Sources of data to tackle the challenges of public transport provision in seasonal tourist destinations

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Abstract

Tourism reconfigures the metropolitan dynamics and the patterns of use of the urban systems. The seasonal nature of tourism produces an impact on the urban hierarchies, since it affects the labour, residential and recreational markets. As a result, people move to and in the destination and it challenges the supply of sustainable modes of transport such as the public transport. This research is set within the context of three demanding challenges that tourist destinations need to face-up: to increase environmental sustainability, to enhance destination competitiveness, and finally to assure quality and comfort of public transport services for the local resident population. Camp de Tarragona region, where Costa Daurada (one of the most important Spanish tourist brands) is located, is analysed to illustrate how different data sources can aid to confront the aforementioned challenges. Given that seasonality is a dynamic phenomenon, suitable data should be flexible in terms of its time framework. To this end data from smart travel cards provided by the consortium that manages the public transport system in the region has been analysed. Data unveiled the impact of seasonality on the evolution of demand throughout the year, the type of transport tickets used, or changes occurred in the geographical distribution of the mobility Alternative data sources such as surveys and passive mobile positioning data have also been examined, and their pros and cons have been addressed.

Keywords: tourist destination, seasonality, public transport, smart travel card data, Costa Daurada

1. Introduction

There is no dispute on the advantages of diverting mobility demand from the use of the most pollutant modes of transport towards the most sustainable ones. Mobilities derived from the activities associated to the tourism industry are not an exception. The analyses carried out have mainly focused on the potential of modal shift towards more efficient modes of transport so as to improve sustainability in the travel to and from their holiday destinations (Peeters and Dubois, 2010). More recently, the interest in the benefits of the shift to more sustainable transport modes regarding intra-destination mobilities has also risen (Scuttari *et al.*, 2018). On these grounds intra-destination public transport use by tourists becomes a relevant research field as it plays a key role in three challenges that require to be properly tackled: environmental sustainability of the mobility system of the area, enhancement of destinations' competitiveness, and guaranteeing quality and comfort of public transport service for the resident population. These challenges involve additional complexity when the arrival of visitors is concentrated during a certain period of the year due to seasonality.

Environmental sustainability of the mobility system of the area

There is an undeniable diversity of environmental implications associated with transport decisions made by visitors. In the first place, it has been well reported that visitors' intra-destination use of the private vehicle yields a negative impact in terms of the emission of greenhouse gases (Guiver and Stanford, 2014). It also damages air quality (Saenz de Miera and Rossello, 2014), and is to be blamed for other environmental negative externalities such as noise (Becken, 2006). In a context where the private vehicle is to be blamed for this range of non-desirable effects, public transport systems must arise as a solution to mitigate the environmental impact caused by visitors' intra-destination mobility decisions. Destinations' mobility managers should adopt a combination of what Stradling *et al.* (2000) called as pull and push actions. While the former

aims to encourage visitors to use public transport, the latter pursues to prevent them from the use of other more pollutant alternatives during their stay. Pull actions that could contribute to enhance the number of visitors who take public transport at the destination are diverse.

Following Gronau and Kagermeier (2007) pull actions should involve the extension of the service to the whole visitors' catchment area and long-term communication campaigns. As visitors have a range of places, transports and activities to choose and combine during the stay, public transport will not be demanded unless it is competitive enough throughout the whole catchment area. Regarding campaigns, their importance lies in the fact that the tourist is not familiar with the public transport system of the place visited. Thus, it is central to precisely identify origins, destinations, and routes in order to define visitors' catchment areas, and to disentangle travel profiles for a more selective design to ensure the success of communication campaigns. Gronau (2017) also suggests the integration of different public transport modes through the implementation of ITS (Intelligent Transport Systems) and the integration of tourist supply with transport. In both cases, data obtained from visitors provide a more accurate knowledge of visitors' travel behaviours and their needs during the stay. Mobility as a service (MaaS) goes beyond public transport integration as it facilitates the full integration of a wide range of transport services into a one user interface (Utriainen and Pöllänen, 2018). As pointed out by Signorile et al. (2018) it can contribute not only to improve the sustainability of the destination but also to provide a better experience to the visitor. The diversity of systems of these technologies in different locations can be a deterrent for their success among tourists nonetheless.

Enhancement of destinations' competitiveness

The importance of the provision of good intra-destination public transport for the development of tourism services has tended to be underestimated by the literature (Law, 2002). However, the contributions of public transport to the competitiveness of a tourist destination are diverse (Mandeno, 2012; Domènech and Gutiérrez, 2017; Hall et al., 2017). In the first place, it increases the potential number of visitors to a certain attraction at the same time that it enables visitors to widen the range of attractions which are accessible to them (Leask *et al.*, 2000; Gutiérrez *et al.*, 2019). In accordance with the enlarged number of attractions which are accessible, tourists' length of stay also can be extended (Gutiérrez and Miravet, 2016a). Public transport also aids to spread visitors around (Albalate and Bel, 2010), which can mitigate the excessive concentration of visitors within certain locations. With respect to visitors' experience at destination, notwithstanding that there is evidence of only a minor impact on overall satisfaction (Thompson and Schofield, 2007), inefficient public transport systems can result in a direct erosion of destinations' reputation (Albalate and Bel, 2010). On the other hand, negative externalities associated with private vehicles such as traffic congestion and pollution impair visitors' satisfaction (Alegre and Garau, 2010). Furthermore, public transport becomes central to promote more walkable, and less dependent on the private vehicle environments, considering that walkability has emerged as a critical challenge nowadays regarding destinations' competitiveness (Anton Clavé, 2019).

Guaranteeing quality and comfort of public transport services for the resident population

Both previous challenges stress the importance of transferring intra-destination visitors' mobility from the private vehicle to the public transport. Nevertheless, an increase in visitors' use of public transport imposes additional pressure on the system to meet service quality and comfort that local residents not only demand, but also deserve. The additional demand associated with the use of public transport by non-residents yields congestion (Albalate and Bel, 2010). Moreover, the on-boarding of an increasing number of users with limited knowledge of the fare system of the area can compromise the operating speeds. Besides, in some situations, the managers of the public transport system will have to operate services that will be attractive to the visitors, but not to the residents, which could imply a reduction of the revenue. Meanwhile, on the other hand, services used simultaneously by residents and non-residents require the satisfaction of needs that may be divergent between the groups.

Seasonality generates additional complexity as services have to adapt to demand oscillations. As a result, information to the users becomes essential in a context where effective communication channels might be different between residents and visitors (Gronau and Kagermeier, 2007). Besides, demand oscillations can cause revenue and operational disruptions to the service provider (Gutiérrez and Miravet, 2016b). In a

context of tight competition between tourist destinations and crescent concern for environmental issues, the need that public transport properly tackles the previous challenges becomes a pressing matter. This is a goal which is impossible to attain without the suitable sources of information, especially when tourism demand is not evenly distributed throughout the year. In fact, the number of works examining seasonal mobilities is very scarce due to the lack of appropriate data (Wang *et al.*, 2018).

The present chapter aims to analyse the sources of data that can aid public transport managers to successfully face the aforementioned challenges in seasonal tourist destinations. It must be taken into consideration that traditional sources of data on mobility have tended to focus on residents' spatial behaviour, while they have tended to neglect how visitors move around. Besides, they have also lacked a dynamic perspective which is essential to capture the oscillations associated with seasonality. Conversely, in the recent years the advent of big data deriving from smart public transport ticketing and mobile phones, along with the adaptation of traditional data sources such as surveys to the tourist context provides a precious tool to more precisely decipher the spatial needs and behaviours of visitors, as well as the interaction with the resident population.

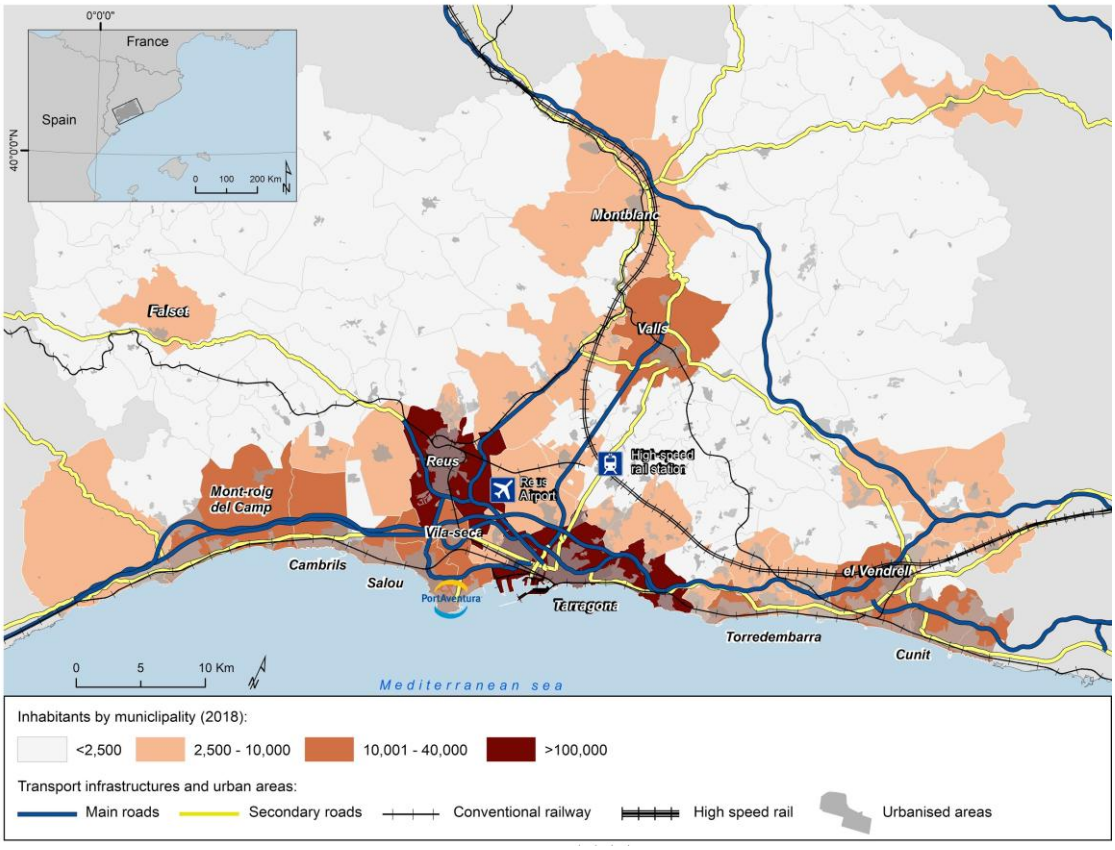
Our attention is drawn by new or relatively new sources of data, and their contribution to better depict the mobility decisions of the visitors and the potential attraction of public transport users from the most pollutant modes of transport within a scenario of strong tourist seasonality, such as the Camp de Tarragona and its touristic brand Costa Daurada (South Catalonia, Spain). The main focus will be placed on the smart travel cards that gather information on the bus utilization by its owner. Big data derived from mobile phones, specific mobility surveys to visitors, and physical measurements for each mode of transport are also covered as part of these alternative data sources. The layout of the chapter is structured as follows: introduction is followed by an analysis of the impact of tourist seasonality on public transport demand, third section centres on the characteristics, advantages and disadvantages of each source of data, and finally, the fourth section is discussion and conclusions.

2. Tourist seasonality and public transport demand

The impact of seasonality on public transport demand has received little attention from researchers despite the fact that it conditions the daily provision of the service due to the deep variations of demand along the year. To illustrate this point, we use data taken from an important tourist destination such as the Costa Daurada. It is the tourist brand from Camp de Tarragona, a Spanish area located in Catalonia, 100 km at the south of Barcelona, whose whole population in 2018 was 617,504 inhabitants. Tarragona, its capital, is a medium sized city inhabited by 132,099 people. In spite of its roman heritage which is catalogued as World Heritage by Unesco, the main points of attraction for tourists are the beaches belonging to the towns located in the central part of the Costa Daurada (Salou, Cambrils and Vila-seca), along with Port Aventura, a theme park located within the municipalities of Vila-seca and Salou, which received 3,6M visitors in 2017. Near them, Reus is another medium sized town inhabited by 103,477 people. The proximity and good communications between these cities and towns enable tourists to move easily and fast from one place to the other.

There are no recent residents' modal splits of the whole Camp de Tarragona area as the latest ones date from 2006. According to them, mobility patterns in the Camp de Tarragona area were characterised by the preponderance of walking with up to 47.3% and the private vehicle with 46.2%. In contrast, public transport had 6.1%, and the weight of the bicycle was almost marginal with 0.5%. Public buses concentrated 4.2% out of the public transport share, while rail transport was much lower, with 1.3%. The high share of walking in urban trips is the result of the compact and dense urban structure of the towns and villages of Camp de Tarragona. In contrast, the lower use of public transport by locals is the consequence of the complex policentrical structure of the territory.

Map 1. Geographical context



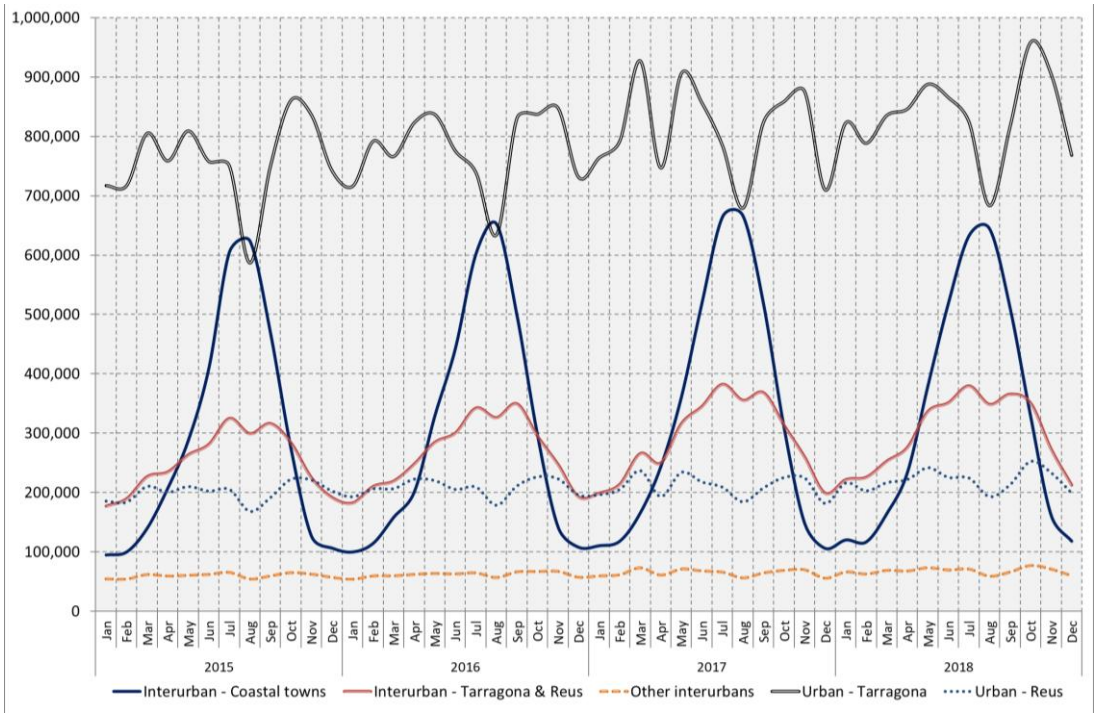
Source: Authors

According to the data provided by the PCTTO[1], the area received in 2018 5.5 M tourists, who spent a total amount of 20.2M overnight stays. The tourist activity within the area is highly determined by seasonality (Duro & Farré, 2015). In fact, the 38% of total overnight stays in 2018 took place during just two months, July and August. The percentage grows up to 66% if June and September are also taken into account. Conversely, the percentage drops to 4% when the demand of November, December, January and February are added together. Literature has highlighted several impacts of seasonality which involve employment instability, limits on the profitability of investments, mismatch in loading capacity, fluctuations in prices, environmental deterioration and, various sociocultural effects between visitors and residents (Cisneros *et al.*, 2018). The analysis of its impact on public transport is nonetheless very limited (Gutiérrez and Miravet, 2016b), despite the fact that the concentration of tourists during certain year periods directly reflects on the public transport demand. According to the data provided by ATM Camp de Tarragona[2], the total amount of public transport travels registered in 2018 was 20,1M. The yearly distribution of these trips presents deep variations depending on the geographical context of the trip, as it is shown in figure 1.

[1] Parc Científic i Tecnològic del Turisme i l'Oci (Scientific and Technical Pak of Leisure and Tourism)

[2] Autoritat Territorial de la Mobilitat (Mobility Territorial Agency) Camp de Tarragona. This public agency is in charge of the integrated public transport system of the area.

Figure 1. Monthly evolution of public transport trips between 2015 and 2018.



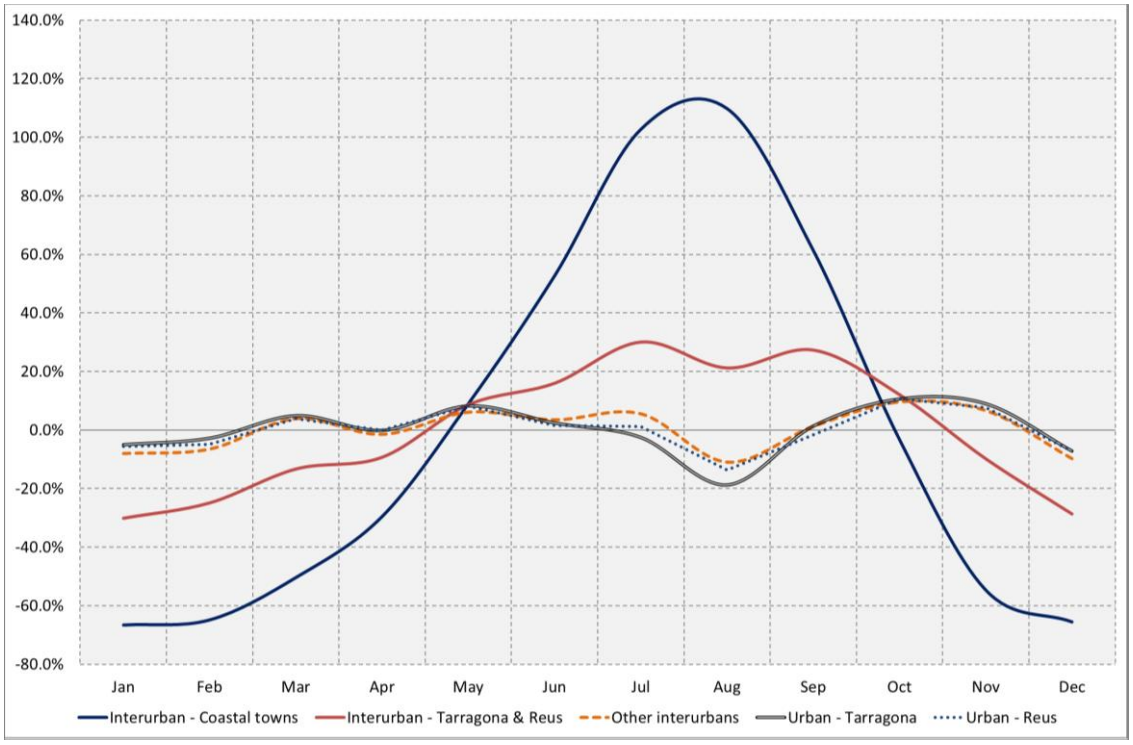
Source: Own elaboration based on data provided by ATM Camp de Tarragona

Figure 1 shows the coexistence of two types of divergent patterns. In the first place, urban transport demand, both in Tarragona and Reus, as well as interurban transport demand in non-coastal towns are defined by a pretty stable evolution of demand along the year. The main disturbance of their stability stems from the reduction of commuting trips due to the arrival of the holiday period. On the other hand, deep monthly oscillations emerge in the interurban demand within coastal towns, Tarragona and Reus. In the case of the interurban demand of Reus and Tarragona, the difference between the lowest and highest monthly figures of travels range from 75% and 100% depending on the year. These fluctuations sharply deepen when the analysis moves to coastal towns, which register much larger variations. The number of interurban trips tends to be around six times higher when the month with the highest number of travels is compared to the month with the lowest one. A closer look at the municipal level reveals even greater differences. In Salou, the town that receives the largest number of tourists, the summer use of public transport is 10 times higher in comparison with the winter.

To verify the incidence of seasonality, seasonality indexes for each month have been calculated. Previously, mobile averages of order 12 were calculated and divided by the monthly average number of trips of the whole period so as to build correction coefficients to get rid of the effect of the trend. Monthly numbers of trips are subsequently divided by these correction coefficients. Finally, seasonality indexes for each month (S_i) are obtained as the result of the ratio between the monthly average number of trips (A_i) and the global average of trips (A) minus 1.

$$S_i = A_i/A - 1 \quad \text{for } i = 1, 2, ..., 12 \qquad (1)$$

Figure 2. Seasonality coefficients between 2015 and 2018 correcting the trend effect.



Source: Own elaboration based on data provided by ATM Camp de Tarragona

Figure 2 compares the monthly evolution of seasonal indexes for the same classifications of municipalities and type of services as presented in figure 1. What appears in figure 2 clearly supports the existence of a marked seasonality in the interurban coastal towns. In January, February and December these towns are around ⅔ below the average demand, whereas in July and August the average is doubled. None of the other categories exhibits such a marked trend. The only category that presents an increase of demand during the Summer months is the interurban services at Tarragona and Reus. The growth of trips during the Summer reaches at the maximum 30%, and the average demand during August is below the one of the months of July and September. The rest of the categories exhibit patent stability throughout the year and a very close evolution of the indexes. These data make apparent the incidence and pressure that the activities which are inherent to the tourist sector can exert on a public transport system, especially when the arrival of visitors behaves seasonally.

3. Available sources of data

In recent years there has been a burgeoning research interest in tourism mobility. This interest has been favoured by the advent of new technologies that have enabled researchers to improve the quality of data used (Hannam *et al.*, 2014). Research efforts using these new technologies have tended to centre on the spatial and temporal dimensions of mobility (Jin *et al.*, 2018), while a lesser number of works have explored visitors' choices among the range of intra-destination modes of transport options. Regarding public transport, the number of contributions that have explored their use by visitors is even lesser. Moreover, seasonal mobility is an issue by itself. In this vein, seasonal travel patterns have been seldom analysed due to data unavailability (Wang *et al.*, 2018). The present section addresses how different sources of data can contribute to the managing of the use of public transport by tourists, and more particularly in those destinations whose main characteristic is seasonality, taking into consideration their advantages and disadvantages while devoting specific attention to the use of big data sets derived from smart travel cards.

3.1 Traditional sources of data on tourists' public transport intra-destination trips

Most of the works that have analysed intra-destination tourism mobilities from the mode of transport perspective have used the data provided by surveys in which visitors were asked about the places they had visited (or were intending to visit) during their stay, as well as the mode of transport they had used (or were intending to use). As a result, researchers have been able to examine the factors that make tourists more likely to become public transport users (Gross and Grimm, 2018). However, most of these surveys did not link the places visited with the modes of transport used to visit them. As a consequence, there is knowledge on whether the tourist has become a public transport user during the stay, but there is no information on the attractions that have been reached by public transport (Le-Klähn *et al.*, 2015). However, along with the lack of detail regarding the basic different dimensions of the public transport travel (what was visited, when, how long the travel lasted), the main handicap lies in the static nature of surveys, which provide a fixed photograph of visitors' mobility. The concerns attached to this issue grow when the inflows of tourists follow seasonal schemes. Other shortcomings are the high costs, low response rate, and misreporting (Shen and Stopher, 2014).

3.2 Big data sets derived from smart travel cards

As opposed to surveys, big data sets derived from smart card automated fare collection systems are characterised by its dynamic perspective as every time a user gets on the public transport vehicle a transaction is collected by the system. As a result, millions of observations are gathered together offering valuable information to understand users' behaviour as well as to help to improve service quality (Schmöcker *et al.* 2017). Given that all transactions are collected, there is total flexibility to combine any time and geographic frameworks (Morency *et al.*, 2007). The utilization of this type of data is not a novel research topic as its usefulness for analysing users' behaviour along with the potential for improving quality service has been underpinned by Bagchi and White (2005) and Pelletier *et al.* (2011). In fact, it has been frequently used to identify different profiles of public transport users (Ma *et al.*, 2013), and to reconstruct origin-destination matrices (Alsger *et al.*, 2015). Nevertheless, analyses within the context of tourist destinations are still relatively scarce (Lu *et al.* 2019).

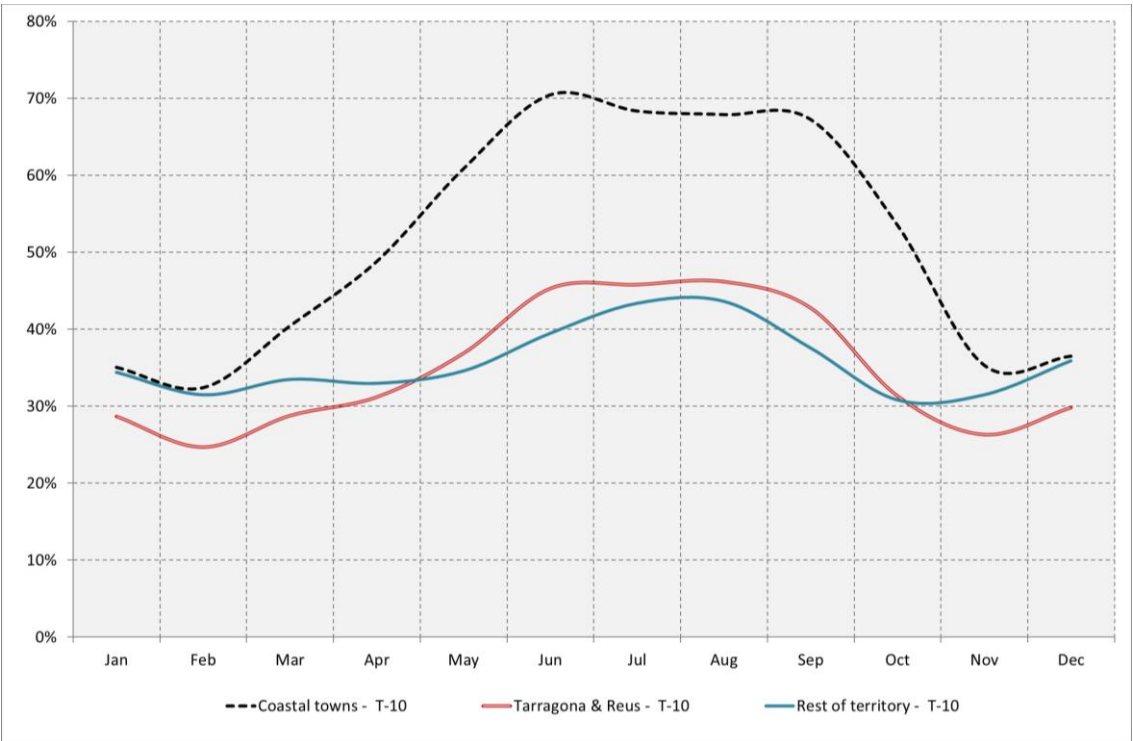
Collaborations between public transport authorities and research institutions have become a frequent strategy for the analysis of this specific typology of data source (Wu *et al.*, 2015). An example of this collaboration is the research project carried out by a research group belonging to the Rovira and Virgili University - GRATET[3] - together with ATM Camp Tarragona, which has been awarded in 2018 with public funding by the regional Government of Catalonia. The aim of this project is twofold. In the first place, it pursues to disentangle the patterns of public transport use made by residents from those of visitors. In this sense, the divergences between both types of user can be captured by some revealing elements. For instance, Wu *et al.* (2015) identify visitors by means of the transport ticket used and the geographical distribution of the trips. Also the time framework is key to properly identify visitors: time span during which the smart travel card was used, year period in which it was used; and day times. The second goal is to explore smart card automated fare collection systems so as to generate sensible information to plan transport services and to design tailor-made transport policies within contexts of non-regular arrival of tourists throughout the year.

Tourism and its seasonality determine the patterns and evolution of a range of some critical elements of the functioning of the public system. Hereafter, the analysis of some of these impacts is examined by means of smart card data. A first effect lies on the type of transport ticket used. T-10, given that it does not establish any time limitations of consumption, and it can be used by more than one person at the same time (allows travelling in group), is the most preferred option by tourists. Figure 3 presents the distribution of transport tickets in three different contexts of interurban services: coastal municipalities, the cities of Tarragona and Reus, and the rest of the Camp de Tarragona. The graph makes apparent the soar of the use of T-10 during the summer period, which reached 70%. The growth in Tarragona and Reus is much more modest, while the rest of the territory clearly exhibits the most stable pattern. Not only the typology of transport tickets, but also the time span during which the travel card is used is affected. A 21.8% of the total number of cards used

[3] Research Group in Territorial Analysis and Tourism Studies.

in 2018 had an activity span[4] of 3 or fewer days. The percentage rises to 36.2% if the card activity span considered is 7 or fewer days. In fact, the 42.4% of the total number of cards that were used to travel in 2018 registered transactions only during the peak season period, which comprises the months of June to September.

Figure 3. Monthly evolution of the proportion of travels undertaken with T-10 fare versus the other fares

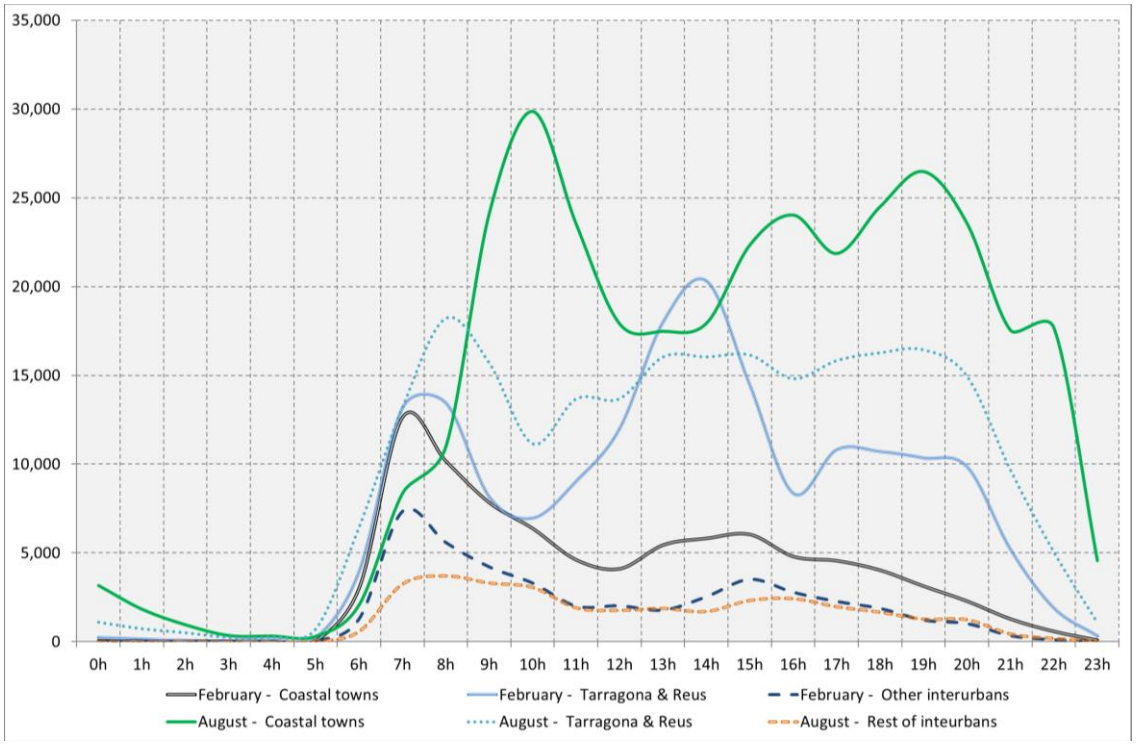


Source: Own elaboration based on data provided by ATM Camp de Tarragona

A second dimension relates to time slots. Figure 4 compares the interurban public transport use in the Camp of Tarragona area in the coastal municipalities, the cities of Tarragona and Reus, and the rest of the Camp de Tarragona. Main differences between February and August basically refer to the softening of the peaks of use in the latter case, together with a time slot deferral of the demand. Again, the differences between both months do not emerge evenly across the territory. They are much more pronounced in the coastal towns; while in the interior towns (rest of Camp de Tarragona) the patterns are more stable along the year. In the case of Tarragona and Reus, their August curve is a hybrid between their February curve and the coastal August curve.

[4] Activity span is defined as the number of days between the first and the last transaction.

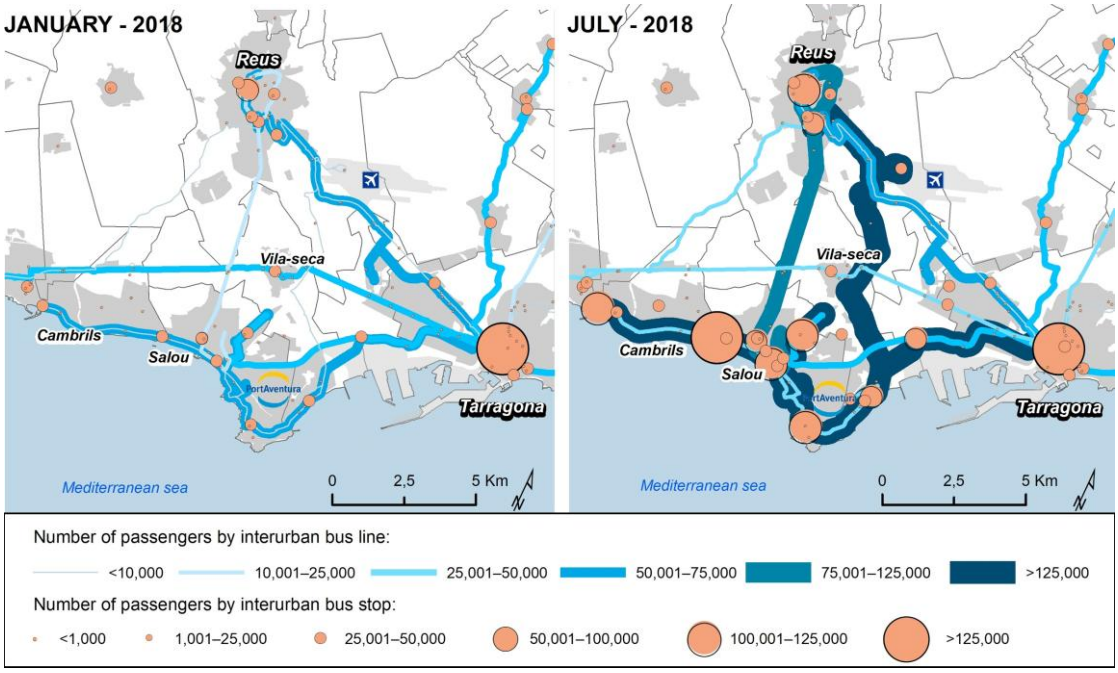
Figure 4. Use of public transport by time slots in February and August of 2018.



Source: Own elaboration based on data provided by ATM Camp de Tarragona

From a geographical perspective, smart travel card data allow bringing the scope of analyses to the smallest possible scale, which in our context are bus stops. Besides, geographical information can be combined with any desired time dimension. In order to illustrate this point, **Map 2** compares the number of boardings by bus stop and bus line in February and August of 2018. The map highlights the extent to which the public transport demand boosts in those bus stops located in the central Costa Daurada area during the peak season, in opposition to the interior areas whereas it remains pretty much stable. Similarly, the map also signals that this asymmetric demand growth between the coast and the interior is replicated when the focus moves to bus lines. The possibility of combining any geographical scale with any time dimension enables public transport authority managers and researchers to assess the impact of bottlenecks or any other incidences with very particular patterns of occurrence such as the impact of events such as strikes, festivals, weather phenomena, or accidents. In the case of isolated events, as the ones previously suggested, ex-post information can be of aid to adapt the service to future similar eventualities as long as they can be foreseen in advance. In the case of continuous disruptions, actions can be designed and subsequently implemented. Smart travel card data also provide data to assess the effectiveness of the actions undertaken.

Map 2. Number of travels by bus stop and bus line in February and August of 2018



Source: Own elaboration based on data provided by ATM Camp de Tarragona

Regarding service performance, smart travel card data provide accurate information that allows the construction of performance key indicators such as commercial speed, vehicle-kilometres, passenger kilometres, schedules adherence or load profile (Trépanier and Morency, 2017). In the context of irregular inflows of visitors, processes such as the boarding of vehicles can be impinged by the soar of the demand during certain periods of the year which results in higher numbers of people getting on public transport vehicles, and also by the increase of the use of single use ticketing, given that non-residents are more likely to acquire single tickets which are paid with coins on the bus. **Table 1** illustrates this point by comparing boarding times in the low and the peak season. Hence, smart card data become a useful tool to pinpoint bottlenecks (Makimura *et al.* 2017).

Table 1. Time needed to get on the vehicle at Tarragona bus station. Comparison between 08/03/2018 (12:00 - 13:00) and 20/08/2018 (12:00 - 13:00)

Season	Day – time slot	Travellers	Single tickets %	Total time needed	Seconds per traveller
Winter	08/03/2018 – (12:00-13:00)	77	30%	11'17"	9"
Summer	20/08/2018 – (12:00-13:00)	128	43%	29'41"	14"

Source: Own elaboration based on data provided by ATM Camp de Tarragona

Actions implemented in Camp de Tarragona using smart travel card data

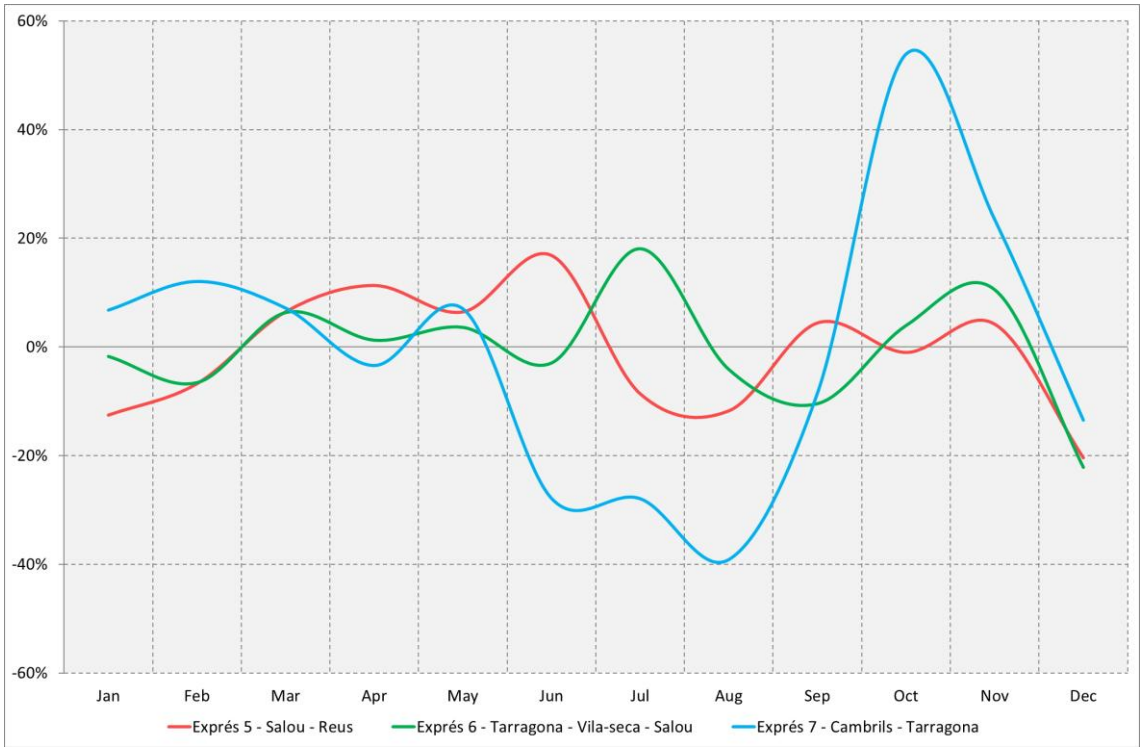
From a more applied perspective, the use of the SGIT data has enabled public transport managers of Camp de Tarragona bus services to more precisely detect disturbances that compromise service quality and implement actions that correct them. Following the three levels of analysis that, according to Pelletier et al. (2011), are enabled by smart travel card data (strategic-level studies: long-term planning; tactical-level studies: service adjustments; and operational-level studies: calculation of precise performance indicators), Table 2, 3 and 4 synthesize how three different disturbances at the strategic, tactical and operational levels have been respectively identified and tackled.

Table 2. Actions implemented at the strategic level

Problems detected with smart card travel data	Action	Result
Local residents face the impacts of overcrowding during the summer period at some times of the day in the bus stops of highly touristic locations. It makes services slower and the experience less pleasant.	Creation of Express bus lines to separate flows of users with different needs: ● Salou – Reus (July 2017) ● Salou – Vila-seca – Tarragona (September 2017) ● Cambrils – Tarragona (January 2018) The aim of these services is to provide fast connections between the most important towns of Camp de Tarragona, attractive for residents and less appealing for tourists.	These lines have important numbers of riders (276,375 trips in 2019). They lack accused peaks during the Summer period (see Figure 5).

Source: Own elaboration

Figure 5. Seasonality coefficients between the putting of the service and 2019 of the lines Salou – Reus, Salou – Vila-seca – Tarragona, and Cambrils – Tarragona correcting the trend effect.



Source: Own elaboration based on data provided by ATM Camp de Tarragona

Table 3. Actions implemented at the tactical level

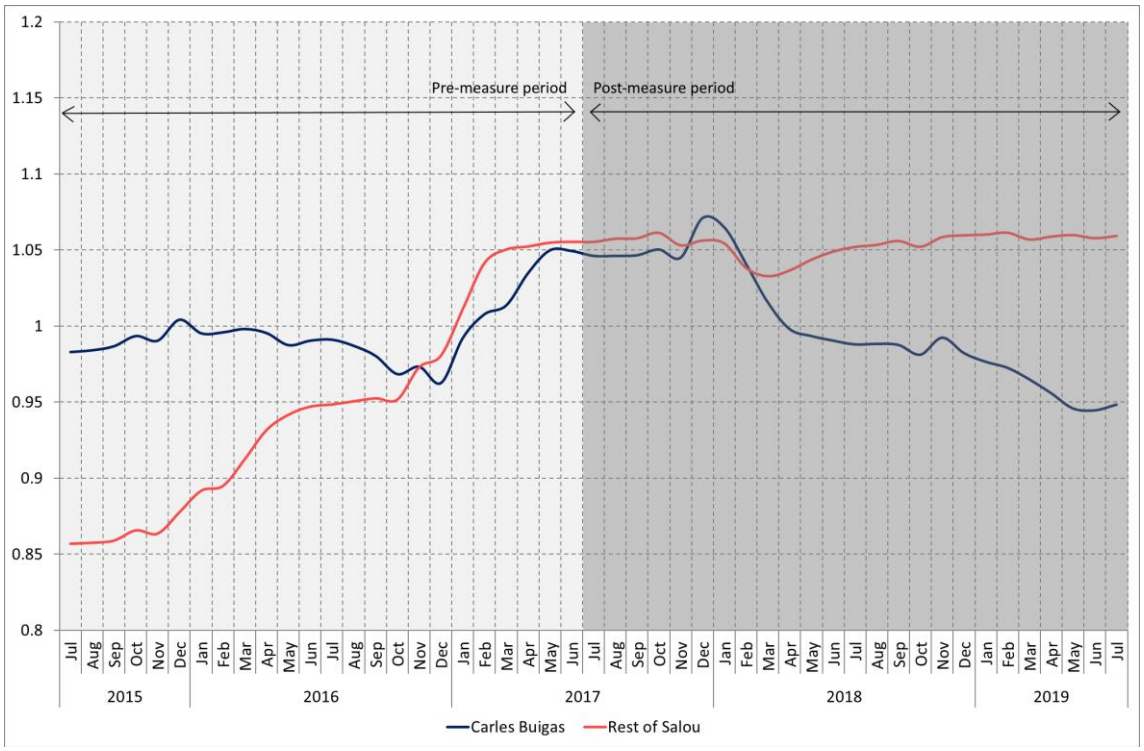
Problems detected with smart card travel data	Action	Result
Congestion at certain central locations and bus stops during certain times in the tourist season. Public transport has to face busy streets full of pedestrians and private vehicles. It is the case of Carles Buigas street in Salou. During the peak season this street registered an average daily traffic of 240 buses. There are marked differences between traffic flows between the winter and the summer season, at the crossing where Carles Buigas street starts.	Public transport services were diverted from Carles Buigas street to Barbastre street in July of 2017 (see **Map 3**). Currently, bus services circulate by the latter street, which is parallel to the former (see **Map 3**).	No drop of users in bus stops of the Carles Buigas area were registered just after the change. As reflected in **Figure 6**, moving averages reached their peak in this area in December of 2017. Afterwards, they started a slight decline, which contrasts with the slow growing trend of the rest of the bus stops of the municipality. This latter tendency is the consequence of the consolidation of the express services which absorbed part of the travellers of the Carles Buigas area (see **Figure 6**). The town hall of Salou has developed a plan to transform Carles Buigas into a pedestrian friendly street (see **Map 3**).

Source: Own elaboration

Map 3. Synthetical representation of the measures taken to diminish congestion at central locations and bus stops in Salou.

Source: Own elaboration

Figure 6. Monthly evolution of boardings registered at bus stops near Carles Buigas vs. other bus stops of Salou



Units: Ratio between moving averages of order 12 and the global monthly average of boardings
Source: Own elaboration based on data provided by ATM Camp de Tarragona

Table 4. Actions implemented at the operational level

Problems detected with smart card travel data	Action	Result
Slower on-boarding process during the peak season	Campaigns have been planned to enhance the prior acquisition of the bus tickets instead of doing it on-board. The bus station of Tarragona is one of the places where the transport operator informs the users that they should buy bus tickets in advance.	The effect is still to be seen. 2020 is not a good year to assess the effectiveness of actions due to the disruptions caused by the COVID-19.

Source: Own elaboration

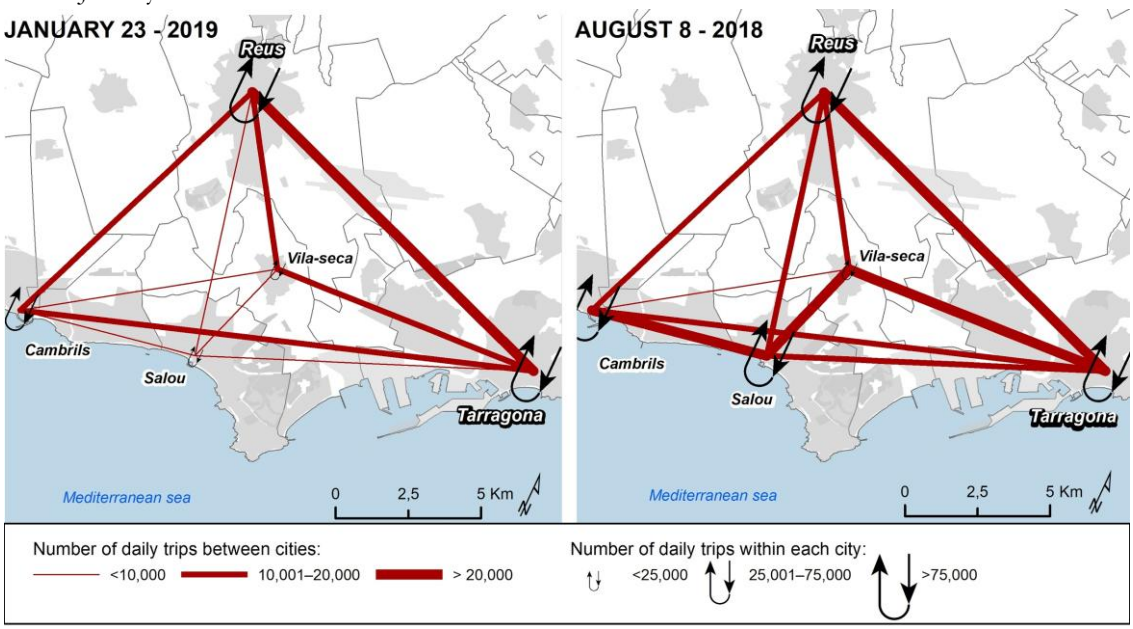
To summarise, smart travel card data offers highly valuable information to understand particular public transport dynamics that combine both residents and visitors' demand, which are essential to adapt the service to the needs of their users, as well as to improve the quality of the service and to mitigate the impact of incidences and bottlenecks. These data are not exempt from drawbacks. By definition data are restricted to public transport records. It implies that records do not contain any socioeconomic information. Moreover, in most occasions there is also a lack of information on alighting that obliges to reconstruct origin-destination matrices by means of algorithms (Alsger *et al.*, 2015).

3.3 Other sources of data

The availability of data related to the use of other transport modes is also necessary to measure the potential gain of users by transferring them from other transport options. The present section will briefly review other potential sources of data: passive mobile positioning data, specific mobility surveys to visitors and traffic measurements.

Each mobile phone can be assigned to network cells as they connect to antennae (Ahas *et al.*, 2008). As a result, this technology makes it possible to examine visitors' spatial behaviour with the same flexibility attached to the time and space dimensions that provides smart travel card data. The difference is that all mobilities, regardless of the mode of transport used are sensed. Another advantage is that its technology easily allows the distinction between residents and visitors, as stays can be detected. It also makes it possible to distinguish specific groups, which is very useful when the interest places on "hard-to-reach groups" (Wang *et al.*, 2018). Also within the framework of the aforementioned research project between GRATET and ATM Camp de Tarragona, the differences in mobility flows between the peak tourism season and the low season have been assessed. As an example, **Map 4** compares the estimated mobility by means of passive mobile positioning within Tarragona, Reus, and the three central Costa Daurada towns (Cambrils, Salou and Vila-seca) in two different days: 8th of August of 2018 and 23 of January of 2019[5]. Globally, the mobility in the peak season day is 34% higher in comparison to the low season day. However, the map unveils that the mobility increase between both days is particularly intense in some relationships, whereas other fluxes remain at similar levels, or even shrink due to the reduction of the mobility attached to work or study reasons.

Map 4. Comparison of mobility fluxes within the municipalities of Tarragona, Reus, Cambrils, Salou, and Vila-seca estimated by means of passive mobile positioning data between the 8th of August of 2018 and the 23rd of January of 2019.



Source: Own elaboration

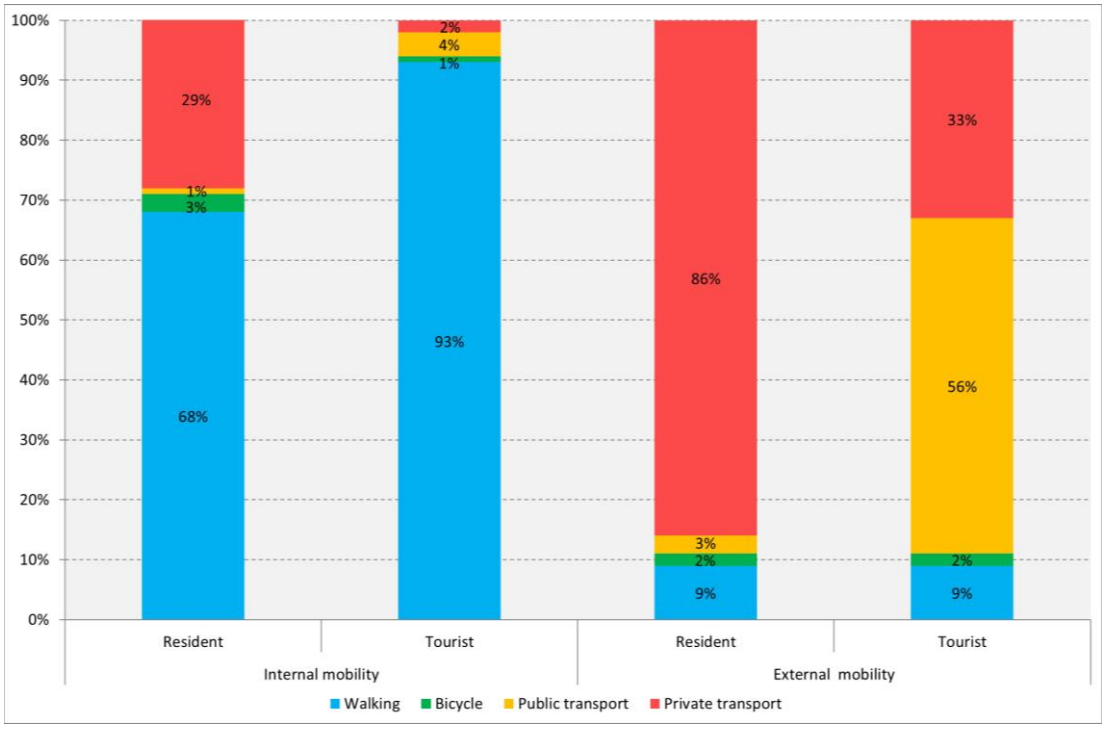
Other passive forms of collecting visitors' mobility information are visitor/destination cards (Zoltan and McKercher, 2015), geo-referenced social media, such as geo-tagged content from Twitter (Chua *et al.*, 2016), or geo-tagged photos from Flickr (Vu *et al.*, 2015), as well as other sensor-based data collected by popular applications and applications designed to collect travel behaviour data for specific research purposes (Wang *et al.*, 2018). The main advantage beyond the time framework flexibility of any type of passive forms of collecting visitors' mobility information lies on the massive data collected in real time irrespective of the size of the geographic scales (Girardin *et al.*, 2008). On the contrary, the main shortcomings are associated with

[5] Both of them are Wednesday. There is no evidence of any particular incidents that could contaminate the patterns of a usual peak and low season days.

the difficulties to combine this type of data with socioeconomic information (Shoval and Ahas, 2016) along with the complexity of extracting transport modes (Chin *et al.*, 2019). A higher degree of precision can be achieved by using active data sources such as GPS data and Bluetooth technologies (Shoval and Ahas, 2016) as the number of observation points is considerably higher. However, this comes at the price of having much smaller samples which results in a substantial shrinkage of data representativeness. This relevant drawback turns into an advantage when the number of observations makes it possible to combine active data sources with surveys (Sugimoto *et al.*, 2019). The duration of the period of data collection also tends to be limited, which arises as an inconvenience to examine dynamic phenomena.

Undoubtedly, the best way of gathering socioeconomic and mobility information at a time is by means of mobility surveys addressed to visitors. These surveys combine three blocks of questions. The first of them comprises specific-mobility questions. The second gathers travel and stay characteristics. The third block collects socioeconomic data. A specific mobility survey to tourists[6] was carried out in the context of the Urban Mobility Plan of Salou[7] in 2018. As shown in figure 7, in which residents' and tourists' modal shares are presented, tourists have a very sustainable and active mobility within the municipality. Their use of the private vehicle is limited to just 2% of the trips, whereas for the resident population the percentage rises up to 29%. None of the groups shows a substantial use of local public transport, even though in the case of tourists the percentage is higher: 3.5% (2.6% corresponds to public buses).

Figure 7. Modal splits of tourists staying in Salou during the summer of 2018.



Source: Own elaboration based on data of the Urban Mobility Plan of Salou.

The scenario dramatically changes for interurban mobility: there is a considerable drop of the active modes for the tourists, and differences between locals and tourists widen. While 86% of the residents' trips depend on the private vehicle, the dominant mode of transport for tourists is the public transport (56.5%). Public bus services are clearly their most frequent choice, with 48.4%, while rail services have a share of 6.8%. Although the private transport use for tourists' trips is much lower than its use by the resident population, there is still a margin to improve. In this regard, the items of the questionnaire would allow identifying the profiles of those tourists that are more inclined to use each of the modes. Thus, the identification of relationships between

[6] The questionnaire was administered to visitors who were staying overnight in Salou, and hence, excursionists were excluded from the sample.

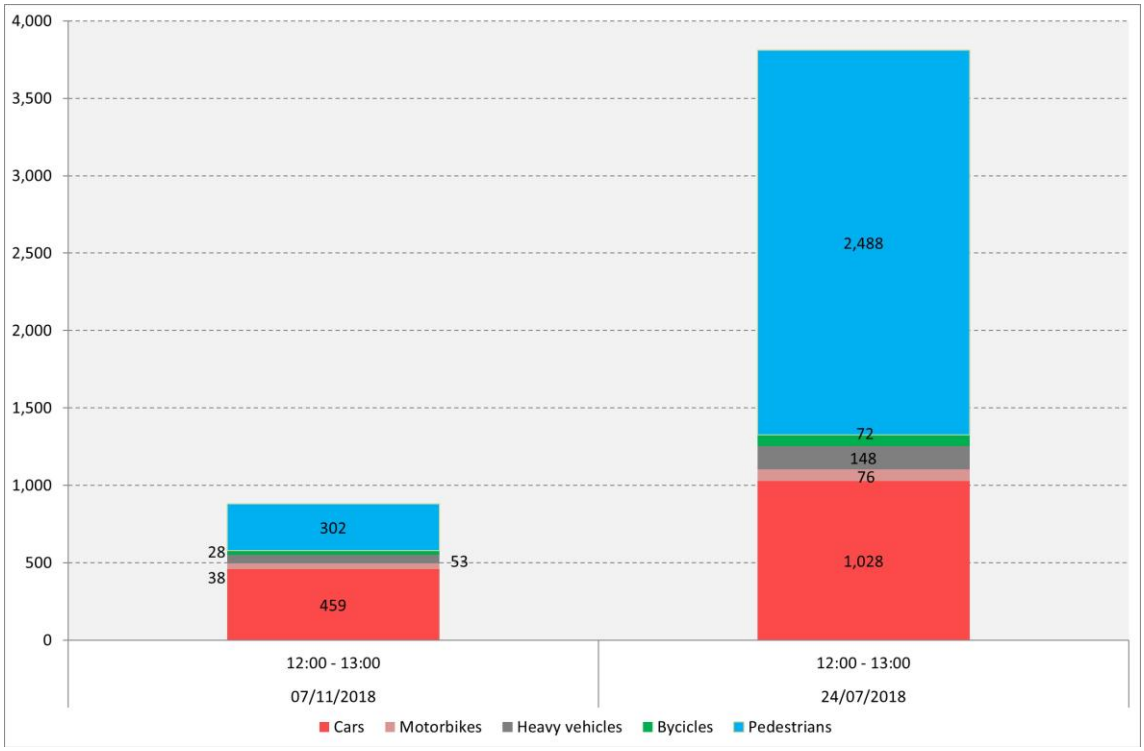
[7] Works in progress

modal decisions and peoples' characteristics would be a first step to design more precise mobility actions focused on certain segments of residents or tourists.

In contrast with the surveys commented in section 3.1, this type of survey offers detailed information on all the movements undertaken by the tourist including who, origin and destination, when, and how. The main shortcoming, analogously to the surveys commented on section 3.1, is the inability to capture dynamic processes. It could be circumvented by carrying out similar surveys throughout a long period of time so as to capture the different scenarios caused by seasonality. Nonetheless, the collection of representative survey based data of different moments of time would imply a considerable growth of the already high cost of surveys.

A much cheaper alternative, although it entails the complete loss of data centred on individuals, is to carry out traffic measurements of the different transport modes at different moments of time. As an example, figure 8 exhibits the different traffic flows in the peak and low seasons by mode of transport[8] in one of the most crowded intersections of Salou. According to the graph, total mobility in a peak season day is more than 4 times higher in comparison to a low season day. However, the growth is particularly large for pedestrians in this particular point, as walking movements are multiplied by 8, while the registers of the rest of the transport modes tend to be between 2 and 3 times higher.

Figure 8. Traffic flows in the intersection of Passeig Jaume I with Av. Andorra of Salou by mode of transport: 7/11/2018 (12:00 – 13:00) vs 24/07/2018 (12:00 – 13:00)



Source: Own elaboration based on data of the Urban Mobility Plan of Salou.

4. Discussion and conclusions

The 4-W paradigm put forward by Kim and Fesenmaier (2015) suggests that tourism mobility involves "who, where, when and what". This framework sets aside an intrinsic and essential part of mobility: "how". The importance of the "how" is highlighted by Hannam *et al.* (2014), who argues that "the action of travel may be not only to serve a particular purpose but can also act as an integral feature of many tourists' experiential demands". This reasoning directly connects with one of the demanding challenges faced by public transport

[8] Almost the entire traffic of heavy vehicles refers to public transport vehicles.

systems in the context of tourist destinations: to enhance destination competitiveness. Not only this, the deployment of public transport services around tourist destinations also has to consider other two main additional challenges to which has the obligation to contribute: to improve environmental sustainability and to guarantee quality and comfort for the local resident population.

The degree of complexity to satisfy these challenges is substantially augmented if a common characteristic shared by many tourist destinations is added to the equation: seasonality. Seasonality implies that not only who uses the public transport or the potential users are changing throughout the year, but also the characteristics of the demand. In other words, how transport services are used considerably change. Under these circumstances, the quality of data becomes essential to confront the aforementioned challenges. The present chapter of this book has examined the potential contributions of different sources of data to the understanding of the mobility patterns in seasonal tourist destinations, stressing the pros and cons of each of them. To do so, data collected in Camp de Tarragona, the region where the Costa Daurada is located, have been used. Costa Daurada is one of most important coastal tourism Spanish brands, and is an outstanding example of seasonality. The oscillations in the tourist flows between the peak and low season are so intense that the mobility patterns and more particularly the public transport demand of the area are completely reshaped from one period to the other (Gutiérrez and Miravet, 2016b). The present contribution has appraised how the particular dynamics of seasonal intra-destination mobility can be approached using these sources of information, and in the case of smart travel card data, it has illustrated how they can support the management of transport authorities and operators in decision-making processes at the strategic, tactical and operational level.

The main objective was thus to address how data can aid to successfully manage public transport companies in contexts of intense seasonality. Following Bagchi and White (2005) and Pelletier *et al.* (2011), it has been shown how big data records derived from smart card automated fare collection systems can support public transport managers. Nonetheless, seasonality poses additional pressure to portray the actual profiles of public transport users. In this context, the analysis of smart travel card data offers complete dynamic information on the type of transport tickets demanded, origins and destinations, and time dimension that arises as a meaningful tool to disentangle the different users' profiles and how their demand evolves during any time framework. It has also been shown how this sort of data is very useful to improve service quality as it allows the identification of the impacts and incidents caused by the irregularity of public transport demand. In this regard, examples have been provided of how particular service disturbances have been detected, measured and tackled by implementing specific actions whose effectiveness can be also assessed. The main drawbacks are that data stick to public transport users and they lack users' socioeconomic information.

In line with Ahas *et al.* (2008), it has been also highlighted how passive mobile positioning data make it possible to depict the whole mobility scene of a territory during any time framework, and therefore, to capture its dynamics through different periods and time slots. It also easily allows distinguishing residents from visitors, and also detecting different profiles of visitors. This is basic to ascertain the potential growths of public transport demand bringing visitors to places that they are not able to access otherwise. On the contrary, precision does not allow disentangling modal splits (Chin *et al.*, 2019). Neither smart travel card data nor passive mobile positioning data include exhaustive socioeconomic data. These can be only obtained through specifically designed surveys to capture visitors' mobility, which combine mobility data with the socioeconomic background of the visitor, at the price of losing the dynamic perspective inherent to seasonality and the whole mobility picture of a territory nonetheless. Finally, street measurements of traffic flows by mode at different moments of time have also been examined.

In the recent years researchers have striven to portray human mobility patterns. In this sense, their conclusions signal that daily mobility is characterized by a deep-rooted regularity, and hence it becomes highly predictable by means of the application of the proper methodologies and highly precise data (Song et al., 2010). Predictability of mobility is a key issue to successfully run public transport authorities. In this sense, to be able to anticipate mobility flows can decisively aid to design routes, networks, frequencies and capacities. And not only this, it is also central to attract the users of other less sustainable modes of transport. However, the scenario is not that stable when the tourism sector participates in the public transport demand. And it gets much more complex when seasonality is a prominent characteristic of the tourism sector of a territory,

since the number of variables entering the equation considerably expands at the same path of the diversity of actors with divergent needs to satisfy. Furthermore, many of these variables are far from being constant through time periods, which introduces a dynamic component within the whole picture.

The instability that stems from tourism seasonality should encourage public transport managers from trying to use the tools that are available to them to better adequate supply to present and potential demands. Undoubtedly, the higher the accuracy of the available data, the closer the fit between supply and the diverse and evolving ranges of demand under the particular circumstances of the mobility patterns of their territories. Given that the lack of available data has traditionally acted as a deterrent of the analysis of the impact of seasonality on mobility (Wang *et al.*, 2018), the use of flexible data in terms of the space and time dimensions can effectively contribute to overcome this matter.

At present, in spite of the potentialities that new sources of data offer to public transport authorities, and the fact that there have been numerous successful experiences that have proved their utility, their use is still limited. As pinpointed by Wu *et al.*, 2015, collaborations between public transport authorities and researchers, like the one between GRATET and ATM Camp Tarragona, have proved effective in learning multiple applications of data. This collaboration is particularly promising in the field of public transport provision within contexts of tourism seasonality, where researchers still have several research questions to answer. Among others, the first of them relates to the building of methodologies that allow the simultaneous combination of different data sources. Second, the dynamic perspective caused by seasonality can be introduced in the analysis of visitors' use and needs of public transport based on the identification of a range of visitors' profiles. Third, potential origin-destination matrices taking into consideration the transferral of private vehicles users to public transport can also be estimated. And fourth, analyses regarding how the operating of services is affected by seasonality can also be undertaken.

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