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Emerging issues and methodologies for the measurement of migration

Measuring cross border mobility and transnational lifestyle between Estonia and Finland with Mobile Positioning Datasets

Note by the Statistics Estonia*

Abstract

The spatial mobility of people is increasing rapidly and transnational lifestyle with living and working in different countries has spread quickly in the world. The mobility of society is significantly influenced by the opening of borders and development of information and communication technology. Studying this highly mobile society is complicated, it is difficult to obtain statistics on transnational jobs, mobile jobs and cross border commuting (Tyldum & Brunovskis, 2005). An important problem hindering gathering of statistics is, however, the fact that people commuting between two countries and places of residence often do not know themselves where they would like to live and what their perspective for the future is (Zaiceva & Zimmermann, 2008; Levitt & Jaworsky, 2007). Due to this, the lives and work schedules of cross-border commuters are unclear and they are not able to provide sufficient information about their statuses in the course of censuses and interviews.

One example of transnational lifestyle can be found at the Estonian-Finnish border (Oopkaup et al 2014). The mobility between these two neighboring countries is heavy because of tourism, businesses and labor commuting. Because of opening borders and the illegal labor market it is hard to control or to gather statistics about cross border mobility and tax payment. There is need for new data sources for gathering statistical information and developing policy measures about such cross border commuting as traditional methods are not effective in describing such diversity of cross border mobility practices (Ahas 2010; Silm & Ahas 2012).

The objective of paper is to introduce methodology for measuring people's cross border commuting using passive mobile positioning data and to illustrate it with Estonia-Finland

* Margus Tiru (Positium LBS, Estonia), Andres Oopkaup (Statistics Estonia), Marjo Bruun (Statistics Finland), Rein Ahas (University of Tartu), Siim Krusell (Statistics Estonia), Maiki Ilves (Statistics Estonia), Siim Esko (positium LBS, Estonia).

case study. We discuss methodological and legal aspects of using such data for measurement of mobility and in relation the labour commuting between two countries. We are using anonymous passive mobile positioning data in order to study the spatio-temporal mobility between Estonia and Finland (Ahas et al. 2008). The study of movements of mobile phones between roaming mobile networks enables to make generalisations on the flow of people between countries and regions (Positium 2014). The privacy of the individuals is strictly protected according to the EU data protection regulations (Directive 95/46/EC; Directive 2002/58/EC).

1. Introduction

The spatial mobility of people is incising rapidly and transnational lifestyle with living and working in different countries has spread quickly in the world. The mobility of the society is significantly influenced by the opening borders and development of information and communication technology. Studying this highly mobile society is complicated, it is difficult to obtain statistics on transnational jobs, mobile jobs and cross border commuting (Tyldum & Brunovskis, 2005). An important problem hindering gathering of statistics is, however, the fact that the people commuting between two countries and places of residence often do not know themselves where they would like to live and what their perspective for the future is (Zaiceva & Zimmermann, 2008; Levitt & Jaworsky, 2007). Due to this, the lives and work schedules of cross-border commuters are unclear and they are not able to provide sufficient information about their statuses in the course of censuses and interviews.

One example of transnational lifestyle can be found in Estonian-Finnish border (Oopkaup et al 2014). The mobility between two neighboring countries is heavy because of tourism, businesses and labor commuting. Because of opening borders and illegal labor market it is hard to control or to gather statistics about cross border mobility and tax payment. There is need for new data sources for gathering statistical information and developing policy measures about such cross border commuting as traditional methods are not effective in describing such diversity of cross border mobility practices (Ahas 2010; Silm & Ahas 2012).

The objective of paper is to introduce methodology for measuring people's cross border commuting using passive mobile positioning data and to illustrate it with Estonia-Finland case study. We discuss methodological and legal aspects of using such data for measurement of mobility and in relation the labour commuting between two countries. We are using anonymous passive mobile positioning data in order to study the spatio-temporal mobility between Estonia and Finland (Ahas et al. 2008). The study of movements of mobile phones between roaming mobile networks enables to make generalisations on the flow of people between countries and regions (Positium 2014). The privacy of the individuals is strictly protected according to the EU data protection regulations (Directive 95/46/EC; Directive 2002/58/EC).

2. Data and available results

2.1. Passive mobile positioning data

Passive mobile positioning data are generated as a part of the Mobile Network Operator's (MNO) operations and are automatically recorded in log files as secondary data of phone use. The more commonly available are Call Detail Records (CDR) and Data Detail Records (DDR). Different operating systems (Ericsson, Nokia-Siemens, Motorola etc.) have different technical solutions and terminology for such data outlets, but most operating systems have a similar structure (Dahlman et al, 2011; Smoreda et al, 2013).

The advantages of CDR data over the traditional methods used in border crossing statistics such as census, surveys and counters are the better spatial and temporal resolution of data; a longer observation period, and the digital and automatic data collection. In the European Union MNOs have to comply with the EU

Directive 2006/24/EC (EU, 2006) for data retention for the period of six months to two years as from the date of communication.

In this study, we used Call Detail Record data from the memory files of the biggest Estonian mobile operator EMT with the market share of 40–45% in Estonia. We use the data about the use of Finnish telephones (roaming) in the EMT network for incoming visits and the use of EMT phones in Finland for outgoing visits. The management of data and segmentation of visitors according to space-time flows was handled by Positium LBS, who used the special software Positium Data Mediator (Positium 2013). For the Estonian phones abroad, we used the data on age groups and gender from the operator's database and calculated the home anchor point network cell in Estonia using the anchor point model (Ahas et al. 2010). Because of data protection and privacy regulations, it is not possible to position phones more precisely in Finland.

CDR location information is initially stored as cell global identity (CGI) which has the unique identity and location for each antenna. Spatially, CGI is the area of the antenna mobile radio coverage, which in reality is not physically fixed. Typically, the GSM network maximum theoretical signal area of a cell is 35 km, but cell antenna located along coastal areas are often further amplified to provide the best possible radio coverage across the sea. All these characteristics of passive positioning data need to be considered when using such data.

2.2. Database used in empirical study

We used the databases of call activities in the EMT network for 2009, 2010 and 2011 year: call activities made by Estonian phones in Finland and call activities made by Finnish phones in Estonia. Call activity is any active use (incoming or outgoing; voice, text, internet, services) of a mobile phone. The database used for the study consists of call activities (time, location) of random IDs (Table 1). The country of origin or nationality of visitors is determined here on the basis of the registration country of the mobile phone. So a phone registered in Estonia may be used by a person of any nationality. Still, the registration of a mobile phone shows the place where the person is spending most of their time or has strong connections with. Random IDs are not identifiable, but a certain phone number is given the same ID by during the trip to another country by the operator. Because of privacy protection requirements we worked with aggregated dataset, it was not possible to study individual entries or ID-s.

Table 1. Data recorded on the call activity used in the study.

Phone user	ID	Time	Location
Finnish (roaming) phone in Estonia	Country; Random ID	ss:mm:h h dd:mm.y y	Network cells
Estonian phones (roaming) in Finland	Random ID	ss:mm:h h dd:mm.y y	Country

2.3. Visitor segments

Based on this CDR data we generate various statistics from roaming logs to describe mobility: number of visitors, number of visits, number of days, and number of nights. In the following section we describe the following statistics (Silm & Ahas, 2012; Järv et al 2014).

Visitor – unique person (mobile phone user, ID) who is travelling to another country, have done call activity(ies) there.

Visit – unique visit to another country by a person. One visit is normally composed by 2 trips: one into destination and second back home from the destination. One person can make a number of visits. We use the visits, which have done directly from Estonia to Finland in case of Estonians and directly from Finland to Estonia in case of Finns, without transit or stopping in a third country.

Trip – unique one way trip to another country by a person, for example trip from Estonia to Finland; or trip from Finland to Estonia.

Number of days – duration of one visit in days.

Number of nights – duration of one visit in nights. The formula for calculating the number of nights in one visit is: nights = days – 1.

We have used different segments of visits/visitors based on visit duration, number of visits per year and number of days spent in another country per year.

Visits. We have divided visits on the basis of the length of stay.

Transit visits – visits to another country (Finland/Estonia) for a short period (may be <3...<12 hrs) and leaving to a third country on the same day.

Visits to the destination divided on the basis of the number of visited days: one day visits, 2–4 day visits, 5 or more days' visits.

Based on the total number of days spent in other country, visitors are divided:

- 1) 1 day visitors
- 2) 2–30 day visitors
- 3) 31+ day visitors
- 4) 183+ day visitors. According to the common definition (WTO), a visitor who is staying in other country for 183 days or more is considered a foreign labourer.

Visitors. We divide visitors based on the number of visits to another country.

- 1) one time visitors
- 2) 2–4 time visitors
- 3) 5 or more time visitors.

2.4. Results

The advantage of passive mobile positioning is that it creates the opportunity to analyse the foreign visits of a large part of the population over a long period of time. We can look at the distribution of

trips by the frequency or duration of visits. The duration of trips can, in turn, be calculated in terms of one trip or year or study period. We can also include the information on the timing and geography of trips into the segmentation process. What follows are the main results of these distributions. The results show that there are more persons making short trips from Finland to Estonia. There are less people travelling from Estonia to Finland, but the total duration of their stay in Finland is very long.

2.5. Duration of trips

The statistics on the duration of trips in the two directions (from Finland to Estonia and from Estonia to Finland) differs greatly. Only the volumes of transit trips and short-term (1–9 days) trips are comparable and demonstrate the importance of short-term visits (probably for tourism and business) in the travel between the two countries. The distribution of trips lasting over 10 days shows the share of commuting for employment purposes, which is what interests us: 13.4% (180,487 trips) of the trips from Estonia to Finland last 10+ days. Most probably this includes persons who work in Finland, but definitely Finns who have taken up residence in Estonia as well. The share of trips from Finland to Estonia which last 10 days or more is only 2.5% (57,564 trips). The number of Estonians who spend 183 days or more (WTO defines them as foreign workers) in Finland is 13,652 (4% of total visitors). 1,155 Finns stayed in Estonia for more than 183 days, which amounts to 0.1% of the visitors. It is very likely that the majority of these people from both countries work or have family relations in the neighbouring country.

Table 2. Visits made between Estonia and Finland by duration, , annual average for 2009-2011

Duration of visits	Estonians to Finland		Finns to Estonia	
	Number of visits	%	Number of visits	%
Transit	156 576	11.6	188 894	8.1
1 day	368 798	27.4	995 209	42.7
2 days	243 663	18.1	547 710	23.5
3 days	126 207	9.4	249 178	10.7
4 days	88 676	6.6	118 419	5.1
5 days	63 911	4.7	63 665	2.7
6 days	41 389	3.1	38 669	1.7
7 days	28 689	2.1	34 649	1.5
8 days	25 544	1.9	24 530	1.1
9 days	23 235	1.7	12 997	0.6
10+ days	180 487	13.4	57 564	2.5
Total	1 347 176	100	2 331 483	100.0

2.6. Frequency of trips

The annual frequency of trips per person (ID) also confirms that for the majority of visitors in both directions it is customary to make one or two trips per year (Table 3). Naturally, the Finns dominate in making one-day trips: 72.2% of them go on one-day trips, whereas the share is only 49.9% for Estonians. Until up to 9 trips per year, the distribution of the frequency of trips is rather even between the visitors of the two countries. In terms of determining labour migration, we are, again, focused on people with 10 or more trips per year. Here, the share of persons who travel “often” from Estonia to Finland clearly stands out, amounting to 10.6 % or 34,767 persons of the total number of travellers. The share of persons who travel “a lot” from Finland to Estonia is only 0.8% of the total number of travellers, i.e. 12,343 persons. Therefore, we should look for people who work abroad particularly among the persons who go to Finland 10 and more times per year. Where exactly the threshold should be set, depends on geographic distance and several other factors. We should probably organise an interview survey, which would help to specify the methodology, and a phone use survey.

Table 3. Visits made between Estonia and Finland by frequency of trips, annual average for 2009-2011

Frequency of visits	From Estonia to Finland		From Finland to Estonia	
	Number of visitors	%	Number of visitors	%
1	164 093	49.9	1 150 877	72,2
2	58 789	17.9	265 630	16,7
3	27 190	8.3	86 411	5,4
4	15 052	4.6	35 460	2,2
5	9 558	2.9	18 124	1,1
6	6 680	2.0	10 784	0,7
7	5 104	1.6	6 909	0,4
8	4 163	1.3	4 741	0,3
9	3 570	1.1	3 488	0,2
10+	34 767	10.6	12 343	0,8
Total	328 966	100	1 594 766	100,0

3. Temporary labour in Finland- Available data and limitations

3.1. Estonian sources and data limitations on temporary foreign labour in Estonia

Statistics Estonia can use two main sources to estimate the number and profile of those who are commuting in purpose of working.

First is Population and housing Census. This source offers sufficient data to estimate both the number of persons who were working abroad during certain period (final weeks in 2011) and also their profile. The disadvantage of mentioned source is only gives information about 2011 and does not offer the continuous time series.

This is offered by LFS but its main problems would be lack of sufficient respondents to describe more contrasted profiles. There would be also problem of underestimation the number of working abroad since it is difficult to reach them who actually works abroad.

An estimation of the Estonian Labour Force Survey can be used as a reference to PHC 2011; according to the survey, people in the 1st quarter of 2012, the total number of people working abroad was 24,800. According to PHC 2011, the number of people working abroad is nearly 25,000.

The number who worked in Finland was more than 15 000 according to PHC 2011, LFS showed nearby numbers- in 2011 the fourth quarter the persons whose job location was 15 900.

3.2. Data limitations for statistics on temporary foreign labour in Finland

Immigration to Finland has increased steadily and markedly since 1990's. As the volumes of immigration have increased, so has the need for information on variety of issues related to immigration.

Statistical information on labour-based immigration is of particular interest for several administrative fields. Information on labour-based immigration is noticeably called for in formulating and monitoring policies and measures in economic and employment administration, in regional development, and in countering black economy. However, statistics on labour-based immigration faces currently severe limitations. Most importantly, the official labour market and employment statistics are based only on population residing permanently in Finland.

For instance, Statistics Finland's annual register-based Employment Statistics, while yielding information on population's economic activity and employment, are based on permanent resident population. Those residing in Finland less than 12 months, or foreign nationals whose residence is attributed as temporary, regardless of the length of their stay, are not included in Statistics Finland's Employment Statistics.

Statistics Finland's Labour Force Survey collects data on employment and unemployment. This data is based on a random sample, drawn twice a year from the Statistics Finland population database. The monthly sample consists of some 12,000 persons and the data are collected with computer-assisted telephone interviews. Due to the nature of its sample construction, this survey does not reach those residing in Finland temporarily. In addition, since the data are collected via telephone interviews and due to possible language barriers, even permanently residing foreign nationals are in a risk of being omitted from and under-represented in Labour Force Survey.

Statistics Finland's Structural Statistics on wages and salaries describe the numbers, hourly and monthly earnings, and the formation and distribution of employees' wages and salaries. The data derive from Statistics Finland's data on wages and salaries and is formed by combining data

collected by employer organisations from their members with those from Statistics Finland's wage and salary inquiries for the unorganised employers.

Structural Statistics cover all public sector employees, but private enterprises employing less than five employees are not included in the data. In addition, agricultural (as well as forestry and fishery) enterprises are excluded from Structural Statistics. Due to these restrictions in data collection, Structural Statistics leave out a cluster of small scale enterprises many of which are run by self-employed immigrants as well as enterprises in agriculture that typically rely on seasonal labour to a considerable extent.

The demand for information about temporary foreign labour is vast, and government agencies, in particular, have requested concomitant data persistently. For instance, in 2004, the Finnish Parliament, while passing the directive on the right of citizens of the European Union to move and reside freely within the Member States, called for monitoring the effects of free movement on labour market. However, the revision and initiation of much legislation continuously summons for reliable and accurate statistical data about temporary foreign labour.

The Programme for the Finnish Government 2011 establishes a definite objective of clarifying and improving statistics and research activities concerning immigration. In its audit report *Työperäinen maahanmuutto* ("Labour- Based Immigration"), National Auditing Office asserts that there are severe deficiencies in availability and usability of statistics regarding temporary foreign labour, particularly from European Union member states.

The most detrimental obstacle for procuring statistics on temporary immigrant labour is the fact that foreign nationals do not acquire, for the most part, Finnish social security number, which is an imperative for register-based statistics production. The Finnish Aliens' Act is currently under revision process and might eventually bring changes that will enable more fluent and comprehensive registering and, thus, statistics production of temporary foreign labour. Proposed revisions to Aliens' Act entail, for one, combining assigning Finnish social security number to third country immigrants with the issuing of residence permit. Secondly, while the authority to assign social security number has earlier been restricted to magistrate offices, and more recently, to Office of Tax Administration, the revised Act would give the local police the right to assign social security numbers for EU-nationals after three-month period of residence.

The revisions would expand the scope of foreign workers possessing the Finnish social security number and would therefore contribute to consistent and reliable register-based statistics production. However, the EU-residents staying in Finland less than three months would even under the revised Act remain unregistered and thus without the social security number. Further still, many EU-residents refrain from registration regardless, and many are not even aware of such an obligation in the first place.

A profound deficiency is the fact that, currently, no government agency bears responsibility for statistics on labour-based immigration. In addition, while several agencies collect information about immigrants and immigration, no strategy to coalesce the information from various registers and databases exists.

To respond to the need for and deficiencies in labour-based immigration statistics production, Statistics Finland has, from the initiation of the Ministry of Finance, set a working group to investigate current limitations and deficiencies in registers, data, and statistics of labour-based immigration. The objective of the working group is to determine prerequisites for efficient and

comprehensive statistics production of temporary immigrant labour, and consequently, present an action plan to meet these essentials.

Improving the registration processes of foreign workers, and developing processes to channel information about temporary foreign workers from enterprises to government agencies are in pressing need. However, such measures aim at profound betterment of statistics production of temporary foreign labour and can be lengthy processes. Therefore, prompt solutions for procuring data on labour-based immigration are in urgent need.

Increasing flows of commuting between Estonia and Finland is of particular interest for several policy-making authorities. However,

free movement of labour within European Union territory sets definite limitations on data collecting of migrant labour, since border control mechanisms no longer yield data. Therefore, new and innovative approaches to data collecting must be developed.

4. Discussion

4.1. Finnish perspective

Three main issues of concern were identified in relation to accessing mobile positioning data for the purpose of producing tourism statistics in Finland and these concerns will also affect potentially producing statistics about temporary labour migration.

First, the current Statistics Act obliges enterprises to provide data on their products and services but not on the clients consuming these products and services. Therefore the current Statistics Act does not oblige MNOs to provide mobile positioning data to Statistics Finland.

Second, according to the Act on the Protection of Privacy in Electronic Communications the identification data may only be processed by a natural person employed by or acting on behalf of a telecommunications operator.

Thirdly, the Office of Data Protection Ombudsman stated that the raw data, although anonymized, still constitutes personal data. The anonymization does not guarantee anonymity of the individual if the identifier individualising the subscriber connection is the same all the time, plenty of observations are collected from the subscriber connection by means of location data and timestamps, and the time of data collection and the number of observations accumulated in this way are in no manner restricted. Thus there arises a need for a mediator to process the data into aggregated form on the premises of the operator. Such mediator has to have access to the raw data maintained by the operator as well as possess methodological competence and tools to process the raw data into aggregated data. This scenario involving a mediator is challenging technically, financially and in terms of organization.

As a conclusion there are two possible paths for Statistics Finland to gain access to the mobile positioning data:

- a) Voluntary basis: Operators process the data into aggregate form either themselves or by use of an intermediate party and deliver the aggregates to Statistics Finland.
- b) Legal basis: Statistics Act should be updated to authorize Statistics Finland to obtain mobile positioning data from operators. In parallel, the Act on the Protection of Privacy in Electronic Communications should be updated to entitle the operators to provide the data for Statistics Finland.

4.2. Can we trust the mobile data?

The data presented in this study is an alternative source for determining international mobility flows. Statistics are interesting and data collection method is cost effective. Here we described only first steps on developing such segmentation algorithms: a) duration of trips; b) frequencies of trips, in addition we have done but not described here c) timing of trips; d) geographical origin and destination of trips. And we discovered potential segments of travellers with mobile phones which are transnational commuters. They have different timing and duration of trips depending from occupation, season and economic situation in origin and destination.

Certainly these statistics have also problems: the total number of visitors was evaluated based on the market share of one large mobile operator. It must *be* emphasised that the study includes people that actively use their mobile phone while abroad, i.e., they have maintained an active connection with their homeland. Clearly there are many persons who use much cheaper local mobile phone services or do not use mobile phones at all abroad. Nationality (country of origin) was determined by the country in which the phone is registered and usually people register their phones in a place with which they have a strong connection or where they stay longest. Certainly there is a need for a detailed phone use study in the future.

Using mobile positioning data in scientific research also has several shortcomings that we have to keep in mind when interpreting the results. One of the weaknesses of such quantitative statistical data is that we do not know the exact motivations and relations lying behind those visits. The most important question is related to sampling: Who have phones? Are they using phones during travels? How often do visitors use phones in a foreign country? As roaming calls are expensive, it is likely that wealthy tourists and businessmen use their phones more often than less active people with a lower income (children, students, pensioners). This means that sampling issues are also related to lower income and age groups. Calling is also connected with cultural differences, such as calling regulations and traditions. Another problem that arises in case of using mobile positioning data is its quantitative structure – we know the locations of calls (dots), but we do not know who is really making the calls, what kind of visit he/she is on, and what kind of transportation he/she is using. The huge amount of quantitative data also poses a problem for data processing and cleaning; the databases are too large to enable using traditional software and data preparation options. From the positive side, getting mobile positioning data does not cause any extra burden and the production of the statistics can be done very fast. Given the limitation of the traditional surveys and administrative register, new alternative source that can give information about labour-based immigration is mobile positioning data. Mobile positioning data is collection of information in mobile operator's network on events that specify a specific subscriber's presence in time and space.

Estonia has been a leading country in the use of the mobile positioning data in various domains. This is because Estonia is one of the leading IT countries in the World with e-government and various public and private IT applications that create the environment that support new technological development in many areas. Analyses based on the mobile data in tourism, transportation and other public domains have been conducted by University of Tartu, Positium and some other organisations already for several years.

It is clear that there are differences between the concepts used in the official statistics and what can be obtained from mobile positioning data. This discrepancies need to be taken into account when

interpreting or comparing results. However, administrative data sources do not always measure what we want to measure, either.

Assessment of accuracy, especially coverage issues, is very problematic for this data source because there are many components that contribute to the coverage bias and assessing all of them, separately or together, is a complex task and requires additional data sources. Some examples of the coverage problems are: people not owning a mobile phone, people having many SIM cards, people changing their SIM to local SIM card when in other country, data available from selected MNOs only.

Passive mobile positioning data (the most likely data available from mobile network operators) contains data about events like making a call or sending a text message only. Due to the nature of passive mobile positioning data, the quality of the estimates based on this data source depend on the changes in the telecommunication market, e.g. prices of the calls and text messages and the way individuals use their mobile phones. Mobile phone technology has developed very fast and people use mobile phones for much more than just calling and texting. It is quite likely that the added possibilities will change people's calling and texting habits and thus the content of data is changing too. Such change in the data will likely affect comparability over time.

From the positive side, getting mobile positioning data does not cause any extra burden and the production of the statistics can be done very fast.

5. Conclusions

In this paper our main focus was to current results and methodology of passive mobile positioning and questions related this methodology. Advantages of this method over the traditional methods used in border crossing statistics such as census, surveys and counters are the better spatial and temporal resolution of data; a longer observation period, and the digital and automatic data collection.

But also the problems which need to be solved can be described. These problems concern legislative aspects, complete access to data, need to develop methodology about measuring labour migration/temporary working. It is important to emphasize that pending questions would be related both of measuring mobility between countries and temporary working.

It is possible to bring out some further steps to move on with process of developing.-

Firstly, such segmentation needs to be properly finalised with a multi-layer analysis to consider all of these factors. Thus, from the aforementioned segmentation methods (frequency, duration, timing, geography), we could compile an algorithm which helps to identify the potential transnational commuters.

Secondly, the result should be compared with national censuses and registers to determine the accuracy of such an algorithm of „passive“ and anonymous positioning. It is vital to emphasise that migration always has two sides – a starting point and a destination – and migration methodology needs to consider the situation, knowledge and needs of both sides.

Thirdly, we should organise a survey on phone use and positioning where people are interviewed and their phone use data is retrieved to be analysed in terms of the connections between their travel behaviour and ICT use.

6. References

- Ahas, R. 2012. Virolaiset työntekijät ovat piilevä voimavara. *Helsingin Sanomat*, 07.12.2012. <http://www.hs.fi/paivanlehti/a1354767656107?jako=ab68c53e44198a132c2c0534436fbb42>
- Ahas, R., Silm, S., Järv, O., Saluveer E., Tiru, M. 2010. Using Mobile Positioning Data to Model Locations Meaningful to Users of Mobile Phones , *Journal of Urban Technology*, 17(1): 3-27.
- Ahas, R. Aasa, A., Roose, A., Mark, Ü., Silm, S. 2008. Evaluating passive mobile positioning data for tourism surveys: An Estonian case study. *Tourism Management* 29(3): 469–486.
- Dahlman, E., Parkvall, S., & Skold, J. 2011. 4G: LTE/LTE-Advanced for Mobile Broadband, Elsevier.
- EU, 2006. Directive 2006/24/EC of the European Parliament and of the Council of 15 March 2006 on the retention of data generated or processed in connection with the provision of publicly available electronic communications services or of public communications networks and amending Directive 2002/58/EC: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:105:0054:0063:EN:PDF>
- Järv, O., Ahas, R. and Witlox, F. 2014. Understanding monthly variability in human activity spaces: a twelve-month study using mobile phone call detail records. *Transportation Research Part C: Emerging Technologies* 38 (1): 122–135.
- Massey, D.S., Goldring, L., Durand, H. 1994. Continuities in Transnational Migration: An Analysis of Nineteen Mexican Communities, *American Journal of Sociology* 99(6): 1492-1533.
- Levitt, P.L., Jaworsky, B.N. 2007. Transnational Migration Studies: Past Developments and Future Trends, *Annu. Rev. Sociol.* 33:129–56.
- Tyldum, G., Brunovskis A. 2005. Describing the unobserved: Methodological challenges in empirical studies on human trafficking, *International Migration*, 43(1/2):17-34.
- Silm, S., Ahas, R. 2012. Spatial Mobility between Tallinn and Helsinki in Mobile Positioning Datasets. Statistical overview. Helsinki-Tallinn Transport and Planning Scenarios, Central Baltic INTERREG IV A Cross-Border Co-operation Programme, 66 p.
- Ratti, C., Sobolevsky, S., Calabrese, F., Andris, C., Reades, J., Martino, M., Claxton, R., Strogatz, S.H. (2010) Redrawing the map of Great Britain from a network of human interactions. *PLoS ONE*, 5(12): 1–6.
- Smoreda, Z., Olteanu-Raimond A.M., & Couronné, T. 2013. In Zmud, J., et al. (Ed.) *Transport Survey Methods: Best Practice for Decision Making*, Emerald.
- Zaiceva, A., Zimmermann K.F. 2008. Scale, diversity, and determinants of labour migration in Europe, *Oxford Review of Economic Policy*, 24(3): 427-451.
- Yuan, Y., Raubal, M., Liu, Y. 2012. Correlating Mobile Phone Usage and Travel Behavior - A Case Study of Harbin, China. *Computers, Environment and Urban Systems* 36(2): 118-130.