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Temporary population mobilities between Estonia and Finland based on mobile phone data and the emergence of a cross-border region

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ABSTRACT

People move for various purposes and lengths of time. Temporary mobilities across borders have become increasingly important but are difficult to observe. In considering temporary population mobilities between Estonia and Finland, the present focus is on the volumes of temporary mobility, characteristics of visits, visitor types, temporal rhythms, distribution of visits to destinations, and their contribution to the emergence of a cross-border region. By making use of passive mobile positioning data (CDR, DDR), it is shown that mobility between Estonia and Finland is frequent, but the durations and temporal rhythms relate to different purposes in different directions. While most visitors are tourists (94% from Estonia to Finland and 99% from Finland to Estonia), regular cross-border travellers (i.e. transnationals) make up 5% of the visitors from Estonia to Finland. Intensive cross-border mobility, relating to regular visitors who spend time in both countries, contributes to the development of a cross-border region between the two countries. Mobile positioning data are of value for measuring and understanding the different types of visitor flows in cross-border regions.

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Mobile positioning data; temporary mobility; cross-border mobility; cross-border region; Estonia; Finland

1. Introduction

Spatial mobilities of people between countries generally indicate the intensiveness of the relations between these countries. People may ‘migrate’ from one country to another and settle more permanently in the destination country, or alternatively they may undertake ‘temporary mobilities’, i.e. visiting the destination country for shorter periods (Lin and Tse 2005). An increased population mobility between countries enhances functional ties between them. Eventually, from a functional perspective, a cross-border region may emerge between intensively connected countries.

In the cross-border context, migration refers to people who change their place of residence from one country to another. However, as opposed to permanent migration, people

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are increasingly practising temporary mobility between neighbouring countries, and their activity spaces extend beyond the borders of these countries (Levitt and Glick Schiller 2004). Temporary mobilities comprise movements that start from one place, last from a day to a year, and end by returning to the original place (Bell and Ward 2000). The motives for these movements include work, study, leisure activities, shopping, family visits, social activities, etc. (Williams and Hall 2000).

Despite the increasing significance of temporary cross-border mobility and its long-term interest for studies of migration and cross-border regions, there have been few studies of this phenomenon due to the difficulties inherent in measuring temporary mobility. National and regional statistics usually cover only the permanent movements of people (i.e. registered migration), which is counted either once or a few times per year. In contrast, temporary mobility is revealed by passenger border-crossing statistics based on means of transport (air, ferry, etc.), visitor surveys, accommodation statistics, and travel agency data. However, all these sources of data have several limitations for the proper estimation of temporary mobility. First, registers and other official data sources are related to one country only. Second, the main focus of such data is tourism-related travel and only rarely are other forms of temporal mobility included. Third, no longitudinal detailed data exist on the mobilities of individuals (time and duration of visits, regularity of visits). Surveys and interviews may cover these aspects for individual visits, but the number of people studied is limited, and answers relate only to the moment of inquiry and rarely provide possibilities for comprehensive longitudinal analysis, especially at individual level. Lack of individual data also does not enable the identification of groups of people with similar temporary mobility.

Therefore, temporary mobility between countries is mainly studied on the basis of commuting between work and the place of residence and the connection between these types of movements and the emergence of cross-border regions (Möller et al. 2018; Pires and Nunes 2018). The extent of other types of flows is difficult to estimate due to the lack of proper data. However, information on the volumes and types of temporary mobility between two or more countries on a longitudinal basis is vital for understanding how the physical movement of people affects the development of cross-border regions.

Information and communications technology (ICT) has opened up several possibilities for analysing the spatio-temporal behaviour of people. The digital solutions that people use create different types of data; transportation smart cards data (Ma et al. 2013), sensor data (bluetooth, GPS, WiFi) (Delafontaine et al. 2012; Shoval 2007), geo-tagged photos, videos and social media posts (e.g. Twitter) (Tenkanen et al. 2017), automated (e.g. Google Places) and manual (e.g. Foursquare) check-in (Noulas et al. 2012), and mobile positioning data (Ahas and Mark 2005) all generate specific output.

Mobile phones provide a unique means of studying human mobility, because they are widespread and people carry them almost everywhere all the time. Thus, data collected via mobile phone (e.g. passive mobile positioning) can be used as a new data source for analysing the short- and long-term spatial behaviour of a large number of people. Passive mobile positioning data have been used to study the mobility dynamics of entire populations, such as seasonal dynamics (Silm and Ahas 2010), residential changes (Kamenjuk, Aasa, and Sellin 2017), settlement hierarchies (Louail et al. 2015), and the hinterlands of cities and functional urban regions (Novak et al. 2013). By considering roaming activities, passive mobile positioning data enable to uncover the quantity and spatial distribution of

tourists (Ahas et al. 2008), the seasonal dynamics (Ahas et al. 2007), tourists' travel behaviour within a destination (Raun, Ahas, and Tiru 2016), identification of loyal visitors (Tiru et al. 2010) and the production of national tourism statistics (Saluveer et al. 2020). Inclusion of incoming and outgoing roaming data mean that passive mobile positioning data provide a means to analyse cross-border mobility and transnational people (Ahas, Silm, and Tiru 2017).

The aim of this article is to analyse the cross-border temporary mobility of people travelling between Estonia and Finland. Both are small countries (Estonia with 1.3 million people; Finland with 5.5 million people) in Northern Europe and both belong to the Schengen Area of the EU, which reduces institutional constraints on travel and movement between these countries. In pursuit of our aim, we propose the following research questions:

1. What are the volumes of temporary mobility, characteristics of visits and visitor types between Estonia and Finland in both directions?
2. What are the temporal rhythms and distribution of visits to destinations, with a focus on the capital city regions of Estonia and Finland?
3. How does temporary population mobility contribute to the emergence of a cross-border region between Estonia and Finland and their capital cities?

We use passive mobile positioning data (Call Detail Records [CDR] and Data Detail Records [DDR]) to answer these questions. We study cross-border mobility in both directions, call activities made in Estonia by people living in Finland, and call activities made in Finland by people living in Estonia. We show only those aspects of cross-border mobility that the mobile phone data allow us to study.

2. Theoretical background

2.1. Temporary mobility

'All the world seems to be on the move' according to Sheller and Urry (2006) in the new mobility paradigm. Mobility in the twenty-first century is characterized by speed and intensity of movement, a variety of modes of travel, and a reduction in the impacts of boundaries and barriers, resulting in an increase in cross-border transactions. Most movements are temporary and vary considerably, but do not involve permanent relocations. Although temporary mobility covers a significant part of overall population's mobility, there is no comprehensive definition. Temporary mobility usually implies a movement that does not result in any permanent change in place of residence (Bell and Ward 2000), and thus implies a return to the place of residence.

Temporary mobility has been studied in different fields (e.g. tourism, second homes, work), although for specific cases and rather unsystematically. There have been attempts to conceptualize the dimensions of temporary mobility (Bell and Ward 2000; Brown and Bell 2005). Hall (2005), for example, classified temporary mobility according to its purpose, duration, frequency and distance.

The 'purpose' of temporary mobility outside one's place of residence varies. A conventional classification draws a distinction between production- and consumption-related movements (Bell and Ward 2000), although nowadays this is becoming increasingly

blurred. The purpose of production-related movements is economic contribution at the destination. This includes work-related daily commuting, seasonal work, weekly or less frequent long-distance commuting, and business travel. Most temporary movements are consumption-related, to access amenities, goods or services for recreation, shopping, hospitalization, conferences and conventions, extended recreational travel, seasonal migration, excursions and family visits (Bell and Ward 2000).

From a 'duration' perspective, there is a need to emphasize differences between travelling and tourism as well as between tourism and migration. Travelling is a movement between different geographical locations, for any purpose and any duration, while tourism refers to the act of taking a trip to a main destination outside a tourist's usual environment, for less than a year, for any main purpose, including business, leisure or other personal matter, other than to be employed in the place visited (UNWTO 2010). Hence, the period of 12 months differentiates tourists from migrants. Temporary mobility includes tourist visits but also short-term movements for employment (otherwise excluded from tourism). Temporary mobility may last from hours (such as leisure-related day trip) to days and months (such as tourism or commuting).

With regard to the 'frequency' of temporary mobility, different types of mobilities have not been properly defined. The temporal perspective of production- and consumption-oriented mobility varies. At one end, production-related mobility involves business travel with short frequent trips to meet clients, suppliers or colleagues. At the other end are seasonal movers with fewer but longer, even monthly stays (Bell and Ward 2000). Consumption-related movements are usually short and frequent trips to friends and relatives, or more extended weekend visits to second homes. In general, consumption-related moves are highly seasonal but production-related moves take place around weeks and weekdays. Holiday trips are concentrated at weekends, public holidays and summer months (Bell and Ward 2000). Temporary mobility results in temporal redistribution of the population from one region to another. Such redistribution differs across the day, days of the week and months as well as during events (Silm and Ahas 2010).

In order to capture the distance of temporary mobility, local, regional, national and international levels have been used. Here it is critical to allow territorial administrative borders to be crossed, between two countries for example (Hall 2005). The distance-decay effect applies to the frequency of trips and trip characteristics (Hall 2005).

2.2. Cross-border temporary mobility and transnationalism

Spatial mobility of the world's population is increasing with the intensification of international migration, short-term migration and tourism. Borders and labour markets are becoming increasingly open, the economy is being reorganized into local–global connections, and accelerated urbanization provides increasing opportunities and needs for employment in larger cities, regardless of nationality. ICT and the ubiquitous Internet mean an increasing availability of information about many places, and imply the ability to become connected to people in those places (Vill, Silm, and Telve 2019). Due to increased spatial mobility, the movement of people often crosses national borders. The availability of transportation and ICT facilitate movement over longer distances with less cost and shorter travel times. This changes travel patterns, increases temporary mobility, and expands everyday activity spaces over borders.

Human mobilities are both autonomous and interrelated, sometimes intimately connected and at other times seemingly disconnected. People make individual mobility decisions, but various types of institutions affect such decisions. Cross-border mobilities can be explained by reference to both individual and institutional factors. Inside the EU, cross-border mobility and cooperation are supported by several initiatives: lowering of customs tariffs, the free movement of goods and people, the single currency, European development funds, etc. (Perkmann 2003).

Decoville and Durand (2019) divide cross-border mobility into two types. The first type is made to gain better knowledge of neighbouring countries, their populations and cultures. Such movements include tourist trips, student exchanges, and visits to friends and family. The second type of movement results from opportunistic behaviour driven by e.g. economic and political differences between the two countries. Most of these movements are work-related commutes (Möller et al. 2018; Pires and Nunes 2018) driven by differences in wages and unemployment between origin and destination. Differences in taxation, cost of living, or real estate prices foster a tendency to live in an area with lower costs while maintaining social ties and jobs on the other side of the border (Van Houtum and Gielis 2006). Movements can be also triggered by changing prices of goods and services, which causes cross-border shopping (Asplund, Friberg, and Wilander 2007).

A single visit to a neighbouring country may result from curiosity, but regular visits suggest individual needs and advantages gained from such visits. When cross-border mobility becomes part of a routine, it indicates a more functional perspective on such practices. Regular visits tend to create shared social spaces and socio-cultural ties across the border (O'Connor 2010). These frequent visits and participation in life abroad may also create a transnational 'feeling' for this person and a related atmosphere in the affected community. The notion of belonging solely to one country starts to become irrelevant and even to disappear altogether. Instead, practices from two or more countries start to appear in the everyday life of these mobile people. The phenomenon in which people cross geographical, cultural or political borders and operate in several countries while having close ties to these countries has been termed 'transnationalism' (Basch, Glick Schiller, and Blanc 1994). Transnationalism can be seen in relation to immigrants who maintain close ties with their country of origin (Bilgili 2014) and as 'fluid social spaces', where migrants simultaneously relate to more than one country without being immigrants in either (Levitt and Glick Schiller 2004; Pries 2005).

Levitt and Glick Schiller (2004) distinguish between transnationals reference to 'ways of being' and 'ways of belonging'. In this context, 'Ways of being' implies being mobile and active in both countries. These activities are observable and measurable and include physical activities (e.g. trips between the countries to visit friends and family, events), communication activities (e.g. phone calls, e-mails), but also economic activities (e.g. financial remittances, investments), and political activities (e.g. participation in elections, membership of political parties) (Bilgili 2014; Zontini 2015). 'Ways of belonging' refers to a sense of membership of a society as a result of memories, cultural experiences and feelings of belonging. Ways of belonging include concrete and visible actions that mark belonging but are difficult to measure. The exact amount of physical presence is not a determining issue. Not all individuals engage in all types of transnational practice and transnational involvement varies in intensity in different domains (Levitt 2009).

2.3. Emergence of cross-border regions

The emergence of the cross-border region has been an important topic inside EU countries. Regions across borders usually show different economic development, political climate, and cultural traditions, all of which can be a barrier to the emergence of cross-border integration (Lundquist and Trippel 2009). At the same time, the differences could be the basis for connections and eventual integration (Decoville et al. 2013). Durand (2015) describes in the production of cross-border space the de-bordering. De-bordering promotes the emergence of cross-border regions by supporting functional relationships and economic integration, and exchange between territories in terms of work mobility, tourism, shopping and communication networks.

Cross-border integration does not derive from mere opening of national borders, but is a result of the active use of borders as resources. Not only do borders mark out the boundaries between states; they are also social and cultural lines with material, imagined, physical and cultural aspects (Kolossoff et al. 2012). Sohn (2014) formulated two cross-border models of integration. The first 'geo-economic model' is based on the generation of benefit from differences in asymmetric cross-border interactions; in other words, from differences in costs and prices. This model affects labour and residential markets, commerce and services. The second 'territorial project' relates to place-making, which includes mutual learning, common understanding, trust and sense of belonging. Different combinations are possible in these two cross-border integration models (Sohn 2014). Durand (2015) highlighted the structural, functional, institutional and ideational dimensions of cross-border integration. The cross-border movements analysed in the present article are associated with the functional dimension. This covers all cross-border movements – economic flows, individual and collective spatial and social practices, communication networks – which range from tourism, leisure, and shopping to residential mobility.

Cross-border movements are very important in relation to spatial integration. However, strong relationships do not necessarily lead to territorial convergence or homogenous cross-border regions (Topaloglou et al. 2005). Differences in movements and connections mean that various types of cross-border regions are formed. According to Decoville et al. (2013), three forms of spatial integration in cross-border regions relate to cross-border commuting. The first is integration by specialization, where work-related commuting takes place to urban centres and residential flows tend to be the opposite direction, moving outwards to the periphery. The second is integration by polarization, where work-related and residential mobility are both towards the urban centre. The third form is integration by osmosis, where work-related and residential flows are in both directions across the border. This last type characterizes the most balanced border region in relation to work and residential movements.

It should be noted that spatial integration supported by reciprocal movement of people does not necessarily imply homogenization of cross-border regions. Different states may have different political and economic interests in regulating population mobility across their borders. Even in the EU, individual states determine the conditions of arrival of non-EU citizens, and EU citizens provide information if they plan to stay for longer periods. Individual states regulate the participation of foreigners in local and national political decision-making, for example, through voting. In addition, individual states also have some interest in the economic impact of cross-border mobility and the flow of

money between them and their neighbours. There is a requirement to pay taxes in one's country of residence; however, the definition of tax residence varies by country, and six months' stay in a year is usually the time limit that determines one's place of residence (European Union 2019).

3. Study area, data and methods

3.1. Study area

The area of interest is defined herein in terms of the mobility of people who cross the border between Estonia and Finland, in both directions. The particular focus is on the capital cities and their surrounding functional urban areas. In the case of Estonia, the urban region of Tallinn is considered to be Harju County (23 municipalities, 0.5 million inhabitants, 4,338 sq.km), and in the case of Finland, it is the region of Helsinki (14 municipalities, 1.5 million inhabitants, 3,827 sq.km) (Figure 1). The mobility is constrained by the Gulf of Finland, which separates the two coasts by 80 kilometres. A one-way ferry ride from Tallinn to Helsinki takes approximately two hours and costs ca 20–25 Euros. By plane the journey takes 35 min.

Estonia and Finland share many cultural, linguistic and historical connections. Trade has flourished across the Gulf of Finland for centuries, with passenger and freight transport by sea and air since the 1920s. However, the Second World War created a rupture in relations, when Estonia was occupied by the Soviet Union and mobility between the two countries ceased. After Estonia re-established its independence in 1991, mobility between Finland and Estonia grew rapidly. In 1993, approximately 2 million visits (on average about 5,500 visits per day) took place by ferry between the two countries. This grew to 4 million visits (on average about 13,100 visits per day) in 1999 when travel became visa-free (Port of Tallinn 2019). Other institutional agreements facilitated mobility still further, such as entry to the EU (Finland in 1995 and Estonia in 2004), and entry to the Eurozone (Finland in 1999 and Estonia in 2011) and to the Schengen Area (Finland in 2001 and Estonia in 2007). By 2016, 8.5 million visits (on average about 23,200 visits per day) took place between Estonia and Finland by ferry (Port of Tallinn 2019). This equates to 1.3 times the entire population of the two countries and over four times that of the urban regions of Tallinn and Helsinki combined. The capitals are also connected by air. In 2016, 117,248 people travelled from Tallinn to Helsinki and 115,284 people flew from Helsinki to Tallinn (Tallinn Airport 2019). Estonians mostly use Helsinki-Vantaa airport as a connecting hub for long-distance flights.

Despite the good connections between the two countries, permanent changes in place of residence (i.e. international migration) take place at a much smaller scale. Very few Finns (<0.1%) live in Estonia, and they constitute a very small proportion of the Estonian population (0.3%) (Statistics Estonia 2019). The number of Estonians in Finland is considerable: 3.5% of the total population of Estonia, but their proportion of the population of Finland is small (0.8%) (Statistics Finland 2019). Finland is more attractive for migrants from Estonia than vice versa, because it is substantially wealthier. In 2017, the average monthly gross salary in the urban region of Helsinki (Uusimaa) was 3,752 Euros and in the urban region of Tallinn it was 1,353 Euros. This almost three-fold difference reflects the context of conventional labour- and leisure-related cross-border mobilities. At the



Figure 1. Study area and urban regions in Tallinn (Estonia) and Helsinki (Finland).

beginning of twenty-first century, the Finnish labour market had a shortage of labour in construction and other industries and services, and when Estonia joined the EU and Schengen area, the labour market opened up to Estonians. However, the purchasing power gap has since diminished and now (and since 2017) more Estonians are returning from Finland than are migrating there.

Recent policies and projects have fostered cooperation between the two countries, and support the creation of a cross-border region consisting of the urban regions of Helsinki and Tallinn. In both regions there is a desire to pursue intensive economic, social and cultural cooperation to increase the relative importance in the international urban system

thanks to the presence of a joint Tallinn-Helsinki cross-border region (Tapaninen 2012). In the early twenty-first century, establishment of the Helsinki-Tallinn Euregio created an initial framework for governing this cross-border region (Pikner 2008). There are even plans for the construction of a subsea crossing to connect Helsinki and Tallinn in order to facilitate the cross-border mobility of people and goods over the next few decades (Tapaninen 2012).

3.2. Mobile phone data

To assess the cross-border temporary mobility of people between Estonia and Finland, passive mobile positioning data (CDR and DDR) consisting of the locations of call activities made by individuals were used. Passive mobile positioning data are recorded automatically in the systems of Mobile Network Operators (MNOs) during any period of active use of mobile phones. The use of mobile phones is widespread in Estonia and Finland, according to the Eurobarometer (2017) survey; 96% of households in Estonia have at least one mobile phone (99% in Finland).

In the present study, data from the two largest MNOs between 2014 and 2016 in Estonia were used, with a combined market share of 73% in 2015 (Tehnilise Järelevalve Amet 2015). This study presents summary statistics based on data obtained from two MNOs. No data from Finnish MNOs were used. Three types of passive mobile positioning data were used, with all datasets being user-based (i.e. data obtained from individuals).

- (1) Inbound roaming data for capturing movements from Finland to Estonia. The data include CDRs and DDRs made in Estonia by mobile phones with SIM cards registered to Finnish MNOs (hereinafter referred to as people living in Finland).
- (2) Outbound roaming data for capturing movements from Estonia to Finland. The data include CDRs and DDRs made in Finland from mobile phones with SIM cards registered to Estonian MNOs (hereinafter referred to as people living in Estonia).
- (3) Domestic data for identifying outbound visits (as described in Section 3.3). The data include CDRs and DDRs in Estonia by mobile phones with SIM cards registered to Estonian MNOs, i.e. residents of Estonia whilst in Estonia.

People of other nationalities may also be included in the dataset; however, they cannot be distinguished. It is assumed that these people are closely linked to Estonia or Finland if they have registered their mobile phone in one of these countries.

The database consists of the locations of incoming and outgoing calls and outgoing text messages, and in the case of one MNO, also internet and data services. For each call activity, the database includes the randomly generated ID number of the phone used, the time of the call activity with an accuracy of one second, the location to the accuracy of the network cell, and the country code of origin of the phone (Ahas et al. 2008). The ID number is generated by the MNO and ensures anonymity; it cannot be associated with a specific individual or phone number. The ID remains the same for all of that user's call activities, which allows us to link different visits over a longer time period and across the databases (domestic and outbound roaming). Domestic data are used to assess the duration of the presence of people in both countries.

The privacy of individuals is fully respected when using mobile positioning data. For passive mobile positioning data, the MNO replaces the personal identification features (name, phone number etc.) with a randomly generated ID. The researchers used the data with this ID and were not able to associate the data with any specific person. The collection, storage and processing of data were in accordance with the EU requirements on the protection of personal data as per EU directives on handling personal data and the protection of privacy in the electronic communications sector through the general data protection regulations (European Parliament and Council of the European Union 2016).

3.3 . Methods

When using passive mobile positioning data, the first stage involves quality control and cleaning. This process consists of the removal of duplicates, checking the data quality and antenna coordinates, detecting missing data, removing technical subscribers and machines, and removing data from ‘travel SIM cards’ (Saluveer et al. 2020).

The analysis is based on visits identified through the locations and times of call activities (see Saluveer et al. 2020). For inbound visits, a new visit is registered when the maximum time period between call activities exceeds 155 h (6.5 days) (Saluveer et al. 2020). For outbound visits, we combined outbound data with domestic data, and identified visits using start and end times in Estonia. The visits may include cases where the border is not actually crossed, such as when sailors use Estonian roaming services but do not physically land and visit the country. Occasional roaming events appear near borders. Such visits are identified and excluded from the analysis (for the full methodology, see Saluveer et al. 2020).

Based on the duration of the visit, transit, same-day and multi-day visits are identified. Transit visits last less than four hours and take place in predefined transit corridors. Same-day visits are visits to the destination country without an overnight stay. For multi-day visits, a person spends at least one overnight in the country. If a person arrives between 00:00–03:59 and leaves on the same calendar day, this is also considered as a multi-day visit.

Four types of visitors, namely tourists, transnationals, commuters and long-term stayers, were distinguished using the methodology of Ahas, Silm, and Tiru (2017) based on the number of days spent in the destination country per year and the number of visits made to the destination country per year (Figure 2). The definitions of visitor types were created with aim of finding people who travel regularly between Estonia and other countries and who are connected to both Estonia and Finland simultaneously, known also as transnational migrants. Transnationalism (by mobility) is analysed from the point of view of origin and destination country. Transit visits and visits where the person stayed in other countries during the visit were removed from the analyses, i.e. only visits where the destination country was Finland for people living in Estonia, and Estonia for people living in Finland are included. For cases where people from Finland visited Estonia, it is not known whether they also visited other countries at the same time; however, all visits that were not transit visits were considered valid.

First, ‘tourists’ spend less of their time in a destination country and have more connection to their country of origin. Tourists (1) took 1–4 visits to the destination and stayed there for less than 50% of the number of days per year (1–182 days), or (2) took 5–52 visits to the destination country and stayed there for less than 25% of the number of

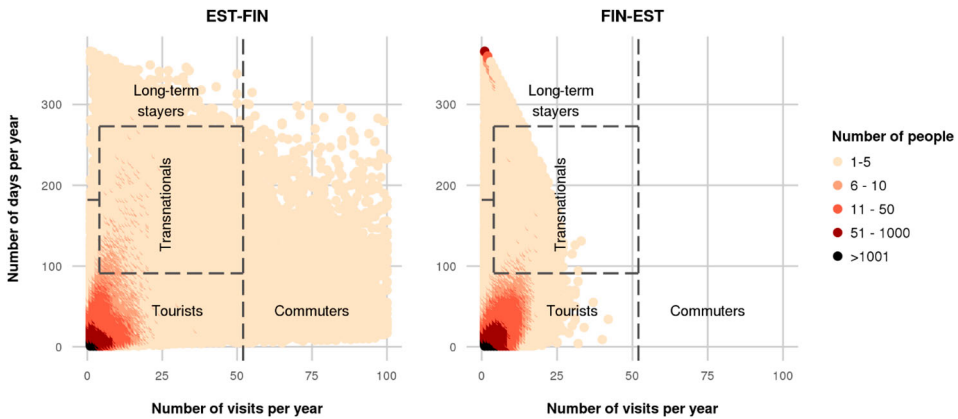


Figure 2. Distribution of people by number of visits and number of days per year in the destination country; (a) people living in Estonia who visited Finland (EST-FIN) and (b) people living in Finland who visited Estonia (FIN-EST).

days per year (1–91 days). Second, ‘transnationals’ are connected simultaneously to both the country of origin and the destination country. They spent more than 25% of their time (at least 92 days) but not more than 75% of their time (up to 273 days) in the destination country, and took 5–52 visits to this country (at most once per week on average). Third, people who move frequently between two countries are ‘cross-border commuters’. They made a visit to the destination country more often than once per week (53 or more visits). Fourth, ‘long-term stayers’ have more connection to their destination country. They (1) made 1–4 visits to the destination country and stayed there for more than 50% of the number of days per year (183 or more days), or (2) took 5–52 visits to the destination country and stayed there for more than 75% of the number of days per year (273 or more days). All the groups except tourists engaged in transnational practices in some way.

The period of analysis covered three years (2014–2016), including visits that took place at least partly during the period 1 January 2014 to 31 December 2016 (the beginning of the visit could have been earlier and the end later, respectively). The analysis was undertaken for each year separately, but three years were combined to create an average for all visits. To understand the extents of temporary migration, correction coefficients were used to generalize mobile positioning data to the whole population.

4. Results

4.1. Volumes of temporary migration and characteristics of the visits

The average total number of visits from Finland to Estonia was twice the number from Estonia to Finland, respectively 2.4 million and 1.3 million visits per year. However, on a relative scale, people from Estonia made on average 1.0 visit to Finland per inhabitant but people from Finland made 0.4 visits to Estonia. On average, 1.5 million people from Finland (unique visitors; 26.5% of total population) visited Estonia and 382,860 people from Estonia (29.1% of total population) visited Finland per study year.

The duration of the visits varied in different directions. People from Estonia made more transit visits and multi-day visits to Finland and people from Finland made more same-day visits to Estonia. Transit visits were approximately 14% of all visits made by people from Estonia to Finland, mostly due to the use of Helsinki airport as a hub. In the opposite direction, from Finland to Estonia, the proportion of transit visits was only 0.8%. People from Finland transit through Estonia by car to Latvia and on towards the rest of Europe. However, the proportion of same-day visits (excluding transit visits) for people from Finland to Estonia was approximately 43% and for people from Estonia to Finland it was 12%. Multi-day visits dominate among people from Estonia to Finland, on average 74% of total visits to Finland, whereas multi-day visits to Estonia by people from Finland were 57%.

People from Estonia also visited Finland more often. On average, people from Estonia who visited Finland made 4.1 visits per year. For people from Finland, the average number of visits to Estonia was much lower, at 1.7 per year. The median number in both directions was 1.0 visits. There were thus many people who made only one visit, but among those from Estonia, many made several visits. The number of days spent in the destination country was higher for people from Estonia to Finland: on average 17.6 days (median 2.3 days), while people from Finland stayed in Estonia for 4.3 days (median 0.5 days) (Table 1).

4.2. Visitor types

A larger number and longer duration of visits per year per person reflects the fact that there were more regular visitors from Estonia to Finland than the other way round. According to the definition of visitor types, the majority of visitors in both directions were tourists. Tourists made up 99% of visitors (1.442 million people) travelling from Finland to Estonia and 94% of visitors (358,813 people) from Estonia to Finland (Figure 3). Regarding the number of visits made by tourists, the proportions were smaller: tourists made 95% of visits (2,308,415) from Finland to Estonia and 62% (825,482) of visits from Estonia to Finland. Hence the proportion of other visitor types was considerably larger for visits from Estonia to Finland: transnationals made up 5.2%, commuters 0.6%, and long-term stayers 0.5%. In all, 20,043 transnational people from Estonia visited Finland annually, and this group made 307,488 visits (23.0% of all visits) to Finland. The proportion of transnational people from Finland travelling to

Table 1. Average volumes of temporary mobility and characteristics of visits between Estonia and Finland.

Indicator	EST-FIN	FIN-EST
Number of visits per year	1,336,913	2,420,369
Visits per inhabitant per year	1.0	0.4
Number of people per year	382,860	1,453,302
Percentage of population	29.1	26.5
Percentage of transit visits	14.0%	0.8%
Percentage of same-day visits (excluding transit visits)	12.2%	42.5%
Percent of multi-day visits	73.8%	56.7%
Number of visits per person per year, average (median)	4.1 (1.0)	1.7 (1.0)
Number of days per year per person, average (median)	17.6 (2.3)	4.3 (0.5)

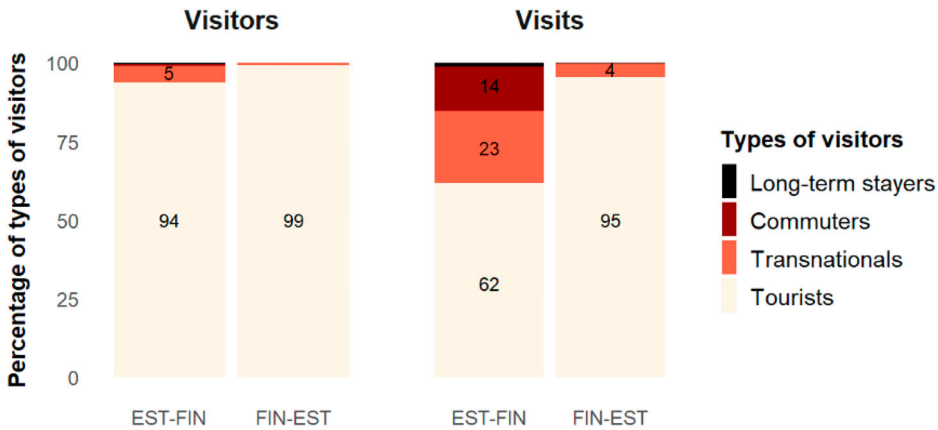


Figure 3. Percentage of visitor types and visits.

Estonia was only 0.6% (8,713 people per year) and they made 102,897 visits (4.3%) to Estonia per year.

In the following sections, the focus is on tourists and transnationals only. The tourist group is the largest and those in the transnational group move regularly between Estonia and Finland and are thus closely related to both countries.

4.3. Temporal rhythm of the visits

On average, people living in Estonia made longer (average 3.1 days, median 1.3 days) visits to Finland than people living in Finland who made visits to Estonia (average 1.4 days, median 0.3 days). The proportion of tourist visits decreased consistently for increasing visit duration (Figure 4, Tourists). For transnationals, most visits from Finland to Estonia lasted 3–4 days, with the number of visits decreasing thereafter. However, from Estonia to Finland, a relatively large proportion of visits lasted either 5 days or 10–11 days (Figure 4, Transnationals). This relates to the weekly rhythm of workdays and is most likely to be related to Estonians who work in Finland.

There are different weekly rhythms among different types of visitors and directions. People living in Finland visited Estonia more often on weekends, and people living in

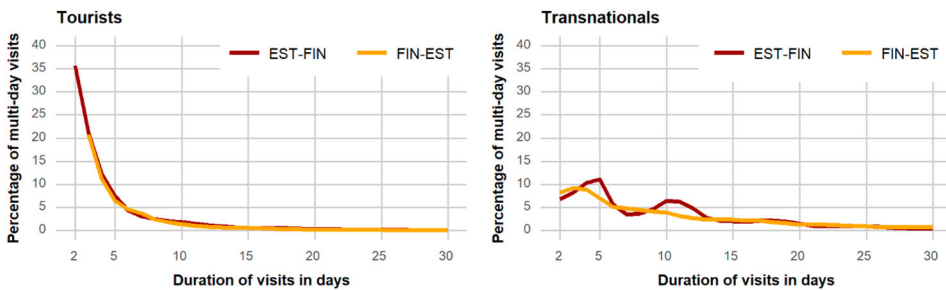


Figure 4. Distribution of multi-day visits (more than 24 h) between Estonia and Finland made by tourists and transnationals based on visit duration.

Estonia visited Finland more often on workdays. Tourists' visits most commonly started and ended at the end of the week. More visits from Finland to Estonia started on Fridays or Saturdays and ended on Saturdays or Sundays. Tourist visits from Estonia to Finland were more evenly distributed over the week with slightly more visits starting on Fridays and ending on Sundays (Figure 5, top). However, the distribution of transnational visits varied considerably over the week. Transnationals' visits from Estonia to Finland started more often on Sundays or Mondays and ended on Thursdays or Fridays. However, transnationals' visits from Finland to Estonia started more often on Fridays and ended on Sundays or Mondays.

The seasonal rhythm of visits varied more for tourists than for transnationals. Tourists from Finland to Estonia made most visits in July (14%), which is the main holiday season in Finland. The proportion for other months was on average less than 10%. From Estonia to Finland, tourists made most visits in August, which is the vacation period for many Estonians, before the start of the school year. In the case of transnational visits, the proportion of visits from Finland to Estonia was highest in December, which is related to the general holiday period around Christmas and New Year. Transnational visits from Estonia to Finland were higher in September, which could be related to the end of the summer holiday (and school holidays) in Estonia.

4.4. Regional distribution of visits at destination

The geographical distribution of visits to the destination varied by direction and types of visitors. Of tourist visits from Finland to Estonia, 73.5% were made only to the Tallinn region. This constitutes 1.7 million visits per year. The Tallinn region was the main destination for tourists from Finland. People from Finland who regularly visited Estonia (i.e. transnationals) appeared more connected to places outside the Tallinn region.

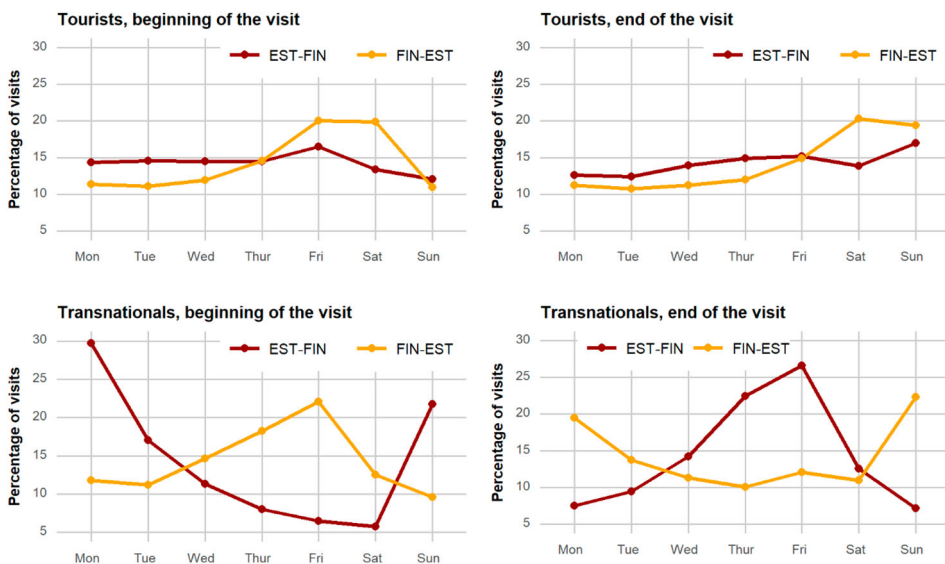


Figure 5. Distribution of the start and end times of the visits between Estonia and Finland made by tourists and transnationals.

Transnationals made 39.7% of their visits (40,265 visits per year) to the Tallinn region only. Other important destinations for transnational people from Finland were Tartu, Pärnu, Paide, Rakvere and some rural municipalities, around 1–2 hours' drive from Tallinn (Figure 6).

Visits by tourists from Estonia to Finland were distributed more evenly throughout the country: 19.6% visited only the Helsinki region, which equates to 157,773 visits per year. Transnationals, however, were more connected to the Helsinki region than tourists. Of their visits, 26.2% (75,118 visits per year) were to the Helsinki region only. Other important destinations were Turku, Asikkala and Tampere (Figure 6). Thus, from Finland to Estonia, tourists predominate in Tallinn and transnationals elsewhere in Estonia (Figure 6). In Finland, visits by both visitor types are more evenly distributed in spatial terms.

5. Discussion and conclusions

In this article, we have analysed cross-border temporary mobility between Estonia and Finland. Annual mobility between Estonia and Finland was frequent, amounting to 1.3 million visits (382,860 visitors) from Estonia to Finland and 2.4 million visits (1.4 million visitors) from Finland to Estonia. These numbers are considerable for two countries with a combined population of less than seven million. Mobile positioning data and related methodology allow us to identify types of temporary mobility between these two countries. As shown, almost all (over 99%) visitors from Finland to Estonia were tourists. From Estonia to Finland, a considerable proportion (5%) of visitors were regular cross-border travellers (i.e. transnationals), who shared their time between the two countries. Transnationals made 23% of all visits from Estonia to Finland. There is an intensive mobility across the border in both directions, which is typical as far as the concept of de-bordering is concerned (Durand 2015).

The duration and temporal rhythm of visits related to different purposes varies in different directions. Visits from Finland to Estonia tended to be related more to holidays, with almost half (43.3%) being same-day visits, mostly at weekends, and 73.5% were to the Tallinn region only. Many movements may be motivated by the stronger purchasing

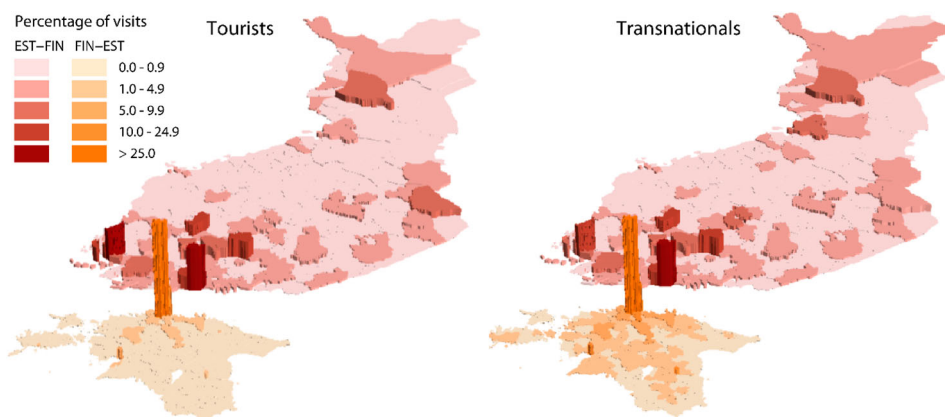


Figure 6. Distribution of visits to destinations between Estonia and Finland by (a) tourists and (b) transnationals.

power of people from Finland in Estonia. Transnationals tended to visit Estonia at weekends and during holiday periods. This suggests that many transnationals who live in Finland have roots in Estonia, and are immigrants in Finland but share their time between the two countries. The visits from Estonia to Finland indicate the significance of employment, from the fact that many from Estonia prefer to be employed in Finland due to the higher salaries there. This work-related mobility behaviour was evident in the temporal rhythms of the visits: visits to Finland mostly began on Sundays or Mondays and mostly ended on Thursdays or Fridays. Both the weekly rhythm and the duration of the visits (relatively higher proportions of visits with durations 5 days or 10–11 days) indicate that these people come back to Estonia at weekends, either every week (5 days at work) or every other week (10 days at work and a longer weekend). There is also a clear cultural influence in the movements, and people appreciate the differences between the urban and rural realms in Finland and Estonia. However, the cross-border mobility between Estonia and Finland seems to operate mainly according to the ‘geo-economic model’ (Sohn 2014) based on economic differences across the border. Similar tendency is well-known in cross-border regions, where differences in costs and prices are highly marked across the border (Möller et al. 2018).

Based on the model of forms of spatial integration of Decoville et al. (2013), the case for Estonia and Finland is one of cross-border integration by specialization. One type of movement takes place in one direction and another type in the other direction. Production-related mobility (work) dominates from Estonia to Finland and consumption-related mobility (leisure) dominates from Finland to Estonia. However, any convergence of prices of goods and services reduces the attractiveness of Tallinn for same-day visitors from Finland. The reverse would apply for the convergence of salary levels between Finland and Estonia, i.e. people from Estonia would no longer be so eager to work in Finland. This would probably reduce population mobility and hinder the development of a cross-border region supported by price differences, which is the main explanation of both the current mobility and the functional cross-border regions. For long-term consolidation of a cross-border region for Tallinn and Helsinki, reasons other than price differentials are also needed. Mobile positioning data are useful for measuring changes in the various kinds of mobilities between Estonia and Finland, and could help policy-makers and planners to identify trends that may cause changes affecting the development of the cross-border region. The impact of prices and salary convergence on the temporary mobility of individuals could be a topic for further study.

The focus in this article is on physical movements across the border, including transnational movements as ‘ways of being’ activities (Levitt and Glick Schiller 2004) and the functional dimension of cross-border integration (Durand 2015). The novelty derives from detailed analysis of mobile phone data, enabling us to capture the temporary cross-border mobility of large populations, which would otherwise be invisible in traditional datasets. It allows the identification of both visitor types and the temporal and geographical distribution of visits. Tourism dominates between Estonia and Finland and the influence of transnationals is lower. Transnationals are nonetheless an important group, because they inhabit the cross-border region and divide their time between the two countries. A specific study that focuses on them would highlight the key motivations and constraints of these people, paving the way for better policy-making and planning for such cross-border regions and taking into account the everyday practices of transnational

people. The roots of transnational people are still significant in their travel behaviours. Among transnationals living in Finland were many of Estonian origin who shared their time between Estonia and Finland but who also preferred to spend their longer vacations in Estonia, their country of origin, thereby maintaining many kinds of relationships through their physical presence.

The mobility of people is the cornerstone for the establishment of cross-border functional regions and is therefore also the basis for the creation of local city networks or systems (Hall and Pain 2006). The visits to Finland made by people living in Estonia covered various parts of Finland, whereas visitors from Finland tended to stay in Tallinn and the surrounding urban regions. The geographical delineation of a functional cross-border region could be another topic of a future study. The present study has used data from MNOs in one country to evaluate mobility flows in relation to that country. Were similar data to become available for all countries, the proposed criteria for defining temporary mobility types and the related methodology could be used for finding cross-border temporary mobility flows and functional regions for larger areas. Within EU border areas, where people increasingly do not relate to one country alone but instead tend to practise cross-border living, the formation and delineation of cross-border regions through mobility is of increasing importance.

In transnationalism and the formation of cross-border regions, there are several further issues to consider, such as factors that influence transnationality, the role of social networks, the stages of transnationality, etc. Methodologically, quantitative and qualitative methods and data could be combined to include opinions and the assessment of movements. In addition to physical presence, it is important to understand how much the cross-border ways of being lead to cross-border ways of belonging (Levitt and Glick Schiller 2004), for whom, and under what circumstances. The growing number of transnationals will bring political issues to the fore, such as the right to vote and the duty to pay taxes, and whether perhaps these matters could be shared between the two sides of the border in a cross-border region. In relation to these topics qualitative studies are highly needed.

Besides the functional formation of cross-border regions, structural, institutional and ideational dimensions should also be considered (Durand 2015). Future research could focus on analysing the social and economic impacts of transnational flows and lifestyles based on patterns of movement. Better awareness of the flows of people and functional areas would lead to more informed policy decisions to account for the needs of people with different mobility patterns.

Analysis based on passive mobile positioning data also has some key limitations. The estimates of physical presence depend on phone use, and there are those who do not use a mobile phone, such as young children, the elderly, and some socio-economic groups (Masso, Silm, and Ahas 2019). The call habits and patterns of phone users vary in space and time due to the characteristics of each individual as well as their social and physical environments (Järv, Ahas, and Witlox 2014). The use of data from only one MNO does not guarantee coverage of the mobility of the whole population either in the country of origin or elsewhere. Comparison and validation of results derived from mobile phone data regarding temporary mobility across other datasets is a challenge, because of the lack of other traditional sources (census, registers) to allow temporary mobility for the whole population to be estimated. Nevertheless, the use of mobile

positioning data and related methodologies are highly valuable for gaining further knowledge about temporary cross-border mobilities and for delineating functional cross-border regions.

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