the accessibility of central places in Switzerland, source: Swiss Federal Office of Spatial Planning (ARE), and on commute census data, complete data set, source: Swiss Federal Statistical Office (BFS), analyses of correlation are carried out using SPSS-software to examine the quality of transport systems ("network quality") on various spatial levels and the implications for mode choice. The quality at any point or section within the network here is considered as the observed difference of travel time ("public transport"-"individual travel"). The data sets are visualized using ArcView-GIS-software producing maps for several spatial levels.

Although the coefficients of correlation of these variables differ depending on the spatial level of the analysed data sets (values for all communities, average values for districts and the Swiss "Kantone") and the level of central places (small centres up to metropolises), the results overall demonstrate the link between differences of accessibility and the observed variations of mode choice. Regarding the potentials of public transport on the one hand and of carpooling on the other, these findings are essential for decisions in transportation planning and transport policies.

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1 Introduction

The following report is based on the concept of differences of trip travel time as a criterion for comparing accessibility, and in its core describes the methodical approach of the author's doctoral thesis project. First, the aim of the study is explained, then data sets are presented concerning accessibility (source: Swiss Federal Office of Spatial Planning, ARE), mode choice (source: Swiss Federal Statistical Office, BFS) and the findings of data analyses and their general relevance for transportation planning and transport policies.

Carpooling as a form of sharing privately owned cars holds a largely underestimated potential[1] for a more sustainable transport policy in Germany. Starting point of the analysis is the thesis of an interrelation between the actual situation of building and usage structures and the observed distribution of mode choice in defined parts of regions.[2] In the light of the author's doctoral thesis project, the aspect of a more efficient utilization of resources in the transportation sector is in focus, with the special issue of which kind of contribution carpooling can make in this regard and how this contribution is to be assessed against the backdrop of the thesis of a competition to public transport[3] that is being brought up regularly.

In Germany, carpooling has not nearly reached the level of distribution it has in the US so far. However, in the eyes of several public transport operators it is very rarely seen as a welcome cooperation partner but, on the contrary, mostly as undesired competition. Are these fears of competition justified, though? To answer this question, unfortunately, no German data could be accessed. The analysis of Swiss data, at first an "emergency solution", proved to be far more than a substitute since the public there may view complete data sets that are of depth, quality and topicality that is much ahead of the German common practice.

The focus lies on the question whether the collected mode choice data for the two modes public transport and carpooling correlate with the differences of accessibility to be analyzed for various spatial levels. These differences of accessibility are taken as the differences in the quality of transport systems (public transport-individual travel) with the unit "trip travel time in minutes", and looked at separately for the connection of all of the 2.896 Swiss municipalities (as of December 31, 2000) with the respective next low-level center, medium-level center, high-level center and the next Swiss metropolis.[4]

First of all, the topography itself indicates the existence of a significant influ-

[1] For Germany in general see(Reinke 1985) and among others (Schäfer 2002).

[2] Essentials in (Kutter 1973), (Kutter 1984), (Kutter and Holz-Rau 1995),(Kutter 2001),(Rümenapp 2005), (Beckmann et al. 2005); analyses with the accessibility criterion "time" are to be found first with Kutter (1984).

[3] For Switzerland see (Dasen 1999), for future situations in Germany, (Kutter 2000). Statements of the public transport sector against carpooling rarely are documented publicly.

[4] Maps K6 "Rural areas: Accessibilities: Individual Travel ..." and K7 " Public Transport...", source: (ARE et al. 2005) pp. 54-55, led to the analyses described in this paper.

ence of the spatial structure on the mode choice made.[5]

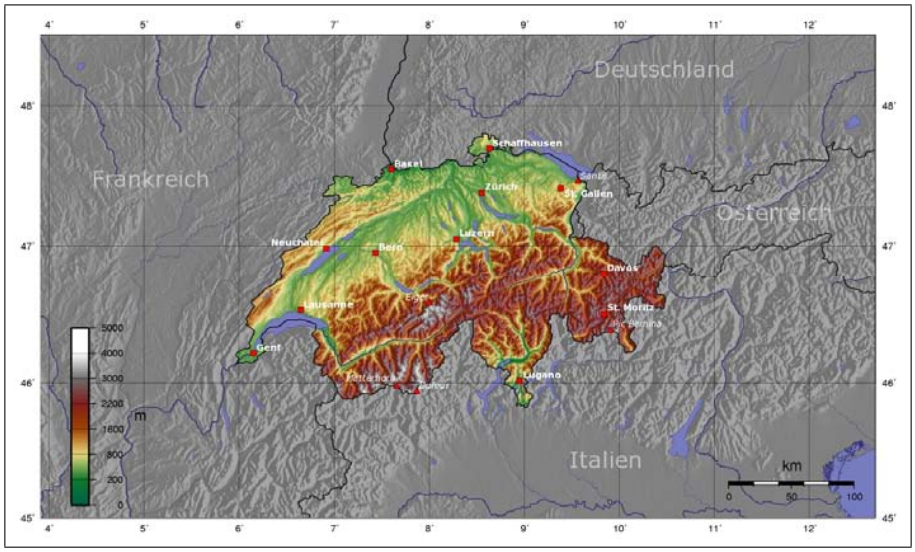

Figure 1: Topography of Switzerland, source: www.wikimedia.org

The spatial location of the settlements is of similar crucial importance to the question of interdependence of settlement structure and transport:

The main focus of the settlement activities lies on the lower altitudes up to ca. 800 m lying roughly to the northwest of a line drawn between Lausanne, Lucerne and St. Gallen, whereas the southeastern, alpine to high alpine part - except a few valleys in the cantons Vaud (Waadt), Valais (Wallis), Grisons (Graubünden) and Ticino (Tessin) - is to be classified as a little to very little populated area. This paper can only reflect on a selection of the data analyses carried out and their visualizations; the following explanations concentrate on the analysis level "metropolitan areas".

The ARE accessibility data refer to the center structure in Switzerland.[6] A methodical problem arises from the fact that Milan as a metropolis does not belong to Switzerland; the BFS as well as the ARE data sets take this into account by choosing Lugano, the highest ranking center in the Swiss-Italian border region, as point of reference. The data shown below concerning differences of trip travel time to the centers refer to this point respectively. Fig. 3 shows the five metropolitan areas of Switzerland:

[5]This assumption is confirmed by numerous ARE (Swiss Federal Office of Spatial Planning) publications ((ARE et al. 2005), (ARE 2003), (ARE 2006a) and (ARE 2006b)) and BFS (Swiss Federal Statistical Office) publications (see e.g. (BFS and ARE 2002)).

[6]The role of the centers for transportation planning and the relevance of the connections between higher-ranking centers for assessing transport network quality are explained, among others, by Bierschenk and Keppeler(Bierschenk and Keppeler 2000).

Figure 2: Settlement areas in Switzerland, source: www.bfs.admin.ch

2 Description of Data Sets

The Swiss Federal Statistical Office (BFS) provided commuters' data of the 2000 National Census (complete data set) in Switzerland in an individually performed compilation in order to create a data set structure that allows for an explicit attribution of commuting actions to the transport modes public transport on the one hand and carpooling on the other as well as their clear distinction from "solo drivers".[7] The presentation of the two modes public transport and carpooling was done on the basis of its own distribution, i.e.: In each case the quintiles indicate which of the displayed values are to be assigned to the categories very high, relatively high, average, relatively low and very low of the respective mode choice proportions; figures with the absolute values for the two modes public transport and carpooling follow below (cf. figures 10 and 11).

The accessibilities of the two modes public transport and carpooling and their mode choice proportions were visualized with ArcView GIS. The usually considered (differences in) journey travel time instead of (differences in) trip travel time cannot be analyzed here since the necessary data is not available. Especially concerning ride-sharing in private cars, unresolved methodical questions such as the consideration of fetch/bring rides, detour factors, and the disposition towards carpooling etc. are to be stated. It is not yet known how they affect mode choice in particular.

[7] The few accessible German data sets with statements about carpooling do not fulfill this requirement.

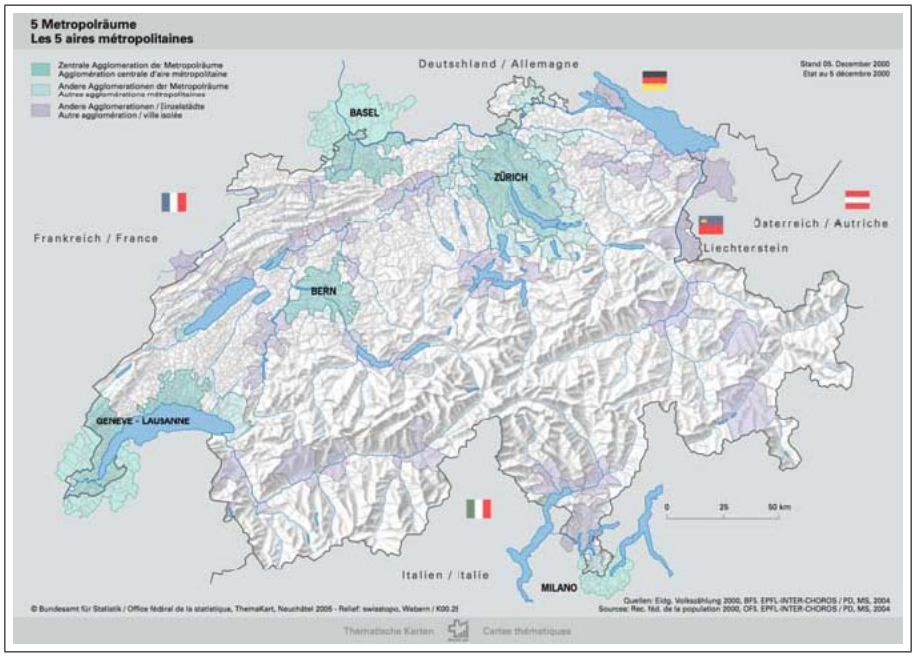

Figure 3: Metropolitan areas in Switzerland, source:www.bfs.admin.ch

Below, maps[8] are shown visualizing the data sets of accessibilities, analyses of transport networks and mode choice:

It clearly shows that high public transport proportions are to be found rather in urban structures and high carpooling proportions rather in rural, sparsely populated parts of regions. However, the analysis of the BFS and ARE data available in this matter did not yield any clear statistical correlation; neither could population density, motorization or commuter proportions be identified as solely relevant explanatory variables. On the other hand, the analyses of the differences in transport network quality allow for clear conclusions which are summarized below.

[8]Fig. 4 to 10 source: BFS/ARE, author's presentation

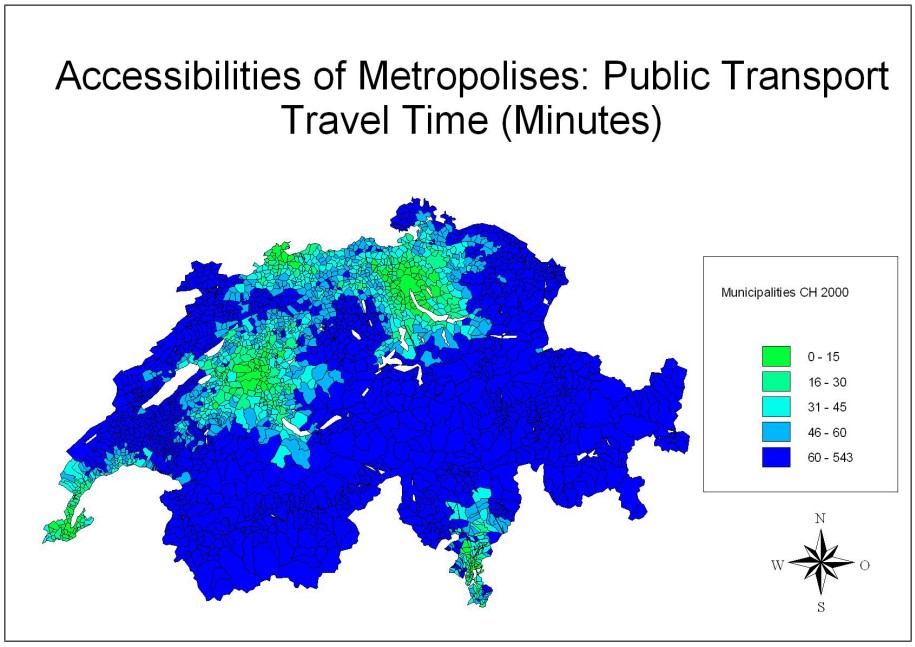

Figure 4: Accessibilities of Public Transport in Switzerland 2000

3 Overview of Data Analyses - Findings

The data concerning differences in trip travel time and the respective proportions of mode choice are available for all 2.896 municipalities. These data sets form the basis of calculation for the municipality level; all other calculations are based on the respective arithmetic mean. The **working hypothesis** reads as follows: "H1: In areas with high differences in trip travel time to the next centers between public transport and carpooling to the disadvantage of public transport, the proportion of carpooling within mode choice is significantly higher than in other areas." The corresponding **zero hypothesis** reads as follows: "H0: In areas with high differences in trip travel time to the next centers between public transport and carpooling to the disadvantage of public transport, the proportion of carpooling within mode choice is (at the most) as high as or lower than in other areas." The approach shall be explained by means of the first two partial hypotheses PH1 and PH2 as well as the zero hypotheses PH0.1 and PH0.2 needed for verification:

Partial Hypothesis PH 1

"On the analysis level of the 2.896 municipalities, the proportion of public transport within mode choice (public transport-modal) correlates with the difference in trip travel time (public transport-individual travel) to the next low-level center (FDKLEIN)."

Partial Zero Hypothesis PH0.1

"On the analysis level of the 2.896 municipalities, the proportion of public transport within mode choice (public transport-modal) does not correlate with

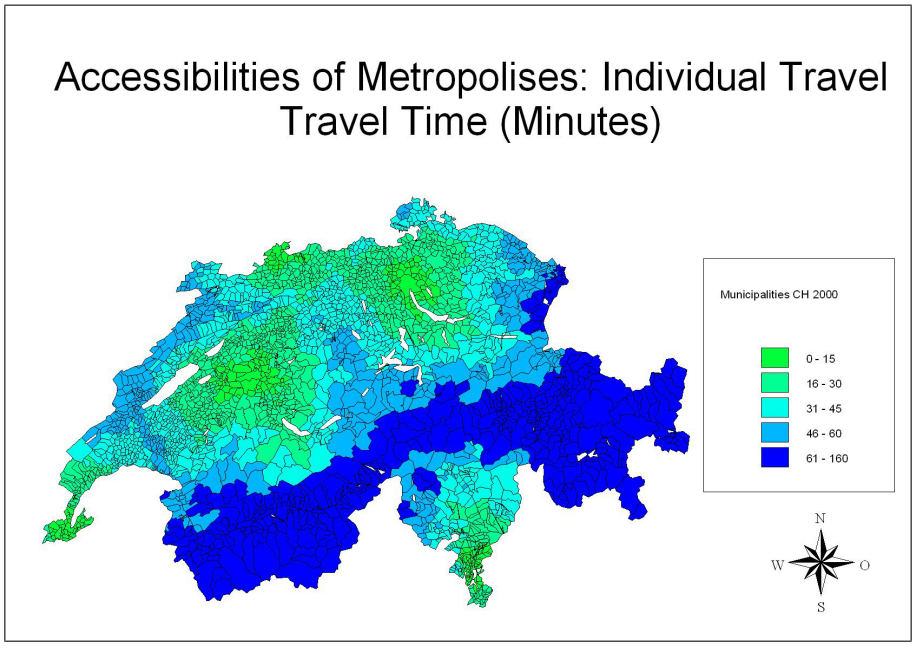

Figure 5: Accessibilities of Individual Travel in Switzerland 2000

the difference in trip travel time (public transport-individual travel) to the next low-level center (FDKLEIN)."

Partial Hypothesis PH 2

"On the analysis level of the 2.896 municipalities, the proportion of carpooling within mode choice (carpool-modal) correlates with the difference in trip travel time (public transport-individual travel) to the next low-level center (FDKLEIN)."

Partial Zero Hypothesis PH0.2

"On the analysis level of the 2.896 municipalities, the proportion of carpooling within mode choice (carpool-modal) does not correlate with the difference in trip travel time (public transport-individual travel) to the next low-level center (FDKLEIN)."

Table 1 gives an overview of the correlation analyses.[9]

By means of the analyses for calculating Pearson's r, each of the 24 partial hypotheses may be either disproved or confirmed. If the zero hypothesis is to be disproved, the partial hypothesis is regarded as confirmed. If the zero hypothesis cannot be disproved[10] since - see PH22 - no significance can be determined, the partial hypothesis cannot be regarded as confirmed. This does not necessarily mean that there is no connection between the analyzed values, but with the data available the assumed connection cannot be verified securely. The assumed direction of relations - positive when looking at the connection between differences

[9] Cf. last page

[10] Cf.(Bortz 2004), ch. 4 Formulierung und Überprüfung von Hypothesen (formulation and validation of hypotheses), here: p. 119 ff.

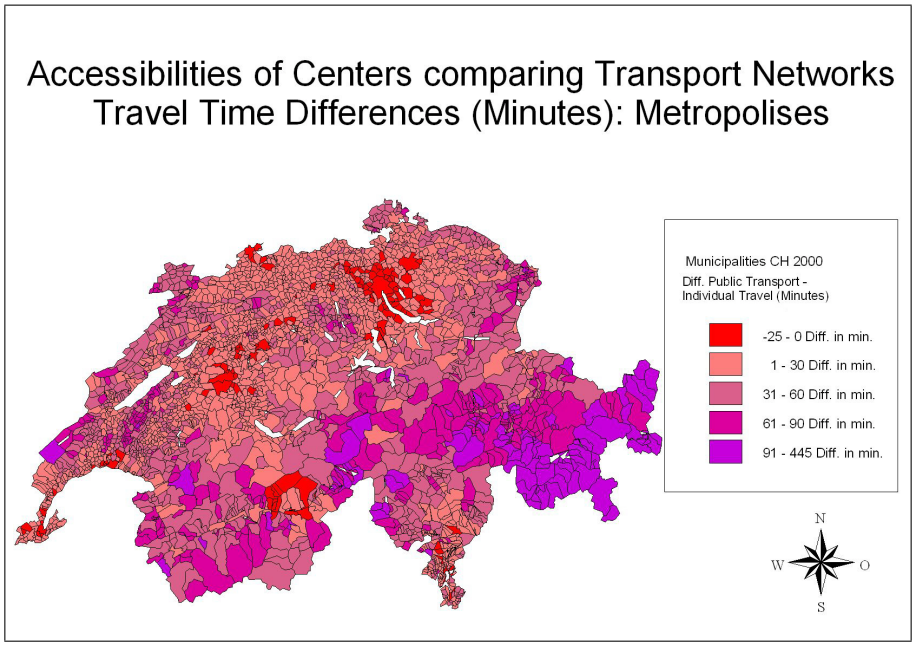

Figure 6: Accessibilities of Centers comparing Transport Networks, Switzerland 2000

of trip travel time and the respective carpooling proportions within mode choice ("the more ..., the more ...") at the one hand, and negative regarding the correlations between differences of trip travel time and public transport proportions ("the more ..., the less ...") on the other - can be confirmed without exception or contradiction.

The working hypothesis H1 is therefore confirmed as a whole.

4 Discussion

The confirmation of the analyzed (main) question means at first that a connection can be verified between the analyzed differences in accessibility and the collected commuters' mode choice data. Furthermore, it confirms the assumption that carpooling is no competition to public transport but is to be seen as compensation for public transport supply at levels below average. This interpretation is underlined by looking at the absolute proportions of the two modes in comparison on the basis of the data from all 2.896 municipalities (figures 10 and 11). Moreover, this interpretation is backed by the fact that only one of 24 partial hypotheses could not be confirmed; only one of the confirmed partial hypotheses is "just" significant, 22 out of 24 are very significant, on the other hand. Last but not least, with all analyzed relations the assumed directions could be confirmed without contradiction.

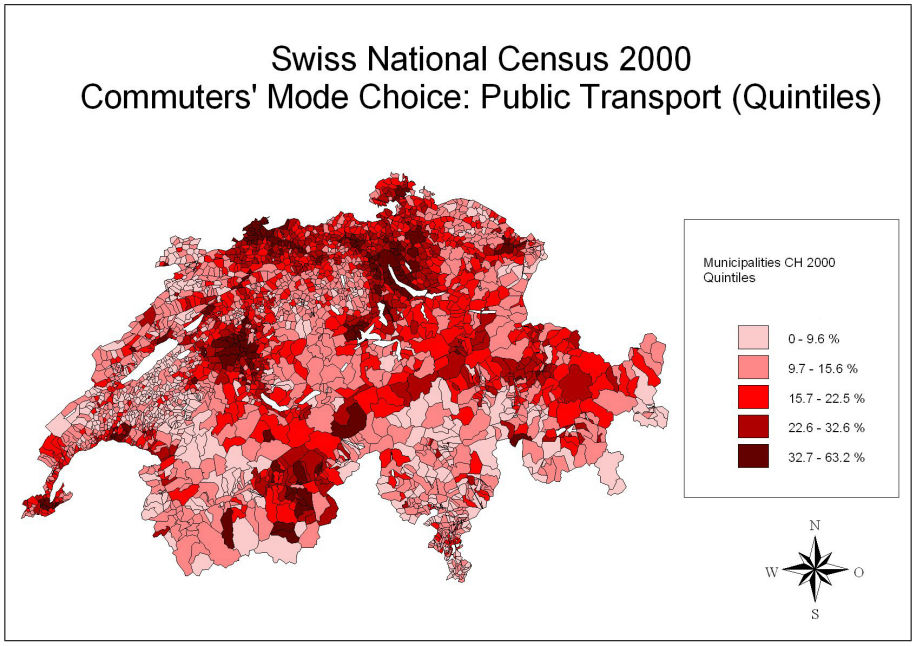

Figure 7: Commuters' Mode Choice in Switzerland 2000: Public Transport (Quintiles)

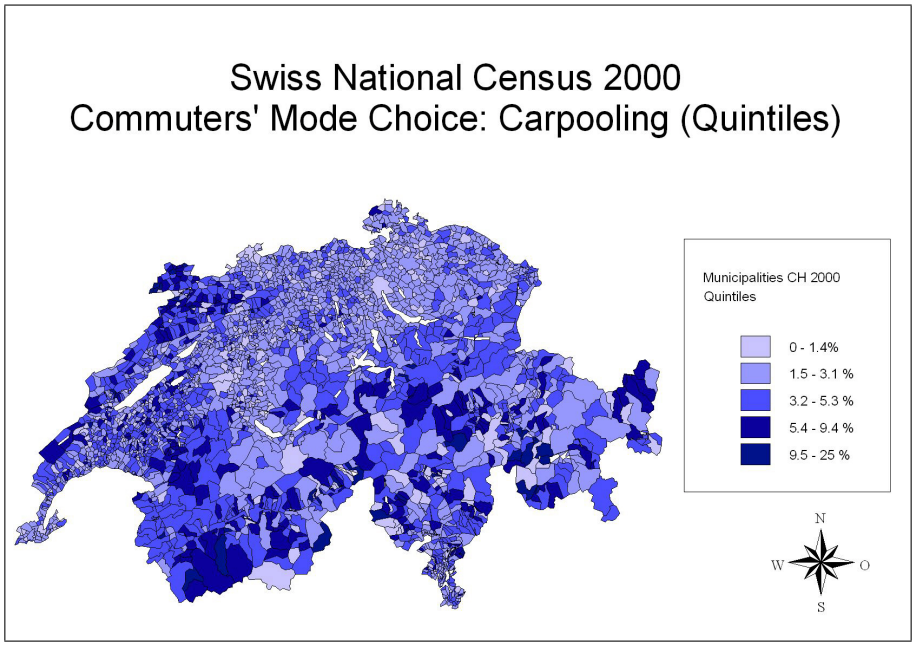

Figure 8: Commuters' Mode Choice in Switzerland 2000: Carpooling (Quintiles)

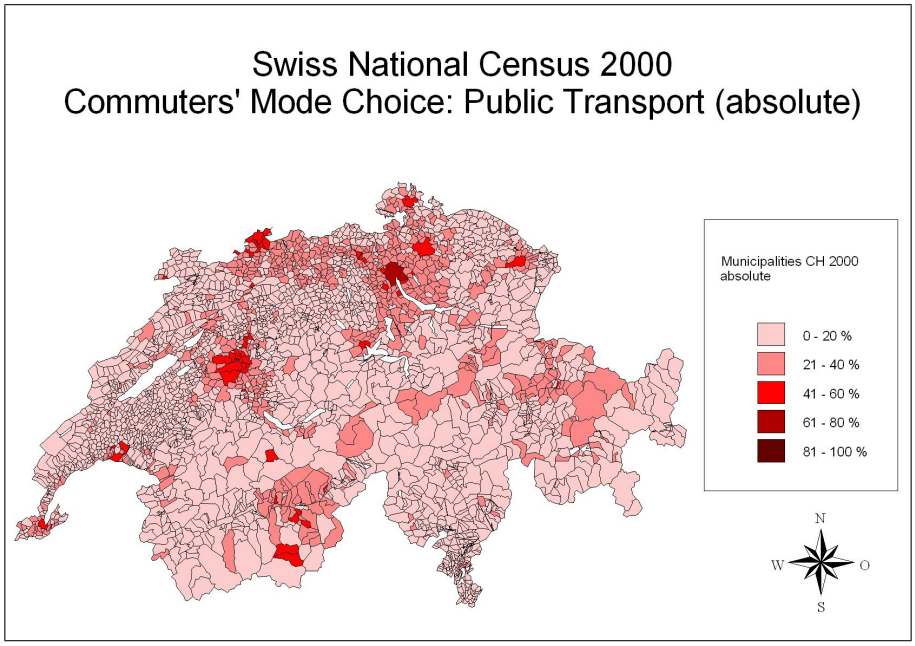

Figure 9: Commuters' Mode Choice in Switzerland 2000: Public Transport (absolute)

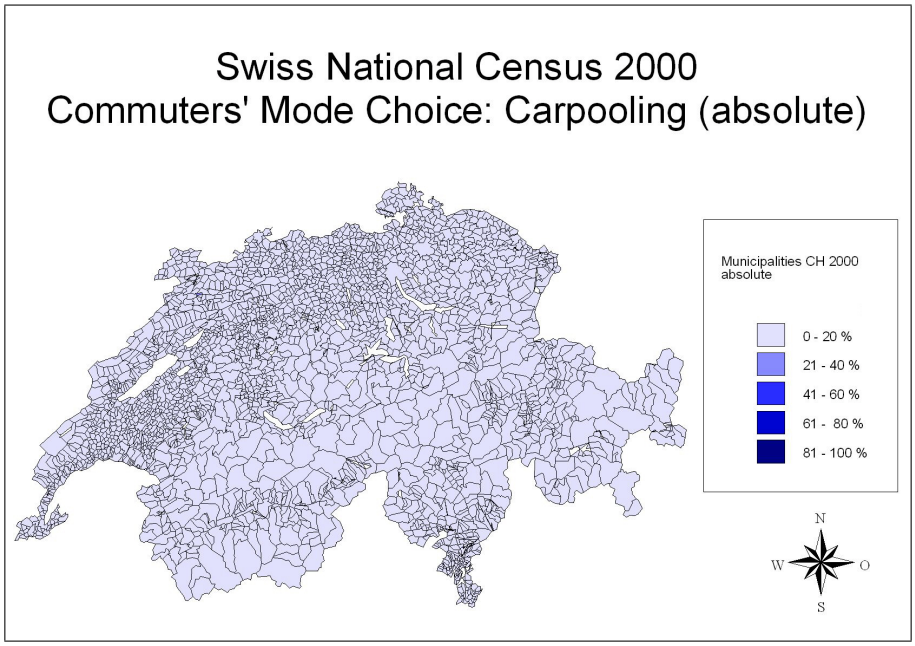

Figure 10: Commuters' Mode Choice in Switzerland 2000: Carpooling (absolute)

5 Conclusion

The thesis of a serious competition between the two modes public transport and carpooling can be clearly disproved by means of the present findings for Switzerland. It is rather a "compensatory relation": Carpooling complements the public transport supply mainly where there is a very high deviation of this supply from the quality level of individual travel. As a conclusion for transportation planning and transport policies, it needs to be stated that measures promoting carpooling in Germany, too, cannot be outweighed or even discarded against public transport reservations of a "protection of status quo" any more. On the contrary, everything needs to be done for a cooperation between public transport and carpooling as well as, if applicable, other forms of "public-individual travel". Furthermore, the findings of the analyses show that the chosen accessibility measure not only may serve a scientific purpose but also is of practical relevance, since the differences in quality of public and individual transport networks evidently are a criterion decisions are based on. Thus the Swiss commuters' mode choice behavior is to be characterized as very rational. Further studies are needed at least due to the lack of knowledge mentioned above about the precise effects carpooling has on realized journey travel times - also in contrast to trip travel times - including detours etc. Regarding suitable accessibility measures there is a considerable need for research on the question of how daytime, working day and seasonal fluctuations of travel demand and thus of the quality of transport networks in the future may be linked with the presentation or even prediction of accessibilities.

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Partial Hypothesis	Level of Analyses	Mode	Level of Central Places	N	Pearson's r	Level of Significance	Zero Hypothesis	Conclusion
PH 1	Municipalities	Public Transport	Low-level-C.	2.896	-0,331	**	PH0.1 disproved.	PH 1 confirmed.
PH 2	Municipalities	Carpooling	Low-level-C.	2.896	0,202	**	PH0.2 disproved.	PH 2 confirmed.
PH 3	Municipalities	Public Transport	Medium-lev.	2.896	-0,337	**	PH0.3 disproved.	PH 3 confirmed.
PH 4	Municipalities	Carpooling	Medium-lev.	2.896	0,232	**	PH0.4 disproved.	PH 4 confirmed.
PH 5	Municipalities	Public Transport	High-level-C.	2.896	-0,339	**	PH0.5 disproved.	PH 5 confirmed.
PH 6	Municipalities	Carpooling	High-level-C.	2.896	0,147	**	PH0.6 disproved.	PH 6 confirmed.
PH 7	Municipalities	Public Transport	Metropolises	2.896	-0,366	**	PH0.7 disproved.	PH 7 confirmed.
PH 8	Municipalities	Carpooling	Metropolises	2.896	0,245	**	PH0.8 disproved.	PH 8 confirmed.
PH 9	Districts	Public Transport	Low-level-C.	184	-0,391	**	PH0.9 disproved.	PH 9 confirmed.
PH10	Districts	Carpooling	Low-level-C.	184	0,459	**	PH0.10 disproved.	PH 10 confirmed.
PH11	Districts	Public Transport	Medium-lev.	184	-0,405	**	PH0.11 disproved.	PH 11 confirmed.
PH12	Districts	Carpooling	Medium-lev.	184	0,449	**	PH0.12 disproved.	PH 12 confirmed.
PH13	Districts	Public Transport	High-level-C.	184	-0,435	**	PH0.13 disproved.	PH 13 confirmed.
PH14	Districts	Carpooling	High-level-C.	184	0,343	**	PH0.14 disproved.	PH 14 confirmed.
PH15	Districts	Public Transport	Metropolises	184	-0,463	**	PH0.15 disproved.	PH 15 confirmed.
PH16	Districts	Carpooling	Metropolises	184	0,508	**	PH0.16 disproved.	PH 16 confirmed.
PH17	Cantons	Public Transport	Low-level-C.	26	-0,436	*	PH0.17 disproved.	PH 17 confirmed.
PH18	Cantons	Carpooling	Low-level-C.	26	0,571	**	PH0.18 disproved.	PH 18 confirmed.
PH19	Cantons	Public Transport	Medium-lev.	26	-0,538	**	PH0.19 disproved.	PH 19 confirmed.
PH20	Cantons	Carpooling	Medium-lev.	26	0,807	**	PH0.20 disproved.	PH 20 confirmed.
PH21	Cantons	Public Transport	High-level-C.	26	-0,499	**	PH0.21 disproved.	PH 21 confirmed.
PH22	Cantons	Carpooling	High-level-C.	26	0,383	X	PH0.22 not disproved.	PH 22 not confirmed.
PH23	Cantons	Public Transport	Metropolises	26	-0,627	**	PH0.23 disproved.	PH 23 confirmed.
PH24	Cantons	Carpooling	Metropolises	26	0,652	**	PH0.24 disproved.	PH 24 confirmed.

Level of Sign. X means not significant
Level of Sign. * means 0,05 = 95 % significant
Level of Sign. ** means 0,01 = 99 % very significant

Table 1 Validation of Partial Hypotheses

Figure 11: Table 1 Validation of Partial Hypotheses