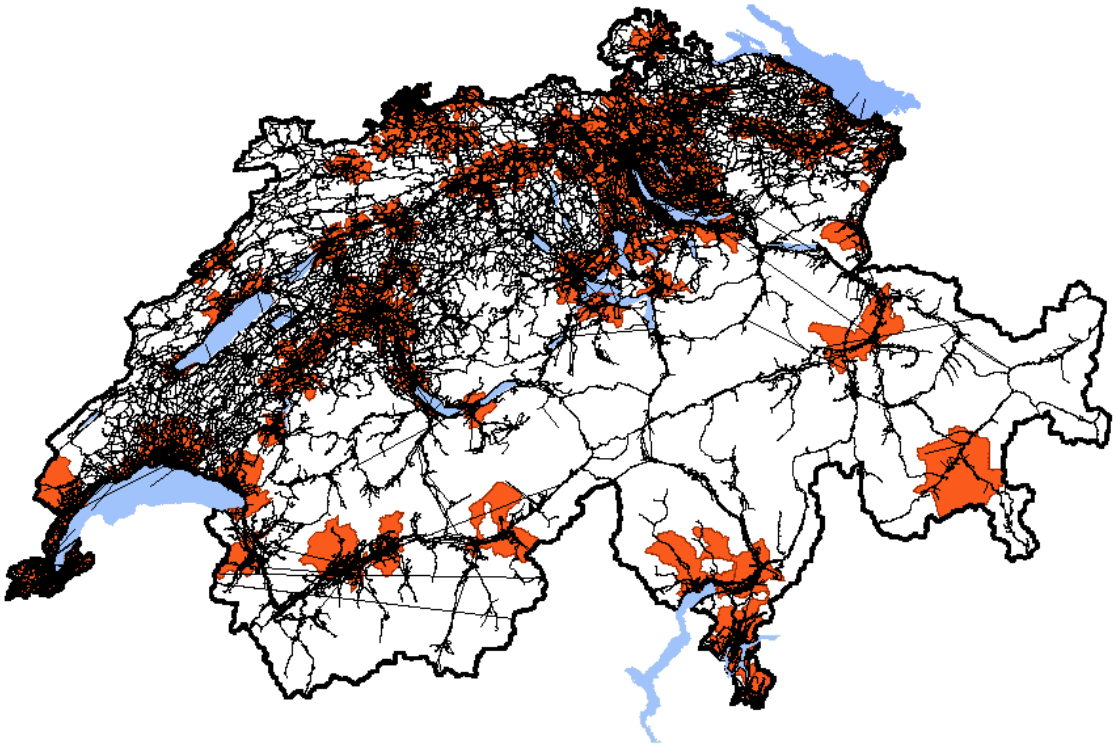

Territorial based Modal-Split analysis of mobility behavior in Swiss agglomerations

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Abstract

Generally, travel surveys provide information on transport related activities. However, when employing survey data for an estimation of transport demand, results depend on whether a residential or territorial approach is applied. The residential approach leads to transport volumes of the inhabitants of a certain area. It considers all trips these inhabitants report independently from the location of trip performance. Contrarily, the territorial approach employs the spatial dimension of an analysis area (e.g. an agglomeration). It considers trip segments that were performed within the study area independently from a respondent's home location.

Depending on the research question the distinction between the two approaches is important to avoid an over- or underestimation of transport volumes. Differences resulting from both approaches are apparent, especially for areas with a high number of jobs and a low number of residents (or the other way round).

For agglomerations (and also other spatial settings) it is relevant to provide exact figures on transport activities that actually occur within their administrative boundaries (e.g. vehicle miles travelled by mode within the Swiss agglomerations). Such figures could help to e.g. evaluate the quality of agglomeration programs.

In the Swiss case, the MCMT provides the data base for such analysis. In 2010, over 62'000 individuals were asked to provide information on various topics such as daily mobility (number of trips, time and distance), trip purposes and mode choice.

Employing the MCMT, the paper presents a territorial based modal split for the Swiss agglomerations. In the Swiss context, such figures are calculated for the first time and allow, in combination with residential based figures, to focus on the travel behavior of Swiss agglomerations in more detail. Agglomerations' territorial based modal splits are then compared to results from the residential based approach.

Keywords

mobility behavior, residential based analysis, territorial based analysis, agglomeration programs

1. Introduction

Since 1974, mobility behavior of Swiss residents is monitored; a statistical survey, the Swiss Microcenzus on Mobility and Transport (MCMT), is conducted every fifth years. The latest survey, realized in 2010 by the Federal Office for Statistics (OFS) and the Federal Office for Spatial Development (ARE), includes data collected from over 62'000 individuals, about various topics providing a consistent base for evaluation of travel behavior of the Swiss population.

Compared to the previous editions, the great improvement of the 2010 MCMT is that it includes calculation of covered distance, based on routes reported by individuals –for every trip over 3km effectuated on the surveyed day. Earlier MCMT included only estimations of individuals of their daily performed distance. Combination of Individual-motorized reported trip with information from road/street national network, permitted to generate a new database ('segments') providing additional information, with a higher "resolution" along the trip-sequence (Road/street type, "curves", agglomeration...).

Agglomerations are important administrative sub-areas in Switzerland. Several aims of the Swiss governmental program are related to these clusters. Their transport performances are of importance for political processes, yet, detailed information on these performances is rare and most studies are based on the transport performance of agglomerations' residents. Therefore, Rosset et al. (2013) chose agglomeration boundaries as reference case study estimating transport performances. However, their study focuses on car kilometer and is limited to this mode of transport.

This present paper aims to perform similar study, extended to traffic modes. Furthermore, a Modal Split analysis of travel behavior in agglomerations (territorial approach) is presented. The document is structured as follow: part 2 informs about agglomerations and the importance of data availability on transport performances occurring within their boundaries. Part 3 begins with a brief reminder of both residential, and territorial based approach, referring to Rosset et al. (2013) study. An extended method applied for this present study is then described. Part 4 presents results obtained from our territorial analysis, with a focus on modal split for the larger Agglomeration. Territorial analyses are compared to residential results. Section 5 presents the limits for travel performance with both methods and of the paper in general. Part 6 concludes.

2. Territorial study: Swiss agglomerations

Swiss agglomeration constitutes 50 administrative sub-areas. In these areas, home, work- and activity places are densely clustered. Over 70 % of the total Swiss population lives within the areas. Swiss governmental program promotes their development, and the amount of financial support depends on the evaluation of an agglomeration strategy to face certain problems like e.g. challenges in traffic (ARE, 2010). The most important agglomerations in term of population are Lausanne, Bern, Basel Geneva and Zürich, where population reaches over a million inhabitants i.e. around 15% of total Swiss population.

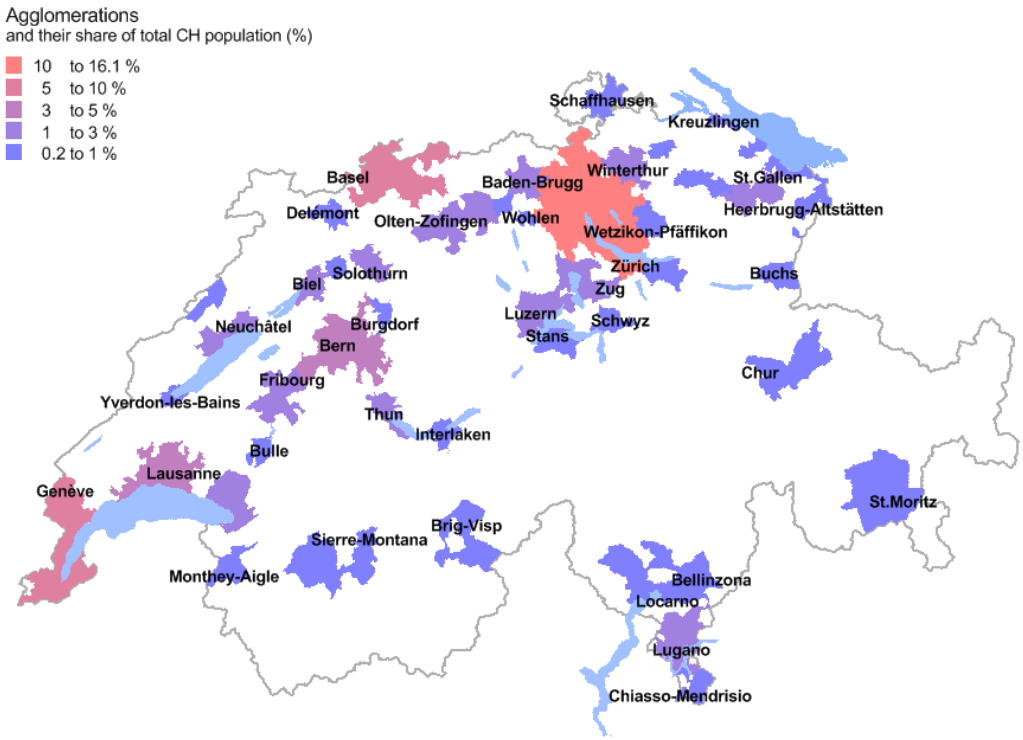


Figure 1: Swiss agglomeration's proportion of Swiss population

One indicator of the legislative period 2011 – 2015 is e.g. that the share of public and non-motorized transport on agglomerations' modal split does not decrease in terms of average daily kilometers travelled per person (Schweizerischer Bundesrat, 2012; BFS, 2012b).

For an evaluation of this indicator figures on daily transport within the agglomerations' is needed. In order to generate such figures, the territorial approach -explained in next section- could be useful.

3. Method

3.1 Residential and Territorial based analysis

Routed information on travel performances allow employing two complementary type of analysis: residential and territorial based approach. Our analysis employs the latter approach, which is illustrated in figure 2.

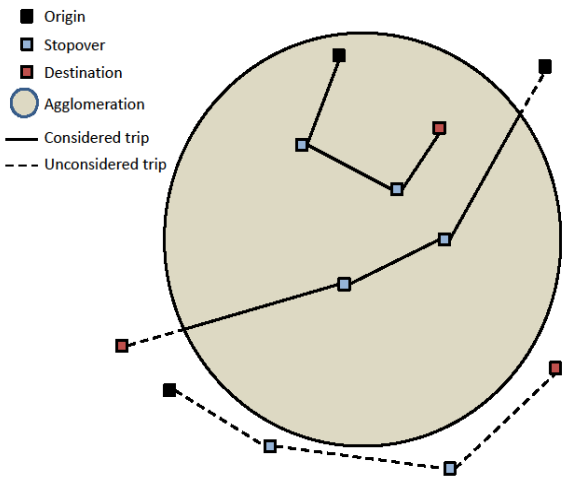


Figure 2: Illustration of territorial based travel performances (calculations include all MCMT-respondents independently from where they live; see Rosset et al., 2013)

The residential based analysis considers all trips performed by agglomeration's residents, independently of the actual location of the trip perfomed. Kilometers performed by people living outside agglomeration are not measured, even when performed within agglomeration boundaries. Thus, the residential based approach only provides estimation of kilometers performed by agglomeration residents in Switzerland.

However, territorial based calculations include all trips of the Swiss residential population performed in- or outside the agglomeration area, autonomously from the traveler's place of residence. This method does not include trips outside of an agglomeration's perimeter, even though performed by an agglomeration's resident.

This method results in the number of kilometers performed by the whole survey population within each agglomeration As the survey population of the MCMT is weighted to represent properties of the Swiss residential population (which is the inference population), the average

kilometer performance can be used to calculate the number of kilometers performed within the study area by the whole residential population of Switzerland. In order to do so, the average kilometer performance by transport mode from the MCMT kilometers is multiplied with the Swiss population and the number of days in a year. Employing the whole survey population is indispensable for the territorial based approach as each respondent in the MCMT could potentially have performed a trip or at least a trip segment within an agglomeration for the reference day.

Rosset et al. (2013) summarized the method as following:

$$\hat{c}_{within} = N_P N_J \sum_{p \in S_P} w'_p \, c_{p,j_p}$$

Whereby $w'_p = \frac{w_p}{\sum_{q \in S_P} w_q}$

With

$\hat{c}_{within}$ = Annually distance [km] travelled within the study area by Swiss residents

c_{p,j_p} = Distance of person p on day j within the study area

w_p, w_q = Statistical weight of person's p and q

S_P = Sample of persons from MCMT

N_P = Residential population of Switzerland

N_J = Number of days per year

3.2 Calculating travel performances within and outside agglomeration's boundaries

Based on the MCMT, combining individual-motorized reported trip with information from a national street network, allowed generating a new database ('segments'). This database provides additional information, with a higher "resolution" along the trip-sequence). It was used by Rosset et al. (2013) to calculate the car travel performance in the agglomerations. However, as their data only provided information on individual-motorized kilometers, no modal split analysis was possible.

In the context of this paper, new measurement of distances in kilometers performed within and outside boundaries of agglomeration must have been computed. In order to obtain this data for every transport mode, routing data from the MCMT were used. These data provide

the geo-referenced geometry of each reported trip. Clipping these routes with agglomerations' boundaries and measurement of each new subdivision was executed with FME software (FME source).

3.3 Modal Split analysis: transport mode categories

In order to calculate the modal split for each agglomeration, the different means of transport are grouped to four modes, as presented in Tab.1:

- Non motorized transport (NMT)
- Private motorized transport (PMT)
- Public transport (PT)
- Others

NMT	PMT	PT	Others
On foot, Bicycle	Motobike, Small motorbike (from 16 y.old.), Motocyle as driver, Motocycle as passenger, Car as driver, Car as passenger	Train, Postal bus, Bus,Tram	Taxi, Leisure car, Truck, Boat, Plane, Skilift, Motorised equipement, Others

Tab 1: Transport mode categories

4. Descriptive statistics: Agglo-Territorial based analysis

The following sections present results on agglomeration traffic according to territorial based calculations. The focus is set on the shares of the nationally performed kilometers on agglomeration territories and on the distribution of the inner-agglomeration Modal Split.

4.1 Share of national mobility within and outside Swiss agglomerations

Figure 3 shows the distribution of the yearly performed total travel demand (passenger kilometers in Mio. km). Considering all transport modes, over 101'000 Mio. kilometers are travelled per year by Swiss residents within Switzerland. This represents slightly more than 37 km per person and day, and is comparable to results of the BFS analysis of MCMT for 2010 (i.e. 36.7 daily-domestic-km per person). Our analysis indicates that more than 67'000 Mio. kilometers are travelled inside the 50 Swiss agglomerations. This represents more than 66 % of the nationally performed kilometers in 2010.

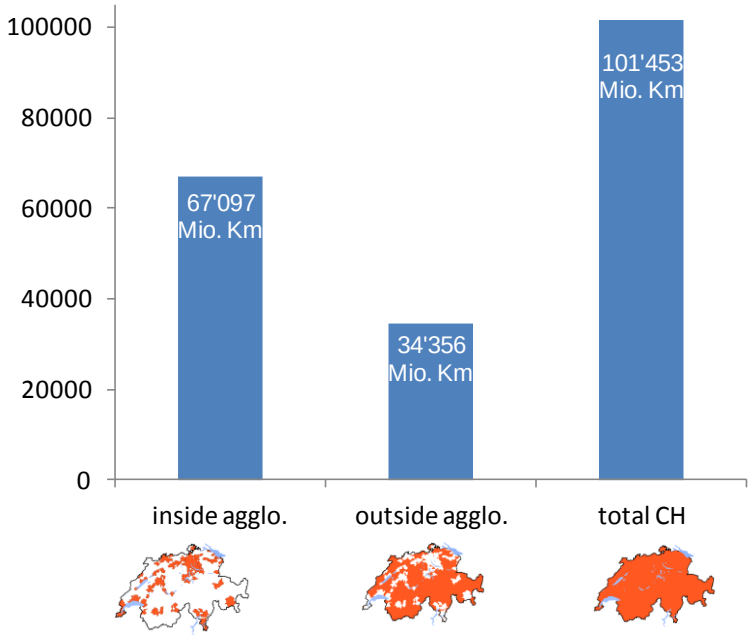


Figure 3: Yearly performed distances (Mio. Km) within and outside agglomerations and total Swiss national inland traffic

These numbers reflect the spatial concentration of activities: agglomerations cover more than a fifth of Switzerland's total surface and represent 73% of residential population and 83% of work locations.

As represented in Fig. 4 and according to the size of agglomerations significant differences in the share of pkm occurring in each agglo can be observed (here differentiated between small (20'000 - 49'999 residents), middle (50'000 – 249'999 residents) and large agglomerations (> 250'000 residents)).

The importance of large agglomerations is evident in general, and of Zürich especially, which clearly represents a separate class. Pkm performed in the agglomeration of Zürich represent a share of around 15 % of all Swiss mobility. This corresponds almost to the sum of the shares of Basel, Lausanne and Geneva.

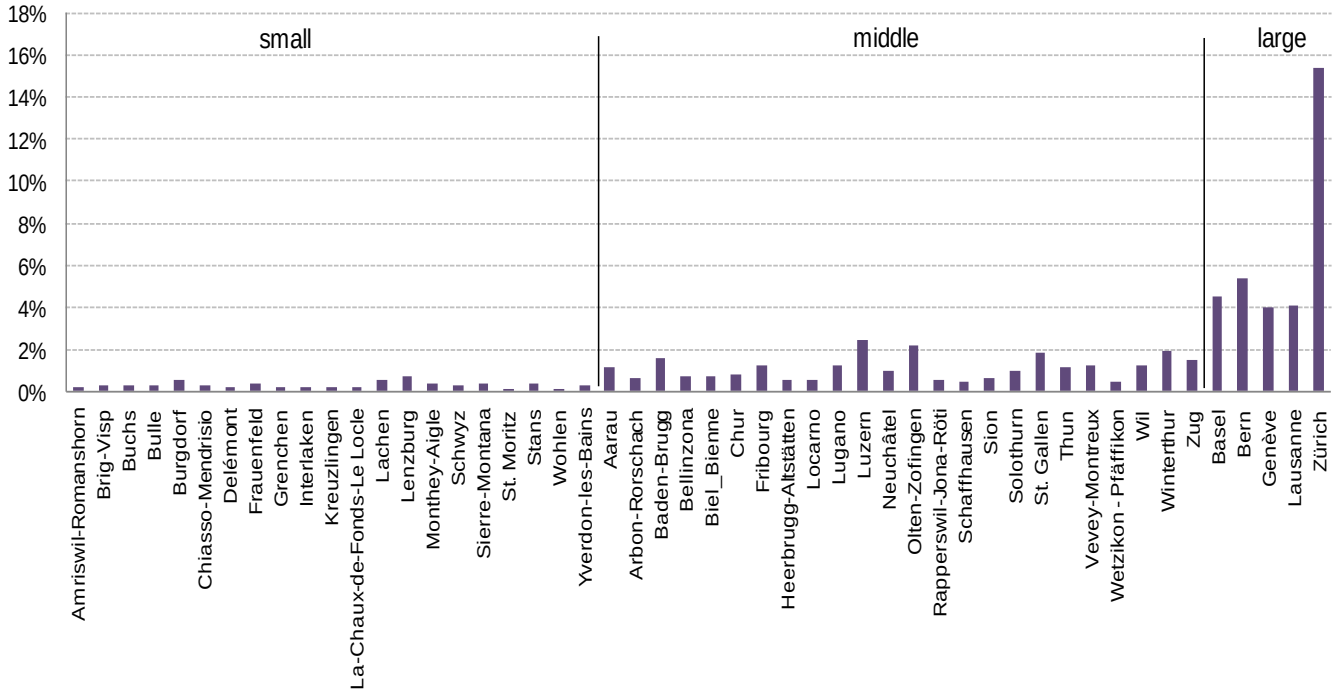


Figure 4: Share of pkm occurring within Swiss Agglo (all transport modes)

4.2 Analysis by transport categories

Fig.5 illustrates the share for each transport-mode category (differing by pkm realized inside or outside the agglomerations boundaries).

The figure indicates that pkm performed inside agglomerations always represents a higher share of the total national traffic, as outside of agglomerations, and this for every type of transport without exception.

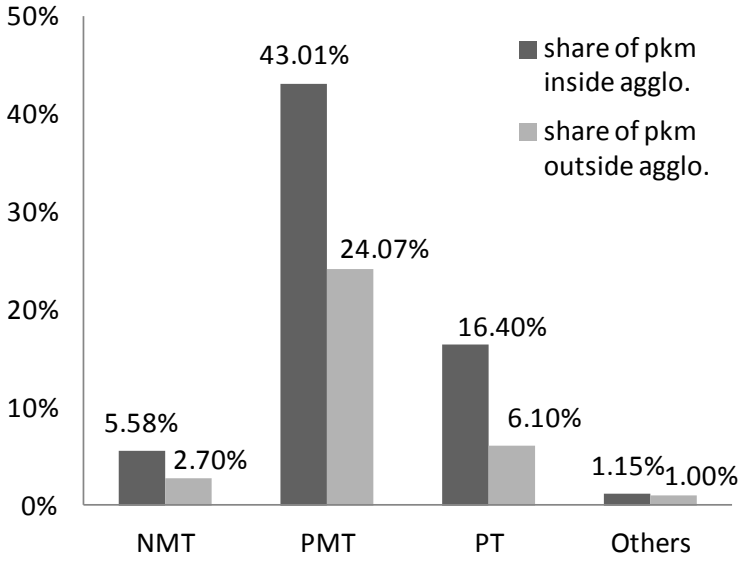


Figure 5: Distribution of pkm within and outside agglomerations by transport- mode category

A greater difference can be observed for public transport; indeed, within agglomerations its share is about three times more important as outside agglomerations. This can be easily attributed to the comparatively high public transport supply within agglomerations.

Modal-Split analyses of pkm performed inside and outside of agglomeration, as well as for pkm performed over all Swiss territory, are compared in Figure 7.

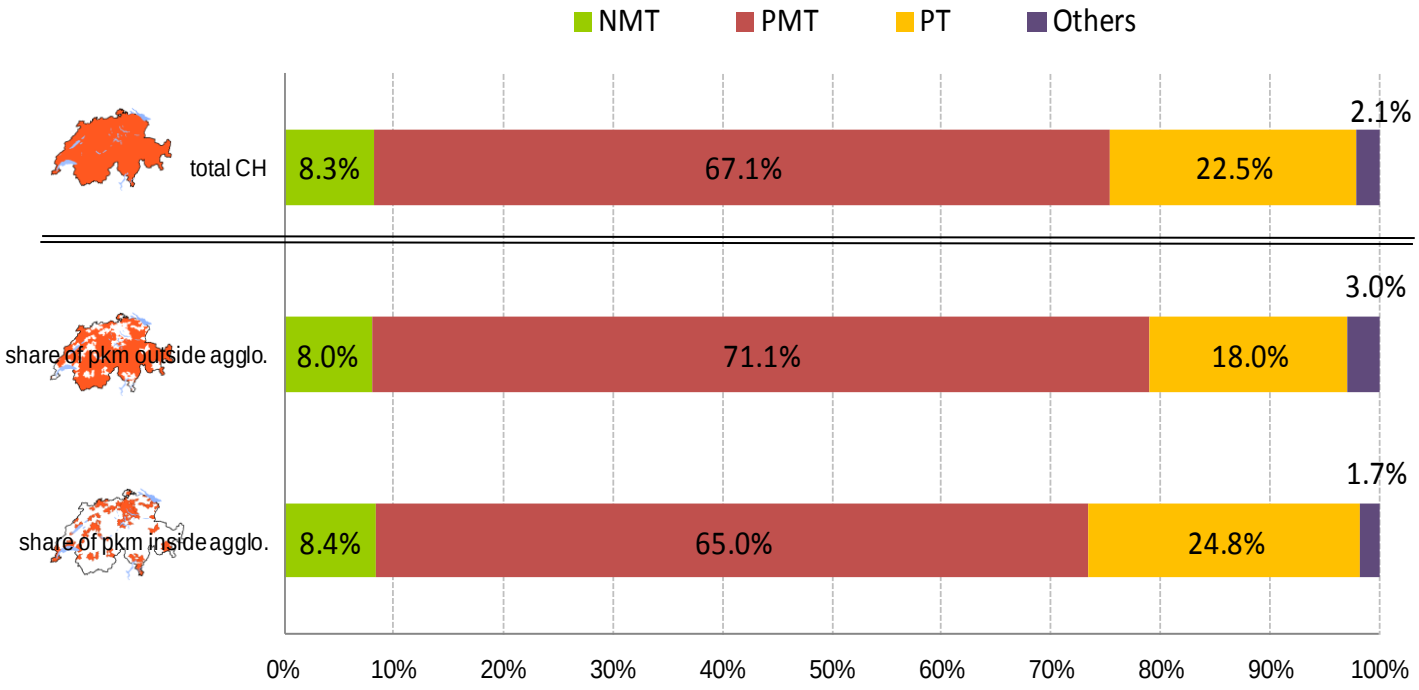


Figure 6: Modal Split total Swiss territory, outside and inside agglomeration pkm.

In both cases, private motorized transport presents the higher share; almost two thirds (outside agglomerations) and more than two thirds (inside agglomerations) of Swiss pkm are realized using a motorized vehicle (i.e. 65 % of total pkm in agglomeration and over 71 % outside agglomeration boundaries).

Around a quarter of pkm are realized using public transport, with – as expected – a higher share realized inside agglomerations, where 24.8 % of performed pkm are covered by public transportation versus 18 % outside agglomerations. Interestingly in either case, less than one-tenth of the distances are covered on foot or by bicycle.

Next we compare the share of pkm (by mode) for each agglomeration by overall Swiss pkm. As shown in Fig.7, naturally the largest agglomerations represent major shares on the nation-wide pkm. Zurich constitutes as well by far the highest shares, for all kind of transport. Distances covered in Zürich by public transportation is the highest of all shares corresponding to more than 20 % of all public transportation distances that occur within Switzerland.

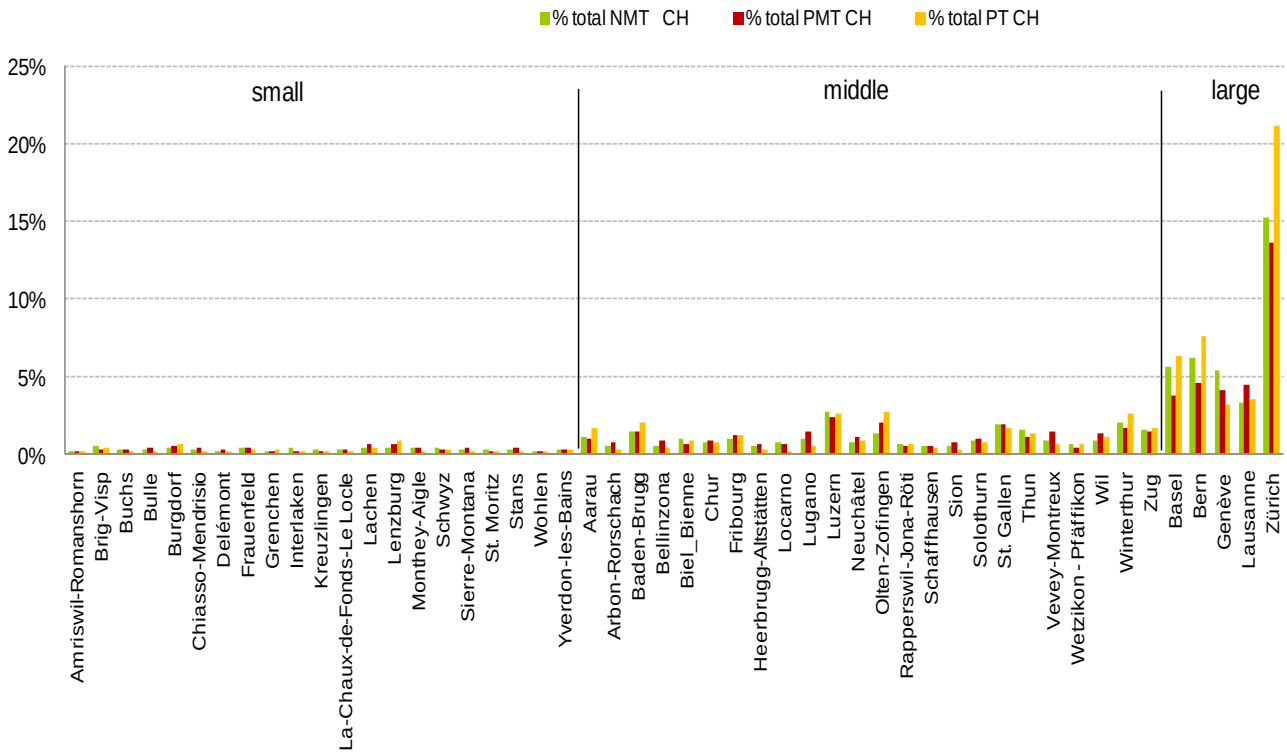


Figure 7: Modal Split of **all** inland performed distances (both within **and** outside agglomerations)

4.3 Agglomeration modal split comparison

Calculation of the inner-agglomeration modal split of each agglomeration provides a more pertinent comparison of mobility behavior, as it allows the comparison between agglomerations of different sizes. Overall, values are in average of 9% for non-motorized transport, 70 % for private-motorized transport, and 20% covered with public transport.

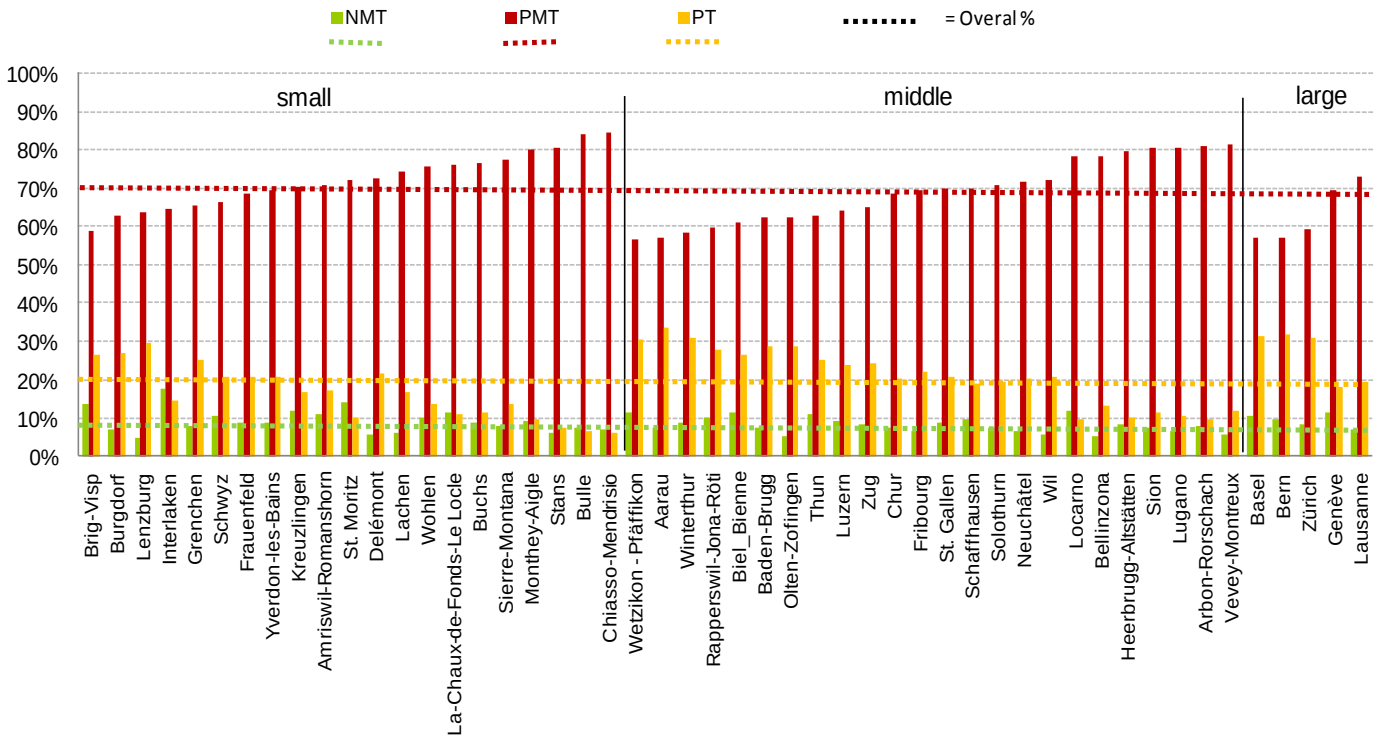


Figure 8: Modal Split within the 50 agglomerations (territorial approach)

Fig.8 shows that the modal split for Brig-Visp., Wetzikon-Pfäffikon and Basel agglomeration are rather similar, even though agglomeration size differs. These Agglomerations, together with Aarau show the lowest shares of PMT with less than 60 % of pkm travelled by a motorized vehicle, about 10% less than overall average. By contrast, Chiasso-Mendrisiom, Bulle and Vevey-Montreux, present the highest shares of PMT with shares higher than 80 %.

Concerning public transport, highest shares are observed for Aarau, Bern, Basel, Winterthur and Zurich, where their share is above average with over 30 %. At the opposite, public transport usage in Lausanne and Genève is relatively low with just about 20%. However, this results need to be interpreted against the method applied: for instance, the high shares of public transport in small agglomerations such as Aarau or Lenzburg might be partly induced by pkm resulting of transit of public transport (e.g. rail trips between agglomerations).

4.4 Comparison with Residential Analysis

Today the Swiss Federal Council defines in their residential legislative period 2011/2015, the agglomerations modal split as one indicator in order to monitor transport behavior in agglomerations, and optimize their transport planning. To quantify this indicator, the analysis is based on where residents live which means pkm by mode are counted inside/outside the agglomeration depending on the residence of the respondents.

Respectively, calculations performed based on the residential based perspective provide slightly different results compared to the territorial based approach conducted in this study. For example, calculating the share of total Swiss pkm travelled within, or outside agglomerations based on the territorial based approach, is not the same as computing the share of total Swiss pkm, based on the residential based approach.

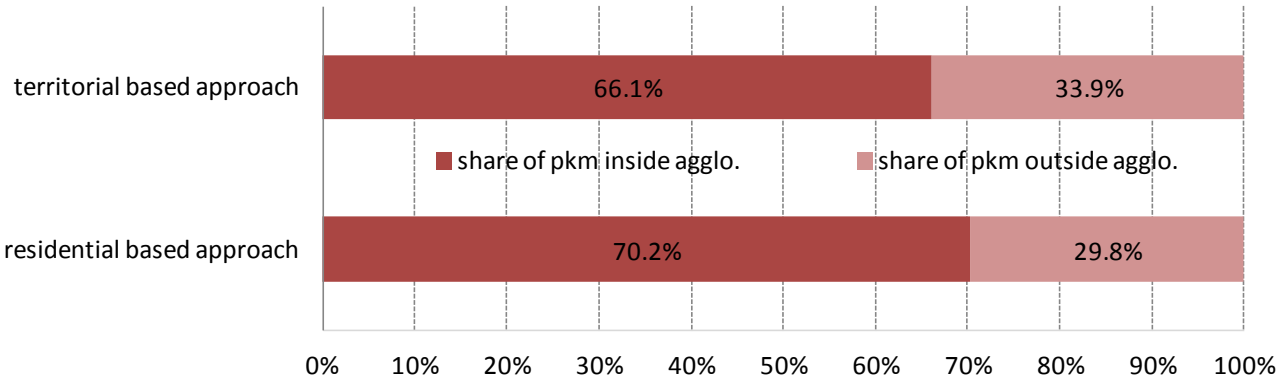


Figure 9: Share of total Swiss pkm travelled within, or outside agglomeration (territorial approach) versus share of total Swiss pkm according to the residence of respondents of the MZMV survey (residential approach)

Both methods indicate generally similar proportions even though shares differ by approx. 4%. The residential based analysis gives a higher estimation of agglomeration transport activities as the territorial approach (respectively 70.2 % versus 66.1 %). Effectively, this means that the residential approach – in general terms – overestimates traffic in agglomerations. Or: in practice and referring to the territorial based approach, more traffic is actually realized outside agglomerations than assumed so far.

A similar observation can be made analyzing the modal split inside or outside agglomerations. Residential based analysis for modal split of transport behavior of agglomeration- or non - agglomeration residents, also presents comparable results. As expected private motorized transport usage of non-agglomeration residents is higher (and hence, public transportat usage lower). However, as shown on Fig. 10, PMT-usage is about 63.2 % of total pkm realized by agglomeration residents (residential approach), while 65 % of total pkm realized inside agglomeration are covered with PMT (territorial approach). (Fig.6)

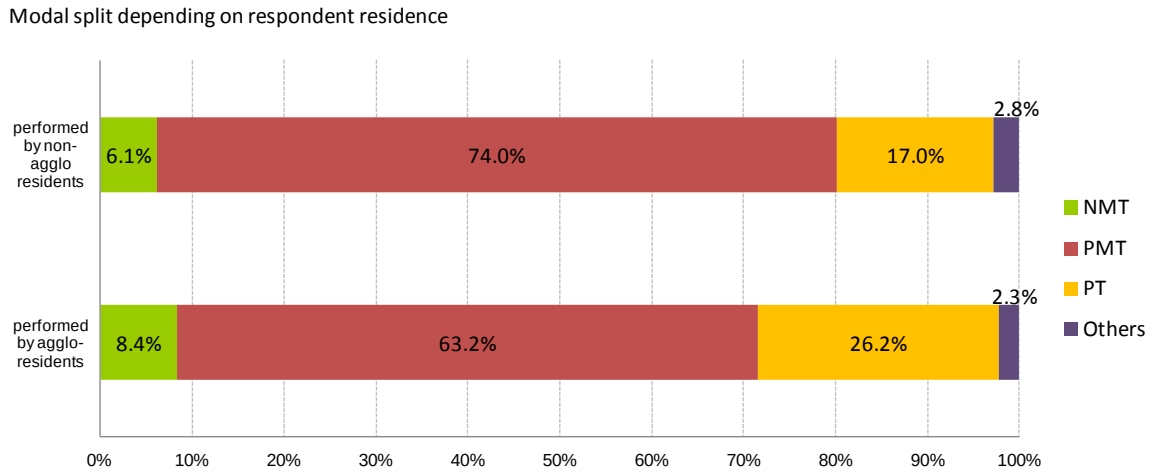


Figure 10: Modal Split based on pkm (in Mio. Km) – residential based approach

On the other side, the residential based analysis provides a lower share of PT-usage inside agglomerations, and a higher share of public transport usage within agglomeration. According to this method, public transport trips represent 26.2 % of total pkm realized by agglomeration residents (residential approach), while territorial analysis implies that this 24.8 % of total pkm effectuated outside of agglomeration are covered with public transport.

Next we compare Modal-split in the largest agglomerations based on both approaches (Fig. 12, 13), in order to evaluate where the difference between both of them is important. Nevertheless, no significant distinction is observed. The difference must probably lie in minor share; and appear in the sum of smaller and middle agglomerations.

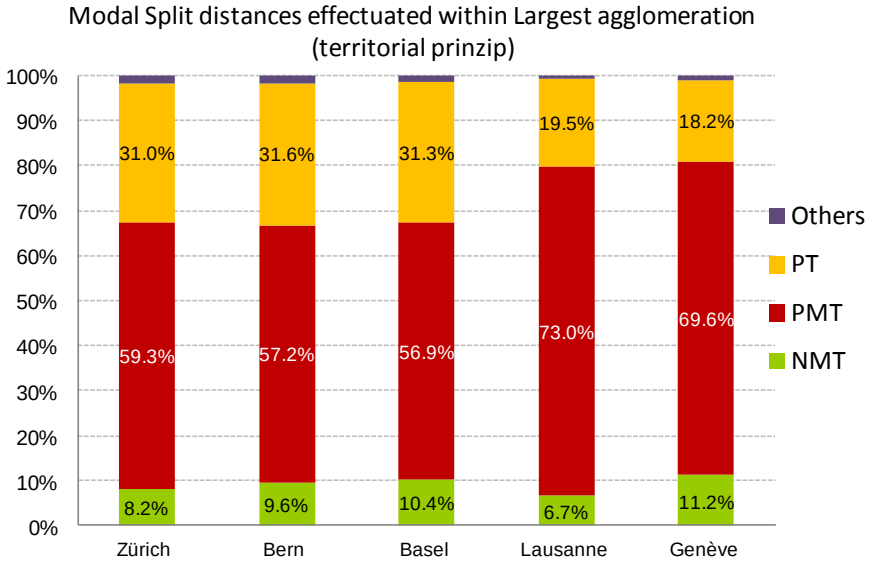


Figure 11: Modal Split within largest agglomerations (territorial approach)

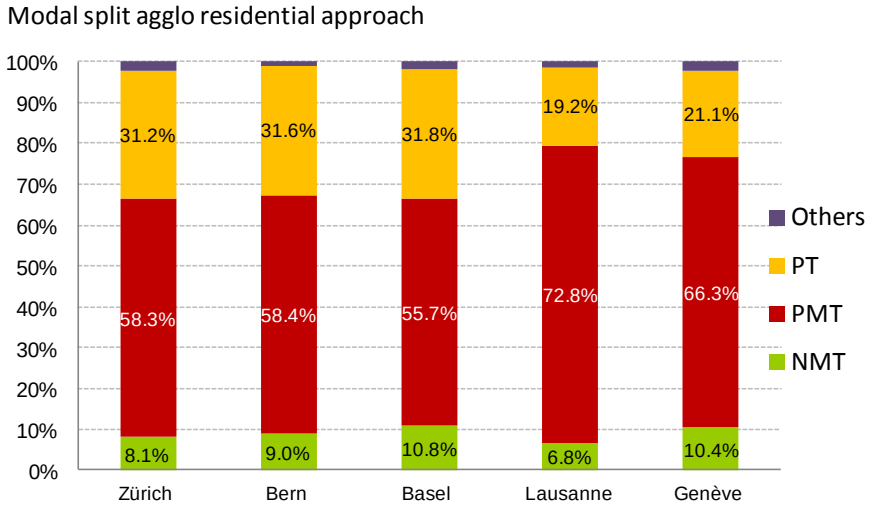


Figure 12: Modal Split within largest agglomerations (residential approach)

5. Limits of the study

The territorial based approach as applied in our study is limited to the survey population of the MCMT. That means, it is based on kilometers from Swiss residents exclusively. It does not include traffic performances of tourists, Swiss-wide transit traffic or any movements of freight. Therefore, the figures only show a portion of the overall traffic in the agglomerations. To calculate the overall amount of traffic in the agglomerations other survey studies have to be analyzed in addition (e.g. the Alpen- und grenzquerender Personenverkehr (BFS, 2007)).

6. Conclusions

The routing system introduced in the MCMT 2010 allows analysing mobility behaviour as well from a residential based as from a territorial based perspective.
The residential based method (currently used in calculation of indicators as part of Swiss governmental agglomeration programs for transport activities), considers all trips performed by an agglomeration's residents, whether they are performed in- or outside the agglomeration area. Any trips performed by people living outside an agglomeration are not considered, even if they are performed within an agglomeration. The residential based approach thus yields the travel performance of agglomeration residents in Switzerland.
Territorial based calculations in contrast include all trips of the Swiss residential population performed within an agglomeration, independently from the location of an actor's domicile. This approach does not consider any trips outside an agglomeration's area, even if it is performed by an agglomeration's resident. Consequently, the territorial based method provides information on the travel performance of the Swiss population within an agglomeration's territory.

The results obtained in this case study show that both methods indicate generally similar proportions. However, shares differ; the residential based analysis provides a higher estimation of agglomeration transport activities as the territorial based approach (respectively 70.2 % versus 66.1 %). We might conclude that with the residential approach traffic in agglomerations is slightly overestimated. A consistent observation can be made considering the modal split inside- or -outside agglomerations; private motorized transport is generally underestimated, and public transport overestimated with the residential approach as with territorial approach.

Whilst this paper presents and compares results from both methods, no conclusion is drawn considering which of them is more accurate, as both may present advantage and disadvantages depending on the purpose of the analysis. It is part of future work to extend this study, with calculations of different kinds (such as transit or mobility of residents within their agglomeration of residence) in order to deepen the analysis.

7. Literature

Axhausen, K.W. (2006) Definition of movement and activity for transport modelling, in: D.A. Hensher and K.J. Button (Eds) *Handbook of Transport Modelling*, Elsevier, Oxford.

Bundesamt für Raumentwicklung (2009) Monitoring urbaner Raum Schweiz – Analysen zu Städten und Agglomerationen, ARE, Ittigen.

Bundesamt für Raumentwicklung (2010) Weisung über die Prüfung und Mitfinanzierung der Agglomerationsprogramme der 2. Generation, ARE, Ittigen.

Bundesamt für Statistik (2011) *Die neue Volkszählung*, BFS, Neuenburg.

Bundesamt für Statistik (2012a) *Mobilität in der Schweiz. Ergebnisse des Mikrozensus Mobilität und Verkehr*, BFS & ARE, Neuenburg.

Bundesamt für Statistik (2012b) Legislaturindikatoren: Leitlinie 5 – Modalsplit im Agglomerationsverkehr, http://www.bfs.admin.ch/bfs/portal/de/index/themen/00/10/blank/ind44.indicator.30100002.4405.html, accessed March, 2014.

Bundesamt für Statistik (2012c) *Leistungen des privaten Personenverkehrs auf der Strasse. Methodenbericht 2012 (Zeitreihe bis 2011)*, BFS, Neuenburg.

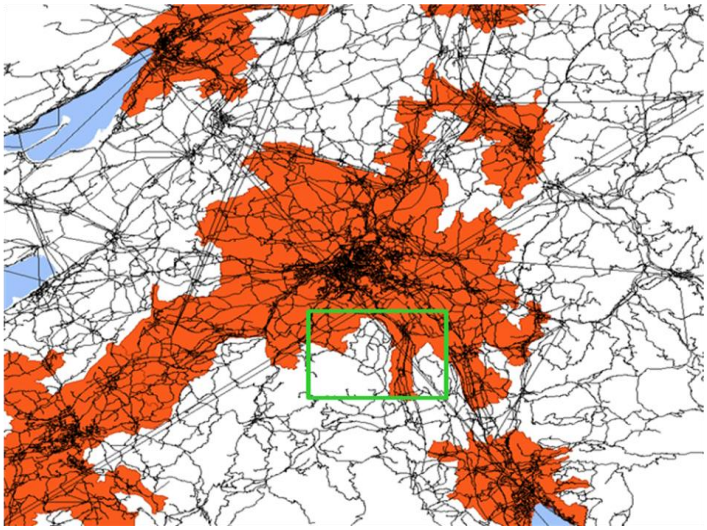
Ohnmacht, T., Rebmann, K. and A. Brügger (2012) Swiss Microcensus on Mobility and Transport 2010: Introduction of the routing-tool and adjusting estimated distances in previous Swiss Microcensuses on Mobility and Transport, conference paper for STRC, May 2012, Monte Verità.

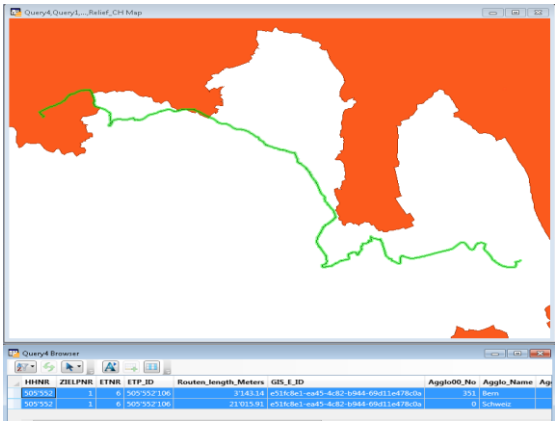
Rosset et al., (2013) Residential and territorial based analysis of mobility behavior in Swiss agglomeration, ARE, Ittigen

Schweizerischer Bundesrat (2012) *Botschaft über die Legislaturperiode 2011-2015*, Schweizerischer Bundesrat, Bern.

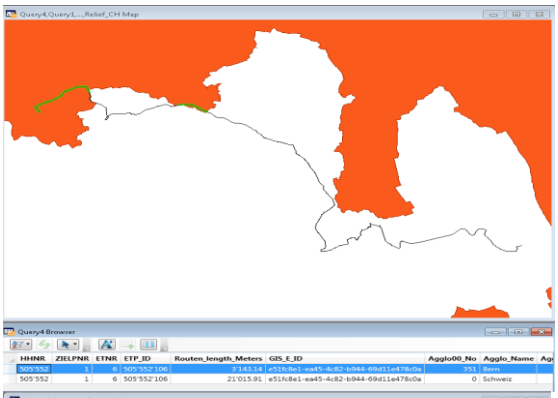
Schweizerischer Bundesrat, Konferenz der Kantonsregierungen, Schweizerische Bau-, Planungs- und Umweltdirektoren-Konferenz, Schweizerischer Städteverband und Schweizerischer Gemeindeverband (2012) *Raumkonzept Schweiz*, Schweizerischer Bundesrat, Bern.

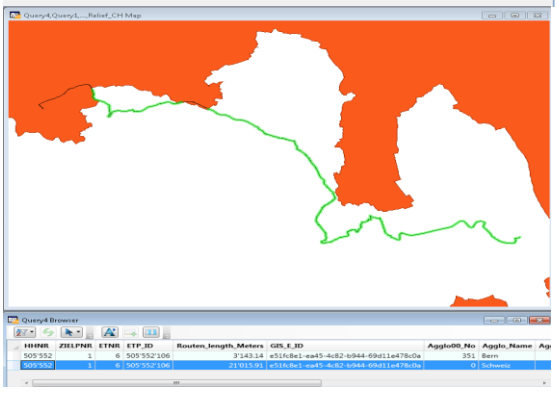
Annex 1: Clipping process; calculation of new Routen length





Each route is clipped with agglomeration boundaries; and new Routen sections length are computed





Annex 2: Routen clip (FME workbench)