Measuring Long-Distance Travel

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Abstract

Analysis of long-distance travel demand has become more relevant in recent times. The reason is the growing share of traffic induced by journeys related to remote activities, which are not part of daily life. In today's mobile world, these journeys are responsible for almost 50 percent of the overall traffic. Traditionally, surveys have been used to gather data needed for the analysis of travel demand. Due to the high response burden and memory issues, respondents are known to underreport the number of journeys. The question of the real number of long-distance journeys remains unanswered without additional data sources. This paper uses an alternative data source, mobile phone data, and compares its results for long-distance travel demand with the national household travel survey (Mikrozensus Verkehr 2015). We take a sample of mobile phone data covering 12 months, and identify the number of long-distance trips. The results indicate that the number of long-distance trips is close in these two data sources.

Keywords

1 Introduction

Analysis of long-distance travel behavior has become more important in recent years since the contribution of long-distance journeys to the overall traffic is growing continuously. Therefore, its influence on urban areas, highways, railroads etc. is becoming greater. Long-distance travel is usually defined as trips, which take place outside of a person's environment. In this paper, a long-distance trip is a trip to a destination more than 50km. In order to develop tools, which are able to provide reliable predictions, one needs data sources describing the current state of long-distance travel demand.

Data collection methods in the field of travel demand research were investigated in the past (Axhausen et al., 2002a; Armoogum and Madre, 2002). The most frequently used data sources are surveys. In case of long-distance travel the number of these is limited (the main sources are national travel surveys). However, all long-distance travel surveys are facing similar problems. On the one hand, due to the high response burden these surveys have a low number of respondents. On the other hand, it is known that number of journeys reported in surveys is too low (Madre et al., 2007; Armoogum and Madre, 2002). Both facts limit the explanatory power of studies and leave the question for the quality of the results unanswered (Kuhnimhof and Last, 2009).

To overcome these limitations alternative data sources are needed. We propose in this paper to use mobile phone data collected by mobile network operators in order to get better estimates of long-distance travel demand. The advantage is the large number of people that can be tracked without spending a lot of effort in a survey. We analyzed 12 months of mobile phone data provided by Swisscom, the largest mobile network operator in Switzerland. The results are compared to the Microzensus, the national Swiss household travel survey covering a substantial share of the Swiss population.

The paper is structured as follows. After a literature review we describe in detail the mobile phone data made available for our studies as well as the national household travel survey used in this paper. Afterwards, we present and compare the results of both data sources regarding long-distance travel. We conclude this paper with a discussion and a conclusion.

2 Relevant Literature

Data collection has always been an important issue in the field of travel demand research. Different methods of data collection were investigated in the past (Axhausen et al., 2002a;

Armoogum and Madre, 2002). The data sources mostly used are surveys, which have various forms (Dillman, 2000) to suit the diverse requirements of the researchers.

In case of long-distance travel the number of surveys is limited. Focusing on Europe, the *Mobidrive* studies are available (Zimmermann et al., 2001; Axhausen et al., 2002b; Chalasani and Axhausen, 2004). These studies focus on a six-week period, which is usually not sufficient for a deep analysis of long-distance travel behavior. Other sources are national travel surveys like the French (Armoogum et al., 2008), British (Department for Transport, 2016) or the Austrian (BMVI, 2012). Furthermore, few studies tried to measure long-distance travel demand, including the California Statewide Household Travel Survey (CSHTS) (Bierce and Kurth, 2014; Cambridge Systematics Inc., 2013), an ifmo study (Frick and Grimm, 2014; Kuhnimhof et al., 2014), the INVERMO project (Zumkeller et al., 2005; Chlond et al., 2006), the Knowledge Base for Intermodal Passenger Travel in Europe (KITE) (Frei et al., 2010) and the DATELINE study (Neumann, 2003).

Due to the high response burden that is usually associated with long-distance surveys (Axhausen et al., 2015; Axhausen and Weis, 2010), it can be expected that the number of long-distance trips is usually underreported. This has been shown, for example, by Janzen et al. (2018). The reasons are not responding frequent travellers as well as travellers claiming not to travel, while answering other questions, so called soft-refusers (Madre et al., 2007). Furthermore, there is a memory effect. Respondents tend to forget tours, which happened some time before the survey (Smith and Wood, 1977; Bradburn et al., 1987; Tourangeau, 1999). Additionally, the vehicle miles travelled are usually heavily underestimated as shown by Wolf et al. (2003).

Consequently, there is a need of alternative data sources. Nowadays, there are mainly two alternative sources available for the analysis of travel demand. Both use passive data collection. On the one hand, GPS data can be used to collect information about travel behavior (Montini et al., 2014). But the collection of GPS data is limited since the cooperation of the respondent is needed and smartphone GPS collection is battery consuming discouraging participation. On the other hand, GSM network operators produce mobile phone billing data that provides an enormous amount of data and has been already utilized in the field of transportation. One of the first applications was the analysis of travel demand induced by tourism (Ahas et al., 2008, 2007). GSM data has been also used to estimate OD matrices (Friedrich et al., 2010; Pan et al., 2006). Altogether, GSM data is a very powerful tool for predictions of human mobility (Song et al., 2010). We will show in this paper that it is as well very useful for the analysis of long-distance travel demand.

Several studies have carried out data quality comparisons. These studies compared, for instance,

CDR data with GPS trajectories (Iovan et al., 2013; Hoteit et al., 2014; Smoreda et al., 2013) as well as on the sociological aspects of using mobile phones like, for instance, in analysis of places relevant in transport planning (Licoppe et al., 2008), concluding that CDR data forms a good proxy for overall tendencies of human mobility thanks amongst others to the large samples of persons and days involved.

3 Data Sources

3.1 Mobile Phone Data

The first data source used in this paper is collected by Swisscom, the largest mobile network operator in Switzerland. According to the Swiss Federal Office of Communications, Swisscom had a market share of 58.8% by the 31.12.2016 (Federal Office of Communications, 2017) The data analyzed covers 12 consecutive months, namely October 2016 to September 2017.

The network operator records for his customers all simple handovers from one antenna to the other. Therefore, it is possible to track the movement of persons for a long period. The only requirement is that the phone's cellular connectivity is on and connected to the Swisscom network. There are two main limitations using this data source. Firstly, the spatial resolution is comparably low since the analysis is limited to the cell tower level. In case of long-distance travel, this spatial resolution is sufficient since a trip is considered to be a long-distance trip, if the covered crow-fly distance is at least 50 km. Secondly, the data is limited to Switzerland. Therefore, it is impossible to identify international trips, which is a limitation when it comes to analysis of travelled distance. However, the number of long-distance trips identified in the mobile phone data is likely to be close to the actual number.

Due to privacy regulations mobile phone data has to be aggregated. The aggregation level used here is the month and the municipality, i.e. for each municipality and each month the number of trips per capita is calculated. We chose in our sample 36 municipalities of different population size. Within these municipalities 500 mobile customers were selected and their long-distance trips were calculated for each month. In this paper, a mobile person is defined as a person that performs long-distance trips. In addition, the share of customers not travelling long-distances is known for each month, which allows us to calculate the number of long-distance trips per capita on a monthly basis. A list of the chosen municipalities including their classification can be found in Table 1

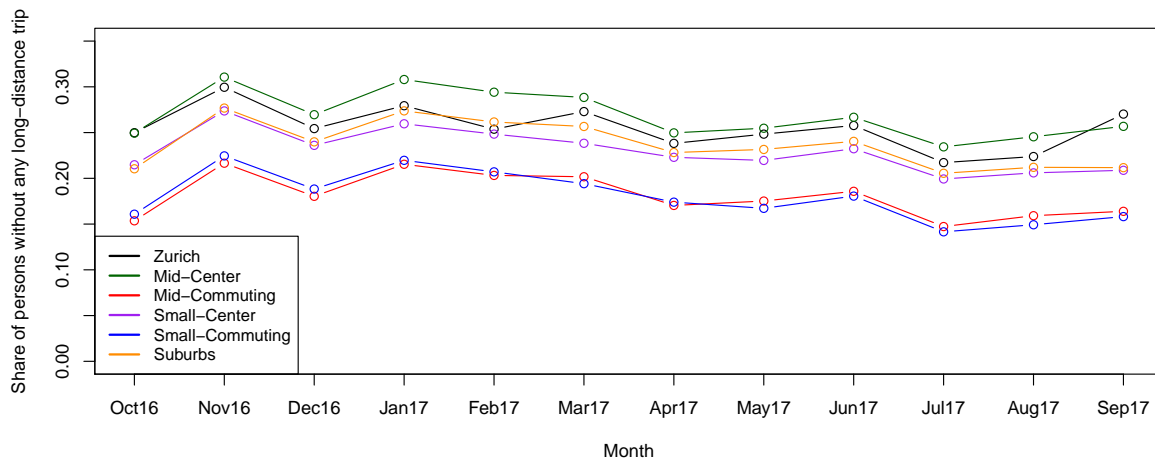Table 1: Municipalities selected for analysis

Class	Abbreviation	Selected municiaplities
Suburb of a city	Suburb	Zollikofen, Sarnen, Risch, Neuhausen am Rheinfall, Plan-les-Ouates, Aesch (BL)
Small towns with potential commuters	Small-Commuting	Einsiedeln, Binningen, Wallisellen, Langenthal, Wohlen (AG), Schwyz
Small towns that are regional centers	Small-Center	Chêne-Bougeries, Davos, Oberwil (BL), Weinfelden, Brugg, Spreitenbach
Mid-size city with commuters to a big city	Mid-Commuting	St. Gallen, , Luzern, Thun Biel/Bienne, Winterthur, Schaffhausen
Mid-size city that is a regional center	Mid-Center	Sion, Uster, Chur, Lancy Vernier, Neuchâtel
A district of Zurich	Zurich	Rathaus, Hochschulen, City Lindenhof, Wollishofen, Leimbach

3.2 Survey Data

The second data set is the Swiss Microzensus, a national household travel survey conducted every five years. The last Microzensus took place 2015 (Swiss Federal Statistical Office (BFS) and Swiss Federal Office for Spatial Development (ARE), 2017). The Microzensus consists of various modules in order to cover many aspects of travel behavior. In order to analyze long-distanced travel, we use the following three modules:

- **Daily Life:** All respondents were asked to report all their travel for one day.
- **Day Tours**: One third of the respondents had to respond to this module and report all their day tours in the last 14 days. The tours reported are longer than 3 hours, without overnight stay and are not part of daily routine.
- **Overnight Stays**: One third of the respondents had to respond to this module and report all their overnight tours in the last 4 months. The tours reported have at least one overnight stay and are not part of daily routine.
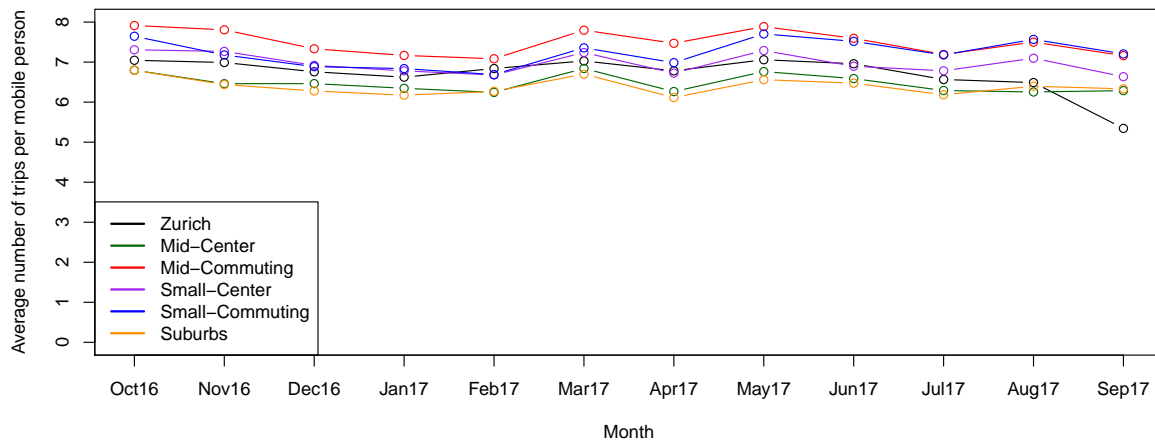
Figure 1: Non-mobile persons (Swisscom data)

Neither of these three modules is limited to long-distance travel. Therefore, the long-distance trips (at least 50 km distance) have to be extracted. In case of the latter two modules, the respondents describe just three trips in detail. Consequently, we do not have trip details, including trip distance, for all trips, if the respondent reported more than three trips. For simplicity, we assume that all trips without detailed information are long-distance trips.

4 Results

4.1 Mobile Phone Data

We analyze the share of non-mobile persons that can be observed in the mobile phone data. A non-mobile person is a person that does not perform any long-distance trip. The share of non-mobile persons by month and by municipality class is illustrated in Figure 1. It is important to state that the share of non-mobile persons is not correlated with the number of long-distance trips or the total distance travelled. We only identify the number of persons that do not travel. The analysis shows that more people travel during the summer months. In addition, December has a higher share of mobile persons than other winter months. This may be due to travel induced by the Christmas days. Furthermore, municipalities with commuters have a higher share of mobile persons, which meets the expectations.

Figure 2: Trips per person (Swisscom data)

The second part of the mobile phone analysis focuses on the number of long-distance trips by mobile person. Therefore, the travel behavior of 18,000 customers (500 from each of the 36 municipalities) was evaluated. The number of trips per month is illustrated in Figure 2 for each of the five municipality classes. Again, it is striking that the municipalities with many commuters have higher long-distance trip rates as the other municipalities. Overall, the trip rates are relatively stable throughout the year.
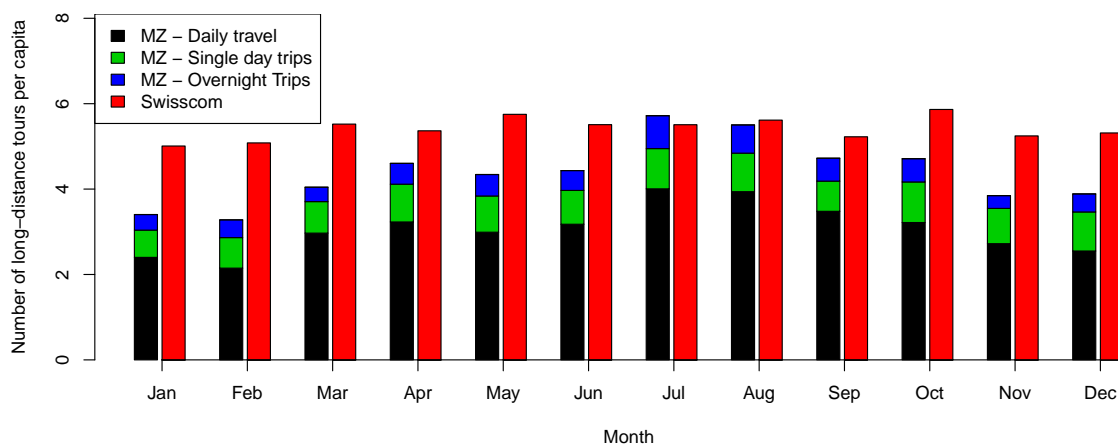
4.2 Survey Data

Analysis of long-distance travel in the Microzensus is split in three parts due to the structure of the survey. Therefore, we need to study the modules for daily travel, single-day travel and overnight travel. Firstly, 57,090 persons were asked about their daily travel, i.e. all trips that were performed during the reported day. In total, just 3620 did long-distance travel in their daily life. These persons performed 5,570 long-distance trips resulting in almost 0.1 trips per capita per day. Secondly, 17,219 persons were asked about their irregular single day trips in the last 14 days. Among the respondents, 2,128 persons did 2,537 round-trips, which results in 0.01 round-trips per capita per day. Thirdly, overnight travel was reported by 17,101 persons, who were asked to describe all their round-trips within 4 months that included a overnight stay. In this module, 8,913 persons travelled on 13,819 round-trips, which results in 0.2 round-trips per capita per month.

The three modules described above are not additive. Thus, the data needs further processing before comparing it to the mobile phone data. While the first module (daily travel) reports one-way trips, the other two modules describe round-trips or tours. We will use one-way trips in the following since this is also the value stated in the mobile phone data. Therefore, we assume that each round-trip has 2.15 one-way trips, which is the trip-tour ratio for long-distance travel as can be observed in available data, e.g. IFSTTAR (2016). Furthermore, the latter two modules have detailed information on tours just for three tours per person. Therefore, some tours have missing information like distance. However, this is a small share and we assume for simplicity that all of these tours are long-distance tours.

4.3 Comparison

The two data sets and their outcomes have to be compared. We use the number of the monthly (one-way) long-distance trips per capita as the main indicator that is evaluated. In case of the Microzensus, the person weights provided in the survey are incorporated. The monthly numbers of long-distance trips are shown in Figure 3.

Figure 3: Comparison of long-distance travel between Swisscom data and Microzensus

One can see that the results differ by season. During the summer holiday time (July to September) the reported number of trips does not differ much between the two data sources. During the other months (October to June) the number of trips recorded by the mobile phone data is higher than in the survey. The reasons are not evident. On the one hand, survey results might be an under-estimation due to several reasons like the high response burden. On the other hand, mobile

phone results might be biased, because it is based on a small sample of Swisscom customers. Another noticeable fact is the uniform distribution of long-distance trips across the months in the Swisscom data, which is an unexpected outcome.

5 Limitations

Both data sets presented in this paper have limitations. The mobile phone data does not include any socio-demographic information. Thus, no person weighting is possible and no information about the customer sample bias is given. In addition, the data is aggregated by month and municipality due to privacy issues, which makes it difficult to detect the potential shortcomings of the data. The Swiss Microzensus has the limitation that it is not meant for analysis of long-distance travel demand. Therefore, one needs to merge three different modules of the survey with three different time horizons. Merging these three sub-surveys to one result is no replacement for a survey with a focus on long-distance travel. Consequently, it is difficult to evaluate which data source more reliable for analysis of long-distance travel.

6 Conclusion

This paper has shown that mobile phone data is a useful data source for the field of travel demand research. Especially, long-distance travel estimators can benefit from this particular data. However, it was not possible to show in this paper that a household travel survey per se under-reports long-distance travel demand. A survey with a detailed questionnaire and a large sample size like the Microzensus can lead to similar results as mobile phone data.

7 Acknowledgements

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