

## Measuring visitor flows using mobile positioning data in three Hungarian second-tier cities

### Abstract

**Purpose** –The research analyses the spatial-temporal behaviour of international visitors using Mobile Positioning Data in three second-tier cities in Hungary: Szeged, Debrecen and Pécs. The aim of the study was to identify the origins of visitors, length of stay, seasonal concentrations and mobility between cities.

**Design/methodology/approach** – A large volume of data generated by foreign mobile phone users was processed and analysed for six consecutive months in 2018. The movements of around 3.5 million foreigners visiting Hungary were captured.

**Findings** – The data showed significant differences in tourist turnover, mobility patterns and flows indicating different levels of tourism activity and potential in the three cities. This included day trips, cross-border tourism, seasonal fluctuations and activity-driven demand (e.g. special events, cultural tourism).

**Research limitations/implications** – MPD data cannot fully explain or predict drivers of visitor behaviour, such as purpose of visit, the precise activities that they undertake there and the experiences that they gain. It can, however, provide information on spatial and temporal flows, patterns and concentrations of visitors.

**Practical implications** –The investigated cities should follow distinct tourism development policies to attract more tourists and strengthen the links with their neighbouring destinations at the same time as differentiating themselves through marketing as competitive alternative destinations.

**Social implications** – Augmenting tourism has socio-economic implications for residents and communities. The development of cultural tourism and local event-based tourism must incorporate community needs.

**Originality/value** -The paper analyses the extent to which mobile positioning data can provide insights into visitors' spatio-temporal mobility and flows in relatively under-visited second-tier cities and it highlights opportunities and gaps for big data research in an urban context.

**Keywords:** urban tourism, visitor mobility, visitor flows, second-tier cities, undertourism, Mobile Positioning Data (MPD)

### Paper type

Research paper

## Introduction

This paper contributes to the growing body of research on visitor mobility in the context of tourism destinations which examine the use of mobile internet and geographic information technology to track and record the movements of tourists in both space and time (Shoval and Isaacson, 2007; Birenboim and Shoval, 2014). The analysis of space-time databases has created important new research opportunities in tourism (Ahas, Witlox and Miller, 2014; Shoval, Isaacson and Chhetri, 2013), even though tracking technologies have already been used in research for almost two decades (Ahas and Mark, 2005; Shoval and Isaacson, 2006). Growing numbers of authors have started to use new technology as a way of providing improved knowledge about tourists' whereabouts and activities in destinations in order to optimise travel behaviour (Hawelka et al., 2014; De Cantis et al., 2016). The use of big data in tourism has been welcomed as a way of overcoming small sample sizes and limiting bias when researching tourist behaviour (Li et al., 2018). It has become a novel trend since the mid-2000s to collect data using advanced tracking technologies in order to analyse spatial visitor behaviour, most commonly using GPS and in a city context (Shoval and Ahas, 2016). Researchers and urban planners alike have become increasingly interested in research involving visitor movement patterns and the factors influencing them (Bauder and Freytag, 2015; Aranburu, Plaza and Esteban, 2016; East et al., 2017). As stated by Shoval and Ahas (2016) such advances in research can help to manage impacts of tourism, improve transport and infrastructure as well as informing product development.

Understanding and managing visitor flows has become an important part of sustainable development, especially in cities that suffer from so-called overtourism. As stated by García-Hernández, Ivars-Baidal and Mendoza de Miguel (2019) big data analysis can be one of the key tools in tourism and flow management and marketing in such cities. Spatial visitor behaviour factors were categorised into three groups by Lau and McKercher (2006): physical (e.g. destination, geomorphology), human (e.g. motivations, type of individual, travel groups, etc.) and time (first-time or repeat visitor, primary or secondary destination). It has been suggested that physical factors may be the most important for policy makers to address as they are related to tourism-related infrastructure and transport development (Sugimoto et al, 2019). However, more complex solutions need to be found in order to manage overcrowding, congestion, accessibility, visitor experience and other urban challenges that might be affected by visitor flow management. It has been suggested that design intervention in tourist spaces should take into consideration the complexity and dynamics of the multitude of visitor flows in the place. One way of doing this can include IT-based instruments to collect visitor data (Beritelli, Reinhold and Laesser, 2020). Coca-Stefaniak (2019) highlights the importance of incorporating smaller towns into research on smart tourism destinations, especially using big data to inform destination marketing initiatives. Ballina, Valdes and Valle (2019) also emphasise the value of smart tourism destination research in medium-sized and smaller cities. Although this research does not focus on smart tourism destinations *per se*, it does examine mobile positioning data (MPD) derived from cell phone towers from smaller cities. The notion of gateway destinations is also significant for this research, as proximity to primary gateways (e.g. capital cities) will inevitably affect levels of visitation (Raun, Shoval and Tiru, 2020).

The main objective of the research is to analyse the spatial behaviour of international visitors with the use of MPD in three second-tier cities in Hungary: Debrecen, Pécs and Szeged. The selection of the cities is justified by their similar population size (ranging between 150-200 thousand inhabitants), administrative, economic and cultural functions, as well as their position

in the urban hierarchy of Hungary. The challenges in these second-tier cities are not connected to congestion and overcrowding rather to under-visitation and an over-reliance on cross-border tourism and day-trips. Although the word ‘undertourism’ is used relatively infrequently in research compared to ‘overtourism’, many countries suffer from an economic imbalance because of uneven flows of tourists to peripheral regions and cities (Soydanbay, 2017; Miftarević, 2023). Although many tourists are familiar with the capital city of a country, regional cities may be overlooked because of a lack of marketing or transport limitations, for example. The term undertourism was also used in the immediate post-Covid era when many destinations were hardly visited, even if they had previously suffered from overtourism (Hard and Vo-Thanh, 2020).

The primary data collection in this study intended to achieve the following research objectives:

- To capture inter-regional and inter-urban mobility patterns of foreign visitors;
- To detect the level of dependency of the studied cities on the capital city Budapest in terms of access;
- To measure the role of these secondary destinations in the international visitor flows in the wider region;
- To differentiate and analyse the spatio-temporal mobility patterns of international tourists and day-trippers.

This research fits the relatively new paradigm of destination consisting of the dynamic flows of tourists (Beritelli et al., 2014).

There are very few tourism studies focusing on global tracking data (Hawelka et al., 2014) and relatively few at national level (Raun, Shoval and Tiru, 2020). However, research in Estonia has been successful in tracking tourists’ activities nationally using cellular network information (Ahas et al., 2008; Kuusik et al., 2011; Nilbe et al., 2014; Saluveer et al., 2020). Such country-wide studies can help to indicate seasonality of visitation, duration of stay and visitor composition, hence mobile positioning data can also enable the generation of detailed statistics on tourism (Saluveer et al., 2020). Previous work on urban tourism has tended to focus on a single spatial scale, namely the city as a whole (Raun, Shoval and Tiru, 2020). Composite indicator research has been recommended for measuring visitor flows in cities at different times and seasons (Amore, Falk and Adie, 2020). Previous GPS tracking research has often focused on small historic cities (Huang and Wu, 2012) with only a few involving larger, multifunctional cities (McKercher et al., 2012; Cohen-Hattab and Shoval, 2015). Research on the digital economy and its relationship to overtourism-related phenomena like the sharing economy has also been emphasised (Moreno-Gil and Coca-Stefaniak, 2020). ICT can be employed to address issues of overtourism, for example, monitoring the number of tourists visiting certain destinations or sites, driving tourists to alternative paths, promoting other sites and so forth.

However, the other side of the coin is undertourism, which has not been researched in much depth (Soydanbay, 2017; Miftarević, 2023), especially in a city context where overtourism was a dominant theme before the COVID Pandemic. From a policy and management perspective, addressing undertourism can be important for destinations trying to overcome economic imbalances or to reduce the environmental and social pressure on over-visited destinations. Overtourism’s seasonal and locational flows ideally need to be transferred to other seasons and locations using ICT tools (Ruggieri and Calò, 2018). It should also be noted that addressing

undertourism has important socio-economic implications for residents and communities. As yet, research has not indicated fully how this could happen, especially in urban destinations, despite the fact that many cities were effectively dealing with undertourism in the immediate post-COVID era (Hard and Vo-Thanh, 2020). Visitor flow and mobility data might provide new insights into this phenomenon.

In summary, the current article makes the following contribution to urban tourism studies:

- It contributes to the rarely researched area of undertourism in cities, especially when addressing economic imbalances
- It analyses the extent to which mobile positioning data can provide insights into visitors' spatio-temporal mobility and flows in under-visited second-tier cities
- It highlights opportunities and gaps for big data research in an urban context

## Literature review

Several authors have started to explore the ways in which ICT could be used to create solutions to overtourism, but many of these interventions could also prove useful for destinations that are relatively under-visited like the Hungarian cities in this paper. Mohanty, Shreya and Choudhury (2021) summarise some of the studies that have considered technological interventions as part of strategies and solutions. These include managing visitors through monitoring, tracking, movement data and big visitor data. Examples include GPS tracking, geotagging, scraped platform data, crowd dispersal systems and artificial intelligence (García et al., 2017; Hardy et al., 2017; Schmücker and Reif, 2022). When managing attractions and periphery, this can include creating alternative routes, promoting places outside the centre and de-seasonalisation. Examples of technological interventions include m-Apps, GIS, 3D geospatial visualisation and market intelligence software. Clearly, technological interventions can be used to manage intelligent or smart transport systems which enable visitors to reach destinations, especially more peripheral or regional areas. However, the location of the nearest airport will have a significant impact, particularly for short break destinations. Social media marketing campaigns are also essential for raising awareness of and promoting new attractions and destinations that may be relatively unknown to international visitors.

Since conventional accommodation statistics hide information on the spatio-temporal behaviour of tourists and traditional survey data are difficult to obtain, the use of new Information and Communication Technologies (ICT), especially mobile-phone positioning data seems to be inevitable. Mobile Positioning Data (MPD) collected and stored by Mobile Network Operators (MNOs) provide useful data sources for the spatio-temporal analysis of human mobility, including tourism (Zaragozí, Trilles and Gutiérrez, 2021). Characteristics of these data make it possible to differentiate not only visitors from local populations, but also international visitors from domestic tourists at any geographical scale. Such data can provide useful information for tourist destinations not only about the volume, the seasonal, weekly and daily distribution of visitors, but also about their movements between different destinations and spatial behaviour at a particular location (Reif and Schmücker, 2020). Based on such information, tourist boards and destination management organisations (DMOs) can design

long-term tourism development policies more efficiently and increase the synergies among various types of destinations (Hasnat and Hasan, 2018; Ni et al., 2018).

There have been very few studies on the development of second-tier cities as tourism destinations. The first challenge is defining what constitutes a second-tier destination. The Institute of European Affairs (2012) defines them as destinations that locate and position themselves between the capital city and small-sized towns and whose economic and social performance have the potential to affect the national economy. Analysing the travel pattern of Chinese tourists to Europe, Jørgensen et al., (2018) applied a loose definition identifying second-tier destinations as less frequented countries by Chinese (e.g. in Scandinavia). Authors noted, however, that first- and second-tier destinations can also be recognised within nations, as did Lojo (2016) for Spain. Earlier definitions like that of King and Choi (1997) emphasise the accessibility of the cities, especially availability of direct flights. In this study, the effect of low-cost airlines (e.g. Liszt Ferenc airport in Budapest and Debrecen Airport) can increase the economic efficiency of regional airports and thus in the longer-term, potentially stimulate the flow of tourist to the airports' hinterland (Button et al., 2018).

In Thailand, second-tier destinations are defined as those that have the potential to attract tourists but are currently under-visited. However, they also specify the importance of being connected with primary tourism cities and neighbouring countries (TAT, 2018). Those researchers who have undertaken research on second-tier destinations tend to focus on domestic tourism and more specifically demand and motivation. Several academic studies have recently emerged from Thailand about second-tier cities, because the Tourism Authority of Thailand has actively encouraged tourists to travel to 55 second-tier cities partly to increase revenue. In addition to promoting the diverse national culture of Thailand, tourist routes were created which distribute travel from main cities to secondary cities (Panyarien et al., 2021). Research in Thailand showed that the main motivations for visiting second tier cities for domestic tourists can be related to social and cultural dimensions like pride or economic incentives like tax deduction policy (Fakare, Talawanich and Wattanacharoensil, 2020). The factors that might also influence international visitors include price, as second-tier destinations are usually cheaper than primary ones, as well as attractions and local food (if they are promoted well).

In their study on Chinese tourists who visit second-tier destinations in Europe, Jørgensen et al. (2018) noted that those tourists tend to be more mature, experienced and independent having travelled more widely in the past. Whether this is necessarily true for destinations that have traditionally attracted more cross-border tourists like second-tier cities in Hungary requires more research. Some studies have suggested the creation of cross-border single packages and cross-border destination marketing to increase competitiveness, especially for long-distance travellers (Kozak and Buhalis, 2019). Unfortunately, there are few examples of this in Hungary despite potential, for example, Hardi et al. (2021) suggest the need for a joint tourism strategy and integrated cultural tourism development for the cross-border towns Komárom in Hungary and Komárno in Slovakia. Distance clearly plays an important role in visitation of second-tier cities, especially those that are relatively far from the national capital and which do not have a regional airport close by. However, the destinations in question in Hungary usually attract European and regional travellers who can drive or take a train or bus to the destinations. This is supported by the research of McKercher and Mak (2019) on the relationship between distance and demand. They confirm that proximate markets are likely to continue to be the largest source of arrivals for most destinations. This is not problematic in cases of under-tourism or relatively low visitor numbers, which is usually the case for second-tier cities. It is less positive for those destinations that suffer from overtourism. Further good news for second-tier destinations that



attract cross-border tourists is that the marketing cost per tourist is much lower for destinations that share land borders with source markets than for more distant destinations.

### Study area

The three cities under investigation in this research are not only similar by their population size and regional administrative functions, but they are also located at similar distances (180-220 km) from Budapest. They equally host large universities, research centres and other important cultural institutions (theatres, museums, etc.) and they serve as regional tourist hubs within their wider surroundings (Fig. 1).

**Figure 1.** The case-study cities



Source: Authors own design

Debrecen is the second largest city in Hungary after Budapest and it is an important economic and cultural centre in the Eastern part of the country close to the border with Romania. The city is the home of the University of Debrecen, but it is also a well-known leisure destination with several spa and wellness opportunities and sport events. Well-attended summer events like ‘Campus Festival’, ‘Flower Carnival’ and the ‘Debrecen wine and jazz days’ are organized every year which make the city attractive for foreign tourists. The main advantage of Debrecen compared to the other two cities is Debrecen Airport, which handled 381 thousand passengers in 2018 and was the second largest in the country after Budapest.

Szeged is the third biggest city in Hungary located in the southern part of the country adjacent to the border with Serbia and near the Tisza river at the interchange of two major motorways leading to Serbia and Romania (Tóth et al., 2020). In addition to many museums, galleries and an opera, the city has a large university and several other academic institutions. Due to its geographical location Szeged is recognized as the “City of Sunshine”, as it has the greatest number of sunny days in Hungary. Among the local attractions are the ‘Open Air Theater

Festival', the 'Halaszlé (Fish Soup) Festival' or the 'SZIN music festival', which are organized every summer drawing many tourists from all over Europe.

Pécs is the fifth biggest city in Hungary located close to the Croatian border. It is the traditional centre of higher education in its region Southern Transdanubia with a prestigious university and other cultural and research institutions. Pécs has a (sub-) Mediterranean character with historical buildings and remains from the Roman period, the Middle Ages, the Turkish conquest and the following centuries, including many Gothic, Renaissance and Baroque buildings including Christian churches and Muslim Mosques and a minaret.

Official statistics on tourism show distinct differences between the cities as far as the tourist turnover and the development of tourism infrastructure are concerned (Table 1). Regarding both the absolute and relative values of the number of beds in commercial accommodation, as well as the number of tourists (especially foreign tourists) and the number of nights spent by them in the city, Szeged has a leading position. Only in the case of the number of nights spent by tourists (also foreigners) in commercial accommodation can we see a levelling out between Szeged and Debrecen. Pécs, which otherwise has (according to many) the most attractive urban landscape of the three cities, is in the last position in every respect. Therefore, it is an intriguing question whether the three cities are able to sustain tourism in their region that is independent from, but also cooperating with Budapest in the form of inter-urban tourist mobility.

**Table 1.** Indicators on tourism development in the three surveyed cities (2018)

	<b>Debrecen</b>	<b>Pécs</b>	<b>Szeged</b>
Total population (thousand)	201.4	142.8	160.7
Number of beds at commercial accommodations	4,328	3,479	5,531
Number of beds at commercial accommodations per 1,000 inhabitants	21.5	24.4	34.4
Number of tourists at commercial accommodations (thousand)	186.0	121.1	223.2
Number of tourists per 1,000 inhabitants	923.9	847.6	1388.5
Number of nights spent by tourists at commercial accommodations (thousand)	420.2	245.1	444.1
Number of nights spent by tourists per 1,000 inhabitants	2086.0	1715.6	2762.8
Number of foreign tourists at commercial accommodations (thousand)	55.2	27.0	74.1
Number of foreign tourists per 1,000 inhabitants	274.3	188.9	461.0
Number of nights spent by foreign tourists at commercial accommodations (thousand)	144.8	65.3	147.1
Number of nights spent by foreign tourists per 1,000 inhabitants	719.2	457.7	915.3

Source: Authors own calculations based on data of the Hungarian Central Statistical Office, 2018

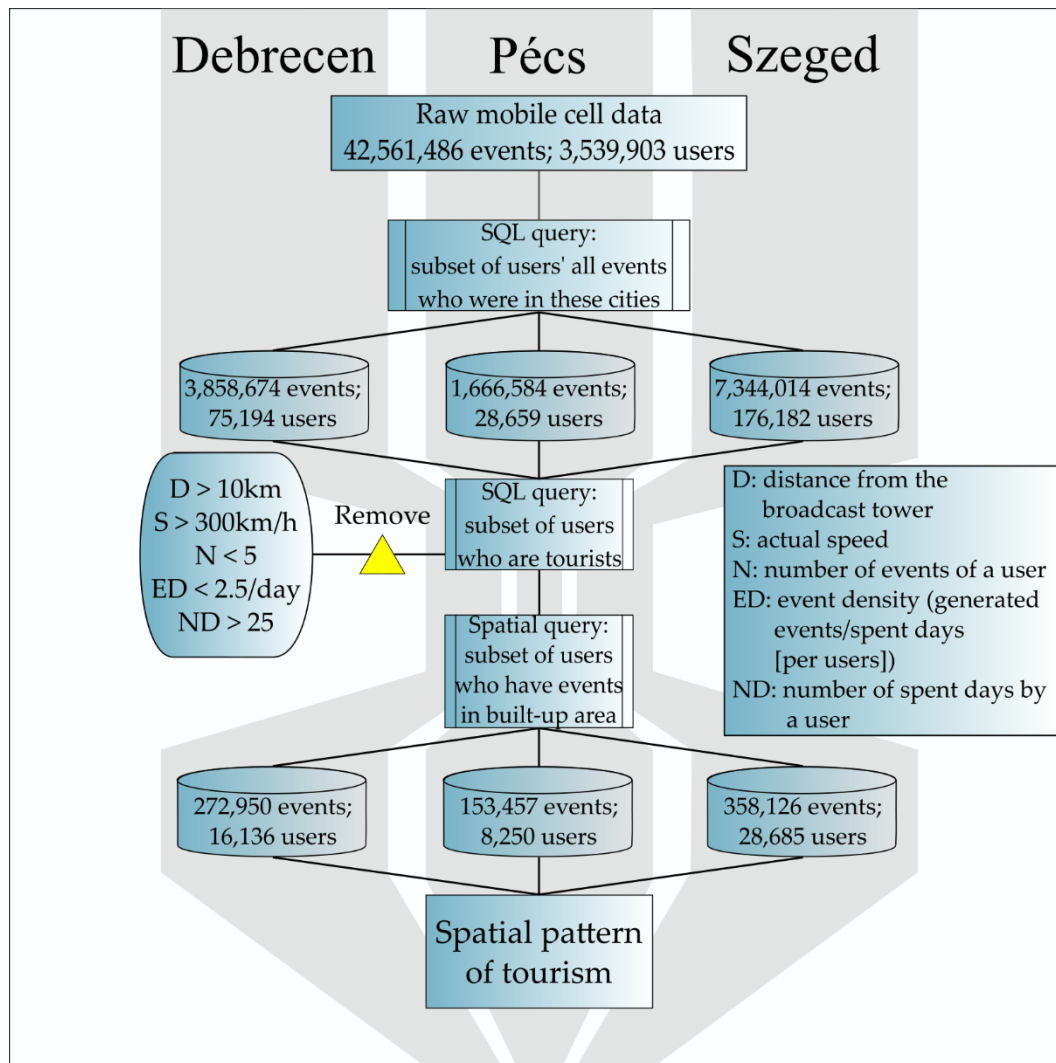
## Data and method

Tourism research is increasingly taking advantage of the opportunities offered by big data (Li et al., 2018). These include information generated by mobile phones, which can be useful when examining destinations where tourist movements are difficult to track (Kim et al., 2020). It can be useful to track tourists who arrive in the destination due to events and whether this generates repeat visits to the country in which they take place (Kuusik et al., 2014). The main advantage of the method is that real-time activities of tourists can be tracked at a certain location which remain usually hidden (i.e. unobserved) by conventional (i.e. accommodation) statistics (Kovalcsik et al., 2022). Next to the advantages limitations of the dataset should also be mentioned. Foreign operators usually have a preferred local network for roaming services to which the user's SIM card connects when arriving in a country. This means that while some countries (where the operator is present) are overrepresented, others remain underrepresented in the dataset. Therefore, to achieve a full coverage of international tourists, data of all mobile network operators (in Hungary three) should be collected and processed. This sets not only a methodological, but also a financial limitation for such research.

In this study we use the depersonalized passive mobile positioning data (MPD) of foreign visitors obtained from one of Hungary's mobile network operators (MNOs) Vodafone Hungary. The MNO had a market share of 26 percent of domestic subscribers and 28 percent of international users in Hungary in 2018 and this research is based on the dataset of six consecutive months between 1<sup>st</sup> July and 31<sup>st</sup> December 2018. The dataset contains the full geolocated call detail records (CDRs) of each international SIM card that connected to the MNO's network in the 6-month period as well as anonymized user meta information for the SIM cards. The dataset provides information about when and where a mobile phone was connected to the network or used cellular data during the investigated period (i.e., log events that are generated each time a user makes a phone call, sends a text message or uses cellular data). The data processing and cleaning followed the methodological considerations put forward by Kovalcsik et al. (2022). To determine the location of an event, we used the estimated position and a circle with a precision radius drawn around it during the processing. This way we were able to give an accurate estimation for the user's position by using the circles of timely consecutive events. The steps of data processing and cleaning are summarized by Figure 2. The original ('raw') dataset was filtered and reduced by merging those CDRs that were created by one SIM card, and referred to one location, thus obtaining the so-called event form, which also includes the time spent variable in that location. With the data processing, the movements of ca. 3.5 million foreigners visiting Hungary and connecting to the MNO during the six-month period could be captured. The total number of CDRs exceeded 42 million.

**Figure 2.** The method of data processing and cleaning





Source: Authors own design

From the raw dataset, records of foreign visitors who visited the three cities (Debrecen, Pécs, Szeged) were filtered according to the following criteria. First, all records of users who generated at least one mobile signal in the administrative territory of the three cities were sorted out. These data contained information not only about which city a user visited, but also where he or she stayed before and after visiting the particular city. Subsequently, a filtering method proposed by Kovács et al. (2021) was applied to exclude data errors and non-touristic events. During the filtering, the 10 km radius (the average distance of cell towers of the MNO) and 300 km/h speed (the natural break of the speed values) thresholds were applied to filter probable data errors. In addition, data of only those users were considered who had sufficient information in the database. Therefore, data of users with less than 5 CDRs in total and an event density below 2.5 were filtered out. In addition, a spatial query was also performed to filter the transit traffic of the nearby highways (which do not cross the built up area of the cities), so only the data of those users were taken into account who had at least one signal within the built-up area of the given city. In order to capture the movements of 'migrant workers' or 'Erasmus students', the number of days spent in Hungary (the time elapsed between their first and last record) was also calculated for each user. If the value reached 25, the user was defined as non-tourist and he or she was omitted from the analysis. This information also enabled us to separate multi-day and one-day visitors. If this value is below 1, the user spent less than 24 hours in Hungary. Since

all three cities are located close to the international borders of Hungary, such users are most probably one-day visitors from the other side of the border (so-called cross-border visitors). Finally, after the filtering process, the final dataset used in this study contains 784,533 events generated by 53,0871 foreign visitors (Table 2). The share of cross-border day-trippers and tourists among international visitors is fairly balanced, although there are differences between the three cities as far as the total number of visitors is concerned. Nevertheless, we think that the final database is reliable and highly representative and, thus, provides a good basis for the research purposes.

**Table 2.** Number of visitors recorded by mobile positioning data in the surveyed cities (1 July – 31 December 2018)

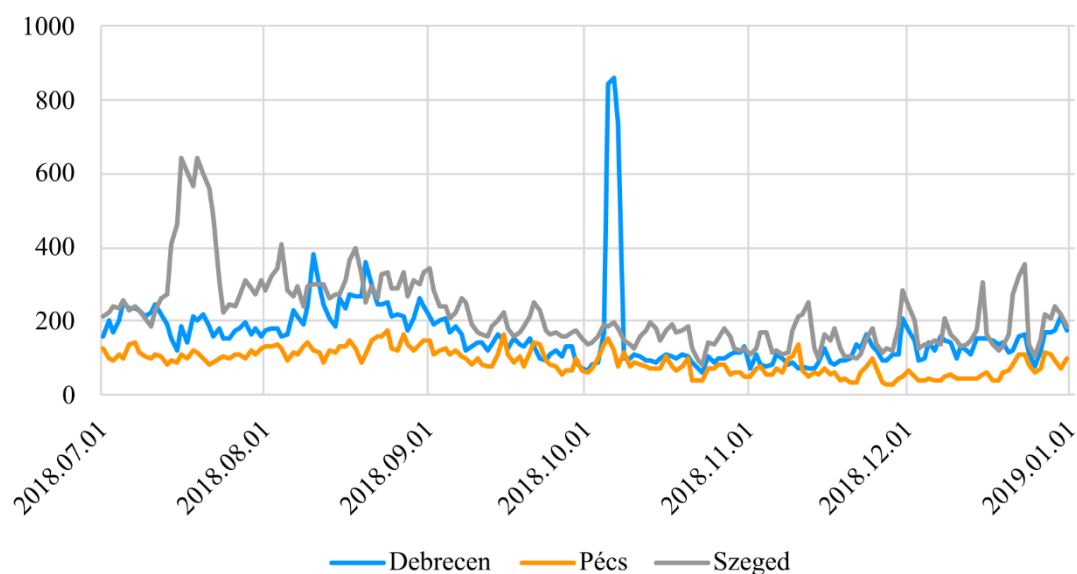
Cities	Day-trippers	Tourists	Total
Debrecen	6,039	10,097	16,136
Pécs	2,856	5,394	8,250
Szeged	18,160	10,525	28,685
<b>Total</b>	<b>27,055</b>	<b>26,016</b>	<b>53,071</b>

Source: Authors own calculations based on CDR data of Vodafone Hungary, 2018

## Findings

According to CDR data, the daily number of foreign visitors shows similar temporal patterns in the three cities (Fig. 3). The number of visitors is highest in July and August, with a secondary peak towards the end of the year (i.e., Christmas, New Year Eve). In the temporal fluctuation of foreign visitors, the role of local events can also be detected. For instance, in Szeged, the 11<sup>th</sup> International Dragon Boat Federation Club Crew World Championships between 16 and 21 July 2018 when 6200 paddlers representing 140 clubs from 28 different countries competed (Kovács et al., 2021). In Debrecen, the main peak was caused by the Michael's day handicraft fair held 5-7 October 2018. However, in the case of Pécs, no such specific event could be detected. In the next stage of the analysis, we separate tourists and day trippers among foreign visitors based on the duration of their visits.

**Figure 3.** The temporal distribution of foreign visitors



Source: Authors own design

Calculating the time interval between the first and the last check-in in the mobile network of the operator while visiting the investigated cities provides us information about the lengths of the stay of each visitor in the cities. According to our definition, day trippers visited the cities for less than 24 hours and did not stay overnight. They could either be cross-border visitors coming to Hungary for a short stay (e.g. leisure, shopping, family meeting) or tourists who otherwise stayed in the country for more than one day (but less than 25 days) and visited the cities during a day tour. We considered ‘tourist’ only those foreign visitors who *spent at least one night* in the surveyed cities. In the following sections, we present and discuss the results for tourists and day-trippers separately.

### *The spatial behaviour of tourists*

After filtering the CDR data, over 26 thousand tourists from 109 countries were captured in the three cities, who generated about 650,000 records during the second half of 2018. The number of tourists and their nationality significantly differ among the three cities, reflecting substantial differences in geographical location and accessibility (Table 3).

**Table 3.** The number and share of tourists in the surveyed cities according to the country of origin (1 July – 31 December 2018)

Debrecen			Pecs			Szeged		
Country	Number of tourists	Share, %	Country	Number of tourists	Share, %	Country	Number of tourists	Share, %
Romania	1,767	17.5	Germany	1,071	19.8	Romania	1,844	17.5
Poland	1,567	15.5	Austria	485	9.0	Germany	1,137	10.8
Germany	679	6.7	France	437	8.1	Poland	781	7.4
Russia	605	6.0	UK	345	6.4	Serbia	771	7.3
Ukraine	563	5.6	Poland	290	5.4	Bulgaria	670	6.4
<b>Top-5 countries</b>	<b>5,181</b>	<b>51.3</b>	<b>Top-5 countries</b>	<b>2,628</b>	<b>48.7</b>	<b>Top-5 countries</b>	<b>5,203</b>	<b>49.4</b>
<b>Other</b>	<b>4,916</b>	<b>48.7</b>	<b>Other</b>	<b>2,766</b>	<b>51.3</b>	<b>Other</b>	<b>5,322</b>	<b>50.6</b>
<b>TOTAL</b>	<b>10,097</b>	<b>100.0</b>	<b>TOTAL</b>	<b>5,394</b>	<b>100.0</b>	<b>TOTAL</b>	<b>10,525</b>	<b>100.0</b>

Source: Authors own calculations based on CDR data of Vodafone Hungary, 2018

Similarly, in all three cities, ca. 50% of tourists arrived from the top five sending countries. However, the group of these countries differ significantly and only Germany and Poland were recorded everywhere among the major sending countries. We can classify the cities on the basis of the sending countries. In this respect, both Debrecen and Szeged can be regarded as Eastward-oriented destinations, since we identified the post-communist countries of Romania, Poland, Russia, Ukraine and Romania, Poland, Serbia, Bulgaria respectively among their major sources of tourists. On the other hand, Pécs is more Westward-oriented, where Germans, Austrians, French and British tourists were among the leading nationalities.

Regarding the temporal distribution of foreign tourists, all three cities can be characterized by high seasonality, which corresponds to the general trends in Hungarian tourism (Marton et al.,

2019; Nod and Aubert, 2022) (Table 4). Almost half (ca. 48% in all three cities) of the visitors arrived in the summer months (July-August) which is related to climatic conditions and the European traditions of school holidays being concentrated in the summer season. The main peak in each destination was in August while the lowest number of visitors was registered in November. Autumn months (September-October) brought relatively more international tourists to Pécs, where natural factors play a role. The city lies on the southern slopes of the Mecsek mountain, a pleasant hiking destination with a dense network of tourist paths and many tourist attractions. On the other hand, Szeged had the highest share of foreign tourist at the end of the year, which can be explained by the city's large Christmas market.

On the basis of the first and last mobile signals of international tourists, the day of arrival and departure can be captured. Regarding the day of arrival in all three cities, two peaks can be identified during the week. The first is on Monday the second is before the weekend (Thursday and Friday). This can be explained partly by the traditional mobility pattern of international tourists concentrating around the weekends and partly by international airfare policies, where the cheapest tickets can be obtained around the middle of the week (Dudás, Boros & Vida, 2017).

**Table 4.** Temporal distribution of foreign tourists in Debrecen, Pécs and Szeged

City	Debrecen	Pecs	Szeged
<b>Seasonality by months</b>			
July-August	47.3	48.6	49.3
September-October	31.0	32.5	26.9
November-December	21.6	18.9	23.8
<b>Arrival day</b>			
Monday	16.0	15.4	15.1
Tuesday	10.7	12.7	11.9
Wednesday	12.1	12.5	13.2
Thursday	15.5	14.9	14.3
Friday	20.1	14.8	15.7
Saturday	11.4	13.8	14.8
Sunday	14.2	15.8	15.0
<b>Departure day</b>			
Monday	11.8	14.2	14.5
Tuesday	10.3	10.9	11.1
Wednesday	11.8	11.4	11.7
Thursday	12.8	13.7	13.3
Friday	14.7	16.5	15.4
Saturday	15.3	17.1	15.2
Sunday	23.3	16.2	18.8
<b>Weekend-Weekday visits</b>			
Weekdays	53.1	56.4	55.5
Weekends	46.9	43.6	44.5
<b>Average nights spent in the city</b>	3.4	4.0	2.9

Source: Authors own calculations based on CDR data of Vodafone Hungary, 2018

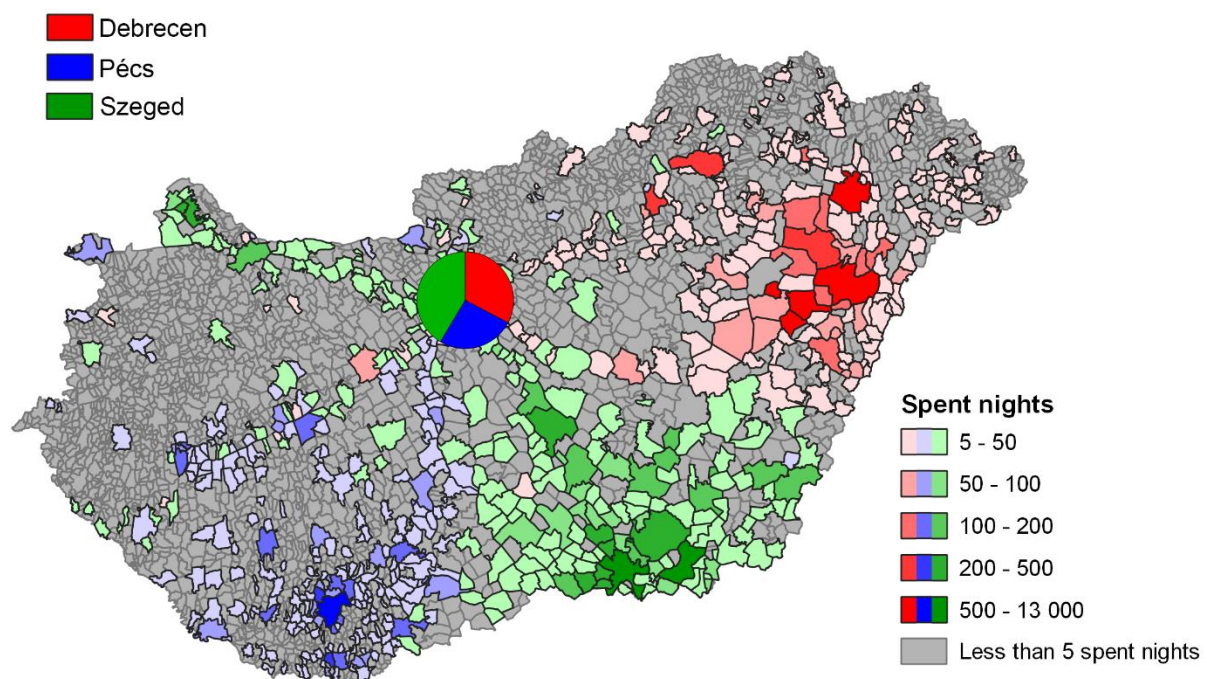
The peak of departure among international tourists was most common on Sunday in Debrecen (23.3%) and Szeged (18.8%) and Saturday (17.1%) in the case of Pécs. The share of weekend visitors (staying from Friday to Sunday) was very similar in all three cities ranging from 43 to 46%. This means that international tourists' mobility concentrated around the weekend in Debrecen and Szeged and only Pécs had slightly higher turnover rate in the middle of the week.

This is the traditional tourist's mobility pattern in Hungarian cities, where a significant number of international visitors arrive by plane to Budapest during weekdays and visit different destinations in the countryside from Friday to Monday. They can be defined as typical weekend visitors, irrespective of how long they stay in Hungary.

The duration of the visits lasted from 1 to 24 days in all three cities and the average length of stay in Hungary was 2.9 days in Szeged, 3.4 days in Debrecen, and 4.0 days in Pécs. Thus, tourists in Pécs were not only spread more evenly during the week, but they also spent more time in Hungary than the visitors of Debrecen or Szeged. The length of stay can be related to the motivations of visit, with people arriving for the sake of the city normally spending a longer time discovering the attractions and enjoying the atmosphere of the city. They can be considered leisure or cultural tourists. On the other hand, foreign visitors who stay a shorter time in the city often arrive for business or professional purposes (e.g. international conferences). In this respect, the favourable position of Pécs is clearly palpable compared to Debrecen and especially Szeged.

One of the main objectives of this study is to analyse the spatial behaviour of tourists, to detect geographically where they go while visiting the three cities and how mobile they are. According to the CDR data, tourists visiting Szeged were the most scattered in space, 28.4% of them spent at least one night outside its county and Budapest (Fig. 4). This ratio was 26.7% in the case of Pécs and 21.7% in Debrecen. Szeged lies at one of the main junctions of the Pan-European Transport Corridor IV, one of the busiest route connecting Turkey and Greece with the core of the European Union. This gives the opportunity of flexibility for travellers both in space and time and results in a shorter length of stay and higher level of spatial dispersal of tourists. Debrecen and Pécs also have motorway connections, but these routes are less frequented ones.

**Figure 4.** Distribution of overnight stays by foreign tourists visiting Debrecen, Pécs and Szeged



Source: Authors own design

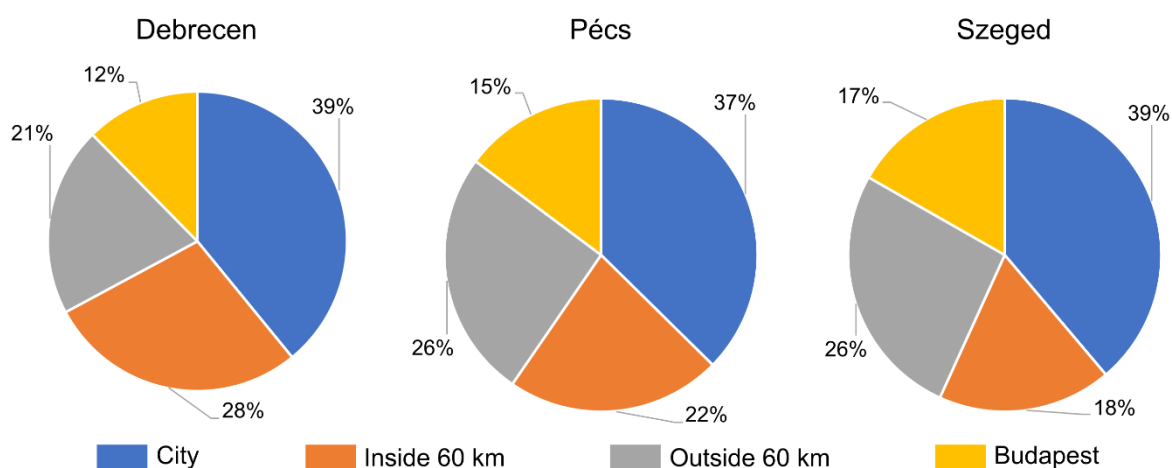


The rate of connectedness with Budapest as the primary tourist hub of Hungary is an important aspect when it comes to policy formulations combating overtourism in the capital and addressing undertourism in second-tier cities. In this respect, foreign tourists to Szeged were most linked with Budapest as 16.3% of them also stayed in the capital city. The connection of the other two cities with Budapest was weaker with 14.8% of international tourists in Pécs and 12% in Debrecen also visiting the capital city during their stay in the country. This means that Debrecen was the most independent city from Budapest, perhaps partly because it has its own airport.

In the study of international tourist flows, it is also important to know to what extent the investigated cities can serve as a gateway of tourism for their wider geographical regions. This was measured by the share of tourists who spent at least one night at another location within a 60 km radius. Our results show that 28% of tourists visiting Debrecen spent at least one overnight at another location within 60 kilometres. This share was 22% in Pécs and only 18% in Szeged. Therefore, although Szeged is visited statistically by more international tourists than the other two cities, it has the smallest synergies with other tourist destinations inside its region (Fig. 5).

The extent of independence from Budapest and strong regional embeddedness in the field of international tourism suggest that Debrecen has the greatest potential among the three cities to decrease the primacy of Budapest within the country and to mitigate the negative consequences of overtourism there. Recent government financed development and regeneration programmes (e.g. a large-scale multifunctional stadium), as well as robust investments in the automobile industry (e.g. a new BMW plant) also seem to enhance the development potential of the city in the field of tourism, including business tourism (Kozma, Radics and Teperics, 2022; Molnár et al. 2020).

**Figure 5.** Spatial behaviour of international tourists visiting Debrecen, Pécs and Szeged



Source: Authors own design

As Lázaro (2022) noted, next to air cargo and logistics development, the role of airports is increasing in local economies, especially in tourism development. As of 2018, there were five international airports in Hungary (Budapest, Debrecen, Győr, Hévíz-Balaton and Pécs-Pogány) supplying 15.3 million passengers. In that year, 97.3% of the passengers (14.8 million people) used Budapest Ferenc Liszt International Airport, which reflects a very high primacy of the capital city in air-traffic in Hungary. The second-largest international airport was in Debrecen supplying 376 thousand passengers in 2018, where low-cost airline tourists from Germany, France, the UK, the Netherlands, Israel, Spain and Italy could directly reach the city. The role of the remaining three smaller airports remained negligible. Regarding the mode of transport, the share of tourists travelling by air was highest in Debrecen (20.2%) followed by Pécs (17.7%) and Szeged (12.5%), which reflects the advantages of air connections provided by Debrecen Airport. On the other hand, Szeged was the most motorway and railway-oriented city as far as international tourists' arrivals are concerned. The dependency ratio on Budapest Ferenc Liszt Airport was the highest in Pécs among the case-study cities in 2018, 17.6% of international visitors arrived to the city via Budapest's airport, which was lower in Szeged (12.4%) and Debrecen (10.5%).

### *The spatial behaviour of day-trippers*

After filtering the CDR data, over 27 thousand day-trippers from 114 countries were identified in the three cities, generating about 140,000 mobile CDRs during the second half of 2018. The number of recorded day trippers and their nationality differ significantly between the three cities (Table 5). The most visited of the three cities is Szeged with 18,160 one-day visitors, followed by Debrecen (6,039) and Pécs (2,856). The share of the top five nationalities is, in all three cases, above 60% which reflects a relatively high concentration. Regarding the nationality of day trippers, our results confirm the relevance of geographical proximity, as a substantial number of day trippers arrived from neighbouring countries. The nearest border crossing-point in Szeged is Röszke 16 km from Serbia, in Debrecen Nyírábrány 31 km from Romania and in the case of Pécs it is Drávaszabolcs 35 km from Croatia. In each city around 40% of day trippers arrived from neighbouring countries with the shortest distance. In Debrecen, 43.7% of one-day visitors come from nearby Romania (31.7%) and Ukraine (12%), 40.2% of day trippers in Szeged arrive from neighbouring Serbia (21.6%) and Romania (18.6%), whereas in Pécs 39.6% of one-day visitors arrive from Croatia (29.8%), Bosnia-Herzegovina (5%) and Serbia (4.8%).

**Table 5.** The number and share of day trippers in the surveyed cities according to the country of origin (1 July – 31 December 2018)

Debrecen			Pecs			Szeged		
Country	Number of visitors	Share, %	Country	Number of visitors	Share, %	Country	Number of visitors	Share, %
Romania	1,915	31.7	Croatia	850	29.8	Serbia	3,926	21.6
Ukraine	724	12.0	Germany	456	16.0	Romania	3,377	18.6
Poland	563	9.3	Netherlands	152	5.3	Germany	2,776	15.3
Netherlands	364	6.0	Bosnia	144	5.0	Netherlands	1,086	6.0
Germany	293	4.9	Serbia	136	4.8	Poland	899	5.0
<b>Top-5 countries</b>	<b>3,859</b>	<b>63.9</b>	<b>Top-5 countries</b>	<b>1,738</b>	<b>60.9</b>	<b>Top-5 countries</b>	<b>12,064</b>	<b>66.4</b>
<b>Other</b>	<b>2,180</b>	<b>36.1</b>	<b>Other</b>	<b>1,118</b>	<b>39.1</b>	<b>Other</b>	<b>6,096</b>	<b>33.6</b>
<b>TOTAL</b>	<b>6,039</b>	<b>100.0</b>	<b>TOTAL</b>	<b>2,856</b>	<b>100.0</b>	<b>TOTAL</b>	<b>18,160</b>	<b>100.0</b>

Source: Authors own calculations based on CDR data of Vodafone Hungary, 2018

Next to neighbouring countries, German, Dutch and Polish tourists were overrepresented among one-day visitors. They probably spent their vacation in Hungary, travelled around and visited the cities as part of a longer stay. In the case of Debrecen, the local airport may also bring short-term visitors who spend a few hours in the city, but do not stay overnight. Overall, although Debrecen takes advantage of the presence of an international airport, the number of day trippers is three-times higher in Szeged without an airport. Nonetheless, the city is situated in a convenient transport location at the intersection of M5 and M43 motorways leading to Subotica (Serbia) and Arad (Romania), which is part of the Pan-European Corridor IV, and provides good opportunities to transit travellers as well as day trippers from other parts of Hungary.

An important aspect of one-day visitors is their temporal distribution. In this respect, we analysed the monthly (i.e., seasonal) and weekly distribution of day-trippers. Concerning the monthly distribution in each city, two peaks could be distinguished, one in the summer season (August) and a second at the end of the year (December). We assume that the latter can be associated with so-called utilitarian shopping, including the shopping for daily goods before Christmas holiday and New Year Eve predominantly from neighbouring countries (Su et al., 2020). On the other hand, the summer peak of day trippers seems to be more related to one-day visits of international tourists staying in other parts of Hungary.

Regarding the temporal distribution of day trippers during the week, we distinguished Monday to Thursday as 'weekdays' and Friday to Sunday as 'weekend' since Fridays are usually the start of cross-border shopping trips. Our data show that day trippers are in general more active during weekends, especially Saturdays, although with slight differences between the cities. The highest share of weekend one-day visitors was observed in the case of Pecs (55.3%), followed by Szeged (52.8%) and Debrecen (50.4%). We divided day trippers into two groups and analysed their weekly distribution: those who come from neighbouring countries and those from the rest of the world. Our results show that cross-border day trippers tend to arrive during weekends whereas day tripper tourists are more evenly distributed throughout the week. For instance, almost 70% of Dutch one-day visitors in Pecs, 57% in Debrecen and 52% in Szeged travelled during weekdays. Likewise, almost 62% of German day-trippers in Debrecen and 56% in Szeged arrived in these cities during weekdays.

## Discussion

This study aimed at investigating the travel patterns of inbound international visitors in three second-tier destinations in Hungary with the use of mobile positioning data (MPD). Results confirmed substantial differences in tourist turnover and accessibility of second-tier cities when their relations to the primary destination of the country (Budapest) was examined. This has implications for addressing undertourism, as it highlights the importance of the connection to the main gateway city of Hungary. The importance of gateways for visitor flows has been emphasised in previous studies (Raun, Shoval and Tiru, 2020). According to official statistics, Szeged performed the best regarding international tourism among the investigated cities, both in quantitative and qualitative terms. However, according to MPD, this city is the weakest within its region as a gateway, as most of the foreign tourists arrive and leave the city quickly due to the Pan-European Transport Corridor. On the other hand, thanks to its airport and inter-municipal connections Debrecen has the greatest potential within its surroundings and this city is the most independent from Budapest as far as international tourists are concerned. Pécs has

the lowest number of international visitors, however, they stay on average the longest in this city, and they are also less concentrated over the weekends. The economic implications of this in terms of addressing undertourism would need to be explored further, but there is good reason to believe that the potential of Debrecen is the greatest to promote local tourism development and mitigate undertourism. In this respect, Pécs could also have good opportunities, but the city should place more emphasis on the development of tourism infrastructure and offering events (like Debrecen and especially Szeged) that attract international visitors. Taking into account the main results of this research, each of the investigated cities should follow different tourism policies to cooperate with Budapest and strengthen the connection with their neighbouring destinations.

## Conclusion

Previous work on undertourism often focused on locations that were remote, lacking infrastructure or suffered from a negative image or security concerns (Ruggieri and Calò, 2018; Gowreesunkar and Vo-Thanh, 2020). Few studies have focused on urban destinations that are not affected by any of these factors, but are still under-visited. The form of data collection employed in this article is not new in urban tourism research, but it has not been used often in the context of undertourism in smaller cities. In Li et al.'s (2018) analysis of the stages of big data research in tourism, this study provides Stage 1 data on tourist segments (i.e. tourists and day-trippers), Stage 2 data on spatial-temporal tourist behaviour (e.g. seasons, weekdays, cross-border) and moves towards Stage 3 research which makes recommendations for destinations and itineraries.

Long-term national and regional policies on balanced tourism development should ideally focus on addressing undertourism as well as combating overtourism. This has been a deliberate national policy strategy in Thailand, for example (TAT, 2018). This study provides some insights into undertourism as a phenomenon in cities building on the work of Gowreesunkar and Vo-Thanh (2020). The latter authors suggest the need to capitalise on niche markets applying appropriate marketing strategies, which can also be relevant here. They even suggest virtual tours as a way of making visitors think differently about destinations. Seraphin (2016) argues that technology can completely alter the image of a destination. This study has several implications for tourism agencies and service providers in Hungary in enhancing attractiveness of second-tier destinations which may also be relevant to other destinations suffering from overtourism in their capital and undertourism in their regional cities. This could involve strengthening links to gateways, using the cities as a base for excursions within the wider region, developing cross-border packages, building marketing strategies around special events and creating a stronger evening economy to encourage visitors to stay overnight.

## Limitations and Further Research

MPD data cannot fully explain or predict drivers of visitor behaviour, such as the reasons that they go to places (Beritelli, Reinhold and Laesser, 2020). It is necessary to go beyond the parameters of location and time in order to collect data about decision-making processes, subjective experiences or expenditure patterns (Shoval and Ahas, 2016). It is always useful to understand the primary motivations of visitors in a destination and whether they are first-time

or repeat visitors (Lau and McKercher, 2006). Future research could build on the work of researchers who have collected realtime information about tourists' feelings (Kim and Fesenmaier, 2015). Social network data could be used to understand how places are experienced in a multi-faceted way (Raun, Ahas and Tiru, 2016). For sustainable policy-making, further research is needed on the primary motivations of international tourists in Hungary as well as their preferred activities in destinations. There is also a need for research in second-tier destinations about how such places can become the 'base' for excursions instead of being mere day-trip destinations. Future research should also take into consideration recommendations in previous studies about alleviating pressure on major urban centres by creating additional regional gateways (Raun, Shoval and Tiru, 2020). It is also an important question to what extent the development of the evening economy and evening events could encourage overnight stays. Tourism development and marketing strategies should also focus on capitalising new niche markets like creative tourism or creating cross-border packages.

## Acknowledgements

Funding: This research has been funded by the Hungarian Scientific Research Fund (OTKA) Grant Agreement No. K135546, and the National Research, Development and Innovation Fund of the Ministry of Innovation and Technology, Hungary, Grant No. TKP2021-NVA-09.

## References

- Ahas, R., and Mark, U. (2005), Location based services—new challenges for planning and public administration? *Futures* 37(6), 547\_561. <https://doi.org/10.1016/j.futures.2004.10.012>
- Ahas, R., Aasa, A., Roose, A., Mark, U., and Silm, S. (2008), Evaluating passive mobile positioning data for tourism surveys: An Estonian case study. *Tourism Management*, 29(3), 469-486. <https://doi.org/10.1016/j.tourman.2007.05.014>
- Ahas, R., Witlox F., and Miller, H. (2014), From the guest editors: Mobility, communication, and urban space. *Journal of Urban Technology*, 21(2), 1-7. <https://doi.org/10.1080/10630732.2014.913420>
- Amore A., Falk M. and Adie B.A. (2020), One visitor too many: assessing the degree of overtourism in established European urban destinations. *International Journal of Tourism Cities*, 6(1), 117–137. <https://doi.org/10.1108/IJTC-09-2019-0152>
- Aranburu, I. Plaza, B. and Esteban, M. (2016), Sustainable cultural tourism in urban destinations: Does space matter? *Sustainability* 8, 699. <https://doi.org/10.3390/su8080699>
- Ballina, F.J., Valdes, L. and Del Valle, E. (2019), The Phygital experience in the smart tourism destination. *International Journal of Tourism Cities*, 5(4), 656-671. <https://doi.org/10.1108/IJTC-11-2018-0088>
- Bauder, M. and Freytag, T. (2015), Visitor mobility in the city and the effects of travel preparation. *Tour. Geogr.* 17, 682–70. <https://doi.org/10.1080/14616688.2015.1053971>



- Beritelli, P., Reinhold, S. and Laesser, C. (2020), Visitor flows, trajectories and corridors: Planning and designing places from the traveler's point of view. *Annals of Tourism Research*, 82, <https://doi.org/10.1016/j.annals.2020.102936>
- Birenboim, A., and Shoval, N. (2016), Mobility research in the age of the smartphone. *Annals of the Association of American Geographers*, 106(2), 283-291. <https://doi.org/10.1080/00045608.2015.1100058>
- Button, K., Kramberger, T., Grobin, K. and Rosi, B. (2018), A note on the effects of the number of low-cost airlines on small tourist airports' efficiencies. *Journal of Air Transport Management*, 72(March 2017), 92–97. <https://doi.org/10.1016/j.jairtraman.2017.12.003>
- De Cantis, S., Ferrante, M., Kahani, A. and Shoval, N. (2016), Cruise passengers' behavior at the destination: Investigation using GPS technology. *Tourism Management*, 52, 133-150. <https://doi.org/10.1016/j.tourman.2015.06.018>
- Coca-Stefaniak, J. A. (2019), Marketing smart tourism cities – a strategic dilemma. *International Journal of Tourism Cities*, 5(4), 513-518. <https://doi.org/10.1108/IJTC-12-2019-163>
- Cohen-Hattab, K., and Shoval, N. (2015), *Tourism, religion, and pilgrimage in Jerusalem*. London: Routledge.
- Dudás, G., Boros, L. and Vida, G. (2017), Comparing the temporal changes of airfares on online travel agency websites and metasearch engines. *Tourism*, 65(2), 187–203.
- García, D. Osborne, P. Kemp, S. and Woodfine, T. (2017), Combining GPS & survey data improves understanding of visitor behaviour. *Tour. Manag.* 61, 307–320. <https://doi.org/10.1016/j.tourman.2017.02.021>
- García-Hernández, M., Ivars-Baidal, J. and Mendoza de Miguel, S. (2019), Overtourism in urban destinations: the myth of smart solutions. *Boletín de la Asociación de Geógrafos Españoles*, 83, 2830, 1–38. <http://dx.doi.org/10.21138/bage.2830>
- Gowreesunkar, V. G. and Vo-Thanh, T. (2020), Between overtourism and under-tourism: Impacts, implications, and probable solutions. In H. Seraphin, T. Gladkikh, & T. Vo-Thanh (Eds.), *Overtourism: Causes, implications and solutions* (pp. 45–68). Palgrave Macmillan. [https://doi.org/10.1007/978-3-030-42458-9\\_4](https://doi.org/10.1007/978-3-030-42458-9_4)
- Hardi, T., Kupi, M., Ocskay, G. and Szemerédi, E. (2021), Examining Cross-Border Cultural Tourism as an Indicator of Territorial Integration across the Slovak–Hungarian Border. *Sustainability*, 13(13), 7225, <https://doi.org/10.3390/su13137225>
- Hardy, A., Hyslop, S., Booth, K., Robards, B., Aryal, J., Gretzel, U. and Eccleston, R. (2017), Tracking tourists' travel with smartphone-based GPS technology: a methodological discussion. *Information Technology and Tourism*, 17, 255–274, <https://doi.org/10.1007/s40558-017-0086-3>
- Hasnat, M. M. and Hasan, S. (2018), Identifying tourists and analyzing spatial patterns of their destinations from location-based social media data. *Transportation Research Part C: Emerging Technologies*, 96(January), 38–54. <https://doi.org/10.1016/j.trc.2018.09.006>
- Hawelka, B., Sitko, I., Beinat, E., Sobolevsky, S., Kazakopoulos, P., and Ratti, C. (2014), Geo-located Twitter as proxy for global mobility patterns. *Cartography and Geographic Information Science*, 41(3), 260-271. <https://doi.org/10.1080/15230406.2014.890072>

- Jørgensen, M. T., Law, R. and King, B. E. (2018), Beyond the stereotypes: Opportunities in China inbound tourism for second-tier European destinations. *International Journal of Tourism Research*, 20(4), 488–497. <https://doi.org/10.1002/jtr.2198>
- Kim, J., and Fesenmaier, D. R. (2015), Measuring emotions in real time: Implications for tourism experience design. *Journal of Travel Research*, 54(4), 419-429. <https://doi.org/10.1177/0047287514550100>
- Kuusik, A., Tiru, M., Ahas, R., and Varblane, U. (2011), Innovation in destination marketing: The use of passive mobile positioning for the segmentation of repeat visitors in Estonia. *Baltic Journal of Management*, 6(3), 378-399. <https://doi.org/10.1108/17465261111168000>
- Kim, Y. J., Lee, D. K. and Kim, C. K. (2020), Spatial tradeoff between biodiversity and nature-based tourism: Considering mobile phone-driven visitation pattern. *Global Ecology and Conservation*, 21, e00899. <https://doi.org/10.1016/j.gecco.2019.e00899>
- Kovalcsik, T., Elekes, Á., Boros, L., Könnnyid, L. and Kovács, Z. (2022), Capturing Unobserved Tourists: Challenges and Opportunities of Processing Mobile Positioning Data in Tourism Research. *Sustainability*, 14, 13826. <https://doi.org/10.3390/su142113826>
- Kovács, Z., Vida, G., Elekes, Á. and Kovalcsik, T. (2021), Combining Social Media and Mobile Positioning Data in the Analysis of Tourist Flows: A Case Study from Szeged, Hungary. *Sustainability*, 13(5), 2926. <https://doi.org/10.3390/su13052926>
- Kozak, M. and Buhalis, D. (2019), Cross-border tourism destination marketing: Prerequisites and critical success factors. *Journal of Destination Marketing and Management*, 14(November), 100392. <https://doi.org/10.1016/j.jdmm.2019.100392>
- Kozma, G., Radics, Z. and Teperics K. (2022), The Role of Sports Facilities in the Regeneration of Green Areas of Cities in Historial View: The Case Study of Great Forest Stadium in Debrecen, Hungary. *Buildings*, 12(6):714. <https://doi.org/10.3390/buildings12060714>
- Kuusik, A., Nilbe, K., Mehine, T. and Ahas, R. (2014), Country as a Free Sample: The Ability of Tourism Events to Generate Repeat Visits. Case Study with Mobile Positioning Data in Estonia. *Procedia - Social and Behavioral Sciences*, 148, 262–270. <https://doi.org/10.1016/j.sbspro.2014.07.042>
- Lázaro, F-B. (2022), How Málaga's airport contributes to promote the establishment of companies in its hinterland and improves the local economy. *International Journal of Tourism Cities*, 8 (2), pp. 393–411. DOI: 10.1108/IJTC-04-2021-0059
- Lau, G. and McKercher, B. (2006), Understanding tourist movement patterns in a destination: A GIS approach. *Tour. Hosp. Res.* 7, 39–49. <https://doi.org/10.1057/palgrave.thr.6050027>
- Li, J., Xu, L., Tang, L., Wang, S. and Li, L. (2018), Big data in tourism research: A literature review. *Tourism Management*, 68, 301–323. <https://doi.org/10.1016/j.tourman.2018.03.009>
- Lojo, A. (2016), Chinese tourism in Spain: an analysis of the tourism product, attractions and itineraries offered by chinese travel agencies. *Cuadernos de Turismo*, (37), 243–268. <https://doi.org/10.6018/turismo.37.256231>

- Marton, G., Hinek, M., Kiss, R. and Csapó, J. (2019), Measuring seasonality at the major spa towns of Hungary. *Hungarian Geographical Bulletin*, 68(4), 391–403. <https://doi.org/10.15201/hungeobull.68.4.5>
- McKercher, B. and Mak, B. (2019), The impact of distance on international tourism demand. *Tourism Management Perspectives*, 31(March), 340–347. <https://doi.org/10.1016/j.tmp.2019.07.004>
- Molnár, S. B. (2023), Undertourism vs. Overtourism: A Systematic Literature Review. *Tourism*, 71 (1). <https://doi.org/10.37741/t.71.1.11>
- Mohanty, P., Shreya, V. and Choudhury, R. (2021), ICT for Overtourism Management: an Exploration. In A. Hassan & A. Sharma (Eds.), *Overtourism, Technology Solutions and Decimated Destinations*. Springer.
- Molnár, E., Kozma, G., Mészáros, M. and Kiss, E. (2020), Upgrading and the geography of the Hungarian automotive industry in the context of the fourth industrial revolution. *Hungarian Geographical Bulletin*, 69(2), 137–155. <https://doi.org/10.15201/hungeobull.69.2.4>
- Moreno-Gil, S. and Coca-Stefaniak, A. (2020), Guest Editorial: Overtourism and the sharing economy – tourism cities at a crossroads. *International Journal of Tourism Cities*, 6(1), 1–7. <https://doi.org/10.1108/IJTC-03-2020-174>
- Ni, L., Wang, X. and Chen, X. (2018), A spatial econometric model for travel flow analysis and real-world applications with massive mobile phone data. *Transportation Research Part C: Emerging Technologies*, 86(April 2017), 510–526. <https://doi.org/10.1016/j.trc.2017.12.002>
- Nilbe, K., Ahas, R., and Silm, S. (2014), Evaluating the travel distances of events visitors and regular visitors using mobile positioning data: The case of Estonia. *Journal of Urban Technology*, 21(2), 91–107. <https://doi.org/10.1080/10630732.2014.888218>
- Nod, G. and Aubert, A. (2022), Methods for measuring the spatial mobility of tourists using a network theory approach. *Hungarian Geographical Bulletin*, 71(3), 287–299. <https://doi.org/10.15201/hungeobull.71.3.5>
- Panyarien, S., Madhyamapurush, W., Pakdeepinit, P. and Sreesoompong, P. (2021), Perception Of Tourists Behavior In Second Tier Cities In Thailand. *PSYCHOLOGY AND EDUCATION*, 58(5), ISSN 1553 – 6939
- Raun, J., Ahas, R. and Tiru, M. (2016), Measuring tourism destinations using mobile tracking data, *Tourism Management*, 57, 202–212. <https://doi.org/10.1016/j.tourman.2016.06.006>
- Raun, J., Shoval, N. and Tiru, M. (2020), Gateways for intra-national tourism flows: measured using two types of tracking technologies. *International Journal of Tourism Cities*, 6(2), 261–278. <https://doi.org/10.1108/IJTC-08-2019-0123>
- Reif, J. and Schmücker, D. (2020), Exploring new ways of visitor tracking using big data sources: Opportunities and limits of passive mobile data for tourism. *Journal of Destination Marketing & Management*, 18, 100481. <https://doi.org/10.1016/j.jdmm.2020.100481>
- Ruggieri, G. and Calò, P. (2018), ICT and tourism impacts in islands. *Ecocycles*, 4(2), 4–11. <https://doi.org/10.19040/ecocycles.v4i2.102>

- Saluveer, E., Raun, J., Tiru, M., Altin, L., Kroon, J., Snitsarenko, T., Aasa, A. and Silm, S. (2020), Methodological framework for producing national tourism statistics from mobile positioning data. *Annals of Tourism Research*, 81, <https://doi.org/10.1016/j.annals.2020.102895>
- Schmücker, D. and Reif, J. (2022), Measuring tourism with big data? Empirical insights from comparing passive GPS data and passive mobile data. *Annals of Tourism Research Empirical Insights*, 3(2), <https://doi.org/10.1016/j.annale.2022.100061>
- Seraphin, H. (2016), Impacts of travel writing on post-conflict and post-disaster destinations: The case of Haiti. In R. Zoe (Eds.), *River tourism: The pedagogy and practice of place writing* (p.17-35). Plymouth: TKT
- Shoval, N., & Isaacson, M. (2006), Application of tracking technologies to the study of pedestrian spatial behaviour. *The Professional Geographer*, 58(2), 172-183. <https://doi.org/10.1111/j.1467-9272.2006.00524.x>
- Shoval, N. and Isaacson, M. (2007), Sequence alignment as a method for human activity analysis in space and time. *Annals of the Association of American Geographers*, 97 (24), 282-297. <https://doi.org/10.1111/j.1467-8306.2007.00536.x>
- Shoval, N. (2008), Tracking technologies and urban analysis. *Cities*, 25(1), 21-28. <https://doi.org/10.1016/j.cities.2007.07.005>
- Shoval, N., Isaacson, M., & Chhetri, P. (2013), GPS and smartphones and the future of tourism research. In A. Lew, C. M. Hall, & A. Williams (Eds.), *The Wiley-Blackwell companion to tourism* (pp. 251-261). Oxford: Blackwell
- Shoval, N. and Ahas, R. (2016), The use of tracking technologies in tourism research: the first decade, *Tourism Geographies*, 18(5), 587-606. <https://doi.org/10.1080/14616688.2016.1214977>
- Su, X., Spierings, B., Hooimeijer, P. and Scheider, S. (2020), Where day trippers and tourists go: comparing the spatio-temporal distribution of Mainland Chinese visitors in Hong Kong using Weibo data. *Asia Pacific Journal of Tourism Research*, 25(5), 505–523. <https://doi.org/10.1080/10941665.2020.1741409>
- Sugimoto K. and Ota K. (2019), Mobility and Spatial Structure in a Local Urban Tourism Destination: GPS Tracking and Network analysis. *Sustainability*. 11(3), 919. <https://doi.org/10.3390/su11030919>
- TAT (Tourism Authority of Thailand) (2018), TAT curates three concepts to promote 55 secondary cities. <https://www.tatnews.org/2018/11/tat-curates-three-concepts-to-promote-55-secondary-cities/>
- Tóth, B., Vida, G., Lados, G. and Kovács, Z. (2020), The Potentials of Cross-Border Tourism Development in the Lower-Tisa Valley. *GeoJournal of Tourism and Geosites*, 28(1), 360–375. <https://doi.org/10.30892/gtg.28128-475>
- Zaragozí, B., Trilles, S. and Gutiérrez, A. (2021), Passive Mobile Data for Studying Seasonal Tourism Mobilities: An Application in a Mediterranean Coastal Destination. *ISPRS International Journal of Geo-Information*, 10(2), 98. <https://doi.org/10.3390/ijgi10020098>