EXPLORING URBAN VISITORS' MOBILITIES. A MULTI-METHOD APPROACH

Antoni Domènech Montaña

UNIVERSITAT ROVIRA i VIRGILI

Exploring urban visitors' mobilities
A multi-method approach

ANTONI DOMÈNECH I MONTAÑA

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FAIG CONSTAR que aquest treball, titulat "Explorant la mobilitat dels visitants urbans. Un enfocament multimètode.", que presenta Antoni Domènech Montaña per a l'obtenció del títol de Doctor, ha estat realitzat sota la meva direcció al Departament de Geografia d'aquesta universitat.

HAGO CONSTAR que el presente trabajo, titulado "Explorando la movilidad de los visitantes urbanos. Un enfoque múlti-método.", que presenta Antoni Domènech Montaña para la obtención del título de Doctor, ha sido realizado bajo mi dirección en el Departamento de Geografía de esta universidad.

I STATE that the present study, entitled "Exploring urban visitors' mobilities. A multi-method approach.", presented by Antoni Domènech Montaña for the award of the degree of Doctor, has been carried out under my supervision at the Department of Geography of this university.

Vila-seca (Tarragona, Espanya), 1 de setembre de 2021
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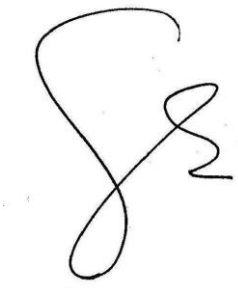

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UNIVERSITAT ROVIRA I VIRGILI
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Aquesta tesi és una fita col·lectiva:

Gràcies per la confiança i el suport incondicional
de tots aquells qui m'heu acompanyat en aquest viatge.

Gràcies, especialment, a la família.

PREFACE

The traditional unavailability of data at urban level for human mobility analysis has made it difficult to implement related research. This scarcity was even more accentuated in the field of tourism mobilities, due to the methodological constraints of capturing data on a floating population contingent. At present, however, there is a huge quantity of data obtained from location-aware technologies (e.g. mobile phone traces, GPS loggers, geolocated social media data, etc.) that have allowed us to break this barrier. Thus, the use of the visitors' digital footprint has opened up plentiful opportunities for developing analytical studies that contribute to identifying, understanding and managing mobility (i.e., spatiotemporal behaviour) at tourist destinations.

Therefore, this dissertation is framed within this research framework. Specifically, it aims to explore urban visitors' mobilities so as to comprehend their spatiotemporal behaviour and identify the effects that their mobilities have on urban tourism destinations. In order to do so, different data sources and different methods have been used and implemented respectively.

To be precise, this research project is based on the compilation of four academic publications that I have carried out in the course of the Ph.D. Program in Tourism and Leisure at the Department of Geography of the Universitat Rovira i Virgili. Accordingly, the present dissertation is structured as follows:

PART I: Consists of two chapters that present the context of the research, describe the research objectives, explain the research design and methodology implemented, and detail the general theoretical framework of the project.

PART II: corresponds to the main core of the thesis, based on the four empirical studies. These case studies cover important research directions related to: 1) the identification of the determinants of sustainable mobility choices taken by tourists once at urban destinations; 2) the understanding of the tourists' spatiotemporal behaviour impact on the economic activity; 3) the analysis of the influence of the built environment on the visitors' mobility at destination; and 4) the detection of over and undervisited city areas. The four case studies are detailed below:

1) Miravet, D., **Domènech**, A. & Gutiérrez, A. (2021). What prompts tourists to become public transportation users at their destination? The case of a Mediterranean city. Travel Behaviour and Society, 24, 10-21. doi: 10.1016/j.tbs.2021.01.007 [JCR Q2 IF: 4.983]

2) **Domènech,** A. Gutiérrez, A. & Anton Clavé, A. (2020) Built environment and urban cruise tourists' mobility. *Annals of Tourism Research*, 81. doi: 10.1016/j.annals.2020.102889 [JCR Q1 IF: 9.011]

3) **Domènech, A.,** Gutiérrez, A. & Anton Clavé, S. (2020) Cruise passengers' spatial behaviour and expenditure levels at destination. *Tourism Planning and Development*, 17(1), 17–36. doi: 10.1080/21568316.2019.1566169 [SJR Q1 IF: 0.727]

4) **Domènech, A.**, Mohino, I. & Moya-Gómez, B. (2020). Using Flickr geotagged photos to estimate visitor trajectories in World Heritage cities. *ISPRS International Journal of Geo-Information*, 11(9), 646. doi: 10.3390/ijgi9110646 [JCR Q2 IF: 2.899]

PART III: presents the discussion about the main findings of the dissertation and provides the general conclusions on the potential of different data sources for the analysis of tourist mobilities. Moreover, a chapter dedicated to some reflections about future research directions is also included.

Note that the research topic, and consequently the objectives formulated (see section 1.2. for more details), have conditioned the use of different data sources and different empirical approaches (see section 1.3 for further information). Consequently, a review of the potential applications of different sources for the study of tourist mobilities has been carried out (see chapter 2). Thus, the thesis can also be useful for researchers in social sciences interested in analysing many aspects related to the sustainability and competitiveness of tourist destinations, from the dimension of mobility.

Before leaving readers to become immersed in the thesis, I think it is important to mention some personal remarks about the meaning of the doctorate for my career and personal development, and also about the results obtained during the process.

I consider the process of doing the PhD has symbolised a personal and professional maturation in which I have invested all my dedication to achieve academic results that I hope to be the seeds of a career linked to academia. During my degree and master's studies, I was fortunate to meet Prof. Gutiérrez, who was the tutor of the final projects. He awakened in me the desire to investigate social issues from a geographical perspective and this, together with my vocation and passion for teaching, placed the option of doing a doctorate at the centre of my priorities. In this context, obtaining a doctoral scholarship was the definitive impulse to start my dream of becoming an academician.

Actually, this doctoral thesis was supported by the Spanish Ministry of Science, Innovation and Universities, through a FPU (acronym of training university professor, from the Spanish "Formación de Profesorado Universitario") grant (FPU15/06947), conceded to me, the doctoral student, and the director, Dr. Salvador Anton Clavé. This grant has allowed for a total of 4 years of full-time dedication to the research project, and has also provided complementary funding to conduct research visits to the following international academic centres:

1) **Universidad Complutense de Madrid** (Spain).
   Research group: Transport, Infrastructure and Territory Group (TGIS), Department of Geography.
   Period: April – June 2019.
   Funding institution: Spanish Ministry of Science, Innovation and Universities (FPU15/06947)

2) **University of Applied Sciences Western Switzerland - HES-SO Valais-Wallis** (Switzerland).
   Centre: Institute of Tourism.
   Period: October – December 2018
   Funding institution: Spanish Ministry of Science, Innovation and Universities (FPU15/06947)

Throughout the years of the doctoral thesis, I have also had the opportunity to devote additional efforts to multiple studies that have given rise to scientific publications, but most importantly to friendships with various authors from different countries and disciplines. In effect, attending international workshops and doing research stays abroad have opened up the possibility for me to establish many collaborations either related to the thesis project or not.

Altogether, at the time of presenting this thesis, I have co-authored twenty scientific articles in peer-reviewed indexed journals, two book chapters and two books. Out of these publications, the following six have a strong relationship with this current work, though they are not included as part of the project:

1) Miravet, D., Gutiérrez, A. & **Domènech**, A. (2021). Sources of Data to Tackle the Challenges of Public Transport Provision in Seasonal Tourist Destinations. In: Zamparini, L. (Ed.) Sustainable Transport and Tourism Destinations (Transport and Sustainability, Vol. 13), Emerald Publishing Limited, 117–138.

2) Gutiérrez, A., **Domènech, A.** & Miravet, D. (2020). COVID-19 and urban public transport services: emerging challenges and research agenda. *Cities & Health*.

3) Gutiérrez, A., **Domènech, A.**, Zaragozí, B. & Miravet, D. (2020). Profiling tourists' use of public transport through smart travel card data. *Journal of Transport Geography*, 88. [JCR Q1 IF: 4.986]

4) **Domènech, A**., Miravet, D. & Gutiérrez, A. (**2020**) Mining bus travel card data for analysing mobilities in tourist regions. *Journal of Maps*, 16(1) 40–49. [JCR Q2 IF: 2.709]

5) **Domènech,** A. & Gutiérrez, A. (**2019**) Determinants of cruise passengers' expenditure at port cities. *Tourism Review*. [JCR Q1 IF: 5.947]

6) **Domènech, A**. & Gutiérrez, A. (**2017**) A GIS-based evaluation of the effectiveness and spatial coverage of public transport networks in

tourist destinations. *ISPRS International Journal of Geo-Information*, 6(3), p.83. [JCR Q2 IF: 2.899]

Furthermore, I have presented research outputs in nine international congresses, conferences, or workshops, out of which the following six have direct relationship with the thesis:

1) Gutiérrez, A., **Domènech, A.**, Zaragozí, B., Miravet, D., Saladié, Ò. (2020) A review of implications and opportunities of the multiple data sources for studying the mobility of residents and visitors in tourist regions. POLITUR International Workshop Webinar on 'Mobilities Transforming Destinations. Urban and regional policies, digital regulatory mechanisms, and place prosperity and sustainability. November 26th–27th, 2020, Vila-seca (Spain).

2) Bassols, N., **Domènech, A.**, Paulino, I. (2020) Mobilities inside a destination: How determining is the local tourist industry? POLITUR International Workshop Webinar on 'Mobilities Transforming Destinations. Urban and regional policies, digital regulatory mechanisms, and place prosperity and sustainability. November 26th–27th, 2020, Vila-seca (Spain).

3) **Domènech, A.**, Gutiérrez, A., Anton Clavé, S. Miravet, D. (2020) Walking the tourist city: family tourists' activity spaces in coastal destination. POLITUR International Workshop Webinar on 'Mobilities Transforming Destinations. Urban and regional policies, digital regulatory mechanisms, and place prosperity and sustainability. November 26th–27th, 2020, Vila-seca (Spain).

4) **Domènech, A.**, Gutiérrez, A. (2019) First-time cruise tourists' intention to recommend a port city: space and time matter. In: NECTAR 2019 Conference: Towards Human Scale Cities: Open and Happy. June 2019, Helsinki, (Finland).

5) **Domènech, A.**, Gutiérrez, A. & Miravet, D. (2018) Determinants of public transport use by tourists of a World Heritage city. In: NECTAR - Cluster 5: Smart Transport for Sustainable Tourism. May 2018, Lecce (Italy).

6) **Domènech, A.**, Gutiérrez, A. & Miravet, D. (2017) Influence of tourists' profiles on mobility patterns at destination: a Latent Class Analysis. In: IGU Catalonia 2017: Tourism Shaping Places: Mobilities and Tourism Destination Evolution. October 2017, Vila-seca (Spain).

Obtaining these results demonstrates that I have tried to be proactive and as organised as possible to be able to push ahead with this workload. I have dedicated my efforts entirely throughout all my studies, but especially in the four case studies that constitute the main core of the present dissertation. Thus, I have taken the initiative from the phase of conceptualisation, passing through the processes of data collection, data debugging and filtering, development of formal analysis (statistical and econometrical), representing the results (through mapping, or via graphs and tables) and finally interpreting and discussing the findings and their implications.

Finally, in this process of designing and developing research studies I have learned theoretical and methodological knowledge and I have acquired interpretive and discussion skills that have ultimately formed me as a researcher. The publications derived from this learning process, both those included and not included in this thesis, have had support from different

research projects in which I have participated since I have been an active member of the Research Group on Territorial Analysis and Tourisms Studies (GRATET) at the Universitat Rovira i Virgili, led by Dr. Salvador Anton Clavé. These projects are indicated below:

1) **Analysis of the role of territorial policies in tourist destination evolution in the mobility era (POLITUR).**
   Funds: €75,000.
   Period 2018-2020.
   PI: Dr. Salvador Anton Clavé and Dr. Antonio Paolo Russo, Universitat Rovira i Virgili.
   Funding Institution: Spanish Ministry of Economy and Competitiveness.

2) **The effects of transformations of global mobility patterns on tourism destination evolution (MOVETUR).**
   Funds: €117,370.
   Period: 2015-2017.
   PI: Dr. Salvador Anton Clavé and Dr. Antonio Paolo Russo, Universitat Rovira i Virgili.
   Funding institution: Spanish Ministry of Economy and Competitiveness.

3) **Effects of COVID-19 on tourist mobility on the Costa Daurada and Terres de l'Ebre (COVTUR-TGN).**
   Funds: €14,500.
   Period 2020-2021.
   PI: Dr. Aaron Gutiérrez, Universitat Rovira i Virgili.
   Funding Institution: Diputació de Tarragona.

4) **Big Data to analyse the mobility of people and optimize public transport services.**
Funds: €10,000.
Period 2018-2019.
PI: Dr. Aaron Gutiérrez, Universitat Rovira i Virgili.
Funding Institution: Agency for the management of university and research grants of the Generalitat de Catalunya.

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ABSTRACT

This dissertation arises from the need to deepen the knowledge of the mobility of visitors, understand the decisions that shape their spatiotemporal behaviour and identify and explore the effects that their mobility has on urban destinations. The thesis is developed around four specific objectives that fall within the scope of visitor tracking research, and that are developed in each of the scientific articles, all of them published in peer-reviewed journals, that make up this thesis. The first article aims to identify the factors, related to the socioeconomic profile of tourists and the characteristics of their stay, that determine the selection of sustainable transport and mobility options to move within the urban destination. The second article aims to analyse and understand how the visitors' spatiotemporal behaviour affects their patterns of economic consumption and, therefore, the generation of income for the local economy. The third article aims to analyse the influence of the built environment on the visitors' mobilities at destination. And finally, the fourth article aims to reconstruct trajectories and / or spatiotemporal flows from geolocated data obtained from social networks in order to detect visitors' mobility patterns at urban destinations. The data sources and methods used to meet the objectives are multiple. In this sense, the thesis also provides an extensive x-ray of the pros and cons of the different data sources available for the analysis of visitors' mobilities in tourist destinations.

RESUM

Aquesta tesi doctoral sorgeix de la necessitat d'aprofundir en el coneixement de les mobilitats dels visitants, entendre les decisions que configuren el seu comportament espacio-temporal i identificar i explorar els efectes que les seves mobilitats tenen sobre les destinacions urbanes. La tesi es desenvolupa entorn a quatre objectius específics que s'emmarquen en l'àmbit de recerca relacionat amb el seguiment de l'activitat dels visitants en destinacions turístiques. Cadascun d'aquests objectius es desenvolupa en cadascun dels articles científics que conformen aquesta tesi doctoral, publicats tots ells en revistes de revisió per parells. El primer article es proposa com a objectiu identificar els factors, relacionats amb el perfil socioeconòmic dels turistes i amb les característiques de la seva estada, que determinen la selecció d'opcions de transport i mobilitat sostenible per moure's per la destinació urbana. El segon article pretén analitzar i comprendre com afecta el comportament espacio-temporal dels turistes en els seus patrons de consum econòmic i, per tant, en la generació d'ingressos per a l'economia local. El tercer article es proposa analitzar la influència de l'espai urbà sobre la forma en què els visitants es desplacen per la destinació. I finalment, el quart article té per objectiu reconstruir trajectòries i/o fluxos espacio-temporals a partir de dades geolocalitzades de les xarxes socials per tal de detectar patrons de mobilitat dels visitants de destinacions urbanes. Les fonts de dades i els mètodes utilitzats per complir amb els objectius de partida són diverses. En aquest sentit, la tesi aporta també una àmplia radiografia dels pros i les contres de les diferents fonts de dades disponibles per a l'anàlisi de les mobilitats dels visitants en destinacions turístiques.

RESUMEN

Esta tesis doctoral surge de la necesidad de profundizar en el conocimiento de las movilidades de los visitantes, entender las decisiones que configuran su comportamiento espaciotemporal e identificar y explorar los efectos que sus movilidades tienen sobre los destinos urbanos. La tesis se desarrolla en torno a cuatro objetivos específicos que se enmarcan en el ámbito de investigación de seguimiento de visitantes, y que se desarrollan en cada uno de los artículos científicos, publicados todos ellos en revistas de revisión por pares, que conforman esta tesis. El primer artículo se propone como objetivo identificar los factores, relacionados con el perfil socioeconómicos de los turistas y con las características de su estancia, que determinan la selección de opciones de transporte y movilidad sostenible para moverse por el destino urbano. El segundo artículo pretende analizar y comprender cómo afecta el comportamiento espaciotemporal de los turistas en sus patrones de consumo económico y, por tanto, en la generación de ingresos para la economía local. El tercer artículo se propone analizar la influencia del espacio urbano sobre la forma en que los visitantes se desplazan por el destino. Y finalmente, el cuarto artículo tiene por objetivo reconstruir trayectorias y / o flujos espaciotemporales a partir de datos geolocalizados de las redes sociales para detectar patrones de movilidad de los visitantes de destinos urbanos. Las fuentes de datos y los métodos utilizados para cumplir con los objetivos de partida son diversos. En este sentido, la tesis aporta también una amplia radiografía de los pros y contras de las diferentes fuentes de datos disponibles para el análisis de las movilidades de los visitantes en destinos turísticos.

CONTENTS

TABLES

FIGURES

PART I. INTRODUCTION

1. Research presentation

The first chapter of this thesis project is dedicated to presenting the context and conceptual framework of the research, to describing the research objectives, questions, and hypotheses, and to explaining the research design and methodology implemented.

1.1. Context

Tourism is an outstanding economic driver for cities and countries even though it is a sector clearly altered by geopolitical uncertainty and global phenomena. In the 1990s, new technologies and globalisation produced a remarkable time-compression that brought individuals from all over the world, but particularly from developed countries, the opportunity to travel and develop tourism experiences (Sheller & Urry, 2004). Since then, the growth of international tourism mobility has been unprecedented. In fact, according to data from the World Tourism Organisation[1], the number of international tourist arrivals has increased from 438 million in 1990 to almost 1.5 billion in 2019. This growth is aided by a system that encourages people's desire to travel, see other places and exchange experiences outside the quotidian spaces.

However, tourism growth has far from developed equitably from a territorial point of view. Not all countries have benefited from these dynamics. Actually, following Florida's arguments on the implications of globalisation for economic development, in which he stipulates that the economic competitiveness of places in the world is clustered in regions and cities that maintain competitive advantages over other areas of the world, the distribution of tourism in the world is also "spiky" (Florida, 2005). Instead of there being a competitive fluidity between destinations, specific destinations are capable of maintaining their tourist' pull or attraction. Thus, those destinations that remain outside this

[1] UNWTO global tourism dashboard: https://www.unwto.org/global-and-regional-tourism-performance

network of international destinations run the risk of being left out of global flows.

Those cities located within the cluster of this spiky world have, therefore, found in the tourism sector the opportunity to reinforce their economic development. In fact, urban areas offer social, cultural, physical and aesthetic stages upon which tourist activity can be played out (Hayllar *et al.* 2008, p.7). These stages form a complex urban structure made up of attractions and infrastructure generally developed for non-tourism purposes, which are shared with the local community and commuters, the majority, and the economic activity of the city, which is mainly unconnected to tourism. Tourism visitation flows tend to be concentrated, however, in specific places of the cities rather than dispersed. These areas of concentration may embrace iconic sights, shopping areas, cultural landmarks or places of historical significance that are complemented by tourism-oriented services to attract more visitors and maximise profits. As a result, these areas of high tourism activity are induced into processes of physical and symbolical changes according to the tourist performances (Baerenholdt *et al.* 2004), and ending up as tourist precincts (Stevenson, 2003) where the positive economic impact associated with the arrival of visitors may be counteracted by the side effects associated with (over)tourism (Milano *et al.* 2019).

The adaptation and reconversion of city areas to attract tourists and visitors brings up research questions with answers that are limited using traditional sources of information. For instance, analysing and understanding the interactions of tourists and locals in urban settings, or how the urban design and the built environment influence and shape the visitors' experience, are questions that methodologically surveys or pedestrian counts cannot help to disclose in detail. On the contrary, the (new) location-aware technologies, such as GPS loggers, mobile phone traces or the digital footprint on social media sites, have allowed us to take this type of analyses to the next level. Therefore,

these technologies have spawned a completely new system of data collection, processing, analysis, and reporting, which has forced tourism researchers to change the way they study tourist behaviour (Hardy, 2020).

Never before in history have researchers and practitioners had the mobility monitoring tools that we have available today. Traditionally, tourism studies concentrated on distributions and flows on international, national and regional levels, neglecting to look into processes on a very localized scale (urban and neighbourhood levels). Currently the field of tourist mobility and tracking research is growing at a very rapid pace, both due to the interest of researchers and practitioners in creating knowledge on the reasons for the spatiotemporal behaviour of tourists (its causes and consequences), and the unprecedented availability of a wide array of sources of information.

Analysing tourist mobility is essential for interpreting the characteristics of the tourist experience, detecting the factors that drive tourists to make one decision over another, evaluating the influence of the characteristics of the built environment on spatiotemporal behaviour, detecting points of conflict in the uses of public areas, identifying possible alternatives to diversify the tourist offer, among many others.

In this context, this dissertation emerges from the need to delve into the knowledge of tourists' mobilities, understand the decisions that shape their spatiotemporal behaviour, and identify and explore the effects that their mobilities have on the destination. To do so, the present work raises different research objectives that are achieved through the implementation of a multi-method approach. In fact, multiple sources of data have been used for the analysis of tourist mobility, to solve the research objectives that are presented in the following section. The existing literature tends to pinpoint the advantages and disadvantages of different data sources to justify the use of one source over the others. However, the opportunities and challenges of each method have

rarely been discussed side by side (Hardy, 2020), and this is also one of the contributions of this dissertation (see section 2.2. and section 9.2).

1.2. Research objectives and hypothesis

The present work is mainly framed in tourist tracking research, which according to Hardy (2020), who complemented the work of Shoval (2012), tends to fit within at least one of the themes/approaches presented in Table 1. Each theme/approach involves different research objectives as well as the execution of different analytical techniques and methodologies.

Table 1. Themes or approaches that tourist tracking research usually fits into

Theme/Approach	Description/Objectives
Descriptive analysis	Exploration of site-specific insights into tourists' use, rather than spatiotemporal behaviour of tourists.
Identification of factors of spatiotemporal behaviour	Identification of the impacts that certain factors have on the spatiotemporal behaviour of tourists.
Creation of typologies	Segmentation of tourists based on their spatiotemporal behaviour.
Understanding tourists' decision-making	Identification of the determinants of tourists' decisions (such as the use of public transport).
Spatial correlation/abilities exploration	Exploration of the built environment characteristics that influence the tourists' spatiotemporal behaviour.
Movement patterns and flow	Identification of patterns of movement within destinations.
Destination consumption	Detection of hot-spots and congestion in specific areas or sites.
Predictive analysis	Implementation of machine or deep learning to predict how tourists will move through space and time.
Physiological effects of tourists' mobility	Assessment of the emotions of tourists through physiological measures (electrodermal activity).

Source: Author's adaptation from Shoval (2012) and Hardy (2020)

Hence, this table is used in this section to frame the research objectives of this thesis into the stream of studies on tourist tracking, and then it is used in the following section to provide more details about the research design and methodology.

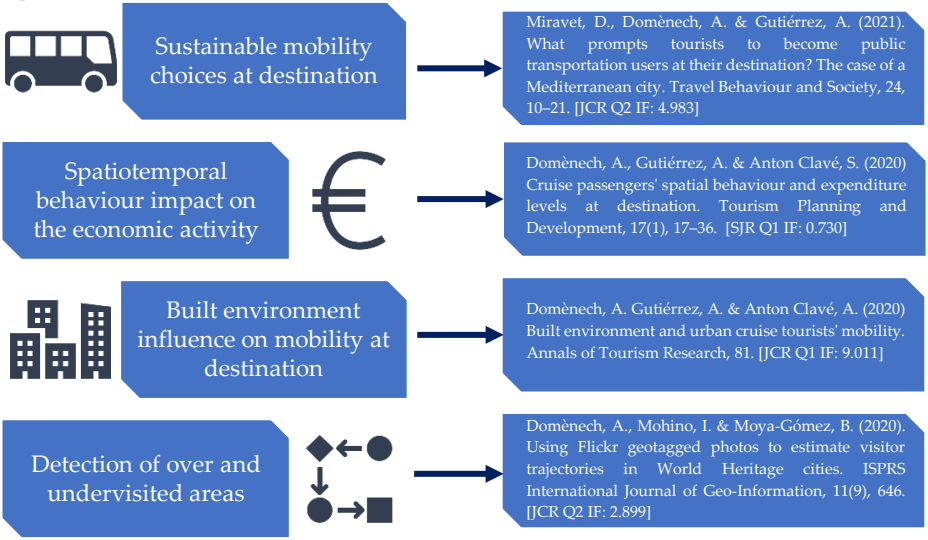
Considering that the purpose of this section is to detail the objectives of this project, it is worth mentioning that this thesis departs from a general research objective to then delve into several specific research aims associated with the four articles that make up this dissertation. Hence, the principal research objective is:

To explore urban visitors' mobilities to comprehend their spatiotemporal behaviour and identify the effects on cities.

Main objective

Then the specific research aims are related and contribute to the four research areas presented in Figure 1, which in turn are associated with the four articles that constitute this project.

Figure 1: Research areas to which this dissertation contributes.



Source: Author's own production

Each case study is nurtured by research questions and hypotheses, as presented in Table 2. These questions and hypotheses are further developed in each of the

research articles that constitute this dissertation. Particularly their formulation is supported by the different reviews of literature.

Thus, in the first place, the first specific objective of this thesis, related to sustainable mobility choices at destination (see Figure 1) is:

> **To identify the socioeconomic and trip-related determinants of sustainable mobility choices taken by tourists once at urban destinations.**

First specific objective

This objective emerges from the sensitivity of tourism destinations to the impact of intra-destination transport and mobility (Guiver & Stanford 2014). In fact, the private car is implicated as the primary source of greenhouse gas emissions, but it also generates deleterious effects that can influence both residents' perceptions of tourism (Andereck & McGehee 2008; Dickinson & Robbins 2008), and tourists' experiences (Alegre & Garau 2010; Eusébio & Vieira 2013; Iglesias-Merchan *et al.* 2014).

The correct management of mobility flows requires, therefore, the analysis of tourists' mobility patterns and the identification of those factors that push tourists to use sustainable modes of transportation. Accordingly, various studies have demonstrated the importance of a modal shift towards public transport (PT) so as to reduce the impact of negative externalities associated with transportation at tourist destinations (Peeters & Schouten 2006; Guiver *et al.* 2007; Liu *et al.* 2017; Scuttari *et al.* 2018). Considering that shedding light on the factors that prompt tourists to use PT at their destinations is a central research objective for promoting destination sustainability, this research project has included a case study dealing with this issue.

Table 2. Research objectives, questions and hypotheses of the dissertation

O1. To identify the reasons why tourists decide to move in a sustainable way at urban destinations.	**RQ1.** What are the factors that push tourists to use public transport during their stay in an urban destination?	**H1.** The mode of transport chosen to reach the destination might be highly influent on the transport choices once at destination.
		H2. The socioeconomic profile of the tourist could also be highly associated with the transport mode used to reach the destination.
O2. To explore how spatiotemporal behaviour patterns at urban destinations influence the positive economic impact of the local economy.	**RQ2.** To what extent the spatiotemporal behaviour of cruise tourists at a given destination acts as a determinant of their expenditure level?	**H3.** Different expenditure levels in the city may also be related to different spatiotemporal mobility patterns. For instance, the higher the time in the touristic areas of the city the higher the expenditure might be.
O3. To analyse how the characteristics of the built environment, and the location of places of tourist interest, shape the spatiotemporal patterns of urban tourists.	**RQ3.** Is there any relationship between the characteristics of the built environment and the way cruise tourists visit the city?	**H4.** Variables related to the syntaxis of the urban space, the physical attributes, the presence or absence of commercial activity and the visibility of tourist points of interest could be highly related to the cruise tourist spatiotemporal behaviour in the city.
O4. To detect flows of urban visitors' mobilities, and therefore spaces over and under visited.	**RQ4.** Can geotagged photographs from visitors be used to reconstruct spatiotemporal trajectories at the street level?	**H5.** The location of mixed commercial and recreational uses might be correlated with the visitor spatial behaviour.

Source: Author's own production

In second place, this research proposes a second specific research objective, associated with the research area of tourist spatiotemporal behaviour impact on the economic activity (see Figure 2), is:

To analyse and understand how tourists' spatiotemporal behaviour impacts the economic activity.

Second specific objective

To this end, the role of the visitors' spatiotemporal behaviour on their expenditure at destination is analysed. The existing literature pinpoints that factors affecting tourist expenditure are those related to their demographic, geographic and psychological characteristics and also travel-related characteristics (Markkanen & Pieszek 2012; Marksel *et al.* 2016).

However, far less attention has been given to the spatiotemporal behaviour of the visitors at destination as an explanatory factor of expenditure (Ferrante *et al.* 2016). Hence, this thesis fills this research gap. Specifically, an analysis has been conducted of the spatiotemporal behaviour of a specific group of tourists whose activity in cities has been widely criticized due to its massive arrival in cities, the intensity of its activity concentrated in a few hours, and the generally low spending on the local economy: the cruise tourists.

In third place, this thesis also aims to contribute to the stream of studies focused on detecting the influence of the built environment on visitors' mobility at destination (see Figure 2). Thus, the third specific objective is:

To analyse the influence of the built environment on the visitors' mobility at destination.

Third specific objective

Public spaces and walkable urban areas are fundamental for the urban tourism experience (Anton Clavé 2019). In this regard, both quantitative and qualitative studies are emerging on the analysis of the walkability of urban tourism areas,

and its effects on tourist spatial behaviour. The relationship between built environment and tourist mobility factors are being explored, at the same time as we are gaining further insight into current debates on tourism pressure in specific locations, and destination carrying capacity (Ram & Hall 2018).

The analysis developed in this thesis investigates the role of space syntax measures (Mansouri & Ujang 2016), and other variables related to the characteristics of the urban space that the literature underpins as essential, either for walkability conditions in cities (i.e. presence of natural elements such as trees (Gobster 1995), absence of discernible slopes (Zhu & Lee 2008), car speed limits (Blečić *et al.* 2015)), attracting tourists (i.e. land uses (Foltête & Piombini 2007) or the visibility of places of interest (Thwaites & Simkins 2007).

Finally, this research project also aims to contribute to the research area of studies dealing with the identification of techniques and potentialities for detecting over and undervisited areas in tourist cities. Thus, the fourth specific objective is:

To detect visitor flows by means of reconstructing spatiotemporal trajectories from geolocated social media data.

Fourth specific objective

The digital footprint associated with the use of position-tracking technologies has represented an opportunity for researchers to develop detailed explorations of tourist behaviour within urban destinations (Caldeira & Kastenholz 2017; Ashworth & Page 2011; Pearce 2001).

In this thesis, I use geolocated photos uploaded on an online photo-sharing platform to implement a detailed methodology to reconstruct visitor trajectories in city centres using the associated time and location data of the photos.

This analysis goes beyond what has been done by studies that have used geolocated data from photo-sharing platforms, such as detecting the most popular tourist attractions or travel recommendations (Girardin, 2008; Sun *et al.* 2015; Zheng *et al.* 2012). Furthermore, it allows us to detect over and underused city areas and correlate these mobility patterns with land uses.

The research questions and hypotheses are approached following different types of empirical analysis and using different data sources, as presented in the following section and in each methodological section of the case studies.

1.3. Research design and methodology

Although this dissertation is based on a compendium of articles and each case study contains its own methodological framework, this section provides a general perspective on the research design of the project as a whole.

The main methodological information of each case study is summarised in Table 3. Moreover, following the structure of Table 1, Table 3 specifies the themes of tourist tracking research in which the four studies that make up this thesis are framed.

Table 3. Methodological details for each case study.

	Chapter 4	***Chapter 5***	***Chapter 6***	***Chapter 7***
Objective and RQ	*1*	*2*	*3*	*4*
Case study	*1. What prompts tourists to become PT users*	*2. Cruise tourists' spatial behaviour and expenditure levels*	*3. Built environment and urban cruise tourists' mobility*	*4. Using Flickr geotagged photos to estimate visitor trajectories*
Data sources	Surveys	Tracking (GPS) + Surveys + GIS layers	Tracking (GPS) + GIS layers	Geolocated photos + GIS layers
Year of data	2015	2017	2017	2010-2018
Target	Tourists	Cruise tourists	Cruise tourists	Visitors and tourists
Sample size	939	154	154	1,565
Study area	Medium-sized city of Roman origin (Tarragona, Spain)			Medium-sized city of medieval origin (Toledo, Spain)
Analysis methods	Logit estimations + CHAID analysis + interactions	Mapping + OLS regression	Mapping + OLS regression	Mapping + OLS regression
Descriptive analysis	✗	✓	✓	✓
Creation of typologies	✓	✓	✗	✓
Understanding tourists' choices	✓	✓	✓	✓
Spatial correlation exploration	✗	✓	✓	✓
Movement patterns and flows	✗	✓	✓	✓
Destination consumption	✗	✓	✓	✓

Source: Author's own production

The first study consists in identifying the factors that prompt tourists to becoming public transport users once at destination. The data source used is a survey answered by 939 tourists that stayed overnight in the city of Tarragona (Spain) in 2015. The data source does not allow the tracking of tourists per se, but it allowed us to disentangle the factors (related to the socioeconomic characteristics of the tourists, the trip-related attributes and the visits undertaken) that push tourists to use public transport at destination. Therefore, the study is framed within two main themes: understanding the decision to use PT and identifying a specific tourist profile who is more prone to use this type of sustainable transport mode.

The second and the third studies are also framed within the city of Tarragona, but the data sources implemented as well as the type of tourist under analysis differ considerably from the first study. On the one hand, in the second study a mixed method is implemented via the combination of 154 GPS tracks belonging to cruise tourists that participated voluntarily in our study and their corresponding qualitative surveys with information on their sociodemographic profile and about the activities implemented in the city. The integration of these data sources allowed us to identify the association between the spatial behaviour of cruise tourists and their expenditure levels. Even though the sample number is discrete, as can be seen in Table 3, the study is framed within a wide range of themes. On the other hand, the third study correlates an array of indicators related to the built environment and the cruise tourists' spatiotemporal behaviour in order to identify those characteristics that attract cruise tourists' flows.

Finally, the fourth study uses geolocated data from an online photo sharing-platform (Flickr) to reconstruct visitors' spatiotemporal trajectories in the city centre of Toledo (Spain) and then analyse their association with land uses. The study, furthermore, categorises the tourist attractions according to the frequency of visitors.

2. General theoretical framework

The second chapter of this thesis project presents the general theoretical background in which this dissertation is framed. Thus, considering the objectives presented in the previous sections, this chapter is structured around two sections. First, some reflections are provided on the understanding of tourism mobilities. The growth of urban tourism, the effects of tourism mobilities at urban destinations, and the importance of tracking research to manage the increased visitors' mobilities are presented. Secondly, a reflection is provided on the data sources available for the analysis of visitors' mobilities.

2.1. Understanding tourism mobilities

In the current mobilities era (Urry, 2007), characterised by the modelling force of the digital context and the global access to information (Bock 2015; Rifkin 2000), the world tourism dynamics are constantly changing, at the same time that they are deeply shaping city trajectories (Anton Clavé, 2019).

Our interconnected world is getting more mobile, and transportation systems and infrastructure are changing across the globe. People travel more and faster than ever before between cities, as well as within regions and cities.

As a result, the analysis of mobilities has emerged as an elementary analytical dimension of this society that is constantly in motion, on the move (Cresswell, 2006). In fact, the mobilities turn, as a conceptual approach (Sheller & Urry, 2006), considers that social, economic and cultural systems cannot be analysed without paying attention to the mobility flows that take place around fixed elements (Cresswell, 2012; Smith & Hetherington, 2013).

Within this context, the growth of cities as tourism sites is enmeshed with processes of globalization and (neo)liberalisation of cities as global agents competing with each other to attract investments, and also more tourists (Colomb & Novy, 2017).

The arrival of tourists and their behaviour at destination is therefore incorporated into the functional dynamics of cities, which are variable both in time and space. However, tourism mobilities are not only restricted to the mobility of tourists, but also include the mobilities carried out by those markets directly or indirectly related to the tourism activity, such as the labour, residential and recreational markets. Consequently, the existence of (seasonal and concentrated) tourism activity reconfigures the urban hierarchies and the patterns of use of the urban systems (Miravet *et al.* 2021). As a result, a set of challenges arise for the sustainable management of mobilities within city destinations, which need to be addressed from the perspective of mobility analysis.

In this context, this section sets the theoretical background from which the thesis departs, focusing first on the growth of urban tourism and the challenges derived from this growth, and secondly, on the challenges established specifically by tourism mobilities within urban destinations.

2.1.1. The growth of urban tourism

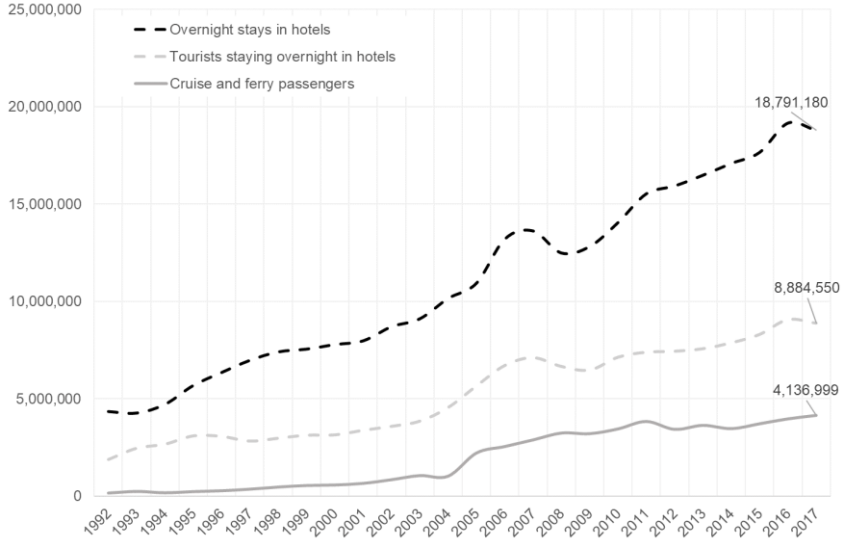
Over the past decades, international tourist arrivals have gone from 25 million in 1950, to over 1.3 billion in 2017 [2]. The growth of the sector has been led primarily by the expansion of urban tourism, which has been expanding globally since the 1980s, but most importantly since the 2000s (as an example, see the growth in the number of tourists in Barcelona – Spain – in Figure 2).

In the aftermath of the global financial crisis of the late 2000s, many urban destinations hailed tourism as the solution for many failing local economies to recover (Russo & Scarnato, 2018). In this context, strategic planning in tourism

[2] UNWTO global tourism dashboard: https://www.unwto.org/global-and-regional-tourism-performance

has been reinforced by the touristification of cities, by creating new (or upgrading already existing) environmental and cultural resources in order to attract and open up new markets.

Figure 2. Number of tourists and overnight stays in hotels and number of cruise and ferry passengers between 1992 and 2017 in Barcelona, Spain.



Source: Author's own elaboration with data from the Department of Statistics of the City Council of Barcelona.

Besides the positive economic impacts that the tourism activity contributes to cities, to ensure a proper management of the destinations, the side effects must not be neglected. Many cities are experiencing the transformation of their everyday sites of activity because of visitor interaction, or how they gaze and go places (Cechini 2016; Russo & Richards 2016). However also, due to sport and culture-led urban regeneration projects (Lee, 2009), hotel development (Türkün, 2011), the emergence of the so-called sharing economy of short-term tourist rentals (Wachsmuth & Weisler, 2019), or overtourism (Dodds & Butler, 2019). These transformations have been creating a day-to-day struggle for

tourist city management and are related either to structural changes (such as land use transformations, building conversions, rent increases, store replacement), immediate nuisances due to the pressure exerted by the tourist activity (such as congestion, privatization, noise, litter, among others), or linked to the commodification of "the cultural", the homogenization of the urban space (Ritzier 2011) and the subsequent loss of distinctive attractiveness (Lew, 2017).

Consequently, the nature of places has been shifting upwards to an extent of what has been known in literature as the "tourismification of the quotidian" (Bourdeau *et al.* 2013), which clearly has aroused tensions and conflicts between residential and tourist uses of the city's commons.

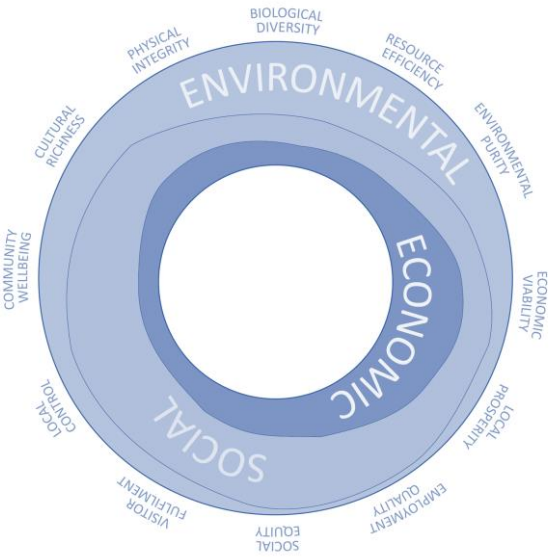
Cities are being adapted to tourists, partially in order to attract demand, but also because they are influenced by "the overwhelming economic success of mass tourism theme parks, cruise ships and historic shopping streets and shopping centres" (Lew 2017, p.9). These transformations are leading to a rise in anti-tourism movements (Seraphin *et al.* 2018) that question the management strategies and the sustainability of the tourist activity itself, regarding the compatibility of the benefit of the local economy, the preservation of endogenous resources and the quality of both the tourist experience and the daily life of the residents.

The challenges facing cities in order to manage their tourism activity are, therefore, multiple. Tourism clearly represents an intrinsic part of how a city develops. It also plays a fundamental role in shaping the well-being conditions of its inhabitants and the tourist experience itself. Consequently, its management should be planned properly to finally become a driving force for the progress of the 17 Sustainable Development Goals (SDG). In particular, Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable. Related to this, some years before the SDG were written, in 2005 the UNEP and the UNWTO formulated the twelve aims for sustainable tourism development (see Figure 3), which define the main structural areas that should be used by

the different stakeholders of the tourism value chain to define and establish mechanisms to plan, monitor and manage the tourism activity.

These master lines along which the tourism industry must work to maximise the economic benefits for the local community, minimise the negative environmental effects, conserve the natural and cultural resources, and ensure the quality of the tourist experience, and they are directly or indirectly related to the way tourism activities take place once at destination.

Figure 3. The twelve aims for sustainable tourism development



Source: UNEP/UNWTO (2005).

2.1.2. Tourism mobilities in urban destinations

According to Koens *et al.* (2018) there are five side effects of city tourism, which are presented in Figure 4. They are all directly or indirectly related to mobility and transport, although three of them have a more explicit relationship.

Figure 4. The five side effects of city tourism according to Koens *et al.* (2018)

Source: adapted from Koens *et al.* (2018)

Table 4 shows the three externalities of Koens *et al.* (2018) that are more related to mobility and the effects on the city and its services, as well as the impact on residents and the quality of the city.

As can be seen, impacts associated with city mobility lead to problematic circumstances that compromise the development of the tourism sector within the city context. On the one hand, the visitor experience and the reputation of the destination can be damaged due to both environmental issues (Becken *et al.* 2017) and mobility problems (Eusébio & Vieira, 2013) alike. On the other hand, local residents may be prone to reject tourism activities (Martín-Martín *et al.* 2018), or at least to move away from the spaces of tourist activity. Consequently, visitors' mobility becomes a central issue in terms of planning and managing urban space and tourism activities and maintaining the quality of life of different groups (Anton-Clavé 2019).

Table 4. Disturbances caused by city tourism in which mobility and transport are involved

Mobility-related issues	Effects on the city and its services	Impact on residents and the quality of the city
Overcrowding of public spaces	Overcrowding on streets and pavements	Mobility issues between residents and visitors and resignification of public spaces Potential worsening of service provisions
	Road congestion	
	Overcrowding of public transport	
Visitor unruly behaviour	Noise and disturbances	Resignification of public spaces Rejection of tourism activities by residents
Local environment impact	Privatization of public spaces and "conquest" of urban space (store replacement, land use changes, building conversions, opening of hotels, hostels and (in)formal rental accommodation)	Loss of distinctive attractiveness, distortion of cultural identity, resignification of public spaces, rising prices, lack of affordable housing
	Increased litter and urban waste	Potential worsening of municipal services
	Increased water usage	Environmental and landscape damage and impact on health and quality of life of residents
	Increased air pollution due to mobility and energy consumption	

Source: Adapted from Koens *et al.* (2018)

Urban tourists tend to concentrate their movements in reduced areas within cities (Ashworth & Page 2011), where multiple kinds of tourist attractions are clustered. Moreover, the visitors' time-restrictions at a destination and their interest in visiting/consuming as many sites of interest as possible make their behaviour a fast and intense experience (Bauder 2015). The overcrowding of central spaces and specific street networks (Bimonte & Faralla 2016; Lin *et al.* 2017) must be managed to get the best possible results from the reception of tourists within cities.

It is in this framework that understanding visitors' spatial behaviour can bring new knowledge about new flexible planning and management procedures and probably new visions about the built environment, its uses, and its benefits (Anton Clavé 2019). In fact, having urban spaces that are pleasant to walk through and well interconnected encourages active mobility, deconcentrates mobility flows and increases the likelihood of a better-balanced tourist consumption of city services.

Therefore, considering the transversal influence of tourism mobility on the sustainable management of tourist destinations, city planners, public authorities, and tourism managers must develop strategies to (1) ensure the environmental sustainability of the urban mobility systems, and (2) enhance the destinations' competitiveness.

On the one hand, there is an undeniable diversity of environmental implications associated with mobility and transport decisions made by visitors once at destination. 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 & Stanford 2014). It also damages air quality (Saenz de Miera & 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 as well as non-motorised modes of transport (walking and cycling) must be seen as a solution to mitigate the environmental impact caused by visitors' intra-destination mobility decisions.

On the other hand, but linked to the previous point, the destination competitiveness will only be enhanced if the design of urban environment is seen as a fundamental aspect for the urban tourism experience and the sustainability of the destination (Anton Clavé 2019). The design of walkable urban areas has multiple effects on the transport mode decisions of both locals and tourists, and influences the individuals' spatial and temporal behaviour

(Ram & Hall 2018). Therefore, the planning of liveable and walkable urban areas can help to deal with urban complexity, especially in successful tourist cities with contradictions and conflicts generated by overtourism (Anton Clavé 2019).

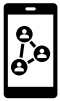
2.1.3. Tracking research, key to managing increased visitors' mobility in cities

The UNWTO (2019) has suggested eleven strategies to address visitor growth in cities. These strategies, which are shown in Table 5, are related to the adoption of smart measures to diversify the tourist offer, disperse and deconcentrate the visitors' flows, and enhance the economic and sociocultural development of the city by engaging the stakeholders in the co-decision process of tourism model definition and improving city infrastructure and facilities.

The eleventh strategy is related to the need to set tourism activity monitoring and response measures. In fact, this strategy is the basis for developing the other 10 strategies proposed. Without the collection of data on visitors' mobilities it is not possible to analyse its causes and consequences. Thus, designing and implementing response measures vis-à-vis the challenges derived from tourism activity must begin with the availability of reliable data on tourism mobilities, and secondly with a robust set of indicators providing objective information.

Considering that visitor spatiotemporal behaviour involves movement and multi-attraction (Caldeira & Kastenholz 2017) and, in turn, this spatiotemporal behaviour defines the positive and negative impacts of city tourism, there emerges the need to obtain reliable data on tourism mobilities, in terms of representativeness, periodicity and spatial and temporal granularity.

Table 5. The eleven UNWTO strategies to address visitors' growth in cities

1. Promote the dispersal of visitors within the city and beyond		11. Set monitoring and response measures 
2. Promote time-based dispersal of visitors		
3. Simulate new visitor itineraries and attractions		
4. Review and adapt regulation		
5. Enhance visitors' segmentation		
6. Ensure that local communities benefit from tourism		
7. Create city experiences that benefit both residents and visitors		
8. Improve city infrastructure and facilities		
9. Communicate with and engage local stakeholders		
10. Communicate with and engage visitors		

Source: Author's adaptation from UNWTO (2019)

In this context, tracking research is key to understanding visitors' mobilities and unravelling the factors that push or pull them to adopt one spatiotemporal behaviour or another. Traditionally, the availability of data on visitors' mobilities was scarce but, as presented in the next section, the advent of new technologies has allowed us to obtain detailed data providing information on tourism and leisure mobilities.

Therefore, analyses within the field of tracking research have been increasing considerably over recent decades, either to test the reliability of the data sources or to provide useful information to regulate and design response measures to the needs posed by the increased tourism mobilities within urban destinations.

2.2. Data sources for the analysis of urban mobilities: what about tourists?

Over many decades, a growing number of studies have been conducted to define, understand and forecast travel behaviour within urban contexts in order to provide long-term guidance and short-term solutions for urban planning and transportation systems' optimization (Yue *et al.* 2014). The analysis of urban mobility has been focused traditionally on detecting daily mobility patterns performed by local residents. However, as tourism has grown as a recurring activity in urban destinations, the need to monitor the mobility of visitors has emerged as an essential step towards articulating strategies aimed at reducing the negative impacts of crowding effects at certain times of the day and seasons of the year.

In tandem, new sources of data linked to location-aware technologies (i.e. mobile phone traces, geolocated social media content, GPS loggers, etc.) have appeared and facilitated the analysis of the spatiotemporal behaviour of visitors.

The new data sources available for the study of tourism mobilities present unprecedented opportunities, despite some still important limitations that researchers must keep in mind when starting a study. In fact, depending on the research objectives and questions, the type of data that will be used will vary considerably. For instance, it is not the same wanting to quantify the number of users passing along a street, as wanting to know when or why.

In this regard, the 4-W paradigm put forward by Kim & Fesenmaier (2015) suggests that tourism mobility involves "who, where, when and what". This framework, however, not only sets aside the "how" they move (i.e. the transport mode) as an intrinsic and essential part of mobility, but also two questions related to the space and its capacity: "how many" visitors are moving and "where" they are passing through. The importance of the "how" is

highlighted by Hannam *et al.* (2014), who argues that the action of travel may not be only to serve a particular purpose but can also act as an integral feature of many tourists' experience. In the same way, we could reason that the number of visitors and their spatiotemporal behaviour within cities is also a factor that conditions the experience of the visitors themselves, and also the residents' perceptions towards the tourism and leisure activities that take place in their cities. In this context, it becomes important to acquire knowledge on the array of data sources available and the potentialities each source of data provides for research purposes.

Following this reasoning, in this section I review different data sources for mobility studies, including traditional and digital ones, following the scheme presented in Table 6. The main objective behind this review is the identification of sources that allow the monitoring of tourism mobilities in an objective and reliable way.

Table 6. Structure of the review on data sources for the analysis of urban visitors' mobilities

Data sources for tourists/visitors' mobility analysis	Traditional sources	Mobility surveys
		Direct observation
		Traffic flows
	Location-aware technologies	Mobile phone data
		Smartphone sensor-based
		GPS devices
		Smartcard data
		Other sensor-based technologies

Source: Author's own production

2.2.1. Traditional data sources for the analysis of tourist mobilities

Traditionally, population censuses and the municipal registers of inhabitants have been the main sources for the study of the daily mobility of the population. However, the information on mobility collected by these operations is exclusively limited to occupational mobility (i.e. for work and / or study reasons) of residents. Therefore, they do not collect information on all those trips derived from leisure, shopping, carrying out cultural or sports activities, tourist visits, etc. Likewise, a second drawback concerns the fact that the data only offers an immobile photograph of the mobility patterns (i.e. origins and destinations, travel time/cost and main mode of transport used). Therefore, interesting aspects such as multimodality, the different stages of travel, the distribution of trips over time, seasons or years are left out of the analysis. Finally, a third and final aspect to consider is the fact that the study universe is limited to residents. Thus, any type of information on visitors is ignored.

In this context, only two types of sources traditionally used to analyse the mobility of people can also be used to acquire knowledge on visitors' mobility. These are the specific mobility surveys and the direct observations and traffic flows, and their applicability is detailed below.

a. Mobility surveys to visitors

Mobility surveys to visitors are based on travel diaries which ask visitors to report trips undertaken during their holiday with the object of obtaining data on travel routes, together with the decisions of how, where, when and why (Zillinger, 2007). Thus, the advantages over censuses and registers mainly derive from the fact that mobility surveys are operations often designed ad hoc to analyse mobility in depth. Thus, this type of data collection method can help

researchers deal with specific aspects, such as the hourly distribution of journeys, the differential use of transport modes according to the user profile, the assessment and perception of the different means of transport, among others.

However, the use of mobility surveys among visitors has been scant and mainly dedicated to specific case studies. Consequently, the availability of data derived nowadays is limited. The main reason why this operation is scarcely used is that the gathering of information related to all the trips undertaken during a whole day makes mobility surveys long. As a result, visitors who are not legally obliged to answer the questionnaires, as opposed to residents who take part in official statistics, are more likely to be reluctant to participate or to complete the whole questionnaire if they become tired of it. Besides, while residents participating in official statistics are easily contacted at their homes, tourists must be contacted on the street or at the transport infrastructures that they need to use to travel. These combined factors make the costs of the statistical operation substantially increase.

Another drawback is based on the fact that mobility surveys do not collect exhaustive information on all the trips undertaken by visitors, given that intra-destination trips tend to be forgotten if they are not asked just after their occurrence (Gutiérrez, Benítez *et al.* 2020). Moreover, surveys are based on samples whose size and representativeness highly depend on the research objectives, the scope of the study and ultimately the budget. The budget, in fact, acts as an important constrainer, since it may condition the length of the survey (i.e. the number of questions included) and the level of geographical disaggregation for which the mobility data are statistically significant. In fact, most of the mobility surveys focus on the quantification and characterization of trips/journeys, but there is little information on the sociodemographic characteristics (sex, age, income, educational level, characteristics of the place

of residence, etc.) of the individuals under analysis, which often limits the implementation of segmentation studies.

In order to address these difficulties related to data collection, one frequent strategy followed by researchers has been the use of visitor surveys which in spite of not being focused on mobility issues, did include a limited number of questions regarding visitors' mobility (Gutiérrez & Miravet, 2016a). Good examples of surveys for tourists in Spain are the *Enquesta de Característiques de la Demanda a la Costa Daurada i les Terres de l'Ebre* (Survey of demand characteristics of Costa Daurada and Terres de l'Ebre) and l'*Enquesta a Turistes de Barcelona* (Survey to tourists of Barcelona). The former has been conducted annually since 2006, while the latter has been carried out since 2016.

Another strategy lies in launching mobility surveys that ask visitors about the trips undertaken during the holiday when they are about to leave the destination (Le-Klähn *et al.* 2015), or conducting the survey among the residents of a territory to unveil their mobility during their holidays (Gross & Grimm, 2018). This latter type of survey gathers information related to a diversity of destinations instead of a specific one.

b. Direct observations and traffic flows

There is a clear distinction between direct observations and the measurement of traffic flows. The former involves the direct observation of subjects (i.e. following them, or observing them in a confined area). The latter only implies counting movements and it can be applied to count the flows of any type of user (e.g. pedestrians, cyclists, cars, motorbikes, etc.) in any part of the city during any time span.

On the one side, the surveillance exercise generates both quantitative and qualitative information since it allows us to record events at the place (where)

and at the time (when) they take place (Jaakson, 2004). Its main drawbacks are that it is a time-consuming activity, it is also highly labor-intensive, and it is complicated to repeat on a recurring basis. As a result, its use has tended to be restricted to case studies with a limited number of visitors being tracked/followed/observed.

On the other side, traffic flows only provide quantitative data, though its costs are relatively low. In the case of tourist destinations affected by seasonality, it is meaningless to implement a static counting of traffic flows restricted to just one period of the year, as the mobility scenario between the peak and the low season will be significantly different. Measurements of traffic flows are common in urban mobility plans. However, most tourist cities and villages affected by seasonality disregard the need to take mobility management measures adapted to both the peak and the low seasons.

2.2.2. Digital sources for the analysis of human mobilities: an opportunity for tourism studies

As indicated in the previous section, the possibilities of traditional sources capturing the floating population (visitors and tourists) are limited and they make it difficult to monitor and study the behaviour of this traveller profile. In territories where the presence of tourists is not regular in time, their arrival, which tends to be concentrated in specific periods of the year, might condition the transport systems and the carrying capacity of public areas. Thus, it is of special value to have data that allow us not only to size, but also identify behaviour patterns so as to properly adjust the transport supply and the planning and management of both the urban environment and the tourism activity.

In this regard, the advent of information and communication technologies and their rapid spread worldwide has brought remarkable advances for mobility and travel behaviour studies (Wang, He *et al.* 2018). The availability of

voluminous and varied georeferenced data from activities developed by the population is increasing at unprecedented levels. A plethora of devices and sensors monitor human activity and provide mobility information: built-in GPS receivers, built-in sensor smartphones, cellular network data, smartcards, applications for mobility services, traffic cameras, Internet browsers, among many others.

In fact, it is estimated that around 80% of the massive data generated by new ICT, also called Big Data, contains spatial/georeferenced information (Leszczynski & Crampton, 2016). To illustrate the amount of georeferenced data that this can signify, Table 7 reveals the amount of content that was generated in 2020 only on the Internet in just one minute on the main platforms.

Table 7. What happened in an Internet Minute in 2020

App/platform	Amount	Unit
Email	190 million	Emails sent
Whatsapp & fb messenger	59 million	Messages sent
iMessage	19 million	Texts sent
YouTube	4.7 million	Videos viewed
Google	4.1 million	Search queries
Snapchat	2.5 million	Snaps created
Imgur	2.5 million	Images viewed
Tinder	1.6 million	Swipes
Facebook	1.3 million	Logging in
Twitch	1.2 million	Views
Shopping	€1.1 million	Spent online
Netflix	764,000	Hours watched
Instagram	694,444	Scrolling
AppStore & GooglePlay	400,000	Apps downloaded
Twitter	194,444	People tweeting
Tik Tok	1,400	Downloads
Amazon, echo & GoogleHome	305	Smart speakers shipped

Source: Lori Lewis (2020). Retrieved from Twitter (@lorilewis).

In this context, the digital footprint has been unquestionably defined as a new challenge (when selecting, processing, and analysing data) for travel behaviour

studies (Salas-Olmedo *et al.* 2018; Wang, He *et al.* 2018), but also as a chance to carry out precise and reliable tourism mobility research (Chareyron *et al.* 2013).

A common characteristic of the new data sources for mobility studies is that they are generally based on the location of users by means of mobile devices fed by radio frequency signals. These mobile devices can either be built-in GPS receivers, smartcards, or smartphones that integrate a multitude of sensors such as camera, GPS, NFC, WIFI, Bluetooth, apps and, of course, cellular network connection. Exceptionally other technologies such as surveillance or traffic cameras or parking sensors, that allow the possibility of monitoring human activities, are independent of whether or not the user carries a mobile device. Among these many new data sources the most used by academics doing mobility research have been the geotagged social media data, the GPS traces from built-in GPS receivers and the cellular network data (Wang, He *et al.* 2018). These sources provide effectiveness and reliability (Shoval & Isaacson 2007a, 2007b; Eurostat 2014; García-Palomares *et al.* 2015) to analyse spatiotemporal behaviours on multiple territorial scales and with a great diversity of research objectives. In this sense, the following lines explain the uses of these data sources, and the purposes and advances carried out in travel research and tourism studies.

a. Cellular network-based data

Telecommunication companies have built large cellular networks with an extensive geographical coverage to provide a competitive mobile communication service (Wang, He *et al.* 2018). Users of telecom companies are periodically and aperiodically (receiving a phone call, sending a SMS or connecting to the Internet) localised by the antenna to which the mobile phone devices are connected. These antennas cover a geographical area (Voronoi polygons; Cell ID) that can be of different sizes depending on the density of antennas. In this sense, the spatial resolution of cellular network-based data can

be of a few hundred meters in urban areas and several kilometres in rural areas (García-Albertos *et al.* 2019; Picornell *et al.* 2015), although it can also variate depending on the telecom company and the applied techniques (Cell ID or triangulation technology) (Wang, He *et al.* 2018).

Furthermore, as indicated by Calabrese *et al.* (2015), this type of data offers a high temporal granularity and is versatile for developing mobility studies (Wang, He *et al.* 2018), since the mobile phone's ID can be tracked on an hourly basis and historical data is being recorded constantly: about thirty minutes to one hour (Picornell *et al.* 2015). In terms of the representativeness of the individuals or the territorial system under study, cellular network-based data is the most reliable of all the data sources, since mobile phone market penetration and geographical coverage is much higher compared to social media sites or smartcards (Gutiérrez, 2018; Wang et al 2018).

Overall, the spatial resolution, the temporal granularity and the representativeness evidence the potential of this detailed and voluminous locational and motional information for mobility research purposes. Overall, the attributes of this data source allow the construction of precise Origin-Destination (OD) matrices at both intra-urban and inter-urban levels. However, it has not yet allowed us to detect accurate travel routes at street level (Tettamanti *et al.* 2012; Chen *et al.* 2016) such as other data sources permit (such as GPS traces). This map-matching procedure is even more challenging in areas with a dense road network, since the number of potential routes increases considerably (Tettamanti & Varga, 2014; Chen *et al.* 2016).

The empirical works of González *et al.* (2008) and Song *et al.* (2010) confirm the validity of these data for mobility research and demonstrate that despite the historical heterogeneity of human travel behaviour, it is feasible to detect a high degree of spatial and temporal regularity. The main drawback of this data, however, is its availability for research purposes, since it is not free of charge and can only be obtained by means of specific licenses and agreements (Bucci & Morton, 2014).

Mobile positioning data is the unique source currently able to observe touristic, non-touristic, and commuting trips at the same time. In fact, once a foreigner mobile phone is used in a given territory, the operators can distinguish the country of origin of the phone. Hence, an identification of the visitors is feasible and, therefore, the potential of mobile positioning data for tourism statistical purposes is beyond question. In this regard, these data have allowed the measurement of the duration, timing, density, seasonality and dynamics of visitations, especially in Estonia (Kuusik *et al.* 2011).

Mobile positioning data have also been used to detect visitor flow patterns at national (Ahas *et al.* 2007; Phithakkitnukoon et al, 2015) and regional levels (Baggio & Scaglione, 2018), and also to identify tourist clusters at intra-urban scales (Calabrese *et al.* 2011).

In their study, Phithakkitnukoon et al, 2015, attempted to identify commuting, touristic and non-touristic trips by crossing the mobile phone data with land uses data. Thereby they could detect tourist flows and tourist behaviour patterns, since main tourist destinations, top destination types and principal modes of transportation used were recognized by the implementation of algorithms (Phithakkitnukoon et al, 2015).

b. Smartphone sensor-based data

Smartphones trigger huge amounts of geolocated data that can be used for research purposes. On the one hand, social media applications developed by third parties provide location-based services and collects geo-tagged and time-stamped content (Yue *et al.* 2014), such as trajectories of activities (i.e. a ride uploaded on a sport tracking application) or locations (i.e. a photo uploaded on a photo-sharing platform). The main limitations are user penetration (Riederer *et al.* 2015) and the potential unreliability of the information provided by the users (Hecht *et al.* 2011). However, geotagged social media data has been widely considered a valuable proxy of human movement in general and tourism

mobility in particular, since it provides detailed spatial information (up to street level precision) for a broad range of applications. For example, geotagged photos from Panoramio, Flickr or Instagram have allowed estimating national tourist statistics (Koerbitz *et al.* 2013), identifying tourist points of interest (García-Palomares *et al.* 2015), depicting tourist concentrations and spatial-temporal movement trajectories within urban environments (Girardin *et al.* 2007), or recommending travel paths based on the past travel information of tourists (Kurashima *et al.* 2013). Also, these data sources have been used to analyse the extent to which there is an overlap in the territorial distribution of tourism images promoted through official tourist brochures and travel guides (Paül i Agustí, 2018) or to compare the spatial interactions between tourists and locals (Li *et al.* 2018). Geotagged context from Twitter has also been used as a source of global mobility patterns (Dredze *et al.* 2016) and cross-border movements (Blanford *et al.* 2015). Meanwhile sport trackers sites and applications such as Wikiloc or Strava have also been used to analyse outdoor activities in natural parks (Barros *et al.* 2019) or in urban contexts (Musakwa and Selala, 2016).

On the other hand, dedicated applications designed by researchers, also called bespoke apps, allow the collection of travel behaviour data for specific research purposes (Wang, He *et al.* 2018). In the field of tourism research, Shoval *et al.* (2018a, 2018b) are the researchers who have brought more advances with this method. They implemented the *sensometer* application consisting in real-time surveying techniques that allowed assessing momentary experiences of tourists in the immediate physical and social environments. The main drawback of these applications is the low rate of engagement and participation of the tourists, and hence potential representativeness problems may arise.

c. Built-in GPS receivers

Analytical studies using built-in GPS receivers have become popular during the last decade to track human activity. These devices can collect high quality data since they continuously record travel trajectories (every second or minute) at an accurate spatial resolution outdoors. However, the spatial resolution can be affected when the GPS signal is lost in dense urban areas or when signal reflection creates multipath noises.

Analytical studies distributing GPS devices to tourists have been widely used in multiple territorial contexts, such as natural parks (Hallo *et al.* 2012), theme parks (Birenboim *et al.* 2013), small historic quarters (Shoval & Isaacson 2007b) and large urban settings (McKercher *et al.* 2012).

The main shortcomings of this tool are that it is quite expensive to provide GPS devices and the fully productive response rate is low (Shen and Stopher, 2014). Furthermore, the duration of the data collection period also tends to be limited, and this is an obstacle when it comes to tracking dynamic phenomena.

On the contrary, the GPS-tracking can be combined with individual surveys that provide tourist profile information and qualitative perspectives.

d. Smartcard data

Big data generated from automated data collection systems using smartcards with an embedded chip are characterized by a dynamic perspective, as each time a user uses the card, the system records its validation. As a result, millions of observations provide valuable insights into understanding user and consumer behaviour. These smartcards can either offer admission to a series of attractions and/or activities within a tourist destination (destination cards), provide admission to a public transport system (travel cards) or allow bank users to withdraw money and pay online or physically (credit cards). These

three types of smartcards have offered new chances for marketing and mobility studies during the last decade, since the users' mobility can be monitored and subsequently analysed.

From the destination cards offered by destination management organisations (DMOs), it is possible to analyse general tourist movements and activity preferences. However, research with these data has been scarce and since the publication of Zoltan and McKercher (2015) new tips and research directions could lead the way towards more detailed studies. Specifically, they analysed the data of a destination card in the canton of Ticino (Switzerland) and detected different visitors' profiles according to their consumption of activities at destination. They pointed out that data coming from these smartcards should be enriched by asking a few demographic, socioeconomic and trip-related questions to the users when they acquire the card, as carried out previously by Zeni *et al.* (2009) in two cultural events in Trento (Italy). This information would highly complement the analysis while also increasing the insights that DMOs received from the gathered data to correctly market the destination products and spaces.

Regarding the data coming from credit cards, the volume of research has also been particularly limited due to privacy concerns and difficulty-to-access. A quantitative study carried out by Sobolevsky *et al.* (2014) with anonymized records of all bank card transactions carried out by the customers of the second largest bank in Spain (BBVA), distinguished the economic activity of domestic consumers from that of foreign visitors. They showed that mobility in Spain tends to differ according to the distance from the origin of the visitors to Spain: the farther away the visitors come from, the more extensive their mobility within the country.

Finally, with the travel card data much more research has been published over the last decades. Integrated transport systems capture all transactions and consequently they offer total flexibility in combining any temporal and geographical framework (Morency *et al.* 2007). Hence, these data are not only a

source for analysing public transport use, but also for optimizing services and improving the quality of the system (Bagchi and White 2005; Pelletier *et al.* 2011). In fact, these data have been used frequently to identify different profiles of public transport users (Ma *et al.* 2013) and to reconstruct OD matrices (Alsger *et al.* 2015). However, there is a lack of information on the individual characteristics of the users. In this vein, enrichment methods consisting of the combination of data from smart travel cards with passengers' surveys (Brakewood & Watkins, 2017) are being implemented.

Despite the undeniable potential of this type of data, the analyses within the context of tourist destinations are still relatively scarce (Lu *et al.* 2019; Domènech *et al.* 2019). In contexts characterized by a seasonal arrival of visitors, the operation of transport services might be affected by the increase of users, as well as the increase in the number of users using single tickets (who in most cases end up paying in cash on the bus). Therefore, travel card data becomes a useful tool for identifying bottlenecks (Makimura *et al.* 2017) and adapting supply to the variable characteristics of demand (Domènech *et al.* 2019).

f. Other sensor-based technologies

Other sensor-based technologies such as video cameras, Wi-Fi access points, Bluetooth or parking sensors, offer a wide variety of possibilities for monitoring travel behaviour. A common characteristic of these data sources is the reduced territorial coverage, but at the same time, the high spatial resolution of positioning and the low-cost of tracking human movements.

Video cameras are a powerful tool for measuring crowds at street carrying level, but also for tracking, counting and monitoring tourists in confined areas. For instance, in a study developed in the railway station square in Riomaggiore (Sachi *et al.* 2001), the authors counted the number of tourists. In two squares in Barcelona, the influence of cruise tourists and their behaviour within the public areas was analysed by Brandajs & Russo (2019) in order to identify how they

interact with local residents and to detect the potential policy implications derived from this.

Most mobile phones are equipped with Wi-Fi and Bluetooth and some studies have tested the potential for analysing visitors' mobility in confined areas. For example, Bonné *et al.* (2013) tracked visitors attending a Belgian three-day international music festival, and students and staff at a Belgian university campus for a period of three months by means of Wi-Fi detection. They dispersed as many detectors as needed over the area under study to guarantee optimal device tracking and pinpointed many implications and utilities of this kind of analytical studies. On their behalf, Versichele *et al.* (2014) used Bluetooth technology to analyse the mobility of visitors to and from the tourist attractions in Ghent (Belgium). In this regard, they validated the Bluetooth tracking within urban environments and underlined its potential for tourism management.

PART II. CASE STUDIES

4. Determinants of tourists' sustainable mobility choices at urban destination

What prompts tourists to become public transportation users at their destination? The case of a Mediterranean city

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Highlights

- Factors fostering tourists' use of intra-destination public transport are identified.
- How tourists travel to the destination is the most decisive determinant.
- The travel to the destination influences the impact of other variables.
- Tailor-made strategies are required to promote sustainable transportation modes.

Abstract

The multiple dimensions of mobility decisions made by visitors add additional pressure to the sustainable equilibrium of destinations that combine residents" daily activities with the arrival of tourists. Thus, the use of public transportation by tourists becomes central to improving ecoefficiency and mitigating negative externalities resulting from the massive mobility of tourists at their destinations. This research addresses the determinants of intra-destination public transportation use and departs from the hypothesis that the main impact derives from the transportation choice made during the longest trip from the traveller's origin to his or her destination. The study uses data obtained from a survey of tourists (N=939) staying overnight in Tarragona (Catalonia, Spain), a medium-sized historic Mediterranean city. Logit estimations, Chi-square Automatic Interaction Detector (CHAID) analysis and interactions in the logit estimations are used to fulfil the research objective. The results suggest that tailor-made strategies are required to foster the use of sustainable transportation modes at tourist destinations. The study therefore highlights the importance of disentangling tourist profiles in order to properly customize mobility policies.

Keywords: Public transport, sustainable mobility, tourist mobility, transport mode choice, tourism destination

4.1. Introduction

Transportation and tourism are co-dependent (Hall, 1999) because there would be no tourism without supporting transportation (Le-Klahn and Hall, 2015). At the same time, previous studies signalled several negative externalities that stem from these transportation activities. Researchers have extensively studied the contribution of tourism transportation to climate change because it is regarded as its most pressing negative environmental impact (Sala *et al.* 2000; Graßl *et al.* 2003; Thomas *et al.* 2004; Fang *et al.* 2018). Indeed, Peeters *et al*. (2007) concluded that climate change is to be blamed for more than half of the externalities associated with tourist transportation. Most studies have highlighted the negative impact of travelling to a destination, specifically with regard to air travel (Gössling *et al.* 2002; Gössling *et al.* 2005; Peters & Dubois, 2010; Rico *et al.* 2019). Nonetheless, tourism destinations are also very sensitive to the impact of intra-destination transport (Guiver & Stanford, 2014). The private car is implicated as the primary source of emissions. Regarding air quality, tourism-associated transportation's negative impact on air quality has been well-documented (Becken 2006; Sajjad *et al.* 2014; Grover *et al.* 2017). More precisely, Saenz de Miera & Rossello (2014) showed that the daily stock of tourists is a significant predictor of air pollution levels in Mallorca. Also, negative impacts related to noise (Becken 2006), road congestion (Palmer-Tous *et al.* 2007; Saenz de Miera & Rossello, 2012; 2013; Sundriyal *et al.* 2018), the growth of transport infrastructure that reduces natural landscapes and wildlife habitats (Davenport & Davenport 2006; Comer & Willems 2011), and road safety (Wilks *et al.* 2017; Rosselló & Saenz de Miera, 2011) have been widely recognized. These deleterious effects can, not only influence residents' perceptions about tourism (Andereck & McGehee 2008; Dickinson & Robbins, 2008), but also tourists' experiences (Alegre & Garau 2010; Eusébio & Vieira 2013; Iglesias-Merchan *et al.* 2014). The correct management of mobility flows requires the analysis of tourists' mobility patterns and the identification of tourist demographics that are more likely to use sustainable modes of transportation. Accordingly, various studies have demonstrated the

importance of a modal shift towards public transport (PT) so as to reduce the impact of negative externalities associated with transportation at tourist destinations (Peeters & Schouten, 2006; Guiver *et al.* 2007; Liu *et al.* 2017; Scuttari *et al.* 2018). Shedding light on the factors that prompt tourists to use PT at their destinations is a central research objective for promoting destination sustainability. In spite of this, previous studies have not devoted much attention to transportation choices of tourists at their destinations (Gross & Grimm, 2018). To address the determinants of the intra-destination transportation decisions by tourists, it is particularly relevant in those destinations where the impact of those decisions is more noticeable. This is particularly the case for small and medium-sized historical cities where the size of the local community is more sensitive to the arrival of a large number of tourists (Ashworth & Tunbridge 2000; Domènech & Gutiérrez 2017), and there are negative consequences associated with their transportation decisions during their stay. In terms of transportation, this higher level of sensitivity associated with smaller areas has been demonstrated by Guiver & Stanford (2014), who show that within small destination areas, travellers can account for one-third of the total travel emissions, whereas Gutiérrez & Miravet (2016b) show how the demand for PT is boosted during the high travel season by the mass influx of tourists to a mid-sized coastal metropolitan area.

In this context, the aim of this research article is twofold. First, it aims to shed light on the factors that encourage tourists to use PT at their holiday destination in medium-sized historical cities. Following Gutiérrez & Miravet (2016a), the analysis departs from the main hypothesis that the mode of transportation chosen to travel to the tourists' destination is the most important factor influencing the use of PT. The second goal of this paper is to examine the validity of the previous hypothesis to determine whether and to what extent the effect of the determinants of the use of PT is sensitive to the mode of transportation chosen to travel to the holiday destination. Verifying the aforementioned hypothesis would imply the existence of divergent responses to the factors that determine the likelihood of becoming a user of the local PT

network and, as a result, the need to implement segmentation strategies that foster the use of PT among tourists. The study has been performed in the city of Tarragona (Catalonia), a medium-sized Mediterranean coastal city of 130,000 inhabitants. The study was based on data obtained from a tourist survey conducted in 2014, 2015 and 2016 (N=939). The survey examined multiple characteristics of tourists that stayed overnight in Tarragona, including their socioeconomic profile and the nature of their stays. It also examined their mobility at the destination during holidays and their use of PT once at their destination.

After this introduction, a review of the relevant literature is presented. Then, a description of the data used in the research and the empirical approach implemented is provided. Finally, the results and the conclusions that can be drawn, together with the implications of this research, are presented.

4.2. Review of literature

Studies that have empirically addressed the determinants of tourists' use of PT during their stay at a destination have carried out their analyses by departing from a diverse set of methodological perspectives, datasets and territorial contexts. In this regard, the theoretical framework put forward by Gross & Grimm (2018) brings order to the literature on the topic. According to them, determinants can be divided in two main groups: objective and subjective. The first group can be further split in socio-demographic characteristics, travel-orientated characteristics, destination characteristics and quality of transport services. Subjective determinants include travel motivation/type of travel and time of the decision.

As stated by Dolnicar *et al.* (2010), the destination has a significant impact on the choice of transportation, even between destinations that are similar (Gutiérrez & Miravet, 2016a). In fact, a comparison of the results between studies is compromised because the works that have addressed the determinants of PT use have been carried out in very different contexts. Some

of these studies are based on data from tourist surveys carried out in big cities (Munich, Germany: Le-Klähn *et al.* 2014; Le-Klähn *et al.* 2015), medium-size cities (Kassel, Germany: Bieland *et al.* 2017), rural or natural areas (Ticino, Switzerland: Masiero & Zoltan, 2013; Dietlmeier 2013), Peak District (UK: Lumsdon *et al.* 2006), coastal destinations (Costa Daurada, Spain: Gutiérrez & Miravet, 2016a; Gutiérrez *et al.* 2019), or even on a country-wide level (Ghana: Nutsugbodo *et al*. 2018; Scotland, UK: Hough & Hassanien, 2010). On the other hand, other studies have examined surveys sent to households and, as a result, the data include respondents who have visited a diversity of destinations (Switzerland: Dolnicar *et al.* 2010; Germany: Gross & Grimm, 2018). The effects associated with the destination can stem from both the characteristics of the area and the quality of the PT and its alternatives. Regarding the former, the type of destination and its size in terms of inhabitants (Gross & Grimm, 2018), along with its attractions (Le-Klähn *et al.* 2015), are factors that must be taken into consideration. However, there are few works that have analysed objective characteristics associated with PT. Lumsdon *et al*. (2006) provides evidence that by offering the right combination of transport and tourism, there is potential for a modal shift among some segments of tourists.

Most of the studies in this field provide empirical evidence of the impact of socio-demographic characteristics, such as gender (Masiero & Zoltan, 2013; Nutsugbodo *et al.* 2018), age (Bieland *et al.* 2017; Gross & Grimm, 2018; Le-Klähn *et al.* 2014; Masiero & Zoltan, 2013), national origin (Hough & Hassanien 2010; Masiero and Zoltan, 2013; Nutsugbodo *et al.* 2018), education (Le-Klähn *et al.* 2015; Hough & Hassanien 2010; Nutsugbodo *et al*. 2018), marital status (Bieland *et al.* 2017; Gross & Grimm, 2018), household size (Gross and Grimm, 2018), income/social class (Gross & Grimm, 2018; Gutiérrez & Miravet, 2016a), occupation (Gross & Grimm, 2018; Nutsugbodo *et al.* 2018), car/driving licence ownership (Gross & Grimm, 2018; Le-Klähn *et al.* 2014), everyday use of PT (Bieland *et al.* 2017) along with language capabilities and previous travel experience (Hough & Hassanien 2010). In contrast, Dietlmeier (2013) found no statistically significant relationship among any of her socioeconomic variables

and the intention to use travel alternatives to a private vehicle. Regarding travel-oriented characteristics, the influence of the size of the party group (Gross & Grimm, 2018; Le-Klähn *et al.* 2015), how the holiday has been organized (Hough & Hassanien 2010; Gross & Grimm, 2018), the length of stay (Le-Klähn *et al.* 2014; Gutiérrez & Miravet, 2016b), repeating destination (Le-Klähn *et al.* 2015; Masiero & Zoltan, 2013; Gutiérrez & Miravet, 2016a), type of accommodation and expenses (Gutiérrez & Miravet, 2016a) have been highlighted.

For the subjective factors, the motivation for the trip and the type of activities that the tourist is planning to undertake are central to the choice to use PT (Gross & Grimm, 2018; Le-Klähn *et al.* 2014; Le-Klähn *et al.* 2015; Masiero & Zoltan, 2013). Despite the fact that the theoretical framework suggested by Gross and Grimm (2018) does not include the subjective perceptions related to the quality and convenience of PT, these are key determinants in the individuals' decision. Dietlmeier (2013) not only highlights individuals' attitudes towards sustainable modes of transport as the most important predictor of PT use during the holidays, but the perceived behavioural control is also identified. In other words, the ability to behave according to the traveller's own beliefs exerts a substantial influence. Le-Klähn *et al*. (2014) states that the tourists' perception of the existence of drive-free benefits, traffic reduction and certain advantages associated with PT triggers its use. The opposite effect is observed when the traveller perceives the existence of inconveniences and restrictions, lack of information and other disadvantages. Additional subjective elements that influence PT use among tourists are perceptions related to service quality regarding accessibility, comfort, reliability (Nutsugbodo *et al.* 2018) and cost (Le-Klähn *et al.* 2015).

Two objective factors deserve particular attention. The first is related to visits that the tourist undertakes during his or her stay. The influence of the attractions visited on the choice of the mode of transportation is a particularly sensitive issue, not only because of its effect on the decision to use PT, but also

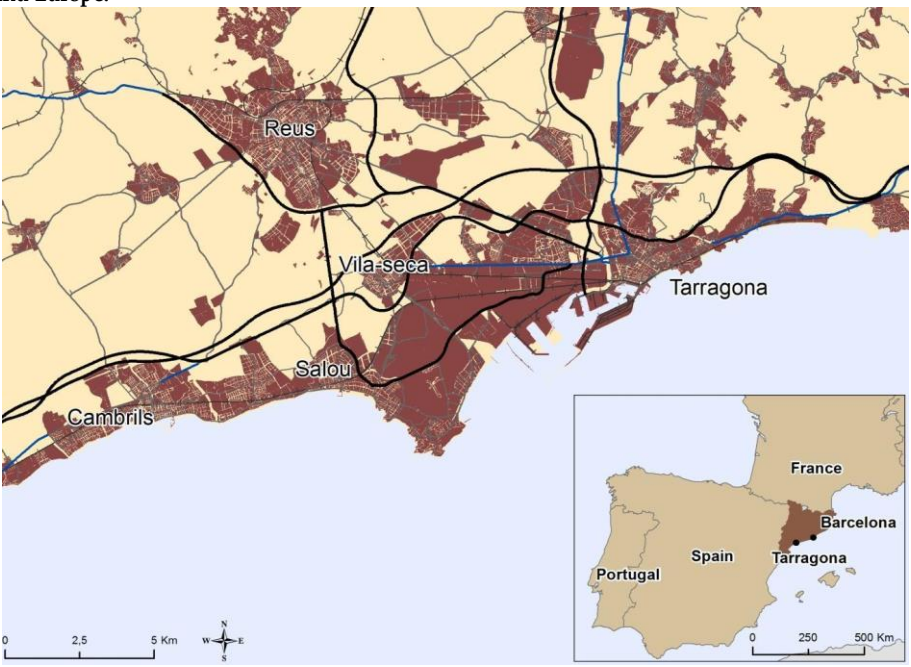
because it raises a subsequent methodological concern caused by the existence of an interdependency between both variables (Masiero & Zoltan, 2013; Le-Klähn *et al.* 2015). In other words, the first step is to decide what to visit, and the second step is to decide how to get there, taking into consideration reciprocal interactions between each of the decisions. The choice of an estimation procedure that does not take into consideration the potential correlation structure of the random components due to the interdependency would result in biased results. To circumvent potential sources of bias, Masiero & Zoltan (2013) and Le-Klähn *et al*. (2015) applied a bivariate probit model. The statistical tests they performed support their methodological election. The second determinant relates to the mode of transportation chosen to get to the destination. Its influence has been highlighted by Dolnicar *et al.* (2010), Bieland *et al.* (2017), Gross & Grimm, (2018) and Gutiérrez and Miravet, (2016a). In particular, Gutiérrez & Miravet, (2016a) found that the selected mode of transportation becomes the most decisive variable, and analogous to the case of the visits undertaken, methodological concerns arise due to the potential endogeneity between the choice of transportation to the destination and the decision to use PT. The results of the statistical tests confirm the biasing effect caused by the correlation of the error terms. Furthermore, the evidence suggests that the unobserved heterogeneity associated with the tourists who travel by plane negatively influences the use of PT at the destination. Despite the fact that previous studies have left no doubt about the influence of transportation decisions on the posterior intra-destination use of PT, to the best of our knowledge, the literature has not yet explored whether the incidence of the determinants for the use of PT depends on the choice of transportation mode used to reach the destination from the traveller's origin.

4.3. Data

4.3.1. Study context

Tarragona is located on the shore of the Mediterranean, 100 km south of Barcelona, the capital of the north-eastern autonomous community of Spain, Catalonia (see Figure 5). The city and its surroundings constitute the second most important metropolitan area in Catalonia after Barcelona. The metropolitan area is inhabited by almost half a million people. Tarragona is the most populated city with 132,299 inhabitants in 2018. According to the official data from the Tourism Observatory of Catalonia, the city attracts around half a million tourists annually, which translates to 2 million overnight stays per year.

Figure 5. The metropolitan area of Tarragona and its location in the context of Catalonia, Spain and Europe.



Source: author's own production

Tourists arrive by various modes of transportation. The city is well-connected through toll motorways. To the northeast, the AP-7 motorway connects Tarragona with Barcelona and the French border. To the southwest, it leads to

Valencia and the rest of Spain's Mediterranean arc. To the west, the AP2 motorway provides connections to Madrid, Zaragoza and the River Ebro corridor. For air transport, the nearest infrastructure is Reus airport, which is 10 km from the city of Tarragona. The Barcelona-El Prat airport (100 km away) is also an important arrival location for tourists heading for Tarragona and Costa Daurada. Tarragona is connected by means of a conventional railway station and a high-speed train station located around 15 km north of the city.

Tarragona's connectivity enhances mobility between the different municipalities in its vicinity, which enables tourists to visit a wider range of tourist attractions. In fact, Tarragona is surrounded by other towns and cities that are also popular tourist destinations that can be reached in just a few minutes, such as the central Costa Daurada and Reus. The former comprises the municipalities of Salou, Cambrils and Vila-seca, which received more than 3.7 million tourists in 2018 due to their beaches. Reus, with 103,477 inhabitants in 2018, is the second most populated city in the area and attracts visitors because of its shopping venues, along with its unique heritage. It is also possible to make day visits to Barcelona from Tarragona.

4.3.2. Questionnaire and data collection

Data were obtained from a survey on tourist demand conducted by the Tourism Observatory of Catalonia. The sample (N=939 participants) was based on surveys conducted in 2014, 2015 and 2016 in Tarragona. People surveyed were adult tourists staying at hotels, hostels, camping sites, tourist apartments, second homes and family and friends' houses.

Questionnaires were completed during various time slots each day during the main tourist season (from June to September), in addition to weekends and on public holidays during the rest of the year. The overall distribution of surveys completed in municipality districts was defined by taking into account the number of tourists hosted in each. For this reason, key locations that attract

most of the tourist influx were chosen as survey sites. The selection of individual tourists to be surveyed at each location was randomly defined.

The first part of the questionnaire collects information on the characteristics of the tourist's stay, including type of accommodation, duration of stay, travel companion(s), whether the tourist had visited Tarragona before and expenses during their stay. Data on the mode of transportation to the tourist destination from the point of origin were also gathered. The survey included information on tourist characteristics and their demographic profiles (e.g., sex, age and country of origin). Tourists were also asked about activities, mobility patterns at their destination and places visited during their stay. Finally, the questionnaire distinguished whether or not the tourists were PT users. No data on the frequency of PT usage were gathered.

4.4. Descriptive statistics

Table 8 presents descriptive statistics for the whole sample. All variables are dichotomous, and each sample observation can only equal 1 or 0. The mean values are interpreted as percentages of people surveyed who gave a specific answer.

The sum of the means of each answer must be equal to 1 for each category, except for the set of variables relating to the attractions or places that tourists visited (or were planning to visit) during their stay in Tarragona, due to the fact that the tourists could indicate in the survey multiple destinations they visited or were planning to visit.

Table 8. Descriptive statistics of the tourists surveyed

Variable	Categories	Mean (N = 939)
Transport mode to arrive at Tarragona	Plane	0.20
	Own vehicle	0.66
	Public transport	0.14
Use of Public Transport once at destination	Use of PT in Tarragona	0,20
Origin	Mainland Spain (excluding Balearic Islands, Canary Islands and Ceuta)	0.58
	France, Andorra and Monaco (excluding Corsica)	0.14
	Countries located less than 2000 km from the destination	0.19
	Countries over 2000 km from the destination and overseas territories	0.09
Accommodation	Second home or apartment	0.20
	Camping	0.24
	Hotel	0.52
	Other places	0.03
Age	Up to 44 years old	0.51
	From 45 to 64 years old	0.40
	65 years old and older	0.09
Spending at the destination	High [€41.7 – €1,000.0]	0.33
	Medium [€25.0, €40.0]	0.22
	Low [€0.68 – 21.9€]	0.27
	Unknown	0.18
Education	High education level (university studies)	0.62
Visits	Barcelona	0.21
	Costa Daurada	0.26
	Tarragona	0.50
	Other places	0.58
	Not visiting any place	0.24
Duration of stay	3 days or less	0.54
	Longer than 3 days	0.46
Accompanied by	Friends	0.06
	Family with children	0.38
	Family trip or partners	0.44
	Others (business trip, schools, etc.)	0.12
Repeater	Not the first visit to Tarragona	0.50

Variable	Categories	Mean (N = 939)
Gender	Male	0.54
Season	Summer	0.59
Year	2014	0.30
	2015	0.38
	2016	0.32

Source: Author's own production

In the dataset, 56% of the tourists completed at least one journey outside Tarragona, whereas 20% only visited places within the city. These results indicate a considerable level of tourist mobility upon reaching Tarragona. The most commonly used transportation mode to arrive at destination from the place of origin was a private car (66%), followed by a plane (20%). Once at their destination, up to 20% of the individuals sampled used PT during their stay.

In terms of tourist demographics, Spain was the dominant nation of origin (58%), followed by France (14%). Additionally, 44% of tourists travelled with their partner or other family members who were not children, while 38% travelled with children. Over half of the tourists (52%) were accommodated in hotels, although camping (24%) and stays in second homes or apartments (20%) were also observed. Almost one-third of the tourists (62%) had a university education, and one-half of the sample were repeat visitors. Overall, a majority of the sample stayed in Tarragona for 3 days or less. Finally, regarding the level of spending at the destination, the variable has been created by implementing tertiles on the average daily spending per visitor at the destination.

4.5. Empirical approach

The empirical strategy involves logit estimations, a chi-squared automatic interaction detection (CHAID) tree analysis, in addition to the introduction of interactions in the regressions.

4.5.1. Logit estimations

First, logit estimations are performed to assess the individual impact of each of the explanatory variables considered in the models. It is expected that the mode of transport chosen to reach the tourist destination is one of the most powerful predictors of the use of public transport at destination. This variable is suspected to be endogenous, as in turn it is highly likely to be directly determined by the place of origin of the tourist (Gutiérrez & Miravet, 2016a). More specifically, our concern is due to the effect of an endogenous multinomial variable (in our case there are three possible discrete outcomes: car, plane and public transport to travel to the destination) on a dichotomous indicator variable (the use of public transport by tourists at the destination). According to Wooldridge (2014), when the estimation involves non-linear models, the use of linear IV techniques, which consist in plugging into a second stage equation the fitted values obtained in a first stage equation instead of using the original variable, leads to inconsistent results. To overcome the potential biasing impact of endogeneity as a result of the influence of a tourist's country of origin on his or her decision of transportation to reach the destination, the estimation methodology suggested by Deb & Trivedi (2006a, 2006b) is followed. This econometric technique envisages introducing latent factors both into the multinomial and outcome equations, which can follow either negative binomial, gamma or logistic distributions. Its use is justified since it suits the particular distributions of our variables and it has been proved to be superior to other econometric alternatives (Shane & Trivedi, 2012).

Thus, the choice of the mode of transportation used to reach Tarragona is expressed as a mixed-multinomial equation:

$$Pr\ (m_i|z_i, l_i) = \frac{exp\ (z_i' \propto_j + \delta_j l_{ij})}{1+\sum_{k=1}^{J} exp\ (z_i' \propto_k + \delta_j l_{ik})} \quad (1)$$

where the probability of an individual i using a transportation mode j is a function of a series of observed variables z_i and a group of unobserved variables l_{ij}, while δ_j represents the loading factor associated with each transportation mode.

The probability of using PT at the destination expressed as a endogeneity-corrected logit:

$$Pr\ (t_{i,}|x_i, m_i, l_i) = \frac{exp\ (x_i'\beta + \sum_{j=1}^{J} \gamma_j m_{ij} + \sum_{j=1}^{J} \lambda_j l_{ij})}{1+exp\ (x_i'\beta + \sum_{j=1}^{J} \gamma_j m_{ij} + \sum_{j=1}^{J} \lambda_j l_{ij})} \quad (2)$$

where the probability of an individual i using PT during his or her stay in Tarragona is a function of a series of control variables x_i, which include the characteristics and demographics of the trip and tourist, respectively, the transportation mode used to reach Tarragona m_i and the unobserved heterogeneity l_{ij} with their respective loading factors λ_j. Each λ_j reflects the impact of the unobserved heterogeneity related to the use of each transportation mode chosen to reach the destination on their probability of using PT there.

The validity of the results of the endogeneity-corrected logit model is conditioned by the result of the test put forward by Deb & Trivedi (2006b), which contrasts the null hypothesis of all λs=0, and hence λplane = λPT = 0, is tested. The rejection of the null hypothesis would imply the rejection of exogeneity, and as a result, the model suggested by Deb & Trivedi (2006a, 2006b) should be implemented.

4.5.2. CHAID analysis and interactions

CHAID analysis enables us to distinguish tourist profiles by means of the detection of those factors critical to the use of PT by tourists during their stay. The subsequent tree division reveals the particular factors that better account for differences in PT use for each of the tourist segments. This information is important because factors that influence different groups' choice of transportation may vary from one group to another, and, therefore, different approaches for each group are needed to successfully achieve a modal switch (Anable 2005).

The CHAID algorithm was designed by Kass (1980) and provides a "tool that identifies [groups of] conditions under which the response distribution of the actions [of a categorized action variable] is more homogeneous" (Van Middelkoop *et al.* 2003). More precisely, CHAID analysis is a non-parametric exploratory technique that allows a meaningful tree-based partition of a population into mutually exclusive exhaustive subsets (Kass 1980). The results are presented in a tree-form diagram. The probability of an event, which, in our case, is the probability that a tourist staying overnight in Tarragona becomes a PT user, is estimated by means of a chi-square test applied to each of the potential predictor variables. The most significant predictor variable is selected in order to split the population into segments. This process is subsequently repeated down the tree for each of the segments obtained, until the predictors applied are not significant or requirements established by researchers (e.g., size of the segments) are no longer met.

In our study, we have decided to impose a restriction on the node and segment sizes. The minimum node size must contain at least 100 observations, and the minimum segment size is established at 50 observations. As can be seen in Table 9, a total of 17 explicative/independent variables are included in the CHAID analysis, whereas the PT use by tourists at their destination is the dependent variable.

Table 9. Variables used to develop the CHAID analysis.

Variable	Categories	Variable	Categories
Ch_UseOfTransport (d)	1= Yes	ch_Who (e)	1= With friends
	2= No		2= With family and partner
ch_Gender (e)	1= Male		3= With children
	2= Man		4= Others
ch_Repeater (e)	1= Repeater	ch_Expenses (e)	1= Low
	2= First-time visitor		2= Mid
ch_Duration (e)	1= Stay of 3 days or less		3= High
	2= Longer than 3 days		4= Unknown
ch_Tertiary (e)	1= Tertiary studies	ch_VBCN (e)	1= Visiting Barcelona
	2= Others		2= Not visiting
ch_Transport (e)	1= Airplane	ch_VTGN (e)	1= Visiting Tarragona
	2= Public Transport		2= Not visiting
	3= Own vehicle	ch_VNOT (e)	1= Not visiting
	4= Others		2= Visiting some place
ch_Accomodation (e)	1= Second home/ apartment	ch_VCD (e)	1= Visiting beach destinations
	2= Camping		2= Not visiting
	3= Hotel	ch_VOTHERS (e)	1= Visiting other places
	4= Others		2= Not visiting
ch_Origin (e)	1= Spain	ch_Season (e)	1= Summer
	2= France		2= Winter
	3= Countries at less than 2000 km	ch_Year (e)	1= 2014
	4= Countries over 2000 km		2= 2015
ch_Age (e)	1= up to 44 years old		3= 2016
	2= 46-64 years old		
	3=65 and older		

(d)= dependent variable; (e)=explicative variable
Source: Author's own production

Regarding the introduction of interactions in the logit estimations, it delves into the objective pursued by the CHAID analysis. In other words, this method tests whether the determinants of intra-destination PT use are sensitive to the mode of transportation chosen to travel to Tarragona. Each variable is interacted with

an indicator variable that distinguishes tourists who have reached Tarragona by air travel or by PT from those who have used a private vehicle. Interactions are introduced one by one. As a result, the total number of estimated models including interactions equals the total number of explanatory variables to be interacted. As any other variable, the degree of significance of each interaction is assessed by means of the t-test. Thus, a significant coefficient associated with an interaction implies that the impact of that variable on the probability of becoming a user of public transport once at the tourist destination is sensitive to the mode of transport chosen to reach the tourist destination.

4.6. Results

4.6.1. Logit estimations

The methodology suggested by Deb & Trivedi (2006a, 2006b) is applied to discern whether either logit estimations, or endogeneity-corrected logit estimations are preferable. First, the endogeneity corrected logit is estimated with the object of contrasting the null hypothesis of λplane = λPT = 0, following the test devised by Deb & Trivedi (2006b). The null hypothesis is tested assuming a distribution $\mathcal{X}^2$ (q), where q is the number of parameters λ and thus, q=2. The probability of λplane = λPT = 0 is 0.18, and consequently, the null exogeneity hypothesis cannot be rejected. Moreover, as it can be noted in the results of the endogeneity-corrected logit estimation shown in the appendix, none of the Lambda coefficients associated with the plane and PT is significant, which indicates that unobserved heterogeneity does not have a significant impact on the probability of using PT once at the tourist destination. The lack of significance of the lambda coefficients is likely to be linked to a hypothetical lack of endogeneity in the model. Thus, it can be concluded that the logit estimation is preferable to the endogeneity corrected logit estimation. The results of the latter estimation are presented in the appendix, including both the logit model with the coefficients associated with the latent factors, together with

the multinomial model, which includes the tourists' origin within the explanatory variables.

Estimation results of the logit models with no correction for endogeneity are shown in Table 10. The difference between model (1) and model (2) lies in the fact that the latter includes the origin of the tourist among the explanatory variables. Both models suggest that the transportation mode chosen to travel to Tarragona is the most determining factor that predicts the use of PT by tourists at their destination. Moreover, the impact associated with travels to Tarragona via PT in both models is higher compared to that associated with air travel.

The results of model (2) indicate that the probability of using PT at a given destination is highly influenced by the point of origin of the tourists. Specifically, more distant destinations make tourists more prone to use PT. It must be highlighted that the introduction of the origin indicator variables in model (2) results in a substantial decrease in the coefficients attached to air travel. This result is consistent with the fact that tourists' origin significantly influences the transportation decision at the tourist destination, as the multinomial mixed logit estimation also makes apparent (see Appendix). Nevertheless, this relationship is not significant in the case of tourists reaching Tarragona by means of PT.

The probability of using PT considerably increases with longer stays. This result is accounted for by the fact that longer stays increase the probability of visiting a greater number of tourist attractions, not only within the city, but also in the surrounding areas (Le-Klähn *et al.* 2014). Additionally, the longer the stay, the greater the tourist's understanding of the PT network, which also makes the tourist more likely to become a PT user. Higher levels of spending are also linked to an increased use of PT, which is consistent with Gutiérrez & Miravet (2016a).

Table 10. Logit estimation results (dependent variable: PT use by tourists at destination). Robust standard errors are presented in parentheses.

	(1) Logit estimation		(2) Logit estimation Including tourists' origin	
	Coef.	Std.Error	Coef.	Std.Error
Intercept	-2.854	(0.607)***	-2.927	(0.611)***
Transport mode to arrive: own vehicle	Reference category		Reference category	
Transport mode to arrive: plane	1.639	(0.262)***	1.057	(0.337)***
Transport mode to arrive: public transport	2.258	(0.298)***	2.263	(0.310)***
Accommodation: hotel	Reference category		Reference category	
Accommodation: second residence/apartment	0.279	(0.272)	0.267	(0.274)
Accommodation: camping	-0.423	(0.416)	-0.48	(0.409)
Accommodation: other places	-0.017	(0.693)	-0.196	(0.732)
From 45 to 64 years old	Reference category		Reference category	
Up to 44 years old	-0.011	(0.215)	0.005	(0.217)
65 years old and older	0.185	(0.365)	0.124	(0.370)
Duration of stay longer than 3 days	Reference category		Reference category	
Duration of stay, 3 days or less	-1.424	(0.277)***	-1.407	(0.274)***
High education level (university studies)	0.051	(0.227)	0.003	(0.229)
Spending at the destination: medium	Reference category		Reference category	
Spending at the destination: high	0.709	(0.273)***	0.704	(0.277)***
Spending at the destination: low	0.124	(0.320)	0.167	(0.320)
Spending at the destination: unknown	0.566	(0.338)*	0.521	(0.343)
Repeater: not the first visit to Tarragona	-0.118	(0.214)	-0.028	(0.221)
Visiting Tarragona	0.159	(0.279)	0.182	(0.280)
Visiting Barcelona	0.588	(0.239)**	0.482	(0.249)**
Visiting Costa Daurada	0.612	(0.249)**	0.643	(0.250)***
Visiting other places	0.499	(0.279)*	0.455	(0.286)
Not visiting any place	0.240	(0.343)	0.241	(0.345)
Gender: male	0.068	(0.200)	0.018	(0.197)
Accompanied by: family with children	Reference category		Reference category	
Accompanied by: family trip or partners	-0.293	(0.275)	-0.305	(0.276)
Accompanied by: friends	-0.302	(0.424)	-0.387	(0.438)
Accompanied by: others	-0.288	(0.334)	-0.324	(0.340)
Season: summer	-0.154	(0.245)	-0.230	(0.251)
Year 2015	Reference category		Reference category	
Year 2014	1.092	(0.250)***	1.070	(0.249)***
Year 2016	0.523	(0.309)*	0.537	(0.308)*
Origin: Spain			Reference category	
Origin: France, Andorra and Monaco			0.104	(0.323)
Origin: countries located less than 2000 km			0.883	(0.339)***
Origin: countries over 2000 km			0.843	(0.431)**

* Significant at 10%, ** significant at 5%, *** significant at 1%.

Source: Author's own production

The decisions regarding the places visited also play a key role in the use of PT. In fact, the probability of using PT at one's destination increases for those tourists who go to Barcelona or to towns belonging to the Costa Daurada during their stay. These destinations are easily accessible by means of PT, given that this mode of transportation is competitive with a private car in terms of travel times. Conversely, interior destinations grouped within the category "Visit other places" are not as easily accessible by means of PT due to the lack of frequency of the services and long travel times, which are responsible for its lack of use. Visits to attractions located within Tarragona do not have a significant impact either.

None of the coefficients associated with the rest of the explanatory variables is significant. Hence, similar to Masiero & Zoltan (2013), the results do not demonstrate a significant influence on one's accommodation. Moreover, and in accordance with Dietlmeier (2013), no evidence of a significant impact of socioeconomic characteristics has been found. Finally, coefficients associated with years 2014 and 2016 are both significant, although the impact of 2016 is much lower and only statistically significant at 10% in models (1) and (2). This result may be related to the movement of passengers in the nearest airport to the city, which influenced the number of tourists who reached Tarragona by air[3]. Aside from the absolute number of passengers, these fluctuations could affect PT use based upon the origin of the passengers.

[3] According to the statistical registers of the public company in charge of civil aerial navigation in Spain, Aena, the number of passengers using the airport nearest the city (Reus Airport) has considerably fluctuated between 2014 and 2016. More precisely, the number of passengers in this airport in 2015 was 17% lower in comparison to 2014. In 2016, the number increased, but it did not recover the cipher registered in 2014.

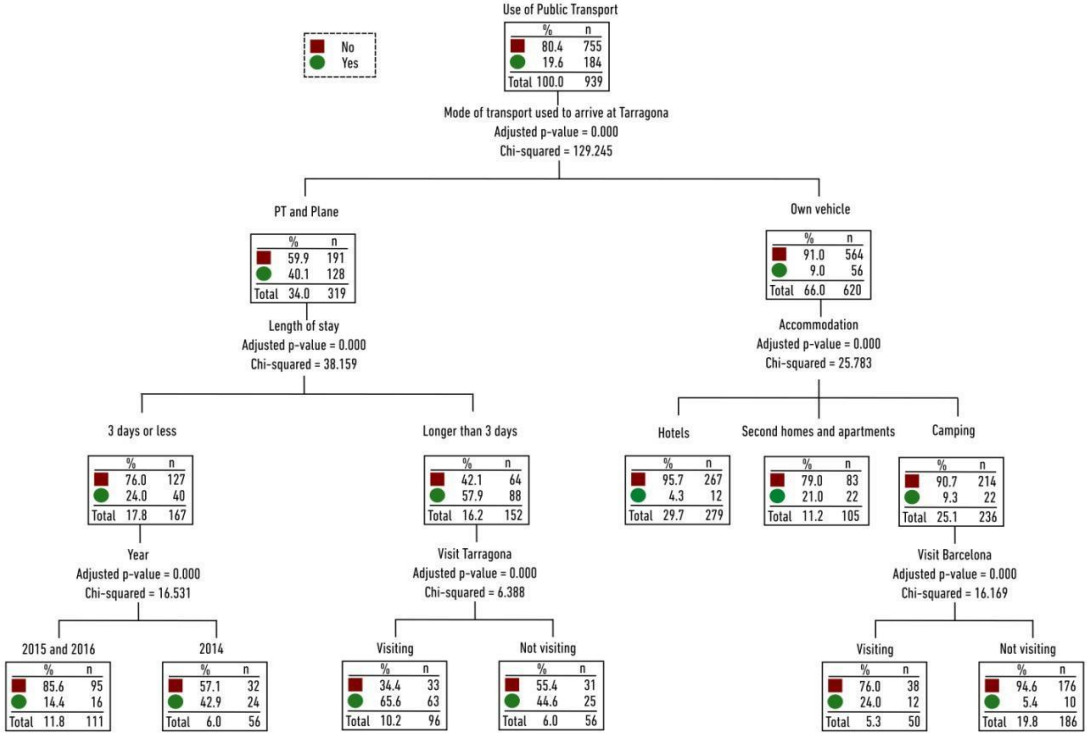
4.6.2. CHAID analysis

The results of the CHAID analysis are shown in Figure 6. A total number of 13 clusters were obtained, and the key variable influencing the mode of transportation used to reach Tarragona was consistent with the empirical evidence obtained in the logit estimations. Whereas the mean use of PT for the whole sample was 19.6%, 40.1% of those who arrived in Tarragona via an airplane or PT (train or coach) used PT during their holiday (Cluster 1). In contrast, PT use for those who arrived in Tarragona in a private vehicle was reduced to 9.0% (Cluster 2).

The conclusions derived from the CHAID analysis are overall consistent with the results obtained in the logit regressions in terms of the variables that cause the greatest impacts. The mode of transportation chosen to travel to the destination is the most determining factor for PT use at the tourist's destination. Additional predictors also play a role in the tree, including the length of stay and the visits undertaken from Tarragona.

Nonetheless, the tree also shows that in contrast to the evidence provided by the regressions, the tourist's accommodation is a decisive factor for those who travelled to Tarragona by means of a private vehicle. Visiting Tarragona, which neither was significant in the regression, emerges in the third level of the tree for tourists travelling by air or PT and staying longer than 3 days.

Figure 6. CHAID analysis results



Source: Author's own production.

On the whole, it is striking that all the splitting variables within the first and second clusters (second and third levels) are different. In other words, the factors that make a difference for those who travelled by private vehicle to the destination are different from those that have the greatest impact for tourists who travelled to Tarragona via air or PT. This could indicate an underlying effect related to the mode of transportation chosen to travel to the destination, which might influence the effect of the rest of the determinants. In contrast with the CHAID model, these differences were not detected in the logit estimations as the sample was taken as a whole, without any partitions. Hence, coefficients only captured a mean global impact, and no distinction regarding the effect of the explanatory variables between groups was allowed. The estimation of separate samples would be an alternative to disentangle the potential divergent impacts between groups. This option has been discarded nonetheless, as it would have made it impossible to capture the strong effect associated with each of the transportation modes used to travel to the tourist destination. Conversely, interactions allow us to distinguish the effect caused by any of the explanatory variables for each of the modes of transportation maintaining the impact derived from the latter.

4.6.3. Interactions

The introduction of interactions examines whether the impact of the determinants of intra-destination PT use is mediated by the transportation mode chosen to travel to the destination. Table 10 compares the results of a model without interactions with the results of models including interactions. Only one interaction can be introduced into an equation at a time, otherwise the coefficients would be biased. For this reason, 26 models with interactions are estimated; each model interacts with one of the explanatory variables. The left column (model 1) in Table 10 shows the results of an alternative logit regression that replicates model (2) presented in Table 9. The only difference is the gathering together of tourists who travelled by plane and PT to the destination,

which follows the structure obtained using the CHAID analysis. The results are compared to those obtained when the interactions are considered.

Table 11. Logit estimation results (dependent variable: PT use by tourists at destination). Comparison of models with and without interactions.

	(1) Ø interactions		(2) Interactions	
	Coef.	Std. Error	Coef.	Std. Error
Model 1. Interaction with "Accommodation: Second residence/apartment"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	2.112	(0.32)***
Accommodation: second residence/apartment	0.342	(0.27)	0.969	(0.38)**
PT or plane x Accommodation: second residence/apartment			-0.987	(0.45)**
Model 2. Interaction with "Accommodation: Camping"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.730	(0.28)***
Accommodation: camping	-0.362	(0.41)	-0.432	(0.45)
PT or plane x Accommodation: camping			0.280	(0.68)
Model 3. Interaction with "Accommodation: Other places"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.798	(0.27)***
Accommodation: other places	-0.003	(0.68)	0.426	(0.71)
PT or plane x Accommodation: other places			-1.165	(1.38)
Model 4. Interaction with "Age: Up to 44 years old"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.441	(0.32)***
Age: Up to 44 years old	-0.005	(0.22)	-0.443	(0.32)
PT or plane x Age: Up to 44 years old			0.773	(0.42)*
Model 5. Interaction with "Age: 65 years old and older"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.910	(0.28)***
Age: 65 years old and older	0.238	(0.23)	0.895	(0.44)**
PT or plane x Age: 65 years old and older			-1.113	(0.6)*
Model 6. Interaction with "Duration of stay, 3 days or less"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.642	(0.35)***
Duration of stay, 3 days or less	-1.279	(0.27)***	-1.450	(0.42)***
PT or plane x Duration of stay, 3 days or less			0.248	(0.45)
Model 7. Interaction with "High education level (university studies)"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.542	(0.4)***
High education level (university studies)	-0.031	(0.23)	-0.201	(0.3)
PT or plane x High education level (university studies)			0.353	(0.44)
Model 8. Interaction with "Spending at the destination: high"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	2.010	(0.34)***
Spending at the destination: high	0.684	(0.27)**	1.055	(0.39)***
PT or plane x Spending at the destination: high			-0.575	(0.44)

	Coef.	Std. Error	Coef.	Std. Error
Model 9 Interaction with "Spending at the destination: low"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.620	(0.28)***
Spending at the destination: low	0.098	(0.32)	-0.347	(0.44)
PT or plane x Spending at the destination: low			0.810	(0.53)
Model 10 Interaction with "Spending at the destination: unknown"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.895	(0.29)***
Spending at the destination: unknown	0.531	(0.35)	0.907	(0.45)**
PT or plane x Spending at the destination: unknown			-0.652	(0.51)
Model 11 Interaction with "Not the first visit to Tarragona"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.585	(0.33)***
Repeater: not the first visit to Tarragona	-0.050	(0.22)	-0.275	(0.33)
PT or plane x Not the first visit to Tarragona			0.391	(0.43)
Model 12 Interaction with "Season: Summer"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.824	(0.37)***
Season: summer	-0.189	(0.25)	-0.119	(0.4)
PT or plane x Season: Summer			-0.107	(0.46)
Model 13 Interaction with "Male"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.696	(0.36)***
Gender: male	0.006	(0.2)	-0.063	(0.29)
PT or plane x Male			0.125	(0.4)
Model 14 Interaction with "Visiting Tarragona"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.332	(0.35)***
Visiting Tarragona	0.211	(0.27)	-0.181	(0.33)
PT or plane x Visiting Tarragona			0.826	(0.44)*
Model 15 Interaction with "Visiting Barcelona"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.817	(0.29)***
Visiting Barcelona	0.480	(0.25)*	0.622	(0.36)*
PT or plane x Visiting Barcelona			-0.235	(0.46)
Model 16 Interaction with "Visiting Costa Daurada"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.789	(0.3)***
Visiting Costa Daurada	0.624	(0.25)**	0.660	(0.32)**
PT or plane x Visiting Costa Daurada			-0.078	(0.45)
Model 17 Interaction with "Visiting other places"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.644	(0.28)***
Visiting other places	0.464	(0.28)	-0.033	(0.48)
PT or plane x Visiting other places			0.895	(0.62)
Model 18 Interaction with "Not visiting any place"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.800	(0.3)***
Not visiting any place	0.270	(0.34)	0.372	(0.44)
PT or plane x Not visiting any place			-0.178	(0.52)

	Coef.	Std. Error	Coef.	Std. Error
Model 19: Interaction with "Accompanied by: Family trip or partners"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.762	(0.35)***
Accompanied by: Family trip or partners	-0.269	(0.27)	-0.271	(0.37)
PT or plane x Accompanied by: Family or partners			0.003	(0.45)
Model 20: Interaction with "Accompanied by: Friends"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.720	(0.27)***
Accompanied by: friends	-0.200	(0.42)	-0.927	(1.1)
PT or plane x Accompanied by: Friends			0.912	(1.18)
Model 21: Interaction with "Accompanied by: others"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.812	(0.29)***
Accompanied by: others	-0.228	(0.34)	0.042	(0.6)
PT or plane x Accompanied by: others			-0.350	(0.66)
Model 22: Interaction with "Year 2014"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.479	(0.31)***
Year 2014	1.054	(0.25)***	0.627	(0.34)*
PT or plane x Year 2014			0.757	(0.43)*
Model 23: Interaction with "Year 2016"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	2.108	(0.32)***
Year 2016	0.565	(0.31)*	1.044	(0.38)***
PT or plane x Year 2016			-0.927	(0.44)**
Model 24: Interaction with "Origin: France. Andorra and Monaco"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.794	(0.28)***
Origin: France. Andorra and Monaco	-0.048	(0.3)	0.022	(0.34)
PT or plane x Origin: France. Andorra and Monaco			-0.415	(0.72)
Model 25: Interaction with "Origin: countries located less than 2000 km"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	2.100	(0.31)***
Origin: countries located less than 2000 km	0.264	(0.29)	1.022	(0.44)**
PT or plane x Origin: countries less than 2000 km			-1.121	(0.51)**
Model 26: Interaction with "Origin: countries over 2000 km"				
Transport mode to arrive: PT or plane	1.764	(0.27)***	1.715	(0.28)***
Origin: countries over 2000 km	0.142	(0.38)	-12.527	(0.64)***
PT or plane x Origin: countries over 2000 km			12.746	(0.73)***

* Significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Author's own production.

There are some variables for which their influence is not affected by the mode of transportation chosen to reach the destination. The effects exerted by the length of stay and the decision to visit Barcelona and the Costa Daurada remain pretty much unaltered, while the coefficients associated with the respective

interactions are not significant. The interaction with high expenses is not significant, although the magnitude of the coefficient associated with the original variable substantially increases. Thus, it can be concluded that the impact of these variables is independent of the means of transportation used to travel to the destination. It could be argued that the non-segmented effect of these factors relates to the fact that tourists are willing to move around to visit attractions. For instance, the longer the length of stay, the more likely it is that the tourist visits further attractions, and as a result, the higher the chances that tourists need motorized transport, including PT. Thus, the strong correlations between these variables and the destinations visited indicate that the lack of information in the dataset distinguishing the mode of transportation used and the attractions visited might be a potential source of bias for their associated coefficients.

There are other variables for which the incidence is determined by the transportation choice to reach the destination. For example, staying in a second home or an apartment increases the probability of becoming a PT user for those who travelled by private vehicle. In contrast, the positive effect for those who travelled by plane or PT is eliminated. With regard to socioeconomic variables, none of which was significant in Table 9 or model (1) in Table 10, changes associated with the impact of age occur with the introduction of interactions. The combined effect of having travelled either by air or PT, together with tourists being young, results in a higher probability of using PT at the destination. Conversely, the rise in the probability of using PT for the oldest group of tourists only occurs for those who reached Tarragona by private vehicle. This effect is eliminated in the oldest tourists travelling via other transportation modes. The visits to attractions within Tarragona increase the probability of using PT among tourists who travelled by plane or by PT. None of these four variables has a significant coefficient when the specification considers no interactions. Thus, the inclusion of the interactions enables the irruption of their subjacent effects, which are attached to a portion of the tourists depending on how they travelled to Tarragona. The probability of

using PT among those who reach Tarragona via a private vehicle increases when travelling a distance shorter than 2,000 km (excluding Spain and France), while for the alternative modes of transportation, this impact is offset by the counter-effect yielded by the interaction. The magnitude of the impact of travel distances longer than 2,000 km must be considered cautiously given the small number of tourists who drove such a long distance. Finally, the year when the questionnaire was completed also impacted the likelihood of using PT.

To summarize, the examination of interactions has demonstrated the impact of accommodations, age and the visits to Tarragona. It has also revealed how the transportation method used to reach the destination influences the effect exerted by other factors for which the models without interactions already exhibited a significant coefficient. Nonetheless, the magnitude of the impact of the interactions is always lower compared with the influence related to the mode of transportation for arriving in Tarragona.

4.7. Conclusions

The present work aimed to test whether the mode of transportation chosen to reach a tourist destination is the main determinant of PT use during one's stay. Secondly, this study assessed whether the impact of the other determinants is influenced by the previous choice in the context of a medium-sized Mediterranean city (Tarragona, Catalonia). The empirical evidence obtained undoubtedly supports the first hypothesis. In fact, the importance of the mode of transportation to the destination is not a new result and it had been previously highlighted by Dolnicar *et al.* (2010), Bieland *et al.* (2017), Gross & Grimm (2018) and Gutiérrez & Miravet, (2016a). Besides confirming the conclusions of previous studies, the results also support the second hypothesis, which represents the main novelty of our study. According to the CHAID analysis, the variables that exerted the greatest influence on the use of PT among tourists who reached Tarragona via a private vehicle are different from those that had the largest impact on tourists reaching Tarragona by an alternative means of transportation. Moreover, the introduction of interactions

in the logit regressions has enabled us to identify the emergence of significant variables (relating to type of accommodation, age and visits undertaken within Tarragona) with an impact limited to just a subset of tourists, together with the influence of the decisions relating to travel to the destination on the impact exerted by other variables.

These results highlight the importance of switching tourists to more sustainable modes of transportation when travelling to the destination, since the use of alternative modes of transportation from the travel origin to the destination encourages tourists to use PT during their stay (Peeters & Schouten, 2006). Furthermore, the promotion of PT among tourists involves the implementation of tailor-made strategies to tackle the segmentation of mobility demand caused by transportation decisions on the way to the destination. Therefore, it is crucial to design customized mobility policies in order to better adapt to each tourist segment's needs and preferences. For instance, our results show that staying overnight in second homes and apartments makes tourists more likely to use PT during their stay only if they have travelled to Tarragona via a private vehicle. The impact for those tourists who have travelled by plane or PT in this particular case vanishes simply because they are likely to use the PT anyway. At the other extreme, we found that tourists who travelled to Tarragona by car and are staying at hotels, are more likely to use a private vehicle instead of PT. This type of tourist is less likely to leave their car at home during the holidays, and probably less susceptible to advertising that promotes the use of PT at the tourist destination. Dolnicar *et al.* (2010) states that the use of the car is avoided at a tourist destination if it is not required or its use is inconvenient. Thus, persuading tourists who travel by car during their holiday to leave it parked once at their destination becomes a central issue, particularly for those destinations where the number of tourists is large enough to have a negative environmental impact on the small local community. Successful strategies promoting the use of PT should involve actions that boost the destination's level of walkability and increase the attractiveness of PT compared to that of a private vehicle. The implementation of both '*pull*' and '*push*' actions should be taken

into account. While the former would prompt tourists to become users of the PT network at their destination, the latter would involve actions that discourage the use of the private vehicle (Therese, 2010; Gärling *et al.* 2002; Stradling *et al.* 2000).

The dataset used in this study does not establish a connection between each attraction or place visited and the mode of transportation used to reach the tourist destination. This is the major limitation of this work, and the results of the variables relating to the destinations visited might therefore be biased. For this reason, future research should explore the interconnections between the decision to visit an attraction and the mode of transportation chosen to get there, as these decisions are reciprocally motivated. This advises to follow similar econometrical frameworks as those put forward by Masiero & Zoltan (2013) and Le-Klähn *et al* (2015). Another concern is that the data used in the present study are restricted to tourists, whereas most destinations (including Tarragona) receive a substantial share of visitors travelling on day trips from areas near enough to avoid staying overnight.

In addition to including transportation choices by excursionists, future research should also take into account the influence of the potential endogeneity caused by the relationship between the transportation choice to the destination and the origin of the tourist. To the best of our knowledge, only Gutiérrez & Miravet (2016a) and the present work have econometrically considered these factors with opposite results. Future research should also take into account that while the incidence of objective determinants has been considered in all studies, the inclusion of subjective factors is much less frequent. Another topic for future research is the impact of the characteristics of the destination. Few studies have examined its effect using tourist surveys in different types of destinations (Dolnicar *et al.* 2010; Gross & Grimm, 2018). Undoubtedly, destinations are diverse, and as a result, it is highly likely that PT use is influenced by the diversity of destination characteristics. Analysing the effect of the destination's characteristics is important for examining the impact of '*push*' factors (which prompt tourists to abandon the private vehicle in favour of more sustainable

alternatives) and *'pull'* factors (which involve actions that would make these alternatives more attractive) on tourists' behaviour, as well as the interactions between each.

5. Understanding tourists' spatiotemporal behaviour impact on the economic activity

Cruise passengers' spatial behaviour and expenditure levels at destination

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Highlights

- The spatiotemporal behaviour of cruisers in a city is monitored using GPS devices.
- Relationship between their spatiotemporal behaviour and their expenditure is explored.
- Cruisers with higher per-capita expenditure spend more time onshore.
- More time in places with mixed commercial and recreational uses implies higher expenditure.

Abstract

The article uses the spatial-temporal behaviour of cruise passengers at a given destination as an explanatory factor of their expenditure. First, it shows that different expenditure levels imply different mobility patterns. Second, it identifies the spatial-temporal variables that better explain the cruise passengers' expenditure at destination. GPS tracking technologies are employed to monitor the mobility of cruise passengers in the city of Tarragona (Catalonia) along with traditional surveys about their expenditure in the city. The combination of both sources allowed for the observation that those tourists with a higher per-capita expenditure are those who spend more time onshore, visit a lower number of tourist sites and spend more time in places with a tourist-oriented, mixed commercial and recreational function. This more thorough knowledge of the relationship between spatial-temporal behaviour and expenditure of cruise passengers onshore is essential for planning the commercial supply and the management of tourists' mobility.

Keywords: cruise tourism, expenditures, tourist mobility, GPS tracking data, spatial analysis, survey

5.1. Introduction

Many researchers have noted that the cruise sector is the fastest growing segment of the tourism industry (Douglas & Douglas 2004; Larsen & Wolff, 2016; Penco & Di Vaio 2014). The annual rate of increase in cruise passengers has been 6.63% since 1990 (according to Cruise Market Watch 2017). Since 2002 the average increase of the number of cruise passengers throughout the world has been one million people. This steady global growth of cruise travel has been fuelled by several interrelated factors such as the internationalisation of the cruise industry (Wie 2005), its oligopolistic structure (Wie, 2005), the increasing size of new ships (Brida & Zapata, 2010) and the increase of the market share as a result of the creation of new demand (Marksel *et al.* 2016). Today cruise tourism is no longer a luxury niche product (De Cantis *et al.* 2016; Ferrante *et al.* 2016); rather, but it is promoted as mass tourism (Dickinson & Vladimir, 2008; Ferrante *et al.* 2016). Cruising has become more accessible for younger cohorts, families, seekers of active vacations and low-income tourists since the price ranges have dropped as a result of the pressure of competition and economies of scale (Marksel *et al.* 2016).

The rapid expansion of cruises to some cities has also led to an increase of criticisms of this mode of tourism. In this regard, studies are emerging, not only to measure the environmental impact generated by the cruise industry (Bonilla-Priego *et al.* 2014), but also to capture the residents' perceptions towards cruise tourism development (Jordan & Vogt 2017; Mccaughey *et al.* 2018). Moreover, it is usually argued that ships arriving in a destination make a major economic impact on the local economy. In fact, the variable of cruise passengers' expenditures is of particular importance when performing a cost-benefit analysis (Brida & Risso 2010). Given the importance of researching this variable, multiple studies have also been developed in order to analyse the expenditure pattern of cruise passengers at a given destination (Brida *et al.* 2012; Henthorne 2000; Larsen *et al.* 2013); and to detect the determinants of cruise passengers' expenditures at destination (Brida & Risso 2010; Gargano & Grasso 2016; Marksel *et al.* 2016).

Although it is commonly understood that factors affecting tourist expenditure behaviour such as the demographic, geographic and psychological characteristics of the passengers and travel-related characteristics must be considered (Markkanen & Pieszek 2012; Marksel *et al.* 2016), far less attention has been given to the spatial-temporal behaviour of the passengers at a destination as an explanatory factor of expenditure.

This research gap was previously referenced by Ferrante *et al.* (2016) in their general framework for collecting and analysing the tracking data of on-shore cruise passengers. Therefore, our paper contributes to the current discussion on the study of the determinants of cruise passengers' expenditures, by analysing how the spatial-temporal behaviour of cruise passengers at a given destination acts as a determinant of their expenditure. The study has been developed in the city of Tarragona, Spain, one of the emergent ports of call for cruise ships in the Mediterranean Sea.

To be precise, we demonstrate how different on-shore expenditure levels indicate different spatial-temporal mobility patterns of the cruise passengers who visit Tarragona by themselves (instead of participating in an organised/guided tour). Besides identifying the area's most commonly frequented by cruise passengers in general and the time that these cruise passengers spent at these places, we detect differences among cruise passengers at different levels of expenditures. Consequently, we identified the spatial-temporal variables that better explain cruise passengers' expenditures.

The data used to reach these research aims come from the use of GPS tracking technologies to monitor the mobility of cruise passengers in conjunction with traditional questionnaire-based surveys. The integration of both sources allows for obtaining information of special interest for destination management organizations (DMOs) and local policy-makers in order to better plan and manage on-shore cruise tourism.

Following this introduction, the second section presents a review of the literature on the key topics of our study (determinants of cruise passengers' expenditures at destination, cruise passengers' spatial-temporal behaviour at destination and cruise passengers' spatial-temporal expenditure levels and behaviour at destination). The third section explains in detail the context of the study, the data used, and the methods applied. The fourth section presents the results obtained. Finally, the fifth section discusses the implications of our findings and emphasizes the concluding remarks of our study.

5.2. Review of the literature

As cruise tourism has experienced exponential growth, there has been a growing interest in developing research related to the cruise sector, especially during the last fifteen years (De Cantis *et al.* 2016; Hosany & Witham 2010; Larsen & Wolff 2016; Papathanassis & Beckmann 2011). However, the research into the cruise industry is still scarce.

Within this context, the main topics studied are the environmental impact of the cruise sector (Bonilla-Priego *et al.* 2014; Carić & Mackelworth 2014; Dowling & Cowan, 2006; Klein 2005); the economical and development opportunities that this sector generates (Chang *et al.* 2016; Dwyer & Forsyth 1998; Thomas & Stoeckl 2015); or the marketing strategies employed (Andriotis & Agiomirgianakis 2010; Xie *et al.* 2012). However, there is also an emergent set of studies about the behaviour of cruise passengers at destination. These kinds of studies are framed in the context of the necessity to increase the knowledge about the activities of on-shore cruise tourists, including the time they spent in certain activities, how they organize their visit, which mode of transportation they use or their level of satisfaction with all these aspects of an on-shore visit.

Most of the contributions related to the behaviour of on-shore cruise passengers focus their attention on the determinants of cruise passengers' expenditure patterns at a given destination (Brida & Scuderi 2012; Douglas & Douglas 2004; Gargano & Grasso 2016; Henthorne 2000; Larsen *et al.* 2013; Lee & Lee 2017) and on the satisfaction and intention of returning to the destination (Brida & Risso

2010; Chang *et al.* 2016). Some of these studies have also considered the time spent at the destination (Gabe *et al.* 2007; Henthorne 2000) as a factor explaining the cruise passengers' expenditure and satisfaction as reported through ad-hoc surveys. Moreover, the study of the spatial-temporal behaviour of cruise passengers at destination as a central aim of the research is gaining interest. The first approaches to the cruise passengers' mobility were developed through observational methods (Jaakson 2004; Scherrer *et al.* 2011). Recently, new tracking technologies, such as GPS devices, have enabled the accurate recording of temporal and spatial behaviour of cruise passengers at destination (De Cantis *et al.* 2016; Ferrante *et al.* 2016).

5.2.1. Determinants of cruise passengers' expenditures at destination

Although there are a great number of studies that analyse the determinants of tourists' expenditure, the focus on cruise passengers has received less attention. The expenditure behaviour of an individual is conditioned by his/her mental, emotional and physical activity in the process of selecting, purchasing, using and disposing of products or services with the aim to satisfy his/her needs and desires (Wilkie 1994). In this sense, the majority of studies that research the determinants of tourists' expenditure include as explaining factors variables related to demographical characteristics (gender, age, educational level and nationality), travel-related characteristics (length of stay, frequency of visit), and psychological characteristics (satisfaction with shopping and entertainment possibilities).

Some studies on the determinants of cruise passengers' destination expenditures have tried to demonstrate the influence of gender in expenditure. While some reveal that women spend more than men (Brida *et al.* 2012; Lee & Lee 2017; Marksel *et al.* 2016), others have obtained contrary results, showing that men spend more than women (Brida *et al.* 2014). While in other studies it was not possible to confirm any relationship (Henthorne 2000). The influence

of age in the expenditure has also been addressed. In some studies it has not been a significant factor (Gargano & Grasso, 2016), while in others, different signs of the effect of this variable have been reported (Brida *et al.* 2012, 2014; Lee & Lee 2017). The effect of the country of origin (Brida *et al.* 2014; Gargano & Grasso 2016; Lee & Lee 2017; Marksel *et al.* 2016), the impact of income (Brida *et al.* 2012; Lee & Lee 2017) and the influence of occupation (Brida *et al.* 2014; Lee & Lee 2017) have also been demonstrated. Some studies have tried to include psychological and travel-related variables, such as the satisfaction with several locations within a given destination (Brida *et al.* 2014; Gargano & Grasso 2016), previous experience at a destination (Brida *et al.* 2012, 2014; Gargano & Grasso 2016; Lee & Lee 2017; Marksel *et al.* 2016), the frequency of cruising (Marksel *et al.* 2016), or the time spent at destination (Brida & Risso 2010; Gargano & Grasso 2016; Marksel *et al.* 2016).

5.2.2. Cruise passenger's spatial-temporal behaviour at destination

In recent years, a growing use of GPS technology for analysing tourist mobilities at destination has been seen (Lew & McKercher 2006; Shoval & Ahas 2016). However, to the best of the authors' knowledge there are only two published studies based on an analysis of the activities of cruise tourists at a given destination using this technology.

One is the study of Ferrante *et al.* (2016) who establish a framework for collecting and analysing data on cruise tourism with the use of GPS technology and the integration of this spatial information with more traditional questionnaire-based-surveys. They propose a detailed procedure to collect data concerning the mobility of cruise passengers who visit a given destination independently and formulate several indicators that allow them to develop a spatial analysis of the cruise passenger's mobility in the cities of Palermo (Italy) and Dubrovnik (Croatia) with 277 and 51 tracks respectively. The second is the study of De Cantis *et al.* (2016) that develops a similar spatial analysis with the

same 277 tracks collected in the city of Palermo (Italy) and a more complex segmentation procedure that allowed them to identify different profiles of cruise passengers depending on their spatial behaviour. Both studies show that cruise passengers with higher incomes and higher education levels who are aged between 36 and 55 years seek a more thorough experience of the destination in terms of time spent onshore and places visited. They propose to incorporate special fares for younger and older cohorts to increase their time spent onshore and, consequently, their potential average expenditure.

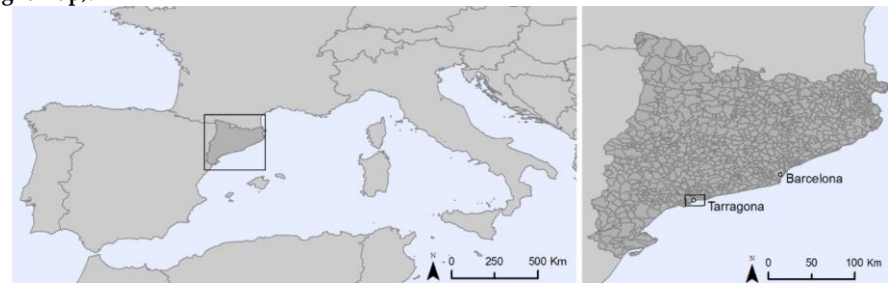
5.2.3. Cruise passengers' spatial-temporal behaviour at destination and expenditure levels

The inclusion of spatial and temporal variables into the analysis of the determinants of cruise passengers' expenditure is of special interest. It has been demonstrated that the length of stay, or the time spent at destination, has a positive and important effect on the tourist's expenditure (Fredman 2008; Shani *et al.* 2010) and also on the cruise passenger's expenditure (Brida & Risso 2010; Henthorne 2000). These approaches have been developed from data obtained through surveys, and they have not considered the length of time spent at different locations within the city. As Ferrante *et al.* (2016) mentioned, the availability of tracking technologies provides a good opportunity to explore how the spatial-temporal behaviour of the tourists influences their expenditure in detail. GPS data combined with survey data can help to investigate whether tourists with different expenditure levels have also different mobility patterns at a given destination. As no previous research addresses this question, our work attempts to contribute to this research gap.

5.3. Study context

Tarragona is the capital of the southern province of Catalonia. It has a population of 131,507 inhabitants (INE 2017) and is located on the Mediterranean coast, 100 km south of Barcelona (Figure 7).

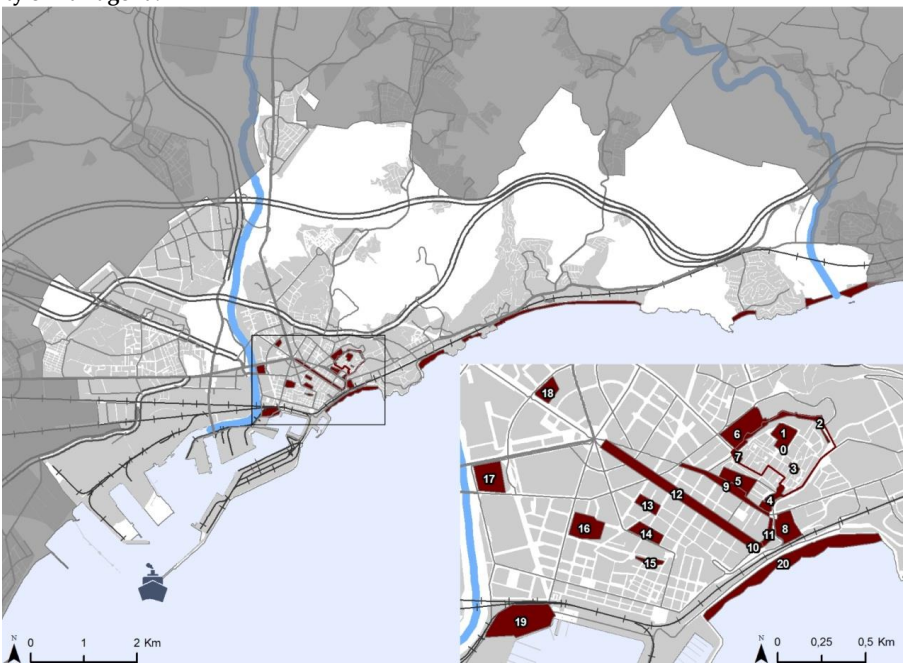
Figure 7. Location of Tarragona in the context of Europe, Spain (up-left map) and Catalonia (up-right map).



Source: Author's own production

Tarragona is integrated into the Costa Daurada tourist brand, a first-rate tourist destination that, according to official data from the Tourism Observatory of Catalonia, attracts around 5 million tourists per year. This area is characterized by the bicephaly formed by Reus (103,123 inhabitants) and Tarragona and the historical balance between their respective economic and administrative capital (Gutiérrez & Miravet 2016b). Furthermore, during the summer season, the coastal municipalities (Cambrils, Salou and Vila-seca) alter the functional hierarchies of the region due to the importance of the sun and beach tourism (Gutiérrez & Miravet, 2016b) and as a consequence of the leisure tourism generated by the area's PortAventura leisure park, which is currently one of the five largest in Europe, surpassing 3.5 millions of visitors per year (Anton Clavé 2010).

Figure 8. Location of the cruise terminal and identification of places of touristic interest in the city of Tarragona.



Note: 0: Upper Town; 1:Cathedral; 2: Walls; 3: Forum square; 4: Roman Circus; 5: Font square; 6: Acheological Promenade; 7: Portal del Roser; 8:Roman Amphitheatre; 9: Rambla Vella; 10: Mediterranean balcony; 11: Passeig de les Palmeres; 12:Rambla Nova; 13:Mercat Central; 14: Local or Colony Forums; 15: Roman Theatre; 16: Tarraco Arena Plaça; 17: Commercial Centre (Central Park); 18: Commercial Centre (el Corte Inglés); 19: Serrallo; 20: Beaches

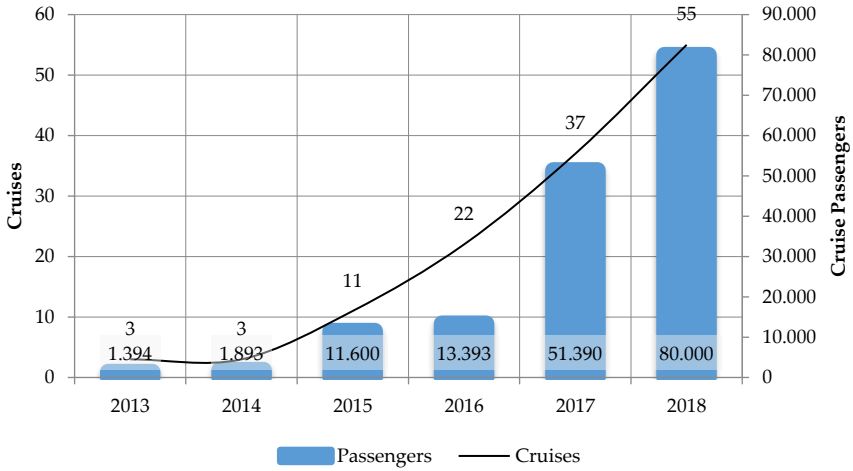
Source: Author's own production

Therefore, in addition to the touristic interest arising from the places surrounding the city of Tarragona, its recreational and commercial centres, its historical tradition and archaeological heritage, and its beaches, make the city itself an interesting tourist destination (Figure 8). The archaeological Roman ruins in Tarragona were granted a UNESCO World Heritage Site designation in 2000, and two more World Heritage designations have been declared since: the cultural heritage of the human towers in 2010 and the Mediterranean diet in 2013. As a matter of fact, Tarragona attracts around a half million tourists

every year in licensed accommodations, which translates into two million overnight stays per year, with family tourism the most predominant.

In addition to traditional tourism, destination management organisations (DMOs) and public authorities must take into account the visits of cruise tourists during the summer season when cruises arrive at the city. The irruption of Tarragona as a destination for cruise tourism is very recent. According to data provided by the Port Authority of Tarragona, the number of passengers rapidly increased in 2017, experiencing an influx of 284% in relation to the previous year (see Figure 9).

Figure 9. Number of cruises and cruise passengers per year since 2013 until 2017 and prevision for 2018.



Source: Author's own production with data provided by the Port Authority of Tarragona.

This increase is associated with the arrival in Tarragona of one of the most important cruise companies of the world, Costa Croiciere. The company has established the Port of Tarragona as a regular port of call, but it also has used it as a base port. In fact, in 2017, 72% of the cruise passengers were in transit, while 14% disembarked and another 14% embarked at Tarragona. Of the 72% of

cruise passengers in transit, 68.5% (25,461) visited the destination by themselves, while the other 31.5% (9,716) participated in organized tours. As can be seen in Figure 9, a growth of 49% of cruises and 56% of passengers in 2018 is expected, which indicates a trend towards the establishment of Tarragona city as a cruise tourism destination.

5.4. Data and empirical approach

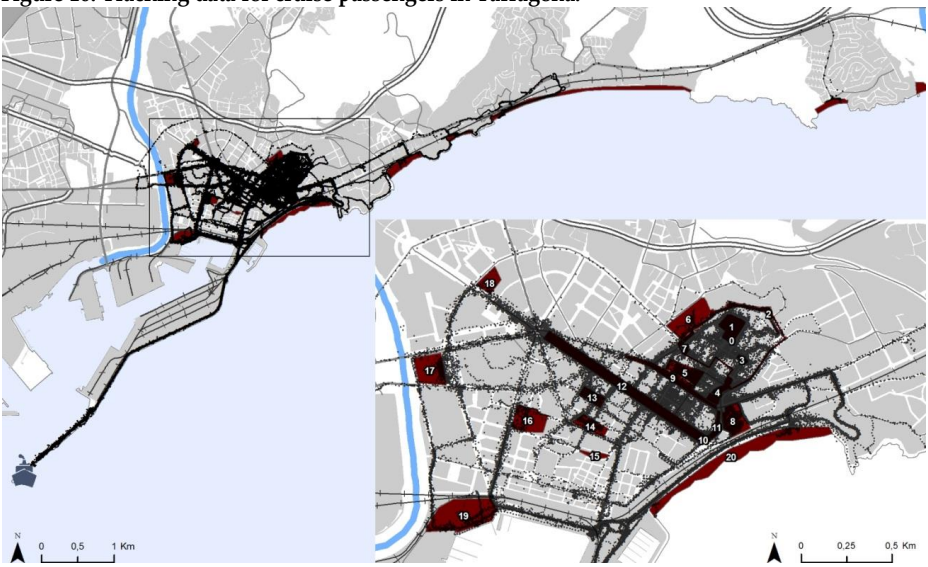
5.4.1. Data

A survey of 161 passengers was conducted in 2017 between 4 August and 27 October at the port of Tarragona, within the arrivals terminal. In addition to these surveys, GPS loggers were distributed to cruise passengers. In order to distribute them, we agreed with the Port Authority that the research team could be located at a key position, just after the exit point from the cruise ship, within the time range of the cruise passengers' disembarkation.

According to data from the Port Authority of Tarragona, 31.5% of the cruise passengers in transit participated in organised tours, while the other 68.5% visited the destination on their own. Independent cruise passengers were selected by implementing a random sampling procedure. All the passengers who wanted to collaborate with our study were provided with a GPS data logger device aimed at recording information on space-time behaviour during their visit to this destination. Once the visit was concluded, before going back to the ship, the passenger returned the device and was asked to fill in the survey. This questionnaire aims to collect information on the main demographic characteristics of the passengers, the activities the participated in, their level of satisfaction with the visit and their expenditure pattern at this destination. Anonymity of all the collected information was ensured for all the participants. As for the tracking device, QSTARZ BT-Q1000XT data logger devices were used. They collected tracking data from the received GPS signal at a very accurate time intervals (that we set at 15 s) and locations with an error margin of about 5-10 m.

Seven of the 161 participants did not visit the city of Tarragona and were excluded from the analysis, and the final sample size includes 154 independent cruise passengers. The aggregate GPS tracking data of all the cruise passengers that participated in our study are reported in Figure 10.

Figure 10. Tracking data for cruise passengers in Tarragona.



Note: 0: Upper Town; 1:Cathedral; 2: Walls; 3: Forum square; 4: Roman Circus; 5: Font square; 6: Acheological Promenade; 7: Portal del Roser; 8:Roman Amphitheatre; 9: Rambla Vella; 10: Mediterranean balcony; 11: Passeig de les Palmeres; 12:Rambla Nova; 13:Mercat Central; 14: Local or Colony Forums; 15: Roman Theatre; 16: Tarraco Arena Plaça; 17: Commercial Centre (Central Park); 18: Commercial Centre (el Corte Inglés); 19: Serrallo; 20: Beaches
Source: Author's own production

Regarding the structure of the sample, the summary of the variables collected through face-to-face interviews are presented in Table 12. Therefore, the cruise passengers who participated in our study are mainly from European Countries (88.3%). Also 17.5% of the participants are younger than 25 years old, more than two thirds are between 35 and 64 years old (69.5%) and 13.0% are older than 65 years old.

Table 12. Summary of the variables collected through face-to-face interview

Variable	Categories	N	%	Variable	Categories	N	%
Day of interview	04/08/2017	11	7.1%	Gender	Female	72	46.8%
	11/08/2017	15	9.7%		Male	82	53.2%
	18/08/2017	15	9.7%	Country of origin	Italy	113	73.4%
	25/08/2017	8	5.2%		Europe	23	14.9%
	01/09/2017	17	11.0%		Americas	12	7.8%
	08/09/2017	15	9.7%		Oceania	4	2.6%
	22/09/2017	16	10.4%		Asia	2	1.3%
	29/09/2017	16	10.4%	First time vs. repeaters	First Time	148	96.1%
	30/09/2017	9	5.8%		Repeaters	6	3.9%
	13/10/2017	18	11.7%	Knowledge of the city	Nothing	118	76.6%
	27/10/2017	14	9.1%		Something	36	23.4%
Age group	16 - 24	11	7.1%	Tourist information	No	127	82.5%
	25 - 34	16	10.4%		Yes	27	17.5%
	35 - 44	38	24.7%	Recommendation of the city	Maybe not	5	3.2%
	45 - 54	37	24.0%		Maybe yes	45	29.2%
	55 - 64	32	20.8%		Surely not	2	1.3%
	65 or above	20	13.0%		Surely yes	102	66.2%
Party structure	Friends	15	9.7%	Per-capita expenditure	0 - 10 €	19	12.3%
	Family	9	5.8%		11 - 25 €	59	38.3%
	Family with children	63	40.9%		26 - 50 €	50	32.5%
	Alone	4	2.6%		51 - 75 €	16	10.4%
	Partner	63	40.9%		> 75€	10	6.5%

Source: Author's own production

The majority of the participants come with family with children (40.9%) or with a partner (40.9%), and 96.1% are first-time visitors. More than three-fourths (76.6%) did not know anything about the city. However, this fact generally did not force them to look for information at tourist information centres. After their visit, 95.4% of the tourists say they would maybe or definitely recommend the city as a cruise destination. All the tourists who participated in the study spent

money in the destination. In total they spent €12.923, which includes transport services (€3.959), shopping and souvenirs (€5.214), visits to museums and cultural amenities (€721), and purchases in coffee shops (€1.036) and restaurants (€1.993€). This expenditure amount translates into an average per-capita expenditure of €31.2. However, 12.3% of the tourists spent less than €10 per-capita, and almost half (49.4%) were included in a per-capita expenditure over €25.

5.4.2. Empirical approach

Empirical strategy involves techniques of spatial analysis in order to analyse whether different expenditure levels are associated with different mobility patterns and statistical methods to detect spatial-temporal variables that better explain cruise passengers' expenditures. Nevertheless, a systematic process of revision and debugging of the recorded data was completed before the analysis was performed to guarantee the maximum reliability of the spatial data.

Several variables regarding the spatial-temporal patterns of the cruise passengers have been calculated and subsequently merged with the corresponding data obtained from the survey. To that end, the following concrete calculations have been performed: the time of the trip in the city (in hours, minutes and seconds), the length (in km), the number of touristic points of interest (TPI) visited, and the relative time spent in the different TPIs. The relative time is the percentage of time that the tourists spent in a specific location in relation to the total time they spent in the city. Some of the TPI were not visited by any of the tourists, and some were classified into larger categories. In sum, the established categories are the following: time in Roman ruins, time in the central market, time along the Rambla Nova and the Mediterranean balcony, time in the Font Square, time in commercial centres, time in Upper Town, time walking through the Rambla Vella, and time at the beaches.

Additionally, in order to detect the most visited places of the city, a 3D Spatial Chart with the 154 tracks has been constructed following the method proposed by Shoval (2008). We used a cell net of 20x20 meters, which allowed us to obtain a more detailed map of the most visited places. Specifically, the height of the polygons was proportional to the average time spent at each cell, and the colours are related to the share of participants for each cell. Cells with a share of participants below 5% were excluded.

Afterwards, the 154 cruise passengers were segmented depending on their per-capita expenditure in order to contrast if different mobility patterns exist between cruise passengers with different levels of expenditure. Per-capita expenditure in transportation has been excluded, and the variable has been divided in three categories by the calculation of terciles. Thus, three additional 3D Spatial Charts have been constructed, one for each level of expenditure (low, mid, high). Additionally, the mean time of visit and the average percentage of visit time at different locations throughout Tarragona have been calculated, depending on the cruise passengers' per-capita expenditure.

As different mobility patterns were observed between the three segments of cruise passengers, we proceeded to statistically measure the correlation or association between the per-capita expenditure and the different spatial-temporal variables collected through the GPS devices.

Therefore, a contrasting hypotheses test was performed using Pearson's correlation coefficient. In our study, this statistical test was also used to identify whether an association between the per-capita expenditure and the cruise passengers' sociodemographic characteristics exists.

After contrasting these hypotheses, a multivariate regression analysis, by the means of Ordinary Least Square (OLS) was applied. The dependent variable selected has been the per-capita expenditure and the explicative variables those related to the spatial-temporal behaviour of the cruise passengers in the city. Therefore, the results of this regression analysis are of special utility for

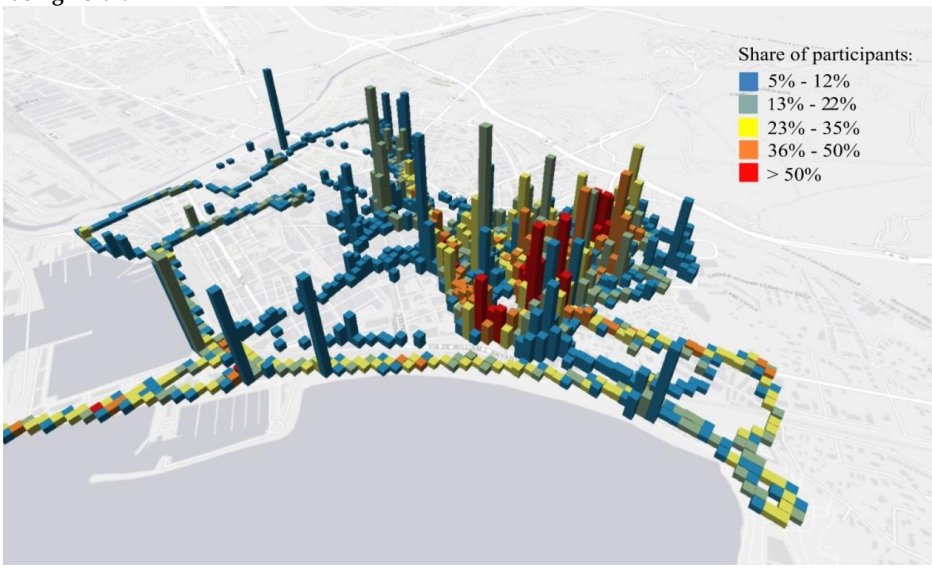
detecting how the spatial-temporal variables influence the cruise passengers' expenditure at destination.

5.5. Results

5.5.1. Overall spatial-temporal behaviour of cruise tourists at Tarragona

Following the method proposed by Shoval (2008), the most visited places and the average duration of visit are represented in Figure 11 using a 3D Spatial Chart.

Figure 11. Share of participants and average time spent on a 20x20 metre grid in Tarragona: view facing north.



Note: Cells with a share of participants below 5% are excluded and a Natural Breaks (Jenks) method has been used to define the intervals
Source: Author's own production

Specifically, the heights of the polygons are proportional to the average time spent at each cell (measuring 20x20 metres), and colours are related to the

number of participants who visited each cell. Figure 11, therefore, shows the most frequented places and the areas where the tourists stayed longer. It is clear that Upper Town and Rambla Nova meet both conditions, while other places such as the Central Market, the maritime neighbourhood (Serrallo), commercial centres and some parts of the beaches are visited by fewer people for larger amounts of time.

Table 13 summarises the variables collected through GPS devices. The percentage of time that cruise passengers spent in these different touristic places of Tarragona was quantified. The average time that cruise passengers were in the city is over 5 hours. In fact, almost two thirds of the tourists (63.7%) spent between three and seven hours in the city. The average length of travel is 25.8 kilometres. However, almost a half of the tourists travelled more than 25 kilometres. These distances include the round trip to the cruise ship, which corresponds to a distance of 10 km that must be covered to arrive at the city centre.

Additionally, 85% of the tourists visit more than six places in the city, with the average being eight or more places visited. Of these visited places, the ones that the tourists visit the most are the Rambla Nova and the Mediterranean Balcony, the Rambla Vella, the Upper Town, the Font Square and the Roman ruins. Meanwhile commercial centres, beaches, the central market and the maritime neighbourhood are the least visited places. The distribution of time spent in these most and least visited places is uneven.

Table 13. Summary of the variables collected through GPS devices

Variable	Categories	N	%	Variable	Categories	N	%
Time of visit *Max: 10h.08'55'' Min: 1h.05'50'' Average: 5h.16'54''*	1 - 3 hours	17	11.0%	**%VT Commercial Centres** *Average: 01h.19'36''*	0	141	91.6%
	3 - 5 hours	62	40.3%		≤ 15%	8	5.2%
	5 - 7 hours	36	23.4%		16 - 30%	2	1.3%
	≥ 7 hours	39	25.3%		31 - 50%	2	1.3%
Length intervals *Max: 51.6 Min: 10.7 Average: 25.8*	10 - 20 km	26	16.9%		>50%	1	0.6%
	20.1 - 25 km	57	37.0%	**%VT Mediterranean Balcony** *Average: 00h.13'59'*	0	47	30.5%
	25.1 - 30 km	39	25.3%		≤ 15%	99	64.3%
	> 30.0 km	32	20.8%		16 - 30%	7	4.6%
Num. visited places *Average: 8.3*	0 - 5	24	15.58%		31 - 50%	1	0.6%
	6 - 10	97	62.99%		>50%	0	0.0%
	11 - 15	33	21.43%	**% VT Upper Town** *Average: 01h.05'35''*	0	29	18.8%
%VT Rambla Nova *Average: 00h. 35'23''*	0	22	14.3%		≤ 15%	49	31.8%
	≤ 15%	90	58.4%		16 - 30%	40	26.0%
	16 - 30%	37	24.0%		31 - 50%	26	16.9%
	31 - 50%	2	1.3%		>50%	10	6.5%
	> 50%	3	2.0%	**%VT Font Square** *Average: 00h.17'59''*	0	65	42.2%
%VT Rambla Vella *Average: 00h.09'22''*	0	23	14.9%		≤ 15%	80	51.9%
	≤ 15%	129	83.7%		16 - 30%	6	3.9%
	16 - 30%	1	0.7%		31 - 50%	3	2.0%
	31 - 50%	1	0.7%		>50%	0	0.0%
	>50%	0	0.0%	**%VT beaches** *Average: 02h.25'42''*	0	129	83.7%
%VT Roman Remains *Average: 00h.21'55''*	0	30	19.5%		≤ 15%	6	3.9%
	≤ 15%	105	68.2%		16 - 30%	5	3.3%
	16 - 30%	14	9.1%		31 - 50%	9	5.8%
	31 - 50%	5	3.2%		>50%	5	3.3%
	>50%	0	0.0%	**%VT Serrallo** *Average: 00h. 09' 16''*	0	98	63.6%
%VT Central Market *Average: 00h.18'01''*	0	115	74.7%		≤ 15%	52	33.8%
	≤ 15%	35	22.7%		16 - 30%	4	2.6%
	16 - 30%	3	2.0%		31 - 50%	0	0.0%
	31 - 50%	1	0.6%		>50%	0	0.0%
	>50%	0	0.0%				

Note: VT=Visiting time
Source: Author's own production

Regarding the most visited places, in the Upper Town the cruise passengers spent on average almost more than an hour, and almost a half of the tourists stayed in this area more than 16% of their visiting time. The cruise passengers spent almost the same average time (around 20 minutes) in the font square and the Roman ruins. However, the majority stayed less than 15% of their visiting time in these areas. Similarly, the tourists spent less than 15% of their visiting time in the Rambla Nova and the Rambla Vella. The main difference between these avenues is that cruise passengers spent an average of thirty-five minutes walking along the first one, and only nine minutes along the second. This may be associated with the attractiveness of the Rambla Nova and the heavier concentration of commercial activities.

On the other hand, in relation to the least visited places, 91.6% of the tourists did not visit the Commercial Centres, 83.7% of them did not go to the beaches, 74.7% did not pass through the Central Market, and almost a third decided not to visit the maritime neighbourhood. Nevertheless, those tourists who did decide to go to the commercial centres and beaches stayed more time in these places on average. Specifically, the average time of stay in the commercial centres is an hour and twenty minutes, while the average time at the beaches is almost two and a half hours.

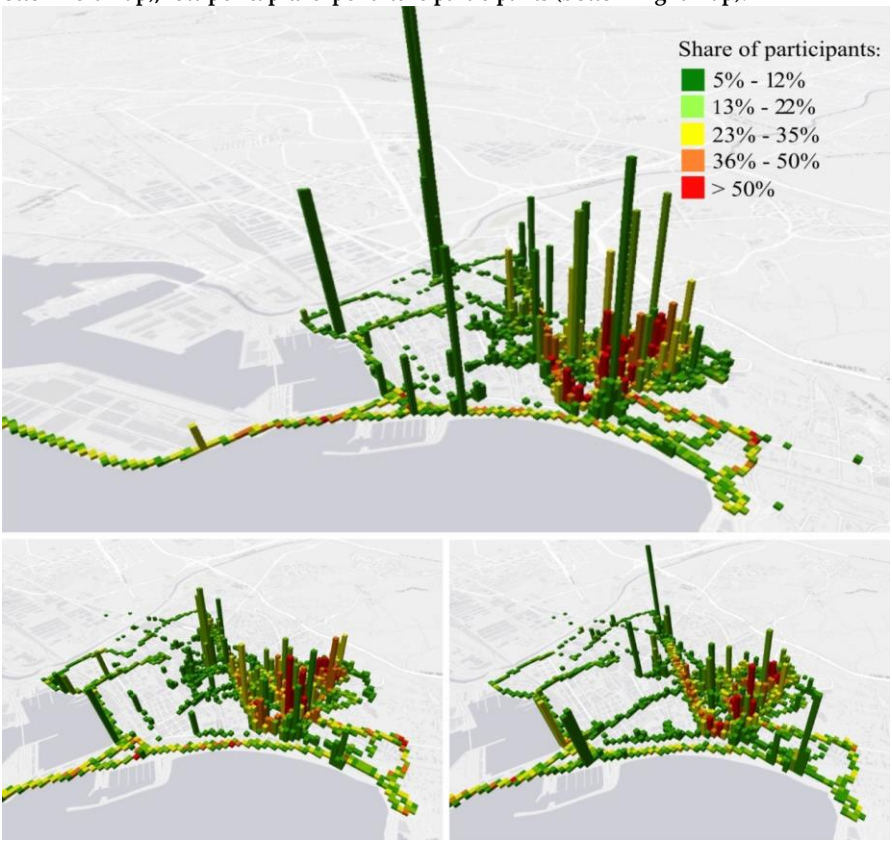
5.5.2. Spatial-temporal behaviour differences according to the expenditure level of cruise tourists

In order to identify whether there are strong differences between those who have a higher per-capita expenditure and those who have a lower per-capita expenditure, two complementary analyses have been performed. On the one hand, the variable per-capita expenditure has been segmented by terciles, and its spatial-temporal patterns have been analysed by the use of 3D Charts (see Figure 12). The group of participants with high per-capita expenditures spent an average of €45, the cruise passengers with mid per-capita expenditures

expended a mean of €16, and the cruise passengers with low per-capita expenditures spent a mean of €4.

Similar to Figure 11, in Figure 12 the heights of the polygons are proportional to the average time spent at each cell, and the colours are related to each cell's share of the participants. The same intervals have been applied to define the share of participants.

Figure 12. Share of participants and average time spent on a 20x20 metre grid in Tarragona: High per-capita expenditure participants (upper map); mid per-capita expenditure participants (bottom-left map); low per-capita expenditure participants (bottom-right map).



Source: Author's own production

The spatial-temporal patterns of the cruise passengers' per-capita expenditures are unequal. The mobility patterns are more homogeneous for the group of participants with a lower per-capita expenditure (bottom right map). This group of cruise passengers are mainly concentrated in the Upper Town but stayed for a lower quantity of time compared to the mid or high per-capita expenditure cruise passengers. Those last two groups have more sprawled mobility patterns. Indeed, in their maps it is possible to appreciate the important time peaks that they spent in commercial centres, along the Rambla Nova and in the Upper Town.

On the other hand, in addition to the contrasts observed in Figure 12, the spatial-temporal differences between the three groups are seen in Table 14 and results of Pearson's statistical correlations between the dependent variable and the spatial-temporal variables are presented in Table 15.

Therefore, the results of the statistical coefficient pinpoint a moderate association of 0.331 (p-value < 0.01) between the per-capita expenditure and the time that the tourists spent in Tarragona. This means that the more time the tourists were in the city, the higher is their expenditure. In fact, the cruise passengers with high per-capita expenditures were in the city for an average of six hours and twenty-six minutes. This represents two hours more than the cruise passengers with low per-capita expenditures and one hour more than those with mid per-capita expenditures (see Table 14).

Table 14. Mean time of visit and average percentage visiting time at different places of Tarragona depending on the cruisers' per-capita expenditure.

	High Expenditures	Mid Expenditures	Low Expenditures
Number of places visited	8.5	8.7	7.7
Average length	27.4 km	26.4 km	23.5 km
Average time in Tarragona	6h. 25' 53"	5h. 06' 56"	4h. 16′ 32″
Av. time at other places*	2h. 44' 00"	2h. 23' 25"	2h. 18′ 22″
N	52	51	51
Time at beaches	02h. 43′ 20″	2h. 08′ 06″	2h. 21′ 45″
% visiting time at beaches	33.0%	28.6%	36.1%
N	9	7	9
Time in Commercial Centres	01h. 40′ 15″	1h. 10′ 24"	25′ 41″
% visiting time in Commercial Centres	24.4%	14.2%	10.0%
N	7	4	2
Time in Central Market	25' 01"	10' 56"	14′ 37″
% visiting time in Central Market	8.0%	3.4%	6.1%
N	17	12	10
Time in Upper Town	1h. 18' 55"	1h. 08′ 59"	46′ 56″
% visiting time in Upper Town	22.0%	24.4%	22.1%
N	46	39	40
Time in Font Square	24′ 57″	15′ 16″	10′ 49″
% visiting time in Font Square	7.2%	5.2%	4.6%
N	37	26	26
Time in Rambla Nova and Mediterranean Balcony	51′ 19″	53′ 23″	30′ 22″
% visiting time in Rambla Nova	15.8%	21,2%	14.4%
N	47	47	41
Time in Rambla Vella	11′ 4″	10′ 02″	06′ 58″
% visiting time in Rambla Vella	3.2%	3.7%	3.4%
N	47	40	44
Time in Roman Remains	24' 5"	21′ 17″	20′ 07″
% visiting time in Roman Remains	6.6%	8.1%	8.0%
N	44	41	39
Time in Serrallo	22' 40"	5′ 28″	01′ 46″
% visiting time in Serrallo	5.2%	2.0%	0.9%
N	16	23	17

*Including transport from and to the ship and excluding places of touristic interest
Source: Author's own production

A significant correlation between the per-capita expenditure and the length of the trip was not detected. However, the descriptive statistics of Table 15 reveal that the average length of the trip of the tourists with a high per-capita expenditure is one km higher than the group with a mid per-capita expenditure and 4 km higher than the tourists with a low per-capita expenditure.

Table 15. Pearson correlation coefficients between per-capita expenditure and explicative variables

	Coefficient
Time in Tarragona	0.331***
Length of the visit	0.118
Places visited during the visit	0.055
Time at beach	-0.010
Time at commercial Centres	0.293***
Time at central Market	0.096
Time at Upper Town	0.191**
Time at Font Square	0.364***
Time at Rambla Nova & Mediterranean Balcony	0.140*
Time at Tarraco Arena	0.080
Time at Rambla Vella	0.107
Time at Roman Remains	0.059
Time at Serrallo	0.096

Robust standard errors: *** Significant at 1%; ** Significant at 5%; * Significant at 10%
Source: Author's own production

The numbers of touristic places visited by the cruise passengers is similar among the three groups of participants. Consequently, there was no statistical association detected between the number of touristic places visited and the per-capita expenditure. Neither was any association detected between the time the tourists spent at beaches, in the central market, along the Rambla Vella, in the Roman ruins, in the maritime neighbourhood (Serrallo) or around the Tarraco Arena. In contrast, important correlations were detected between the time that the tourists were in commercial centres, in the Upper Town, in the Font Square, and along the Rambla Vella and the Mediterranean Balcony. In fact, the more time the tourists were in these areas, the higher was their per-capita expenditure, with the correlation being 0.293 ($p<0.01$) in the commercial centres,

0.191 ($p<0.05$) in the Upper Town, 0.140 ($p<0.10$) in the Rambla Nova and the Mediterranean Balcony and 0.364 ($p<0.01$) in the Font Square.

Overall, places where the cruise passengers spend more money were also where more commercial activities and restaurant businesses oriented towards tourists were located. A statistically significant association was not found between the sociodemographic characteristics and the variable per-capita expenditure. However, some interesting trends can be drawn from the descriptive statistics seen in Table 16. There are no major differences related to country of origin or age among the three expenditure-based groups of cruise passengers.

However, there are important differences related to the accompaniment and the previous knowledge of the city. First, the high per-capita expenditure group had a higher presence of tourists travelling with a partner (48.1%) than the other, lower-expenditure groups. Second, the low and the mid per-capita expenditure groups had a higher knowledge of the city before visiting it than those cruise passengers who had high expenditures. This leads to the conclusion that a better knowledge of the city leads to better planning of the visit and thus a lower expenditure. The relationship between the knowledge of the destination and the expenditure has been addressed previously in other studies by considering whether this is the first time visiting the city. Therefore, some studies pointed out that those cruise passengers who visit a destination for the first time are more likely to spend more money than those who are repeat visitors (Opperman 1996; Marksel et al 2016).

Table 16. Cruisers' sociodemographic characteristics depending on their per-capita expenditure.

	High Expenditures	Mid Expenditures	Low Expenditures	Total average
Origin: Italian	71.2%	70.6%	78.4%	73.4%
Accompanied by: family with children	34.6%	39.2%	49.0%	40.9%
Accompanied by: partner	48.1%	41.2%	33.3%	40.9%
Accompanied by: others (friends or other family members)	17.3%	19.6%	17.6%	18.2%
Age: 24 years old and younger	5.8%	7.8%	7.8%	7.1%
Age: between 25 and 44 years old	40.4%	23.5%	41.2%	35.1%
Age: between 45 and 64 years old	42.3%	51.0%	41.2%	44.8%
Age: 65 years old and older	11.5%	17.6%	9.8%	13.0%
Previous knowledge of the city	15.4%	21.6%	33.3%	23.4%
N	52	51	51	154

Source: Author's own production

5.5.3. The spatial-temporal determinants of expenditure level at destination

We have verified the spatial-temporal behaviour of the cruise passengers who spent the most at this destination and confirmed that an association between the per-capita expenditure of the cruise passengers and the places that they visit exists. Now a regression analysis can be used in order to identify how all these spatial-temporal variables analysed in conjunction can explain their expenditure. In this sense, a multivariate regression analysis has been carried out by the means of an Ordinary Least Square (OLS) model, including all sets of variables obtained through GPS devices.

As can be seen in Table 17, which contains the results of the OLS, a total of six variables have significant coefficients. Therefore, they are the spatial-temporal determinants that better explain the per-capita expenditure of the cruise passengers in the city of Tarragona.

Table 17. Results of the OLS (dependent variable: per capita expenditure)

Variable	Std. Coefficient	Std. Dev.
Time in Tarragona (in h.min.sec.)	0.213	(0.000)*
Length of the visit (in km)	-0.067	(0.295)
Number of points of touristic interest visited	-0.214	(0.723)**
Time at beaches	-0.067	(0.001)
Time in Commercial Centres	0.270	(0.001)***
Time in Upper Town	0.201	(0.001)**
Time in Font square	0.371	(0.001)***
Time along Rambla Vella	0.110	(0.002)
Time in Roman archaeological sites	0.024	(0.001)
Time in maritime neighbourhood (Serrallo)	0.115	(0.002)
Time around Tarraco Arena	0.125	(0.032)
Time along Rambla Nova and Mediterranean Balcony	0.176	(0.001)**
Intercept: 12,471**	**R**: 0.603	**R^2**: 0.363

Robust standard errors: *** Significant at 1%; ** Significant at 5%; * Significant at 10%
Source: Author's own production

First, the significance of the variable regarding the time the cruise passengers spent in the city should be emphasised. With a significance of 90.0% ($p < 0.10$) and a standardised coefficient of 0.213, we can state that the more time the cruise passengers are onshore visiting the city, the higher their per-capita expenditure tends to be.

Second, the results of the OLS shows that variables regarding the time spent walking through the Upper Town and along the Rambla Nova and the Mediterranean Balcony and the number of points of touristic interest visited also has an important explanatory force, with all three having a significance of 95% ($p < 0.05$). The standardised coefficient of the two first variables is positive, being 0.201 for the first and 0.176 for the second. This means that the more time the tourists are in the Upper Town and/or walking along the Rambla Nova and the Mediterranean Balcony, the higher their expenditure. Meanwhile, the standardised coefficient of the third variable is negative, which indicates that

those tourists who are more active in visiting different points of touristic interest spend less in the city.

Finally, from the results obtained, it is possible to confirm that the variables related to the time cruise passengers spent in the Font square and in the commercial centres are the indicators with the most explanatory force. Both variables present the highest standardised coefficients, positive in both cases, and significant at 99.9% ($p < 0.01$).

5.6. Discussion and conclusion

This study has taken advantage of the tracking technologies to demonstrate the relationship between the level of expenditure of cruise passengers and their mobility patterns at a given destination. We have demonstrated that by the use of GIS and GPS technologies it is possible to accurately study the spatial-temporal behaviour of cruise passengers at destination in combination with survey data in order to obtain findings of interest for destination planning and development.

Similarly to the results obtained by Henthorne (2000), the average time of the cruise passengers in Tarragona is five hours and sixteen minutes. This is much more than the one hour and fifty minutes reported by Jaakson (2004) and the three hours and fifty minutes reported by Brida *et al.* (2010), de Cantis *et al.* (2016) and Ferrante *et al.* (2016). The findings of our study demonstrated that the amount of time spent onshore is a key variable for explaining the per-capita expenditure of cruise passengers. The same conclusions have been previously highlighted by the literature (Brida & Risso, 2010; Gargano & Grasso, 2016; Marksel *et al.* 2016). Therefore, more effort should be put forth to extend the time cruise passengers spend in a given city. The organisation of local markets, gastronomic initiatives or improvised guided tours could help achieve this end.

As was emphasised by de Cantis *et al.* (2016), the amount of time spent onshore is not always positively related to either the length of the tour or the number of attractions visited. Indeed, the results of our study demonstrate that the length

of the excursion to the visited city had no effect on per-capita expenditure. Moreover, the higher the number of attractions visited, the lower the expenditure. This idea suggests that new experiences related to historical, cultural or gastronomic entertainment should be marketed towards the most active tourist profiles to incentive their expenditure and attempt to keep them in certain areas of the city.

We have not found any statistically significant evidence that pinpoints an association between per-capita expenditure and the socio-demographical characteristics of the cruise passengers, unlike other studies that reported significant effects from variables such as the country of origin (Brida *et al.* 2014; Gargano & Grasso 2016; Lee & Lee 2017; Marksel *et al.* 2016), income levels (Brida *et al.* 2012; Lee & Lee 2017) occupation (Brida *et al.* 2014; Lee & Lee 2017) or age (Douglas & Douglas 2004).

Furthermore, we have seen that those tourists who invest more time in visiting the key touristic points of the city (Upper Town, Font square, and Rambla Nova and the Mediterranean Balcony) and the commercial centres are those who produce a higher per-capita expenditure. From the perspective of tourists, they are more likely to participate in the commercial activities located as close to the touristic places as possible, rather than travelling to the commercial centres that are located in the periphery of the city. In fact, we have demonstrated that only 8.4% of the tourists were willing to go to the commercial centres; however, their expenditure was definitively higher than those who did not go to these places. That said, the presence of mixed commercial-use facilities in the most frequented places is a key element for boosting tourist expenditure.

The understanding of cruise passengers' spatial-temporal behaviour at a given destination is crucial to ensuring the efficient management of tourist attractions, facilities and services provided as well as avoiding overcrowding and congestion in the city. Therefore, knowing more details about the cruise passengers' mobility within the destination may have important implications for destination planning, transport development, conceiving new attractions or

managing the existing ones (Lew & McKercher 2006). Local authorities must put forth effort in providing positive experiences for the cruise passengers while mitigating problems of coexistence with the residents' quotidian activities, which is fundamental to correctly managing the social, economic, and cultural impact of cruise tourism at a given destination. In this regard, further research is needed. In the subfield of cruise passenger mobilities at destination, further studies need to be developed from the urban-planning perspective by considering how the characteristics of the urban space influence the way the cruise passengers move through it. This would be useful to know why, from the tourist's point of view, some areas are excluded from the tourist activity and why other routes enjoy a higher concentration of tourists. Second, more studies should be done to measure the residents' and local stakeholders' perception towards the arrival and growth of cruise tourists in order to develop a sustainable model that allows for the management of the traffic generated in some areas and to maximize the benefits of these visits for the destination.

6. Analysis of the influence of the built environment on the visitors' mobility at destination

Built environment and urban cruise tourists' mobility

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Highlights

- Relationship between urban built environment and spatial behaviour is studied.
- Cruise passengers' mobility in a city is monitored using GPS tracking technologies.
- Space syntax and walkability measures are used to analyse cruise tourists' mobility.
- Few factors determine cruise passengers' spatial behaviour in the city.
- Key factors are visibility of tourist points of interest and economic activity.

Abstract

The article studies the relationship between the characteristics of the built environment and the spatial behaviour of cruise passengers in a city. For this purpose, the mobility of cruise passengers visiting the city of Tarragona (Catalonia) is monitored by means of GPS tracking technologies and analysed through the use of Geographic Information Systems. In order to identify what determines the spatial behaviour of cruise passengers, consideration has been given to diverse and multiple indicators related to the syntax of the urban space, the physical attributes of the urban space, the commercial activity and the visibility of tourist points of interest. Results show that the visibility of tourist points of interest and the type of economic activity found in the streets of Tarragona have more influence over the spatial behaviour of the cruise passengers than other factors related to the characteristics of the urban layout. The resulting information is particularly valuable for city management, since it provides a better knowledge of the characteristics of the areas that cruise tourists move through and spend more time in.

Keywords: Cruise tourism, tourist mobility, GPS, GIS, spatial analysis, space syntax, walkability

6.1. Introduction

As cruise tourism has experienced exponential growth, there has been a growing interest in developing related research, especially during the last fifteen years (Papathanassis & Beckmann 2011). There is a significant volume of research on the role of cruise tourism in generating new and dynamic opportunities in port cities (Dwyer & Forsyth 1996; Pratt & Blake 2009). Analysing the determinants of cruise passenger expenditure at a given destination (Gargano & Grasso 2016), and their satisfaction with the visit (Brida *et al.* 2012) have also emerged as hot research topics. However, the rapid expansion of cruise trips to some cities has resulted in greater criticism of this mode of tourism. In this regard, studies are emerging that measure the environmental impact of the cruise industry (Bonilla-Priego *et al.* 2014), and which also home in on residents' perceptions of cruise tourism development (Jordan & Vogt 2017). Furthermore, the study of the spatial-temporal behaviour of cruise passengers at destination is becoming more popular because it facilitates appropriate management of tourist mobility at destination, avoids congestion effects and boosts economic impact. The first approaches to cruise passenger mobility were developed through observational methods (Jaakson 2004; Scherrer *et al.* 2011). Recently, tracking technologies, such as GPS devices, have enabled an accurate recording of the temporal and spatial behaviour of cruise passengers at destination (Ferrante *et al.* 2016). Additionally, there has been more research recently on the relationship between tourist pedestrian movement and the street network structure and characteristics of the urban environment (Edwards & Griffin 2013; Hall & Ram 2018; Zheng *et al.* 2017; Mansouri & Ujang 2016) due to the natural correlation between the walkability of the built environment and the visitor's use of it (Anton Clavé 2019).

In this context, this article aims to analyse the relationship between the characteristics of the built environment and the spatial behaviour of cruise tourists in the city. Consequently, the article analyses how cruise passengers move through the city. However, primarily the study detects and weighs up

the effects of various groups of indicators that the literature pinpoints as significant for pedestrian mobility. Therefore, GPS devices are used to monitor the spatial behaviour of cruise passengers when they visit the city of Tarragona (Catalonia). Then, the data collected is integrated into a GIS in order to spatially relate to (1) the syntaxis of the urban space, (2) the physical attributes of the urban space, (3) the commercial activity in the urban space and (4) the visibility of tourist points of interest. Accordingly, regarding the research aim, two research questions have been proposed:

RQ1: Is there any correlation between the spatial-temporal behaviour of the cruise tourists through the city and the characteristics of the built environment?

RQ2: Which variables exercise a greater influence over the spatial-temporal behaviour of tourists?

The results from applying space syntax measures and other morphology and functional urban indicators initially reveal the most frequented spaces and the time spent in them. Secondly, and equally importantly, they inform on the characteristics of the areas that tourists move through and spend time in, which is particularly valuable for managing tourist cities.

Following this introduction, the paper presents a review of the relevant literature. Consequently, reference is made to two types of studies: those related to analysing cruise passenger mobility and those focusing on the use of space syntax and walkability indicators to analyse tourist mobility. After reviewing the literature, we present the territorial context where the research is conducted. Then, the data and methods are specified. Subsequently, the results are presented, and finally, the discussion and conclusions are presented.

6.2. Review of literature

6.2.1. Analysing cruise passenger mobility at destination with GPS data

The widespread availability of tracking technologies such as GPS, geolocated social media data, smart cards, Wi-Fi, Bluetooth and mobile phone traces (Shoval *et al.* 2014) have allowed a fast proliferation of studies on tourist mobility over the last decade (Shoval & Ahas 2016). The effectiveness and reliability of GPS tracking data (Shoval & Isaacson 2007a, 2007b) and the passive mobile positioning data (Eurostat 2014) have boosted the possibilities of analysing spatial-temporal behaviours on multiple territorial scales and with a great diversity of research objectives. Data obtained by means of these tracking technologies has been used to detect visitor flow patterns (Baggio & Scaglione 2018), regulate the carrying capacity of tourist points of interest to avoid overcrowding, develop new tourist attractions, improve allocation of accommodation and restaurant services to maximise exposure to visitor traffic (Edwards *et al.* 2009), and reduce friction between tourists and the local population (Shoval & Isaacson 2007a). They have also been used to identify seasonal demand patterns (Ahas *et al.* 2007) and to improve the management of destination marketing (Kuusik *et al.* 2011). Moreover, there is more and more literature that incorporates tourist emotions and experiences into the analysis of the spatial behaviour (Grinberger *et al.* 2014; Kim & Fesenmaier 2014), as it helps to understand subjective feelings conveyed by the tourists when they visit a destination. Nevertheless, as pointed out by Edwards *et al.* (2009), when it comes to analysing tourist mobility, there are only a few researches that consider the relationship between the tourist movements and the destination design and infrastructure.

GPS data has been used to analyse the mobility of tourists in zoos (Birenboim *et al.* 2015), natural parks (Hallo *et al.* 2012), theme parks or confined attractions (Birenboim *et al.* 2013; Xiao-Ting & Bi-Hu 2012), small historic quarters (Shoval & Isaacson 2007b) and large urban settings (McKercher *et al.* 2012). Despite this increased GPS usage, there are only three published studies based on an analysis of the cruise passenger behaviour at destination using this tool. First, there is the publication by Ferrante *et al.* (2016), which establishes a framework for collecting and analysing data on cruise passenger mobility. They propose

using GPS to collect mobility data on cruise passengers and subsequently integrate this spatial information into traditional surveys, to formulate indicators for developing a detailed spatial analysis of mobility. They develop two case studies in the cities of Palermo (Italy) and Dubrovnik (Croatia) with 277 and 51 tracks, respectively. Second, there is the publication by De Cantis *et al.* (2016) that develops a very similar spatial analysis with the same 277 tracks from the city of Palermo (Italy), at the same time as they perform a segmentation procedure which identifies different cruise passenger profiles based on their spatial behaviour and sociodemographic characteristics. Third, there is the study developed by Domènech *et al.* (2019) with 154 tracks in the city of Tarragona (Spain) where they show that cruise tourists with different expenditure levels also have different mobility patterns. These types of studies are particularly useful for destination management organisations, public authorities and service enterprises (i.e., restaurants, accommodation or attractions) for two reasons. First, they provide knowledge on the most frequent routes taken by cruise tourists. Second, they distinguish multiple tourist profiles according to their spatial behaviour at destination. However, further knowledge is needed to determine the characteristics of the urban environment that attract tourists when they are visiting the destination, such as land uses, distribution of attractions, sight lines, among others (Edwards *et al.* 2009).

6.2.2. *Space Syntax and walkability of the urban space*

Public spaces and walkable urban areas are fundamental for the urban tourism experience (Anton Clavé 2019). In this regard, both quantitative and qualitative studies are emerging on the analysis of the walkability of urban tourism areas, and its effects on tourist spatial behaviour. The relationship between built environment and tourist mobility factors are being explored, at the same time as we are gaining further insight into current debates on tourism pressure in specific locations, and destination carrying capacity (Ram & Hall 2018). In this context, walkability is being targeted as a potential tool for analysing and

improving the quality of the urban space (Sharipov & Demirkol 2018) and for upgrading the tourism experience (Kanellopoulou 2018). Accordingly, it can be used by local and regional authorities, as well as by planners and urban designers dealing with urban complexity, especially in successful tourist cities with contradictions and conflicts generated by overtourism (Anton Clavé 2019).

Linking walkability and the urban tourism experience, Gorrini & Bertini (2018) proposed usefulness, comfort, safety, attractiveness and legibility as a set of criteria for assessing the walkability level for tourists in urban areas. All these indicators are closely associated with the characteristics of the built environment, such as urban layout and design. However, little research has been undertaken on urban tourism and walkability including space syntax indicators. Although research with space syntax approaches and studies on walkability consider different types of indicators, they share their common focus on analysing how urban space design influences pedestrian mobility.

On the one hand, according to the space syntax theory, the structure of the urban network is the first key to generating mobility. This is also coherent with the theory of natural movement which pinpoints that, in general, attractors are distributed equally in areas that are more conductive to mobility, or these attractors multiply the mobility patterns established by the urban layout (Hillier *et al.* 1993).

On the other hand, researches about urban walkability indicate that walkable places often concentrate the main attractions and accommodation supply in cities and attract the highest number of visitors (Anton Clavé 2019). This is because they form a fluid connection between different destinations within a reasonable expenditure of time and effort, and in a secure, pleasant and attractive context (Southworth 2005). Different types of variables have been considered to analyse the walkability of the urban environment. Proximity and accessibility have been considered as critical factors for defining a walkable built environment (Lo 2009), as well as other indicators such as the mix of land uses, street connectivity, aesthetics, density, form, pedestrian amenities,

personal safety, recreational uses, public spaces, traffic measures, among others (Alfonzo 2005; Buckley *et al.* 2016). Nevertheless, the availability and reliability of the data is a limitation when developing analytical methods (Anton Clavé 2019).

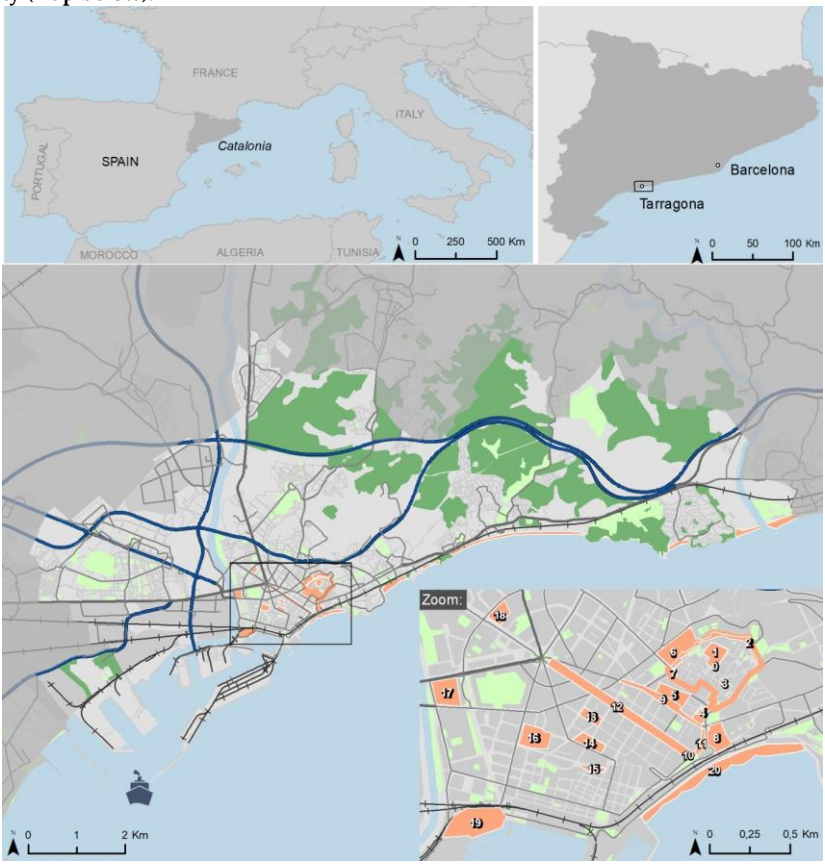
Our research is part of a large group of studies that use, among others, space syntax indicators to explain the movement of pedestrians in urban space (Koohsari *et al.* 2016; Zhai *et al.* 2018). A state-of-the-art report on this group of studies can be consulted in Sharmin & Kamruzzaman (2017). From their study, it is clear that research applying space syntax techniques to analyse tourist mobility is scarce and very recent in time (Edwards & Griffin 2013; Li *et al.* 2016; Mansouri & Ujang 2016; Wang, Li *et al.* 2018). Edwards & Griffin (2013) applied the space syntax approach to examine visitor spatial data collected in Sydney and Melbourne (Australia) by means of GPS devices. They stated that the relational properties of the street network are important for understanding tourist mobility, just as the location of the tourist points of interest in the street network. Li *et al.* (2016) applied a space syntax analysis to the street network of Gualangyu (China) and analysed its relationship with tourist spatial behaviour. They used cell phone locations (GPS and location based services) to track the mobility of the tourists, and their results pointed to a high positive association between the integration of the street network and the spatial behaviour of tourists. Wang, Li *et al.* (2018) used space syntax and kernel density to study the evolution of the spatial structure and the functional properties of Shichahai historic and cultural conservatory area (Beijing). They demonstrated that the tourist-oriented functions tend to cluster in a highly accessible and easily identified street network, while the resident-oriented functions are generally in less advantaged topological spaces, separated from the tourist areas. Mansouri and Ujang (2016) used gate observation and space syntax analysis to demonstrate that pedestrian tourist movement in Kuala Lumpur city centre is highly and mainly influenced by land uses and elements of attraction, as opposed to the configurational attributes of the street network.

Therefore, in line with Mansouri and Ujang (2016), in addition to the space syntax measures, our analysis includes other variables related to the characteristics of the urban space that the literature underpins as essential for walkability conditions in cities. Hence, we have considered the presence of natural elements such as trees (Gobster 1995), the absence of discernible slopes (Zhu & Lee 2008) and car speed (Blečić *et al.* 2015). In addition, as mixed land use and presence of commercial activity also condition the spatial behaviour of pedestrians (Foltête & Piombini, 2007), they have been included in this research. Finally, variables related to the visibility of places of interest (POI) have also been incorporated, since according to the experiential landscape theory, human behaviour can be altered by the perception of the spatial dimension (Thwaites & Simkins, 2007), together with other variables related to open views (Lindsey *et al.* 2008) and the visibility of stretches of water (Gobster, 1995).

6.3. Case study

The city of Tarragona is located on the Mediterranean coast, 100 km south of Barcelona (Figure 13). The recreational and commercial centres of Tarragona, its historical tradition, archaeological heritage, and beaches, make the city an attractive tourist destination.

Figure 13. Location of Tarragona (upper maps) and identification of places of tourist interest in the city (map below).



Note: 0: Part Alta; 1:Cathedral; 2: Walls; 3: Plaça del Fòrum; 4: Roman circus; 5: Plaça de la Font; 6: Archaeological promenade; 7: Portal del Roser; 8: Roman amphitheatre; 9: Rambla Vella; 10: Balcó del Mediterrani; 11: Passeig de les Palmeras; 12:Rambla Nova; 13:Mercat Central; 14: Fòrum de la Colònia; 15: Roman theatre; 16: Tarraco Arena; 17: Commercial Centre (Parc Central); 18: Commercial centre (el Corte Inglés); 19: Serrallo; 20: Beaches
Source: Author's own production

The archaeological Roman ruins in Tarragona were certified as a UNESCO World Heritage Site designation in 2000. Furthermore, the city has received two more World Heritage designations: the cultural heritage of the human towers

in 2010 and the Mediterranean diet in 2013. According to data from the Tourist Observatory of Catalonia, Tarragona attracts around a half million tourists every year in licensed accommodation. This converts to 2 million overnight stays per year, with family tourism being the most predominant.

Tarragona has only emerged recently as a destination for cruise tourism. According to data provided by the Port Authority of Tarragona, the number of passengers grew rapidly in 2017, with an increase of 40,000 cruise passengers in relation to the previous year (Table 18). This growth is associated with the arrival in Tarragona of one of the world's most important cruise companies, Costa Crociere. The company has established the Port of Tarragona as a regular port of call, but it also has used it as a base port. In fact, in 2017, 72% of the cruise passengers were in transit, while 14% disembarked and another 14% embarked at Tarragona.

Table 18. Number of cruises and cruise passengers per year from 2013 to 2018

Year	Cruise passengers	Cruises
2013	1,394	3
2014	1,893	3
2015	11,600	11
2016	13,393	22
2017	51,390	37
2018	98,126	57

Source: Author's own production with data provided by the Port Authority of Tarragona.

The analysis of how the characteristics of the built environment influence cruise tourist mobility in a city such as Tarragona, has two explanations. First, Tarragona is a new site for cruise tourism, and therefore most of the cruise passengers are making their first visit to the city. Consequently, the urban structure and built environment are potentially the factors that influence cruise tourist decisions the most as they move through the city. Second, cruise tourism is a growing activity and lessons can be learned for the future, both from the perspective of managing the tourist experience and the urban space.

A couple of additional factors related to the urban layout of Tarragona should be considered, as they could condition cruise tourist mobility through the city. The most promoted area for tourism is the city centre, especially the Part Alta (upper town) where most of the monuments and world heritage sites are located. The long distance from the cruise terminal to the city's tourist venues means that the cruise passengers have to take a shuttle bus or a taxi to arrive at their destination. On the contrary, if tourists are in the city centre and want to go to the beaches, they have to overcome two physical barriers: the slope between the upper part and the promenades along the beaches and the railway, which, since its construction in the middle of 19th century, separates the main urban blocks from the Mediterranean Sea. Given these particular characteristics of the urban morphology of Tarragona, we have focused our study on the central part of the city (see zoom in Figure 13).

6.4. Data

Data collection was conducted in 2017 between 4 August and 27 October at the port of Tarragona. This period was chosen because of the diversity of cruise ships (in terms of number of ships and size) arriving in Tarragona in 2017. With the permission of the Port Authority of Tarragona, the field research team was located at a key position, just beyond the exit point from the cruise ship, within the time range of cruise passenger disembarkation. GPS loggers were distributed to in transit, self-organised cruise passengers according to a random sampling procedure. All the passengers who wanted to collaborate with the study were provided with a GPS QSTARZ BT-Q1000XT aimed at recording information on space-time behaviour during their visit. These devices collected tracking data from the received GPS signal at very accurate time intervals (15 seconds) and locations, with an error margin of about 5-10 meters. A sample of 161 independent cruise passengers was obtained. Seven of the 161 participants did not visit the city of Tarragona and were excluded from the analysis. Thus, the final sample size included 154 independent cruise passengers. Once the cruise passengers returned the device to the research team at the cruise ship,

they were asked to complete a survey to gather information on their main demographic characteristics and their level of satisfaction with the visit.

6.5. Empirical approach

As can be seen in Table 19, different variables were calculated to fulfil the research objective and answer the two research questions. The GPS data was used to calculate the number of tourists who walked through each segment of the street network in the city of Tarragona, and the average time tourists spent in them. Besides, four additional types of indicators relating to the built environment were calculated according to the street segments.

First, the space syntax toolkit extension of the Quantum GIS software was used to compute, four space syntax indicators relating to attributes of the city's street network. Space syntax indicators can be calculated on different scales. A global scale analysis measures the average depth of a line or segment with respect to all other lines or segments in the whole area, while the local scale analysis makes this calculation within a certain radius (Li *et al.* 2016). In the present study, a local radius of 400 meters, that is, the distance of 5 minutes on foot, was established and indicators of connectivity, depth, choice and integration were computed. Connectivity measures the number of neighbouring street segments directly connected to one particular street segment (Dettlaff 2014). Depth is defined as the smallest number of syntactic steps (in the topological sense) needed to reach one street segment from another. Choice refers to the frequency at which a street segment is crossed by the shortest topological route between another two arbitrarily chosen street segments within the defined radius. In other words, choice is used to measure the possibility of a segment being an access path to other street segments (Wang, Li *et al.* 2018). Whereas, integration refers to the accessibility of a street segment or the potential for a segment to attract traffic (Hillier & Hanson 1984).

Second, other indicators related to the physical characteristics of the urban space were also calculated. These were the street incline, the presence of

vegetation taller over 2 meters and the maximum speed at which vehicles can circulate. Hypothetically, as the literature pinpoints, streets with a gentle incline (Zhu & Lee 2008), greater shade generated by the vegetation (Foltête & Piombini 2007; Gobster 1995) and vehicles circulating at a lower speed (Blečić *et al.* 2015), can lead to a greater number of tourists walking along these streets.

Third, information was collected about the type of land uses in order to ascertain whether the presence of commercial activity is favourable for cruise tourist movement, as proved previously as a determinant of pedestrian mobility (Foltête & Piombini 2007). In this sense, through fieldwork, trades located on the ground floor were mapped and classified as food, restaurants, fashion and souvenirs, banks and resident-oriented commerce.

Fourth, the proximity to elements or points of interest was considered. As the perception of the spatial dimension influences human spatial behaviour (Thwaites & Simkins 2007), variables on the visibility of points of interest from the streets were defined. Places were classified into seven groups depending on their typology. The visibility of World Heritage Sites (WHS) was divided into three categories: (1) streets located in the Part Alta with visibility of WHS located in the same neighbourhood; (2) streets beyond the Part Alta with visibility of the Roman amphitheatre and Roman circus; and (3) streets with visibility of WHS located downtown. The other four place typologies are the streets integrated into (4) the Serrallo neighbourhood, (5) public and tourist spaces with visibility of the urban landscape, such as Rambla Nova, Rambla Vella and Plaça de la Font, (6) public spaces with visibility of the Mediterranean Sea, such as the Mediterranean Balcony and promenades along the beaches and (7) streets with visibility of the commercial centres and markets.

Table 19. Main characteristics of the variables calculated

Type of variable	Name of variable	Description	Source
Cruise tourists' mobility	Tourists per segment	Number of tourists who walked through a given street network segment	Own elaboration by means of GPS data
	Average time per segment	Average time that tourists stay in a given street network segment	
Space Syntax indicators	Connectivity	Number of neighbouring segments directly connected to a segment.	Own elaboration with Space Syntax toolkit of QGIS
	Integration	Accessibility of a segment or the potential for a segment to attract traffic.	
	Choice	Frequency at which a segment is crossed by the shortest topological route between another two arbitrarily chosen segments within the defined radius.	
	Depth	Smallest number of syntactic steps (in the topological sense) needed to reach one segment from another	
Physical attributes	Slope	Street incline in percentage.	Calculated from the TEM of Catalonia[1]
	Vegetation > 2m.	Presence of taller vegetation over 2 meters.	Calculated from LIDAR of 2011[2]
	Maximum speed	Maximum speed cars can drive along streets	Own elaboration through field work
Commercial activity	Food	Supermarkets, bakeries, and greengrocers	Own elaboration through field work
	Restaurants	Restaurants, bars, coffee shops	
	Fashion & souvenirs	Shoe stores, clothing stores, souvenir shops and similar	
	Banks		
	Resident-oriented commerce	Services, retail, administration, education and medical services	

Type of variable	Name of variable	Description	Source
Visibility of places of tourist interest (POI)	Visibility – WHS in Part Alta	Visibility of WHS from any street located in the Part Alta neighbourhood	Own elaboration through field work
	Visibility – WHS (Amphitheatre and Circus)	Visibility of the amphitheatre and the Roman circus from any street located beyond the Part Alta neighbourhood	
	Visibility – WHS in Downtown	Visibility of World Heritage Sites located downtown	
	Streets – Serrallo	Streets integrated into the Serrallo neighbourhood	
	Visibility – wide urban landscape	Public and tourist areas with great visibility of the urban landscape	
	Visibility – Mediterranean	Public and tourist areas with visibility of the Mediterranean Sea	
	Visibility – commercial centres	Streets surrounding the commercial centres and markets.	

Note: [1] Terrain Elevation Model: conformed by a regular grid of 1x1m., with a mean square error of 0.15m. (http://www.icgc.cat/Administracio-i-empresa/Descarregues/Elevacions/Model-d-Elevacions-del-Terreny-d-1x1-m).
[2] Light Detection and Ranging or Laser Imaging Detection and Ranging: minimum density of 0.5 m2 (http://www.icgc.cat/Administracio-i-empresa/Descarregues/Elevacions/Dades-lidar).
Source: Author's own production

After calculating these indicators, descriptive statistics of the cruise tourists participating in the research were calculated, and a spatial analysis was performed. To answer the first research question, bivariate regression analyses were carried out to explore the relationships between the dependent variables (number of tourists and average time per street) and the various explanatory variables considered. To answer the second research question, five multivariate regressions have been applied for each dependent variable, including only

those explanatory variables that were significant in the bivariate models: a first regression that includes the space syntax variables; a second that incorporates the two significant variables of the set of physical characteristics of the urban space; a third that includes the variables related to commercial activity; a fourth with the variables related to the visibility of tourist spaces; and a fifth with all the variables included in the precedent multivariate analysis. All the analyses were performed at the level of the 2,473 street network segments included in the central part of the city (see zoom in Figure 13). The modelling technique applied was an Ordinary Least Square regression. As the measuring units of the variables are different, the results are interpreted following the standardised coefficients. The standardised coefficients allow comparability between indicators, as they represent the relative importance of each variable in the regression equation.

6.6. Descriptive statistics

6.6.1. Characteristics of the sample

As can be seen in Table 20, the cruise passengers who have participated in the study come mainly from European countries (88.3%), with Italy being the most represented nationality. More than two thirds of the participants were between 35 and 64 years old (69.5%). The majority came accompanied by relatives and children (40.9%) or their partner (40.9%). A total of 96.1% cruise tourists visited the city for the first time, and this makes for an interesting analysis of how the built environment is related to cruiser mobility in the city, i.e. how the urban area influences the way cruise tourists move through it. More than three quarters (76.6%) did not know anything about the city before visiting it. However, only 17.5% of the tourists looked for information about the area to visit when they arrived at the destination.

Table 20. Characteristics of the sample

Variable	Category	N	%	Variable	Category	N	%
Date	04/08/2017	11	7.1%	Origin	Italian	113	73.4%
	11/08/2017	15	9.7%		European	23	14.9%
	18/08/2017	15	9.7%		Others	18	11.7%
	25/08/2017	8	5.2%				
	01/09/2017	17	11.0%	Party structure	Friends	15	9.7%
	08/09/2017	15	9.7%		Family	9	5.8%
	22/09/2017	16	10.4%		Family with children	63	40.9%
	29/09/2017	16	10.4%		Alone	4	2.6%
	30/09/2017	9	5.8%		Partner	63	40.9%
	13/10/2017	18	11.7%	Repeater	1st visit	148	96.1%
	27/10/2017	14	9.1%		Repeater	6	3.9%
Gender	Women	72	46.8%	Prev. knowledge of the city	Nothing	118	76.6%
	Men	82	53.2%		Something	36	23.4%
Age group	16 - 24	11	7.1%	Prev. info about the city	No	127	82.5%
	25 - 34	16	10.4%		Yes	27	17.5%
	35 - 44	38	24.7%	Recommendation of the city	Maybe not	5	3.2%
	45 - 54	37	24.0%		Maybe yes	45	29.2%
	55 - 64	32	20.8%		Surely not	2	1.3%
	65 or more	20	13.0%		Surely yes	102	66.2%

Source: Author's own production

6.6.2. Areas within the city visited by cruise tourists

Table 21 presents the frequency of cruisers who visited the areas and points of interest, and the average time of their visit. The 154 cruise tourists spent an average time of over 5 hours in Tarragona. A total of 80% of the cruisers visited the Part Alta, the Rambla Nova, the Roman archaeological legacy and Rambla Vella. Less visited areas were commercial centres, beaches and the Tarraco Arena. The average time that cruisers spent in the areas and POIs varies substantially. Beaches, with an average of 2h. and 25min. are clearly the areas where they stayed the longest, followed by commercial centres, with an average of almost 1h. and 20min, and the Part Alta with an average time of 1h. and 5min.

Table 21. Frequency of cruise passengers who visited the spaces and points of tourist interest (POI) and average time of visit.

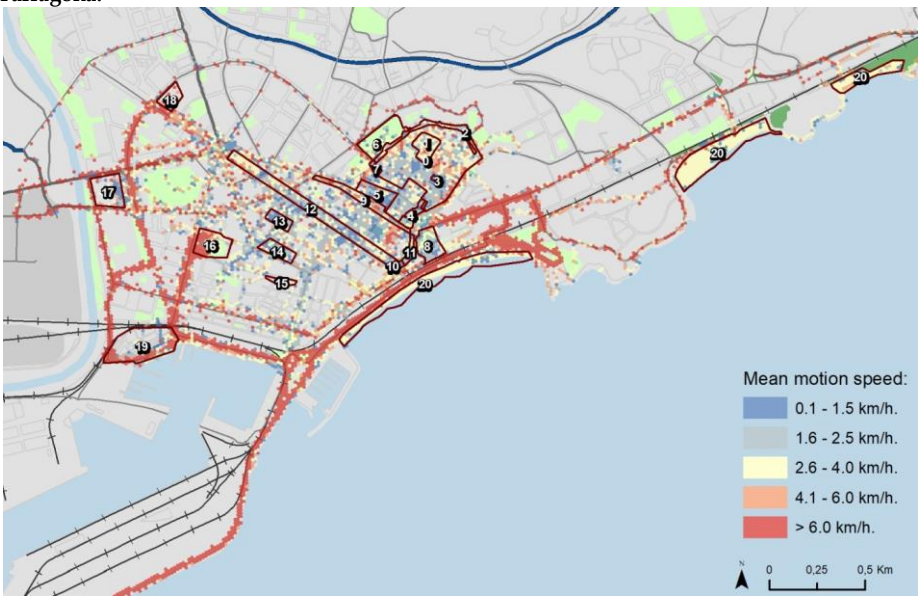
POI	Cruise passengers	%	Average time	Standard Deviation
Rambla Vella	131	85.07%	00h. 09' 22"	00h. 11′ 20′′
Wolrd Heritage Sites (WHO)	124	80.52%	00h. 21' 55"	00h. 29′ 11′′
Rambla Nova	132	85.70%	00h. 35'23"	00h. 29′ 21′′
Part Alta	125	81.17%	01h. 05' 35"	00h. 52′ 00′′
Balcó del Mediterrani	107	69,.8%	00h. 13' 59"	00h. 13′ 01′′
Plaça de la Font	89	57.80%	00h. 17' 59"	00h. 26′ 46′′
Serrallo	56	36.36%	00h. 09' 16"	00h. 27′ 02′′
Mercat Central	39	25.33%	00h. 18′01′′	00h. 24′ 16′′
Tarraco Arena	38	22.73%	00h. 02' 02"	00h. 00′ 42′′
Beaches	25	16.23%	02h. 25' 42"	01h. 47′ 28′′
Commercial centres	13	08.44%	01h. 19' 36"	01h. 25′ 33′′
Average visit	154	100.00%	05h. 16′ 54′′	02h. 06′ 17′′

Source: Author's own production

6.6.3. General cruise tourist mobility patterns

The aggregated GPS tracking data of the 154 cruisers who participated in our study are presented in Figure 14. It shows the average speed of movement of cruisers when they visit the city, by segmenting the speed according to the categories of pedestrian velocity proposed by Bauder (2015). It clearly showcases the routes used by cruisers to go from the cruise terminal to the city and return to the cruise ship, which are the cells in a darker red, and places where tourists move slowly, which are the cells in darker blue. The places where the cruisers spend longer periods of time are mainly concentrated in the Part Alta and along the Rambla Nova, and to a lesser extent in certain areas with beaches and shopping centres.

Figure 14. Average consumption speed of the urban space by cruise passengers in the city of Tarragona.



Note: 10 meter-sided hexagonal grid cell; 0-1,5km/h.: standing; 1.5-2.5km/h.: strolling; 2.5-4.0km/h.: walking slowly; 4.0-6.0km/h.: walking fast; >6.0 km/h.: running or using means of transport
Source: Author's own production

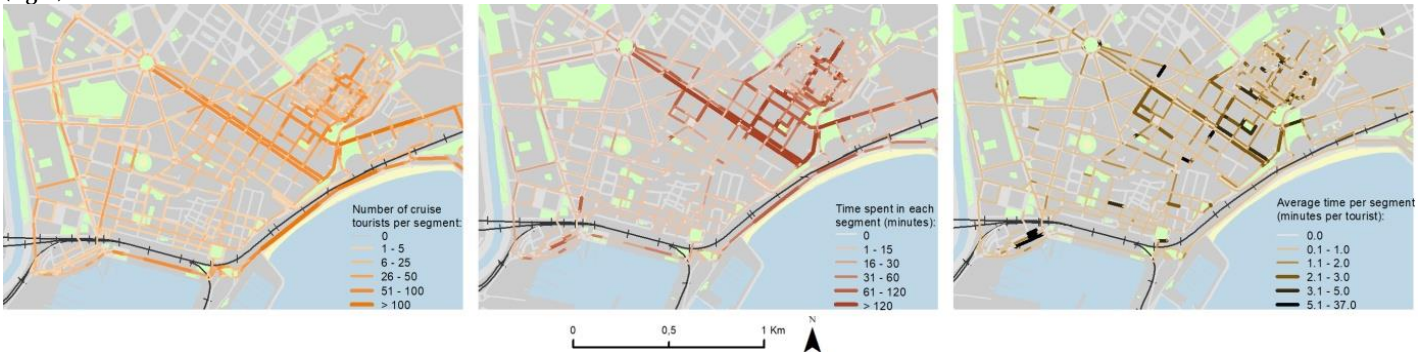
6.7. Results

6.7.1. Relationship between the characteristics of the built environment and the spatial behaviour of tourists in the city

Figure 15 shows the distribution of cruisers per street network segments in the centre of Tarragona, as well as the number of minutes they have spent in each segment and the corresponding average time. Both the frequency of cruisers per street segment and the average time have been used as dependent variables when applying subsequent statistical models.

Figure 16 shows the spatial values of the explanatory variables used in the statistical models designed. They correspond to space syntax indicators regarding attributes of the city street network configuration, other indicators regarding the characteristics of the urban space, and also to variables regarding the presence of commercial activity and the visibility of tourist spots.

Figure 15. Number of cruise passengers per segment (left); Time spent in each segment (centre); Average time cruise tourists spent in each segment (right).



Source: Author's own production

Figure 16. Indicators per street segment related to the built environment in Tarragona

Source: Author's own production

Results of the bivariate regressions, shown in Table 22, indicate that the two dependent variables, the number of cruise passengers (1) and the average time per street segment (2), are significantly associated with most of the explanatory variables (at least 95.0 % ($p < 0.05$)). However, no association has been detected with the variable regarding the incline of the streets or the variables regarding the visibility of commercial centres and World Heritage Sites located downtown. The variable related to the visibility of the Amphitheatre and the Roman Circus is significantly correlated with tourist frequency, but not with the average time spent there.

More precisely, as for the explanatory variables regarding spatial syntax, the standardised coefficients show that both the dependent variables have a significantly positive association with connectivity, integration and depth. However, results associated with average time are less explicative. As for the set of variables regarding the physical attributes of the urban space, the presence of vegetation is also highly associated with greater cruise passenger frequency and the longer time spent in certain areas. Conversely, both dependent variables are negatively associated with the maximum speed at which vehicles can circulate through the road network. In this sense, the higher the maximum speed, the lower the cruise passenger frequency and average time. Turning now to the set of explanatory variables relating to commercial activity, important positive associations have been identified between both dependent variables and the greater presence of food trades, restaurants, fashion and souvenir shops.

Regarding the results of the visibility variables for tourist areas, positive and statistically significant associations are highlighted between both dependent variables and the visibility of World Heritage Sites located in the Part Alta neighbourhood, the visibility of a wide urban landscape and the visibility of the Mediterranean Sea. The visibility of the Serrallo neighbourhood is associated negatively with tourist frequency, while it is associated positively with the average time.

Table 22. Bivariate regression analysis

Explicative variables	(1)				(2)			
	Coef.(B)	Std.Dev.	Std. B	R^2	Coef.(B)	Std.Dev.	Std. B	R^2
Connectivity	2.069***	0.223	0.184	0.034	0.131***	0.018	0.147	0.020
Integration	0.167***	0.009	0.364	0.132	0.007***	0.001	0.189	0.036
Choice	0.002***	0.000	0.393	0.155	0.000***	0.000	0.087	0.008
Depth	0.009***	0.001	0.334	0.111	0.000***	0.000	0.131	0.017
Slope	-0.007	0.060	-0.002	0.000	-0.002	0.005	-0.007	0.000
Vegetation > 2m	0.012***	0.001	0.248	0.061	0.001***	0.000	0.143	0.021
Maximum speed	-0.135***	0.014	-0.191	0.036	-0.003**	0.001	-0.054	0.003
Food	7.467***	0.786	0.188	0.035	0.472***	0.063	0.150	0.022
Restaurant	6.512***	0.505	0.251	0.063	0.545***	0.040	0.265	0.070
Fashion&souvenirs	5.742***	0.453	0.247	0.061	0.266***	0.037	0.145	0.021
Banks	13.147***	1.443	0.180	0.032	0.346**	0.116	0.060	0.004
Resident-oriented business	1.737***	0.230	0.150	0.022	0.103***	0.018	0.112	0.013
Visibility–WHS in Part Alta	15.670***	1.354	0.227	0.051	0.362***	0.110	0.066	0.004
Visibility–WHS (Amphitheatre and Circus)	24.354***	2.160	0.221	0.049	0.285	0.175	0.033	0.001
Visibility – WHS in Downtown	-3.373	2.874	-0.024	0.001	0.228	0.227	0.020	0.000
Streets–Serrallo	-5.180***	1.314	-0.079	0.006	0.451***	0.104	0.087	0.008
Visibility–wide urban landscape	30.387***	1.265	0.435	0.189	0.564***	0.111	0.102	0.010
Visibility–Mediterranean	47.774***	5.845	0.162	0.026	1.436**	0.468	0.062	0.004
Visibility–commercial centre	1.135	2.465	0.009	0.000	0.220	0.195	0.023	0.001

Note: (1) Dependent variable: Number of tourists per segment; (2) Dependent variable: average time (in minutes) per tourist and per segment. Robust standard errors: * 90.0%; ** 95.0%; *** 99.9%
Source: Author's own production

The visibility of the WHS located beyond the Part Alta neighbourhood (Roman amphitheatre and Roman Circus) has a high impact on tourist frequency, but it is not associated with the average time. Lastly, no association has been identified between the dependent variables and the streets with visibility of

WHS located downtown and the streets with visibility of the commercial centres.

6.7.2. Identifying the main indicators for tourist spatial behaviour

To answer the second research question (about the impact from the different variables), the explanatory variables detected as significant in the bivariate regression models have been included in multivariate regression analysis performed according to types of variables (Table 23), and for all the variables (Table 24). The specifications that take the number of cruise passengers per segment (1) as a dependent variable have a higher coefficient of determination, R2, than the specifications taking the average time (2) as a dependent variable.

In relation to the regression of the space syntax indicators (Table 23), it is observed that choice and integration are the variables that influence tourist frequency the most (1). Only integration provides an important explanatory value of the average time that cruisers spend in certain areas of the city (2).

With regards to the regressions that include the two variables related to other characteristics of the urban space, it is observed that both the presence of vegetation over 2m and the maximum speed at which the vehicles can circulate are significant, at 99.9 % ($p < 0.01$), with the association being positive in the first case and negative in the second. The incidence of both variables on the frequency of cruise passengers (1) is higher than their influence on the average time (2).

As for the regressions that incorporate explanatory variables related to economic activity, all the variables corresponding to tourist-focused commercial activities have a positive and significant association, at least at 95.0% ($p < 0.05$), with the variable related to restaurants being the one with higher incidence. The presence of banks indicates the central position of urban

spaces. Therefore, as the tourists walk through the most central spaces, this is a significant indicator for explaining cruiser frequency in the streets of Tarragona. It is also important to highlight that the resident-orientated activities have a negative association with the dependent variables. Therefore, the greater the presence of local-oriented business in the streets, the lower the average time and number of cruise passengers.

Table 23. Multivariate regression analysis according to types of variables.

	(1)			(2)		
Explanatory variables	**Coef. (B)**	**Std. Dev.**	**Std. B**	**Coef. (B)**	**Std. Dev.**	**Std. B**
Connectivity	0.504*	0.282	0.045	0.049**	0.024	0.054
Integration	0.064***	0.015	0.140	0.005***	0.001	0.139
Choice	0.001***	0.000	0.257	0.000	0.000	-0.031
Depth	0.002***	0.001	0.087	0.000**	0.000	0.055
Overall model	$R^2 = 0.189$ | Sig. = 0.019			$R^2 = 0.039$ | Sig. = 0.251		
Vegetation > 2m.	0.015***	0.001	0.296	0.001***	0,000	0.160
Maximum speed	-0.176***	0.014	-0.249	-0.005***	0.001	-0.085
Overall model	$R^2 = 0.121$ | Sig. = 0.000			$R^2 = 0.027$ | Sig. = 0.000		
Food	2.755**	0.878	0.069	0.168**	0.071	0.053
Restaurants	4.874***	0.566	0.188	0.509***	0.046	0.248
Fashion & souvenirs	4.512***	0.500	0.194	0.156***	0.040	0.085
Banks	9.916***	1.444	0.136	0.090	0.117	0.016
Resident-oriented business	-1.085**	0.282	-0.094	-0.061**	0.023	-0.067
Overall model	$R^2 = 0.119$ | Sig. = 0.000			$R^2 = 0.080$ | Sig. = 0.000		
Visibility – WHS in Part Alta	17.998***	1.141	0.260	0.442***	0.109	0.081
Visibility – WHS (Amphitheatre and Circus)	24.581***	1.813	0.223	0.330*	0.173	0.038
Streets – Serrallo	-1.689	1.083	-0.026	0.524***	0.103	0101
Visibility – wide urban landscape	31.203***	1.153	0.447	0.624***	0.110	0.113
Visibility – Mediterranean	50.815***	4.844	0.173	1.532***	0.462	0.066
Overall model	$R^2 = 0.333$ | Sig. = 0.000			$R^2 = 0.031$ | Sig. = 0.000		

Note: (1) Dependent variable: Number of tourists per segment; (2) Dependent variable: average time (in minutes) per tourist and per segment. Robust standard errors: * 90.0%; ** 95.0%; *** 99.9%
Source: Author's own production

Finally, in relation to the regressions with the variables relating to the visibility of tourist areas, we have detected a high incidence of the visibility of wide urban landscapes, with significant associations at 99.9% ($p<0.01$) in both models. This means that tourist frequency and the average time per street is higher in those public and tourist areas with more visibility of wide urban landscapes. The visibility of WHS located in the Part Alta neighbourhood, the visibility of the Roman amphitheatre and the Roman circus, and the visibility of the Mediterranean Sea also have an important impact on the dependent variables.

Results of the joint multivariate regression analysis are set out in Table 24. The coefficient of determination for the first specification is much greater than the coefficient for the second model. This means that the independent variables considered are more explicative of cruise tourist frequency per street segment, than the average time they are in each segment. As the measuring units of the variables are different, it is important to observe the standardised coefficients in order to guarantee comparability. These coefficients reveal the relative importance of each variable within the regression equation.

In the first model, where tourist frequency per street is the dependent variable, it is observed that most of the variables are statistically significant. The variables with greater incidence on the higher cruise tourist frequency in certain spaces of the city, are the visibility of wide urban landscapes, the visibility of WHS located in the Part Alta, the visibility of the Amphitheatre and the Roman Circus, the presence of vegetation over 2m, the visibility of the Mediterranean Sea and the number of commercial activities focusing on fashion and souvenirs. Among the space syntax indicators, choice and depth are statistically and positively associated with the dependent variable. It is related to the fact that pedestrians tend to choose the visually shortest route out of the competitive routes in the street network (Hillier *et al.* 2012; Lerman *et al.* 2014), especially when they do not know the layout of the built environment through which they are moving, as is the case of cruise tourists visiting Tarragona. In contrast, we

have detected a statistically significant negative association with the dependent variable in relation to the presence of resident-oriented businesses.

Table 24. Joint multivariate regression analysis

	(1)			(2)		
Explanatory variables	**Coef. (B)**	**Std. Dev.**	**Std. B**	**Coef. (B)**	**Std. Dev.**	**Std. B**
Connectivity	-0.257	0.246	-0.023	0.028	0.026	0.031
Integration	0.003	0.013	0.007	0.002	0.001	0.049
Choice	0.002***	0.000	0.272	-0.000	0.000	-0.008
Depth	0.001**	0.001	0.049	0.000	0.000	0.038
Vegetation > 2m.	0.008***	0.001	0.152	0.000**	0.000	0.050
Maximum speed	-0.013	0.014	-0.018	-0.001	0.002	-0.022
Food	2.198***	0.656	0.055	0.159**	0.070	0.051
Restaurants	2.442***	0.438	0.094	0.430***	0.047	0.210
Fashion & souvenirs	3.501***	0.379	0.151	0.137***	0.040	0.075
Banks	6.288***	1.092	0.086	0.042	0.116	0.007
Resident-oriented business	-0.580**	0.218	-0.050	-0.057**	0.023	-0.062
Visibility – WHS in Part Alta	12.835***	1.081	0.186	0.378***	0.115	0.069
Visibility – WHS (Amphitheatre and Circus)	21.179***	1.606	0.192	0.381**	0.171	0.044
Streets – Serrallo	-0.734	1.606	-0.011	0.484***	0.104	0.093
Visibility – wide urban landscape	25.108***	0.974	0.359	0.244**	0.114	0.044
Visibility – Mediterranean	51.094***	4.189	0.174	1.564***	0.446	0.067
Overall model	R^2=0.512 | Sig.=0.000			R^2=0.117 | Sig.=0.000		

Note: (1) Dependent variable: Number of tourists per segment; (2) Dependent variable: average time (in minutes) per tourist and per segment. Robust standard errors: * 90.0%; ** 95.0%; *** 99.9%
Source: Author's own production

With regard to the second model, where the average time that tourists spend in certain areas of the city is the dependent variable, the variables with the greatest impact are the presence of restaurants, the number of fashion and souvenirs shops, the visibility of WHS in the Part Alta, the visibility of the Mediterranean Sea, the visibility of the Serrallo neighbourhood. Furthermore, contrary to the

first specification, in the second model none of the space syntax variables is significantly associated with the average time tourists spend per street segment.

Results of the joint multivariate regressions highlight that urban configuration and design are important generators of cruise tourist mobility (Hillier *et al.* 1993), but not highly determinant of the time the users decide to spend in each street segment. Therefore, this research pinpointed that the presence of attractors such as commercial activity, restaurants and points of interest is key to understanding where cruise tourists prefer to spend more time during their visit. Therefore, results underpin that cruise tourist behaviour is shaped by their perception of the spatial dimension (Thwaites & Simkins 2007) and by the presence of mixed land use and commercial activity (Foltête & Piombini 2007; Mansouri & Ujang 2016) that give them multiple possibilities to engage in specific activities.

6.8. Discussion and conclusion

This article has demonstrated that the configurational attributes of the street network are useful for understanding cruise tourist spatial behaviour in Tarragona. However, results also revealed that indicators referring to the visibility of tourist places and the type of economic activity are more consistent and have higher incidence. Those results are in line with previous research that confirms the importance of the relational attributes of the urban form, but pinpoint the presence of attractors as a greater explanation of pedestrian spatial behaviour (Foltête & Piombini 2007; Mansouri & Ujang 2016).

Furthermore, the study has shown that when the space syntax indicators are used to explain cruise tourist spatial behaviour at a destination, it is important to consider not only the number of cruise tourists who walk along the streets, but also the average time that they spend in them. Therefore, after performing the multivariate regression analysis we have seen that, regarding the space syntax indicators, choice is the variable with the highest effect on tourist frequency in certain areas in the city. Indeed, the literature identifies choice or

option as the space syntax measure that has stronger and more consistent correlation with pedestrian movement, than other conventional syntactic measures (Hillier *et al.* 2012). This is because pedestrians are more likely to choose the visually shortest route out of the competitive routes in a network (Lerman *et al.* 2014).

In contrast, when the average time that the cruise passengers stay in the streets of Tarragona has been taken as the dependent variable of the multivariate regression, results showed integration as the space syntax indicator with the highest impact. Integrated streets are accessible and attractive to pedestrians for natural movement (Sharmin & Kamruzzaman 2017). In fact, Li *et al.* (2016) demonstrated that in the historic town of Gualangyu (China), the street network integration is highly and positively correlated with tourist pedestrian movement. Nevertheless, the relation between integration and the cruise passengers staying longer in certain streets of the city can be a result of the multiplier effect of local attractors (Mansouri & Ujang, 2016), such as commercial activity and places of interest. These findings are consistent with results obtained by Mansouri & Ujang (2016), that pointed to urban activities and land uses as very important factors explaining tourist spatial behaviour. Precisely, the results show a greater consistency of the indicators related to commercial activity and visibility of tourist attractions. On the one hand, the higher presence of restaurants, souvenir and fashion shops per street segment has been associated with a higher frequency of tourists, but also with a greater average time. In contrast, a negative association has been identified between the presence of economic activities oriented towards the local people and the tourist inflow.

On the other hand, variables related to the visibility of tourist attractions also affect the tourist frequency and the average time per street. Results show that those streets with a visibility of wide urban landscapes, visibility of the Mediterranean Sea and proximity to World Heritage Sites in the Part Alta and nearby are positively associated with the presence of cruise tourists. However,

there are tourist areas with reasonably good walkways that interest few cruise passengers, such as the streets with visibility of World Heritage Sites located in the downtown area and the streets with visibility of the Serrallo neighbourhood. This may be related to the distance that separates the central part of Tarragona from downtown where these tourist places are located. In this regard, more efforts should be made by the local authorities to integrate attractions into the network and foster a higher level of mixed land use between attractions so as to obtain more compactness and connectivity between attractions (Jacobs 1961).

In accordance with the results obtained for the indicators related to other physical characteristics of the urban space, the more vegetation over 2 meters there is along the streets, the higher the number of tourists and the average time that they spend in them. Therefore, the presence of shade is an aspect that tourists take into account when visiting the city, as it makes the spaces more walkable (Foltête & Piombini, 2007). The maximum speed at which the vehicles can drive is also a determinant of cruise passenger frequency along the streets (Blečić *et al.* 2015). Hence, it has also to be considered by the public authorities concerning city planning, to ensure safety in public areas.

Last, but not least, this article highlights the importance of considering the average time that the tourists spend in different places in the city, when discussing the influence of the built environment design over tourist spatial behaviour in cities. In fact, the main constraint of cruise tourist mobility in the city is their time, as they are in the city for a limited number of hours.

This study has proven the utility of analysing characteristics of the built environment in order to understand mobility decisions of cruise visitors in a city. It is an exploratory study by nature and, certainly, since the validity of the model has been established, it can be further enhanced using larger samples. This will also allow defining segmented patterns according to the characteristics of visitors. Otherwise, characteristics such as the length of street segments and the width of the pedestrian space should be considered in future

studies, as they could be important explanatory variables regarding cruise tourist mobility. Moreover, authors may suggest that if the method is replicated in other cities and those cities have the arrivals of cruise port close to the visitors' attraction area, it would be worthwhile analysing the significance of the distance from the port to the city, and the different paths that visitors can follow to plan their tour. In this study, this variable has not been considered because all the cruise tourists had to take public transport services due to the long distance from the port to the urban centre.

Thus, although methodological limitations can be identified, the results from this research are particularly valuable since they provide better knowledge of the characteristics of the urban areas that cruise tourists prefer to move through and spend more of their time. In this regard, it can also give valuable insight into public administrations that have to consider urban planning and design as key factors for both the tourist experience in the location and their satisfaction, and the prosperity of the people who live in there. Along these lines, as the continuous growth of tourism is a challenging situation for destination management organisations and local and regional authorities, because pressure on public and urban spaces is increasing considerably, the empirical evidence provided can be particularly useful for mitigating problems caused by cruise passenger mobility in certain places in the city, through better design and management of the built environment.

In this vein, future research should analyse in greater depth the time component of tourist spatial behaviour, in order to detect to what extent the functionality of the built environment is altered by their presence, and how this is affecting other users in the urban system. Hence, different issues have to be analysed from a time-geography perspective, such as the variability of processes of interaction between locals and tourists in specific spaces during the day, the week or according to seasons of the year; the potential effects of agglomeration caused by cruise tourism for a few hours, both intense and massive, over the carrying capacity of the different streets; the relationship between the sequence

of activities developed by tourists in relation to the availability of services, attractions and points of interest; or changes to the built environment in particular places as a consequence of the increasing number of visitors.

Linked to this last example, it is important to mention that destination management organisations have to ensure that neither the attractiveness nor the meaning of public spaces are lost. Furthermore, the subjective perception of the urban landscape by both locals and tourists also has to be an issue of consideration, because an important part of the human spatio-temporal behaviour is due to the subjective feelings about the environment they are moving through. Therefore, complementary analysis contrasting the mobility of locals and tourists should be done to measure to what extent the particular perception of each one group influences their spatial behaviour. It would contribute significantly to the debate on how a liveable and socially, economically and environmentally sustainable urban space has to be configured.

7. Detection of tourist flows with the digital footprint

Using Flickr geotagged photos to estimate visitor trajectories in World Heritage Cities

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Highlights

- Visitor spatiotemporal trajectories are reconstructed along with the urban network using thousands of geotagged Flickr photos
- A process of trajectory reconstruction using advanced GIS techniques has been implemented.
- The spatial behaviour has been used to classify the tourist sites offered on the city's official tourist map, as well as to identify the association with the land uses.
- Overflowed streets and shadow areas underexplored by visitors are pinpointed.

Abstract

World tourism dynamics are in constant change, as well as they are deeply shaping the trajectories of cities. The "call effect" for having the World Heritage status has boosted tourism in many cities. The large number of visitors and the side effects, such as the overcrowding of central spaces, are arousing the need to develop and protect heritage assets. Hence, the analysis of tourist spatial behaviour is critical for tackling the needs of touristified cities correctly. In this article, individual visitor spatiotemporal trajectories are reconstructed along with the urban network using thousands of geotagged Flickr photos taken by visitors in the historic centre of the World Heritage City of Toledo (Spain). A process of trajectory reconstruction using advanced GIS techniques has been implemented. The spatial behaviour has been used to classify the tourist sites offered on the city's official tourist map, as well as to identify the association with the land uses. Results bring new knowledge to understand visitor spatial behaviour and new visions about the influence of the urban environment and its uses on the visitor spatial behaviour. Our findings illustrate how tourist attractions, and the location of mixed commercial and recreational uses shape the visitor spatial behaviour. Overflowed streets and shadow areas underexplored by visitors are pinpointed.

Keywords: visitor spatial behaviour; mobilities; visitor flows; urban tourism; geotagged photos; Flickr; Toledo

7.1. Introduction

Urban tourism has been expanding globally since the 1980s. In the current mobilities era (Urry 2007), characterised by the modelling force of the digital context and the global access to information (Bock 2015; Rifkin 2000), the world tourism dynamics are in constant change, at the same time that they are deeply shaping the trajectories of cities (Anton Clavé 2019). In the aftermath of the global financial crisis of the late 2000s, many urban destinations hailed tourism as the solution for many failing local economies to recover (Russo & Scarnato 2018). In this context, strategic planning in tourism has been based on the touristification of cities, by means of the creation of new (or the upgrading of already existing) environmental and cultural resources in order to open up new markets. Sport and culture-led urban regeneration projects (Lee, 2009), hotel development (Türkün, 2011), the emergence of the so-called sharing economy of short-term tourist rentals (Wachsmuth & Weisler 2019), or over-tourism (Dodds & Butler 2019) are creating a day-to-day struggle for tourist city management and, furthermore, they are shifting the nature of places upwards to the extent of what has been known in literature as the "tourismification of the quotidian" (Bourdeau *et al.* 2013). In tandem, tensions and conflicts between residential and tourist uses of the city's commons have started to appear. Many cities are experiencing the transformation of their everyday sites of activity because of visitor interaction, or how they gaze and go places (Cechini 2016; Russo & Richards 2016). These transformations might be structural (such as land use changes, building conversions, rent increases, store replacement), related to immediate nuisances created by the pressure exerted by the tourist activity (such as congestion, privatization, noise, litter, among others) or might be linked to the commodification of "the cultural", the homogenization of the urban space (Ritzer 2011) and the subsequent loss of distinctive attractiveness (Lew 2017). Touristified cities are being adapted to tourists, partially in order to attract demand, but also because they are influenced by "the overwhelming economic success of mass tourism theme parks, cruise ships and historic shopping streets and shopping centres" (Lew 2017, p.9).

These transformations are leading to the rise of anti-tourism movements (Seraphin *et al.* 2018) that question the management strategies and the sustainability of the tourist activity itself regarding the compatibility between the benefit of the local economy, the preservation of endogenous resources and the quality of both the tourist experience and the daily life of the residents. In addition, the impact of tourism in cities with the presence of UNESCO World Heritage (WH) assets is enhanced by the potential risk of losing their designation (Seraphin *et al.* 2018). In many of these WH cities, tourism started to develop advantaging from the "call effect" for having the WH status. However, the large number of visitors and the side effects are arousing the need to develop and protect heritage assets to serve the needs of the tourists and stakeholder communities (Bourdeau & Gravari-Barbas, 2016). It is in this context that destination management competitiveness (Crouch 2011) becomes essential.

One of the major challenges in urban tourism management is created by the overcrowding of central spaces and specific street networks (Bimonte & Faralla 2016; Lin *et al.* 2017). Visitor spatiotemporal behaviour involves movement and multi-attraction (Caldeira & Kastenholz 2019) and, consequently its analysis is critical for tackling the needs of the destinations correctly. Urban tourists tend to concentrate their movements in reduced areas within cities (Ashworth and Page 2011), where multiple kinds of tourist attractions are clustered. Moreover, the visitors' time-restrictions at a destination and their interest in visiting/consuming as many sites of interest as possible make their behaviour a fast and intense experience (Bauder 2015). It is in this framework that understanding visitors' spatial behaviour can bring new knowledge about new flexible planning and management procedures and probably new visions about the built environment, its uses and its benefits (Anton Clavé 2019).

With the advent of position-tracking technologies (Caldeira & Kastenholz 2017) and the need for a detailed examination of tourist behaviour within destinations/cities (Ashworth & Page 2011; Pearce 2001), the scale of analysis has zoomed in progressively. During the last few years, there has been an

important increase in studies on spatiotemporal tourist behaviour at destination (Domènech *et al.* 2020a; McKercher & Lau 2008) that have enabled new analyses (or improved/completed existing ones) on the use of space by tourists on different scales (Hawelka *et al.* 2014).

In this regard, our study contributes to this research field on urban tourist mobility studies, by providing not only useful information for public authorities aimed at both improving the tourist experience and mitigating the side effects on the local population, but also a cost-effective and agile instrumental method to analyse urban tourist mobilities that could be replicated elsewhere. In this vein, this study aims to analyse the visitor spatial behaviour within the historic centre of the World Heritage city of Toledo (Spain), using geolocated photos of one of the most popular and accessible photo-sharing websites, Flickr. According to existing literature, the excessive tourist pressure on certain places of the historic centre of Toledo is causing conservation problems for monuments, to which are added the drawbacks of excessive touristification (Solís *et al.* 2020) that tends to make the historical centre a "theme park in history", to the detriment of other land uses and activities (Zárate 2007).

Concretely, this study aims to use the reconstruction of individual trajectories on street level to analyse to what extent there is an overlap between the visitor spatial behaviour, the Toledo official tourist map (see Figure A1 in the Appendix) and the typology of land uses. We hypothesize that the definitive visitor flow map could match with the location of the tourist sites promoted in the official tourist map of Toledo, as demonstrated by Paül i Agustí (2018), but also with the presence of mixed commercial and recreational land uses (Jansen-Verbeke 1986; Domènech *et al.* 2020b).

To achieve the aforementioned objective, we implement a detailed methodology to monitor visitor behaviour in city centres, by going beyond of what has been done by studies that have used geolocated data from photo-

sharing platforms, such as the detection of most popular tourist attractions or travel recommendations (Girardin 2008; Sun *et al.* 2015; Zheng *et al.* 2012).

Thus, the potential of this data source to reconstruct physical trajectories on the street layout using the photographers' digital spatial footprints (considering the associated time and location data of their photos) is approached.

The fulfilment of the research objectives will open new opportunities for urban tourist mobility studies. The results will clearly help to classify the tourist sites according to the flow of visitor trajectories per street segment where they are located. Therefore, this study could be of interest for public authorities to identify intensive uses of specific areas of the cities, as well as undervisited monuments that could help to both mitigate the impact of tourism growth and set up sustainable cultural destinations (Aranburu *et al.* 2016). Furthermore, in the current era of COVID-19, this study may bring interesting implications for academia, practitioners and policy managers, in a context in which international tourist mobility has almost come into a halt, but locally-based tourist flows have been reinforced (Iaquinto 2020). Hence, the analysis implemented could be considered a rapid and economic way to monitor human mobility and social interaction in dense urban spaces in the new paradigm that has burst into the era of mobilities (Urry 2007).

Following this introduction, the paper presents a review of the relevant literature on the urban tourist mobility studies in cultural heritage cities, in order to highlight the opportunities, strengths and limitations of multiple data sources, especially data from social media and photo-sharing platforms such as the one used in this study, Flickr. Then, information regarding the city under analysis is provided. The data used and methods implemented are explained in the fourth section of the manuscript. The subsequent section exposes the results obtained, along with a discussion on the findings of other similar studies. Finally, the conclusions of the work are underpinned.

7.2. Data sources for urban tourist mobility studies in cultural heritage cities

7.2.1. Challenges for tourist mobility studies in cultural heritage cities

Although the main objective of the UNESCO listing is the identification and protection of sites of outstanding value, the designation has been widely used in marketing strategies to attract more tourists (Caust & Vecco, 2017). An increase of tourist arrivals implies also higher tourist flows within the historic centres designated as WH which may have a twofold effect. On the one hand, the higher presence of tourists might induce an economic impact on the local economy as well as a positive cultural exchange. On the other hand, the visitor flows may represent an overload in areas with a complex structure such is the case of historic centres (De Luca *et al.* 2020). Thus, the cultural integrity of the heritage sites may be affected and damaged since the load capacity of these sites is reduced. Furthermore, the social cohesion and identity of the local community (Cechini 2016; Russo & Richards 2016) may also be compromised because of the tourismification of historic centres (Bourdeau *et al.* 2013). Either structural transformations such as land use changes, building conversions, rent increases or store replacement, or immediate nuisances created by over-tourism might lead to a downward spiral of cultural degradation with negative influences on both the quality of life of citizens and tourist experience (Lew 2017), leading to a configuration of an unsustainable model of tourism.

According to the World Tourism Organisation (UNWTO), nonetheless, the massive arrival of tourists at destinations or the over-tourism effect does not have to represent a threat if public authorities develop a smart and effective control of visitor flows in the destination (UNWTO, 2018). In this context, therefore, emerges the need to manage visitor flows and set up sustainable cultural destinations (Aranburu *et al.* 2016). Thus, the minutely analysis of the spatiotemporal behaviour of visitors should be implemented not only to

identify intensive uses of specific areas and places, but also to design new strategies of redistribution via the promotion of undervisited yet with potential sites or monuments (Richards 2002; Dredge 1999). Then, if we consider the centres of heritage cities not only as leisure and tourism places, but also as activity places (Jansen-Verbeke 1986) that intermesh formal and informal activities carried out by locals and visitors, there are key elements such as primary attractions combined with characteristic features of the urban environment, that induce a certain spatial behaviour. However, the data available for the analysis has been traditionally limited and, while it is true that in recent years there has been a substantial increase in the sources available thanks to the emergence of positioning technologies (as we will review in the next subsection), there are still some significant limitations and challenges; besides that, the analyses developed in small and medium-sized heritage cities, such as the case of the present study, are few.

7.2.2. From classical tourism statistics to position-tracking technologies: increasing spatial and temporal granularity

Never before in history have researchers and practitioners had the mobility monitoring tools that we have available today. Since the last decades of the 20th century, scholars have been calling for more and better research on urban tourism. Previously, tourism studies concentrated on distributions and flows on international, national and regional levels, neglecting to look into processes on a very localized scale (urban and neighbourhood levels). Some of the reasons for the traditional scarcity of specific research on urban tourism in general, and on spatiotemporal tourist behaviour in particular, were (and still are) the methodological challenges facing the task of gathering data. Classical tourism statistics cannot track tourist travel behaviour since they usually provide data from survey-based hotel occupancy which, in addition, miss those tourists who do not stay overnight at the destination (one-day visitors) or those who do not stay overnight in regulated accommodation (i.e., short-term rentals). In this regard, direct observation (Jaakson 2004), travel diaries (Zillinger 2007) and

recent digital position-aware technologies are the three tracking methods available (Hardy *et al.* 2017). Even though both direct observation and travel diaries have traditionally constituted the primary data collection tool, they present some limitations such as low participation levels or inadequate/insufficient information on spatiotemporal visitor behaviour (McKercher & Lau 2008; Shoval & Isaacson 2007a).

With the advent of position-tracking technologies, the scale of analysis has zoomed in progressively (Caldeira & Kastenholz 2017), though there are still several limitations related to the spatial resolution and the temporal granularity of the sources. Among the multiple sources of information that monitor human mobilities, the most used to track tourist behaviour at the urban scale have been the positioning loggers, the mobile phone satellite position records and geotagged content coming from social media. The three data sources have their strengths and limitations for the analysis of urban tourist mobilities within cultural heritage cities. Therefore, below we reviewed their main characteristics, showing special emphasis on geotagged social media data, since it is the data source used in this study.

7.2.3. Positioning loggers

The positioning loggers have helped to explore visitor travel patterns on different scales, ranging from national/international tourism (Wu & Carson 2008), to movements within urban destinations (McKercher & Lau 2008) or within confined recreational areas (Birenboim *et al.* 2013). The main advantage provided by this method is the possibility to integrate the GPS tracks with ad hoc surveys answered by the participants. Hence, socioeconomic characteristics of the individuals can be crossed with their spatiotemporal behaviour. This methodology has been carried out previously in WH cities. Such are the cases of the studies developed in the historic centre of Melaka in Malaysia with 384 participants (Md Khairi *et al.* 2018) or in the old city of Acre in Israel with 88 participants (Tchetchik *et al.* 2009). Similarly, both studies showed that different

visitor profiles can be detected in WH cities according to their socioeconomic characteristics and, more importantly, based on their spatiotemporal behaviour. In this regard, they indicate that the study of visitor behaviour has to help city managers to improve mobility management plans to guarantee the quality of the tourist experience as well as the preservation of the heritage sites.

However, despite the undeniable contribution of positioning loggers as a tracking methodology, they suffer some drawbacks (Versichele *et al.* 2014). Some of these disadvantages might be related to technical issues such as (1) transmission problems, (2) warm-up times before getting a valid position, (3) the cost of voluminous post-processing information from GPS loggers or (4) the non-applicability to indoor contexts. Nonetheless, the main limitation comes from a (5) potential selection bias (since certain population groups would be more participative, over-representing these individuals in the sample) and (6) a relatively low number of observations that may also condition the representativeness and the analyses.

7.2.4. Mobile phone satellite position records

Mobile phone satellite position records and cell phone usage have also opened up multiple opportunities such as identifying urban activities and their spatial-temporal evolution almost in real time (Calabrese *et al.* 2011) and understanding tourist travel behaviour (Phithakkitnukoon *et al.* 2015). The potential to identify different user profiles with this data source has been shown in the heritage cities such as Rome (Calabrese *et al.* 2011) Venice (Mizzi *et al.* 2018) and Florence (Mamei and Colonna, 2018). However, cell phone tracking encompasses certain limitations related to the uneven spatial accuracy (limited by the density of cell towers over the study area and thus posing a problem when studying movements on a local scale). Despite this limitation, the study of Mizzi *et al.* (2018) achieved a spatial granularity not commonly seen in studies with mobile phone data. They were able to reconstruct the mobility paths on the road network of around 3000 devices during the Carnival of Venice and the Festa del

Redentore in 2017. Thus, every time each device was used for a phone call or to access to the Internet recorded a GPS location that allowed the authors to reconstruct trajectories. The authors present this reconstruction as an innovative tool that must be used to analyse how the tourist flows impact on the quality of life of residents and on the preservation of cultural heritage. Nevertheless, these data are not generally free of charge and the high cost might represent an important barrier for academia, practitioners and public authorities.

7.2.5. Geotagged social media sources

Social media sources (photo sharing web sites such as Flickr, Twitter, Panoramio or Instagram; or social sport tracker sites and applications such as Wikiloc or Strava) connected with tourism activity, have contributed greatly to ameliorating both data collection and analysis issues, potentially contributing to urban tourist research. As stated by Chareyron *et al.* (2013), big data unquestionably represents a new challenge for tourism. In addition, the recent widespread use of camera devices with GPS (including smartphones and tablets) enables storing geographical information for each photo taken. These geolocated photos allow us to estimate national tourist statistics (Önder *et al.* 2014; Yuan & Medel, 2016), identify points of interest or (tourist) landmarks by selecting representative and relevant photographs from a particular spatial region (Jaffe *et al.* 2006), depict tourist concentrations and spatial-temporal movement trajectories within urban environments (Zheng *et al.* 2012), even rank them quantitatively (Yin *et al.* 2011) or recommend travel paths based on the previous travel information of tourists (Cao *et al.* 2010; Kurashima *et al.* 2013; Okuyama & Yanai 2013). In addition, these data sources have been used to analyse the extent to which there is an overlap in the territorial distribution of tourism images promoted through official tourist brochures and travel guides (Paül i Agustí 2018), and to compare the spatial interactions between tourists and locals (Li *et al.* 2018).

The geolocated social media data can be considered a valuable proxy of human movement since it provides detailed spatial information (up to street level precision) for a wide range of applications, such as identification of anomalous movements (Chae *et al.* 2015), point of interest categorisation (Andrienko *et al.* 2013) or community detection (Wakamiya *et al.* 2011). In fact, according to García-Palomares *et al.* (2015), it is on an urban scale that these sources show the greatest potential, since they gather users' travel experiences.

Despite all these advantages, multiple drawbacks also arise when using geolocated social media data. The main limitations are user penetration (Riederer *et al.* 2015) and the potential unreliability of the information provided by the users (Hecht *et al.* 2011). Both limitations could lead to a representativeness bias. In the first place, the territorial context under analysis is subjected to the popularity of the social network from which data are analysed. For instance, the number of Flickr users is highly correlated with the number of tourists from North American and European countries where the social network is more popular (Yuan & Medel, 2016). However, this correlation is much lower for Chinese users due to a lower user penetration in that country. Secondly, the nature of photo sharing networks is not transversal among them. In fact, the most widely used social networks for research purposes have been open access repositories that provide accessibility for downloading and analysing the data. Such is the case of Flickr, that in contrast to other photo sharing social networks, such as Instagram, offer much less noise when analysing data. This is related to the type of users and to the multiple factors that push them to upload content on photo sharing platforms, such as attention seeking, social influence, disclosure or information sharing (Malik *et al.* 2015). Another drawback of geolocated social media data is related to the reconstruction of trajectories, which are much coarser than tracking trajectories obtained by positioning loggers or mobile phones (Arase *et al.* 2010), since the photos taken by the users may not be very continuous in time, or perhaps the users do not upload all the photos taken on the social media platform. An additional limitation of this kind of data is that there is no detailed information

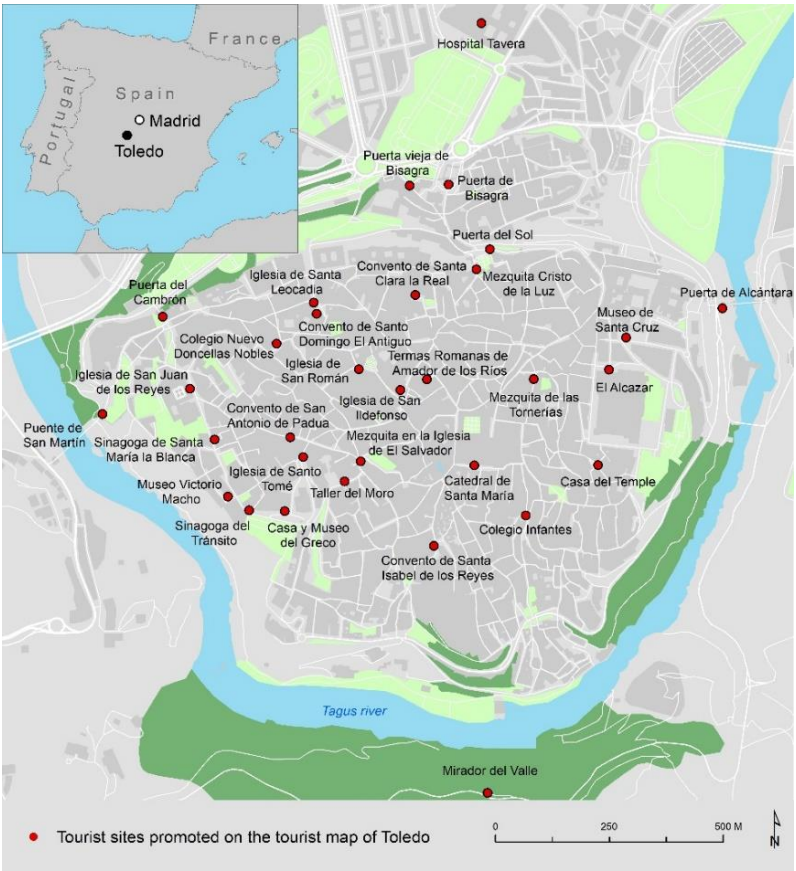
on the socio-economic and demographic profile of the tourist, or about their previous travel experiences.

Despite its limitations, the large amount of data uploaded onto the cloud makes it possible to approach the routes that visitors follow and to detect the most visited points of interest. In this regard, previous studies have defined routes as a sequence of previously identified city landmarks/regions of interest that a person visits (Girardin *et al.* 2008; Zheng *et al.* 2012). Most of these studies represent straight connections as routes between tourist attractions (Comito *et al.* 2016; Kádár 2013; Girardin *et al.* 2008). Meanwhile, some of them are instead travel recommendation systems based on minimizing distances or optimizing the number of visited attractions (Sun *et al.* 2015; Cao *et al.* 2010; Kurashima *et al.* 2013). Only a limited number of them provide a visitor flow along with the network. For instance, Orsi & Geneletti (2013) used 3656 photos from Panoramio and designed a methodology to reconstruct hiker flows along with the trail network of the Dolomites natural park (north-eastern Italy). In addition, Yin *et al.* (2011) used Flickr photos from 12 cities and proposed a method to identify the most repeated travel sequences between main attractions. However, to the best of the authors' knowledge, there is no study that reconstructs individual visitor trajectories and infers them to the urban network, which is the methodological contribution of our study. Furthermore, none of the mentioned studies analyse the association between the visitor flows and the land uses in order to detect how the spatial behaviour is shaped by the presence or absence of specific characteristics of the urban environment. In fact, the studies that explore this dimension do so by means of aggregating the photos at cell level (not at the level of visitor flows through the streets as in the present study), and checking if there is a spatial correlation between the spatial distribution of photos and the presence of attractions, services and facilities linked to the tourist offer (Encalada *et al.* 2017; Salas-Olmedo *et al.* 2018).

7.3. Study context

Toledo, with a population of 84,282 inhabitants (INE, 2018), is the capital city of the Autonomous Community of Castilla-La Mancha (Spain). It is located at the centre of the Iberian Peninsula, just 70km at the south of Madrid, the largest Spanish metropolitan area (see Figure 17).

Figure 17. Location of the tourist sites promoted on the official tourist map of the historic centre of Toledo.

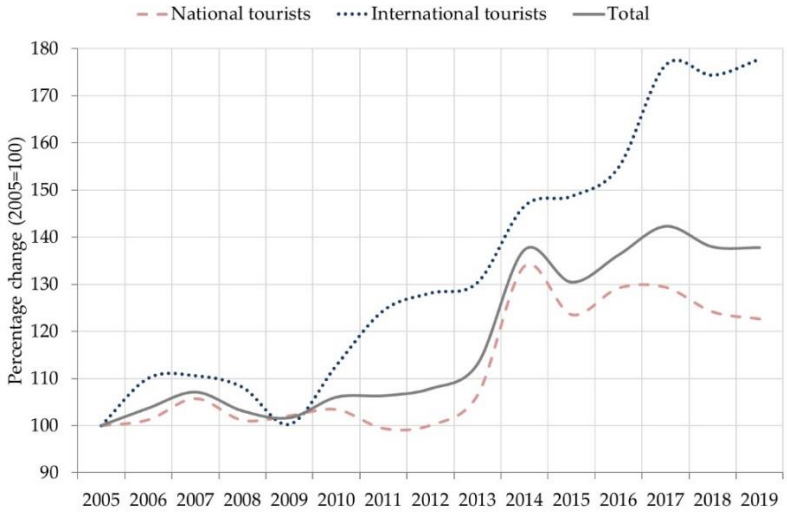


Source: Author's own production

Toledo is known as the city of the three cultures (Christian, Jewish and Muslim) and was declared a World Heritage Site by UNESCO in 1986 for its exceptional history, traditions and valuable monumental and architectural heritage. Every year for the last five years its singularity has attracted around 600,000 tourists staying overnight in hotels, 65% of which are Spaniards (INE, 2018).

As can be seen in Figure 18, where the percentage change of tourists staying overnight in hotels (Base 100 = 2005), a registered important growth in the aftermath of the global financial crisis was detected, with a remarkable increase of up to 80% of international tourists. This international projection is explained by its central position in the Iberian Peninsula and its proximity to Madrid (less than 30 min by High-Speed Train and less than 1 h by road). Even above tourists, one-day visitors are the population segment with the greatest presence in the city. In fact, it is estimated that around 3 million visitors passed through Toledo in 2018 (Europa Press 2019).

Figure 18. Percentage change of tourists staying overnight in hotels (Base 100 = 2005)



Source: Authors' own elaboration based on data from the hotel occupancy survey of the Instituto Nacional de Estadística (INE) de España (INE, 2018).

The historic centre of Toledo not only stands out for the value of its monuments, but also for its geographical location and landscape value: it extends over a steep and irregular rock that is surrounded and isolated by the Tagus River (Tajo in Spanish; Tejo in Portuguese), the longest river in the Iberian Peninsula. Mobility within the historic centre might be complicated by the nature of its own location, by the structure of a network of Muslim heritage and by its large extension (122 ha), being the largest in Spain. Due to these attributes, the historic centre is mainly pedestrianised.

The historic centre has been losing resident population since the mid-20th century, going from 29,184 inhabitants in 1950 to 10,441 inhabitants in 2018 (Solís *et al.* 2020). At the same time, public policies have revitalized economic dynamics in the historic centre that have promoted museification and touristification, but which consequently have also promoted processes of commodification of space and gentrification (Escudero *et al.* 2018). As the economic activity linked to tourism has strengthened, the numbers of tourists have been increasing substantially. Therefore, tourism and hospitality activities constitute the sector with the highest number of establishments in the historic centre (Zárate 2007). At the same time, these tourism-oriented economic activities have grown following clear polarized spatial patterns in comparison with the location of the traditional and resident-oriented activities (Solís *et al.* 2020; Escudero *et al.* 2018). In this regard, multiple challenges arise for the management of visitor flows in the face of the pressure, saturation and congestion that takes place in certain areas of the historic centre (Zárate 2007). In addition to this problem linked to the management of visitor flows, there are social organizations that have been warning of urban projects that could imply the disappearance of cultural vestiges in the surroundings of the historic centre and that, consequently, would jeopardize the status of WH, and with itself the

quality tourist image of the city[4]. Although this is, for the time being, simply a theoretical problem (since only two WH sites have been delisted to date), the perception of the residents and other stakeholders about the situation is not a minor issue (Bourdeau & Gravari-Barbas 2016).

7.4. Material and methods

7.4.1. Data collection and cleaning

The data used in this study to mine visitor routes within the historic centre of Toledo were downloaded from the photo-sharing site Flickr, thanks to the possibility of obtaining geolocated photos via the Flickr API (https://www.flickr.com/services/api/). The geolocated photos used to reconstruct spatial trajectories cover eight consecutive years (photos taken from January 2010 to December 2017). The previously mentioned advantages of this photo-sharing website (see Section 2.2.3), including a large volume of available (free) data, influenced our decision to use it as our main data source. The "flickr.photos.search" and "flickr.photos.getInfo" methods of Flickr API on a Python script were used to gather and store a set of 57,824 geolocated photos (P), taken by 3077 users (U) within the administrative boundaries of the city, in a MongoDB collection. Each geolocated photo (p_{iu}) has the following attributes, among others:

- id: unique ID of the uploaded photo (pid).

[4] Toledo. Sociedad, Patrimonio y Cultura (2019). Manifesto Fundacional. Available online: https://toledosociedadypatrimonio.blogspot.com/p/quienes-somos.html (accessed on 28 October 2020).

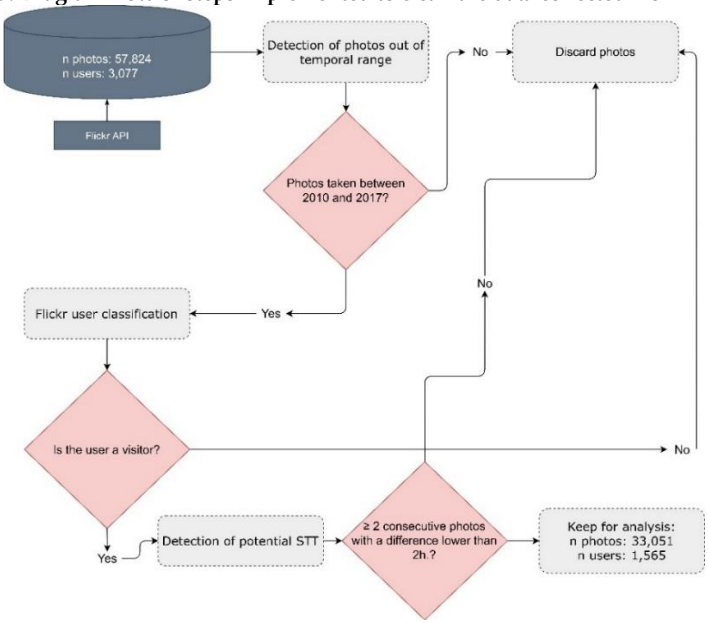
La voz del Tajo (2020). La Ciudad Histórica de Toledo, en la Lista del Patrimonio Mundial en Peligro. Available online: https://www.lavozdeltajo.com/noticia/45424/provincia/la-ciudad-historica-de-toledo-en-la-lista-del-patrimonio-mundial-en-peligro.html (accessed on 28 October 2020).

- owner-id: unique user ID of the person who uploaded the photo (up).
- longitude: (geotag information) x coordinate (xp).
- latitude: (geotag information) y coordinate (yp).
- dates-taken: date and time when the photo was taken (tp).
- dates-posted: date and time when the photo was uploaded.

The data were uploaded into the R environment in order to clean and filter the dataset (see diagram flow presented in Figure 19). Out-of-date range photos were removed, since some photos uploaded in the reference period may have been taken prior to the defined temporal frame. A yearly exploratory analysis was carried out to identify whether the spatial patterns of the photos and users were different between years and the same patterns were found (see Figures A2 and A3 in the appendix).

In addition, a similar number of users per year was detected (see Table A1 in the appendix). Then, only geolocated photos suitable for extracting visitor travel trajectories were selected. In this regard, we established a criterion to determine whether photos were taken by one-day visitors, tourists or local inhabitants since their behaviour and routes within the city are expected to be different. To this end, three indicators were calculated that allowed us to classify users according to their use of the social network (see Table 25). They are based on the average number of months active per year in Toledo, the difference between the maximum and the minimum dates of the photos taken during the same month in the city, and the total number of years active in the city.

Figure 19. Diagram flow of steps implemented to clean the data collected from Flickr.



Source: Author's own production

Table 25. Criteria of Flickr users' classification.

Type of User	Months active/ Year [1]	Days difference (max – min) [2]	Years active [3]
No overnight stay:			
First-time visitor	1	0	1
Repeat visitor	1	0	>1
One overnight stay:			
First-time tourist	1	1	1
Repeat tourist	1	1	>1
More than one overnight stay:			
First-time tourist	1	>1	1
Repeat tourist	1	>1	>1
Local:	>1	-	>=1

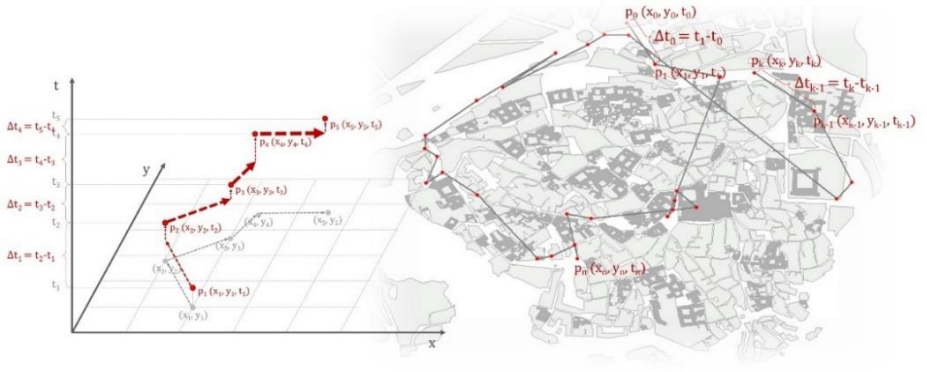
[1] Months active/Year = Number of months active per year; [2] Days difference (max-min) = difference between the maximum and minimum dates of a specific month, or mean of the difference between the maximum and minimum dates of n specific months in n years; [3] Years active = number of years active.

Source: Author's own production.

It is worth mentioning that Flickr provides information about the accuracy level of the geographical coordinates of each photo, ranging from 1 to 16: world level = 1; country level = 2–3; regional level = 4–6; city level = 7–11; street level = 12–16. Our database consisted of photos with the two maximum levels of spatial accuracy (15 and 16). Hence, we did not have to exclude photos due to inaccurate coordinates.

To detect potential spatiotemporal trajectories (STTs), each user's photo collection was denoted as $P_u \subseteq P$, where all the photos $p_{id} \subseteq P_u$ were taken by the same user (u_p) and were chronologically sorted as a spatial and temporal sequence (see conceptual scheme in Figure 20). For each user, multiple STTs can be reconstructed, as they may have taken the photos at different times of the day or on different days.

Figure 20. Conceptual scheme of how to build routes from Flickr photos.

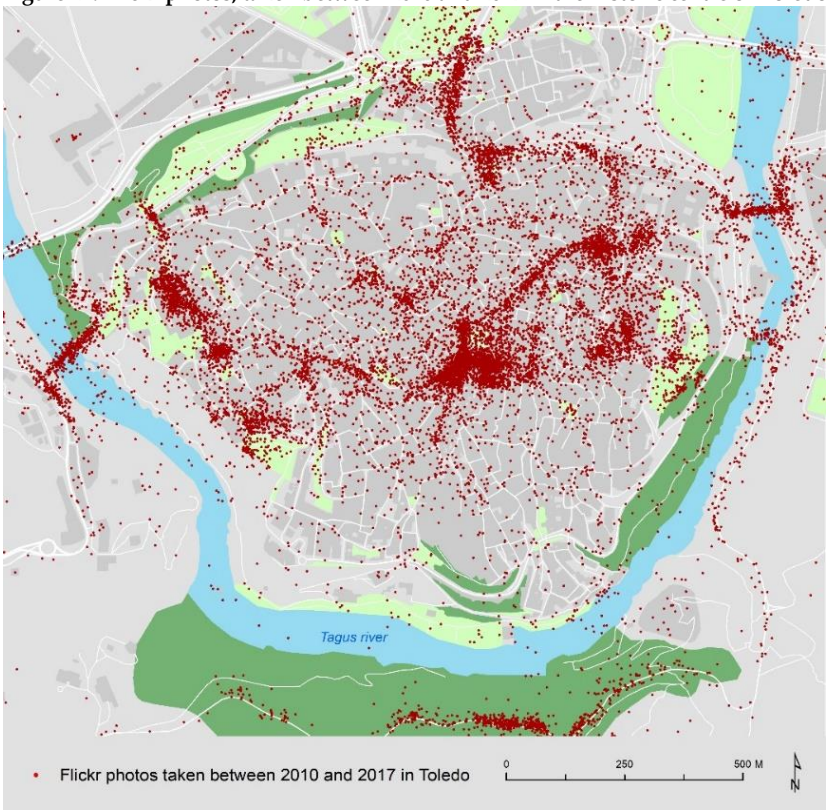


Source: Authors' own elaboration, adapted from Zheng et al. (2012).

Each STT must have a minimum of 2 photos (with different spatial coordinates) to reconstruct a spatiotemporal trajectory, and the time difference between two consecutive photos in the same STT cannot be greater than two hours, as otherwise it is considered that it could highly disturb the trajectories obtained. A two-hour inactivity period (or lower) could represent the time that a user visits some specific space of interest, or stops for lunch or dinner. For example,

a user with ten photos taken between 10 a.m. and 12 p.m., and five photos taken between 5 p.m. and 7 p.m. would have two sequences, since the time difference between the last photo taken at midday (12 p.m.) and the first one taken mid-afternoon (5 p.m.) is greater than two hours. After cleaning the data and implementing all the steps presented in Figure 19, a total of 33,051 photos taken between 2010 and 2017 (both years included) belonging to 1565 visitors were kept for analysis. Their spatial distribution can be observed in Figure 21.

Figure 21. Flickr photos, taken between 2010 and 2017 in the historic centre of Toledo



Source: Author's own production.

As can be observed in Table 26, in which the distribution per type of user of the Flickr accounts and photos kept for analysis is presented, more than two thirds of the users were classified as one-day visitors.

Table 26. Distribution of accounts and photos kept for analysis by type of visitor.

	Accounts		Photos	
	n	%	n	%
No overnight stay:	**1139**	**72.8**	**17,514**	**53.0**
First-time	1040	66.5	16,007	48.4
Repeat	99	6.3	1507	4.6
One overnight:	**243**	**15.5**	**7372**	**22.3**
First-time	218	13.9	5948	18.0
Repeat	25	1.6	1424	4.3
More than one overnight:	**183**	**11.7**	**8165**	**24.7**
First-time	151	9.7	6621	20.0
Repeat	32	2.0	1544	4.7
Total visitors	**1565**	**100.0**	**33,051**	**100.0**

Source: Authors' own elaboration.

7.4.2. Empirical approach

The empirical approach followed in this article consisted of reconstructing STT between consecutive photos in order to build a city flow map. Due to urban characteristics of the historic centre of Toledo, presented in Section 3, and the fact that it is mainly a pedestrianised area, travel mode information is not considered. Subsequently, statistical procedures were used to find out whether there was an association between visitor mobility and land uses in the city centre.

a. Reconstruction of spatiotemporal trajectories

With the photo sequences, the ArcGIS Network Analyst extension was used to reconstruct each STT on the street network. First, the total number of Flickr photos per street segment was calculated via map-matching (Barros *et al.* 2020). This procedure could also have been carried out with the number of unique

users per street segment. However, based on studies that used the total number of photos to define the popularity of sightseeing hotspots (García-Palomares *et al.* 2015; Kádár 2013), and considering that, after an exploratory analysis, we did not detect differences in the spatial distribution of photos and users, we opted for the first option. This variable was used to establish the hierarchy of the street network [5].The average length of each street segment in the historic centre of Toledo and the standard deviation is around 40 m.) (see Figure 22).

In our study, using quintiles we defined the thresholds between hierarchies: the highest level (1) was assigned to those street segments with more than 37 photos; hierarchy 2 to those with 12 to 36 photos; hierarchy 3 to those with 5 to 11 photos; hierarchy 4 to those with 2 to 4 photos; hierarchy 5 to those with 0 to 1 photos. The hierarchy used a heuristic method that mostly limited the route search to the highest levels of the hierarchy [6]. This means that the streets with a higher number of Flickr photos are also more likely to be selected as routes by each user sequence.

[5] (The street network used in this study has been downloaded from the download centre of the National Geographic Institute of Spain (http://centrodedescargas.cnig.es) and belongs to the Project CartoCiudad (https://www.cartociudad.es).

6 ArcGIS (2020). About network analysis with hierarchy. Available online: https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/network-analysis-with-hierarchy.htm (accessed on January 2020).

Figure 22. Street segment hierarchy according to number of photos assigned

Source: Author's own elaboration.

Table 27 shows the number of visitors that took photos in the historic centre of Toledo at any time between 2010 and 2017, with their corresponding number of potential spatiotemporal trajectories (STTs). After running the network analysis, 50% of the potential STTs (1048) were reconstructed, since two additional debugging processes were carried out:

- Around 2% of the potential STT could not be reconstructed due to sequence error problems between photos (illogical distribution).

- Around 48% of potential STTs were discarded since they had an insufficient spatial distance between photos (trajectories that were no longer than 1 km).

Table 27. Potential spatiotemporal trajectories and final number of spatiotemporal trajectories reconstructed.

	Potential STT [1]	Sequence Error	Insufficient SV [2]	Reconstructed STT	
				n	%
No overnight stay:	**1276**	**31**	**623**	**622**	**49**
First-time	1140	30	544	566	50
Repeat	136	1	79	56	41
One overnight stay:	**381**	**8**	**161**	**212**	**56**
First-time	322	8	141	173	54
Repeat	59	0	20	39	66
More than one overnight stay:	**446**	**17**	**215**	**214**	**48**
First-time	371	16	181	174	47
Repeat	75	1	34	40	53
Total	**2103**	**56**	**999**	**1048**	**50**

[1] Potential = maximum possible number of spatiotemporal trajectories to be reconstructed (derived from the analysis of the photos kept for analysis); [2] SV = Spatial Variability between photos forming the same sequence. If the length of the sequence is shorter than 1 km, it is discarded. Source: Author's own production.

Finally, with the 1048 STTs reconstructed, a city flow map was a built and the tourist sites offered in the official tourist map of the historic centre of Toledo were classified according to the percentage of STTs that passed through the streets where they are located. In other words, with respect to the total number of STTs reconstructed, it was calculated the number of trajectories passing through the different streets of the heritage centre of Toledo, following this formula:

$$\%\ STTs\ per\ street = \frac{n_s}{n_t} x\ 100$$

where n_s is the number of STTs per street and n_t is the total number of STTs reconstructed.

Then, the 32 tourist attractions promoted on the official tourist map of Toledo (see Figure A1 in the appendix, corresponding to the official map) were classified based on this indicator, establishing the following criteria:

- >30% STT per street: primary attractions of 1st order.
- 20.1–30.0% STT per street: primary attractions of 2nd order.
- 10.1–20.0% STT per street: secondary attractions.
- 2.6–10.0% STT: complementary attractions.
- <2.5% STT per street: need to gain visibility.

b. Association of visitor mobility and land uses

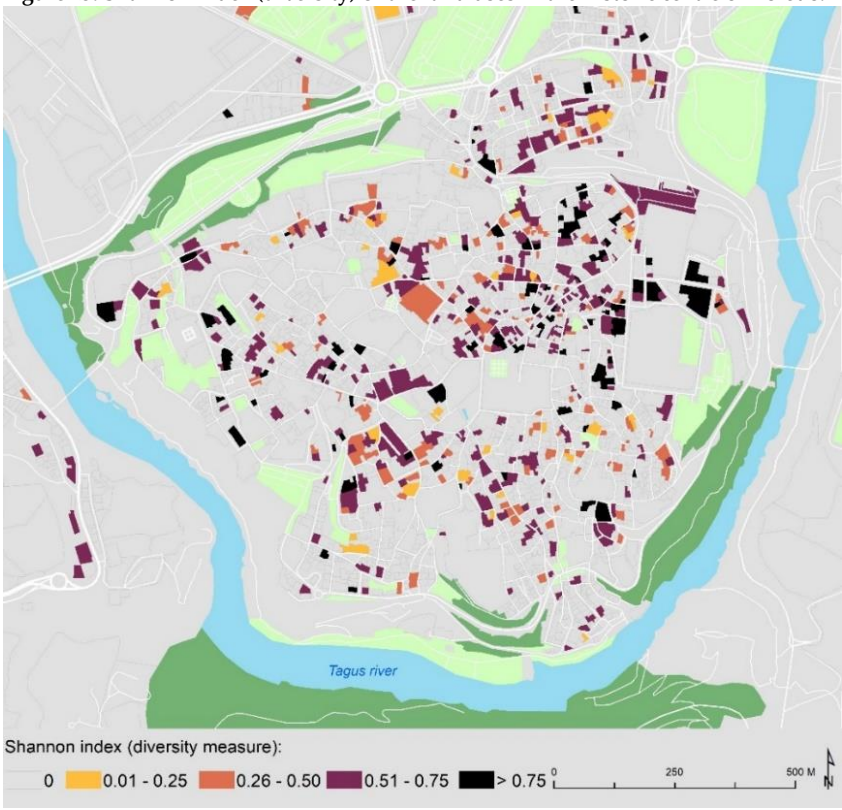
Finally, two statistical procedures were implemented with the number of visitor STTs per street. On the one hand, it was correlated with the land uses (http://www.catastro.meh.es/esp/acceso_infocat.asp) in the historic centre of Toledo using a rank correlation test. Specifically, we calculated the Spearman correlation indicator between the number of visitor STTs per street and the total number of square metres allocated to the following different land uses (both in absolute terms and relative terms: percentage concerning the total surface):

- Warehouse—parking: garages, storage rooms and parking lots.
- Residential: single-family and multi-family homes.
- Offices: offices, including banks and insurance companies.
- Retail and commerce: commercial premises, workshops, galleries, markets and hypermarkets.
- Hospitality and leisure: hotels, bars and cafes.
- Cultural: museums, libraries, colleges or schools.
- Religious: cathedrals, churches, chapels, convents or parish centres.

- Singular buildings: historical-artistic monuments.

Furthermore, with these data related to the land uses, the Shannon index (Shannon 1948) was calculated to assess the diversity and mixture of land uses (see Figure 23), and this was also correlated with the number of visitor STTs per street.

Figure 23. Shannon index (diversity) of the land uses in the historic centre of Toledo.



Source: Authors' own elaboration.

On the other hand, two linear regression models (Ordinary Least Squares—OLS—method) were applied according to the nature of the explanatory

variables (absolute terms: square meters; relative terms: percentage of square meters with respect to the total). A stepwise method for fitting the models was selected, and hence only significant and explanatory variables were kept in the models' specifications.

The OLS can be defined as follows:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_n x_n + \varepsilon$$

where Y is the dependent variable that we are modelling (number of STT per street); β_0 is the constant/intersect; β_n are the coefficients that determine the relationship and intensity of each explanatory variable (x_n) with respect to the dependent variable (Y). The sign (+/−) associated with the coefficient indicates whether the relationship is positive or negative; and ε is the residual error (portion of the dependent variable that is not explained by the model).

7.5. Results and Discussion

7.5.1. Visitor mobility patterns in the historic centre of Toledo

Table 28 presents the average length of the 1048 visitor STTs that were reconstructed with their corresponding standard deviation. Overall, the average length of the SST amounts to 4.9 km. Those visitors that do not overnight in Toledo have a shorter average length than those visitors who stay overnight. This result is in line with the literature on visitor spatial behaviour, which pinpoints those visitors with shorter stays as those who tend to stay centrally and visit outstanding attractions, while those with longer stays tend to visit a greater range of attractions and have wider mobility patterns (McKercher *et al.* 2012; McKercher & Lau 2008). On the contrary, we have not detected a clear difference between first-time visitors and repeaters as some other researches did previously (Caldeira and Kastenholz 2017). This may be related, on the one hand, to the fact that there are few STTs corresponding to repeating users (135 repeat vs. 913 first-time). While, on the other hand, surely

more than one first-time visitor may be an actual repeat visitor, for the simple fact that we do not know the complete travel history of individuals, but rather we use the proxy that Flickr offers us in this regard.

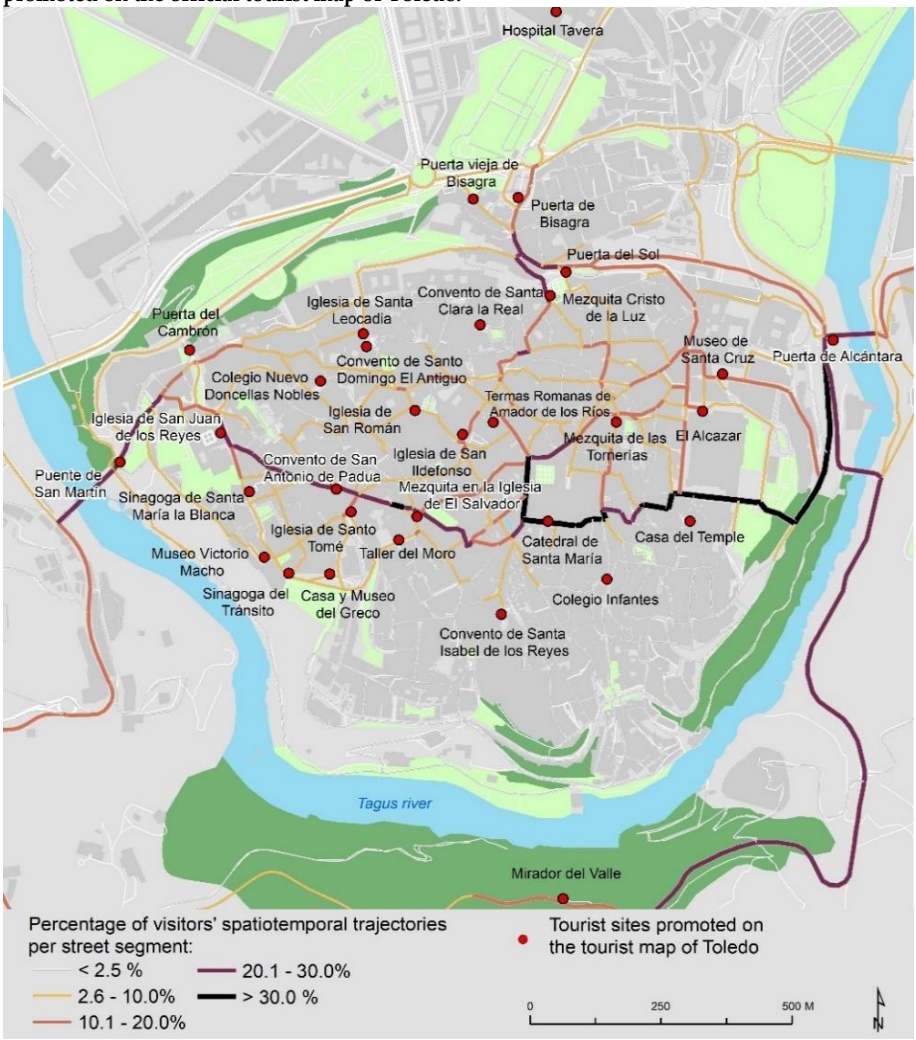
Table 28. Descriptive statistics of the visitor spatiotemporal trajectories (STTs) that were reconstructed.

	N Accounts	STTs	Average Length (km)	Standard Deviation
No overnight stay:	**565**	**622**	**4.6**	**5.5**
First-time	525	566	4.6	5.4
Repeat	40	56	4.4	5.9
One overnight stay:	**148**	**212**	**5.7**	**12.0**
First-time	132	173	5.4	13.2
Repeat	16	39	4.1	3.4
More than one overnight stay:	**107**	**214**	**5.2**	**13.1**
First-time	89	174	5.4	13.0
Repeat	18	40	7.1	13.7
Total	**820**	**1048**	**4.9**	**9.1**

Source: Authors' own elaboration.

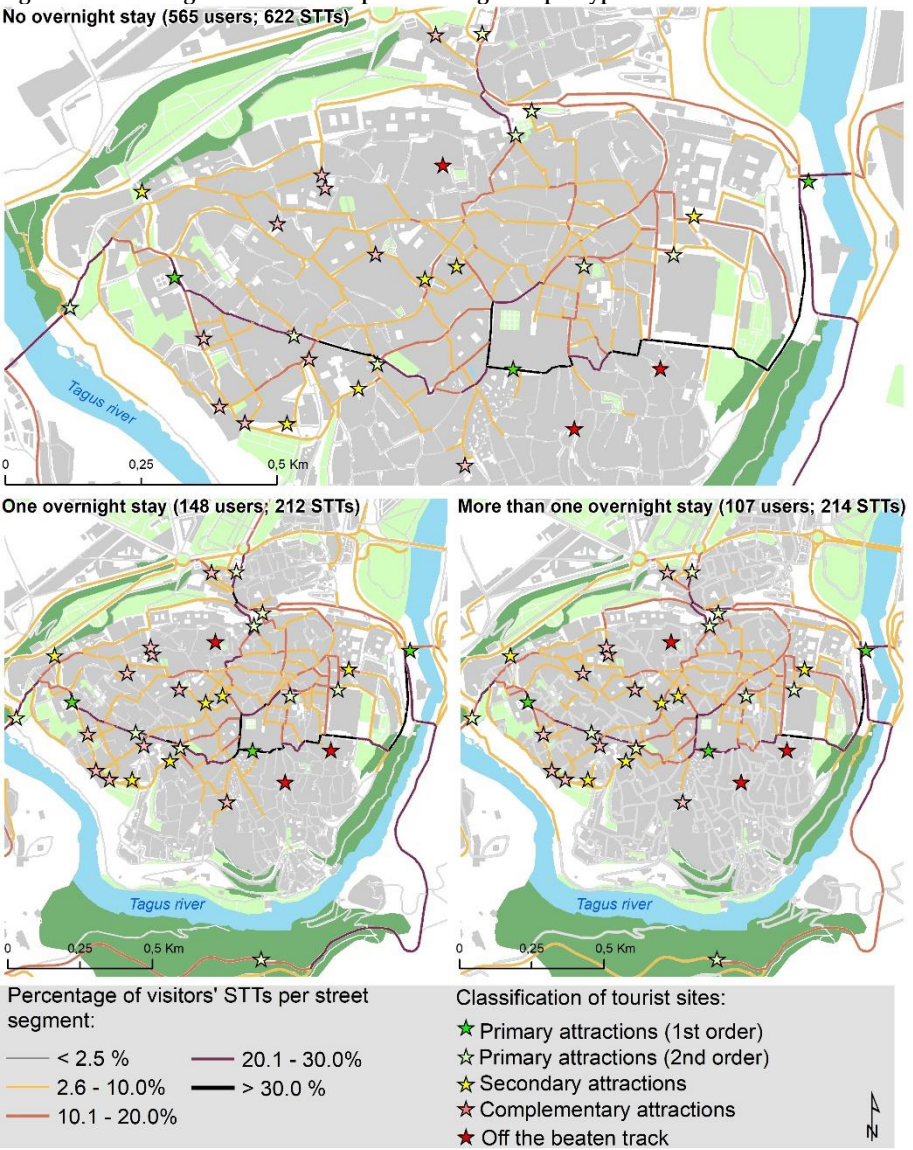
The number of STTs per street segment are mapped in Figure 24, together with the 32 tourist attractions promoted on the official tourist map of Toledo. The STTs classified according to the type of users, are also presented in Figure 25. In each map presented in Figure 25 the STTs per street were mapped as a percentage of the total reconstructed STTs of each type of user to ensure comparability.

Figure 24. Percentage of visitor STTs per street segment and location of the tourist attractions promoted on the official tourist map of Toledo.



Source: Authors' own elaboration.

Figure 25. Percentage of visitor STTs per street segment per type of visitor.



Source: Authors' own elaboration.

Existing literature on visitor spatial behaviour indicates that the spatial distribution of primary and secondary attractions has an essential influence over visitor spatial behaviour, irrespective of whether the attractions are clustered or dispersed influence whether visitors move widely or narrowly within a given destination (McKercher & Lau 2008). Every tourist city/destination has its idealised sight images or icons that are promoted by both public and private tourism operators. This generates a pushing effect towards these sites that leads to a repetition of itineraries, and hence the creation of mobility patterns that are transversal across visitor types (Donaire 2012). In the particular case of the historic centre of Toledo, the visitor flows are characterized by forming a spine that runs from east to west (or vice versa) and by a peripheral distribution towards the north and, to a lesser extent, towards the south. Apart from the central spine of Toledo, the viewpoint located in the south of the historic centre (just on the other side of the Tagus River) and the access gates in the north of the city centre (Puerta de Bisagra and Puerta del Sol) also stand out.

Therefore, from the maps, it is possible to identify the streets that absorb more visitor flows, while revealing at the same time those areas within the city that are underexplored by visitors. The streets strolled and places visited within the city tend to be concentrated (Ashworth & Page, 2011). Outside these streets the tranquillity is high. In this regard, considering there are multiple monuments underexplored and numerous potential itineraries, a strategy to manage visitor flows should be carried out (Dredge 1999; Zárate 2007). In this regard, from the maps shown, it is possible to classify the tourist sites according to the percentage of STT per street segment where they are located (see Table 29).

Table 29. Classification of the tourist sites according to the percentage of STTs per street segment where they are located.

Tourist Sites Order		Tourist Sites
Primary attractions	1st order (>30% STT)	• Catedral de Santa María • Monasterio San Juan de los Reyes • Puerta de Alcántara
	2nd order (20.1–30.0% STT)	• Puerta de Bisagra • Puerta del Sol • Alcázar • Puente de San Martín • Mirador del Valle • Iglesia de El Salvador • Mezquita Cristo de la Luz • Convento de San Antonio de Padua • Mezquita de las Tornerías
Secondary attractions	(10.1–20.0% STT)	• Casa y museo de Greco • Taller del Moro • Puerta del Cambrón • Iglesia de San Ildefonso • Museo de Santa Cruz • Termas Amador de los Ríos
Complementary attractions	(2.6–10.0% STT)	• Sinagoga del Tránsito • Convento de Santa Isabel de los Reyes • Iglesia de Santo Tomé • Colegio Nuevo Doncellas Nobles • Colegio de Santa María la Blanca • Iglesia de San Román • Iglesia de Santo Domingo • Iglesia de Santa Leocadia • Puerta Vieja de Bisagra • Hospital Tavera • Museo Victorio Macho
Off the beaten track	(<2.5% STT)	• Convento de Santa Clara la Real • Colegio Infantes • Casa del Temple

Source: Authors' own elaboration.

Hence, iconic tourist sites occupying a neuralgic position along the most fluctuated streets, such as the Catedral de Santa María (Saint Marie Cathedral), in the city centre, or the Puerta de Alcantara (Alcantara's Gate), in the east access to the city centre, have been classified as primary attractions of first

order. Other important sites such as the Puerta de Bisagra (Bisagra's Gate) or the Alcázar have been classified as primary attractions of second order. Then, sites such as the Greco and the Santa Cruz museums have been classified as secondary attractions. Other sites located in peripheral areas or adjacent streets, such as the Tavera Hospital or the Transito synagogue, have been classified as complementary attractions. Meanwhile, those places located in streets where less than 2.5% of the STTs pass through, have been assigned the category of "off the beaten track", since these places have an almost non-existent incidence on visitor spatial behaviour. Precisely, from the perspective of the design and planning of strategies for visitor flows management, these attractions should gain visibility to deconcentrate the flows from primary attractions.

7.5.2. Land uses association with visitor' spatial behaviour

As demonstrated in the previous section, the promotion of tourist sites on the official map shapes visitor spatial behaviour. However, little is known about the association of land uses with the spatial behaviour of the visitor within the heritage city. In this regard, the implementation of the Spearman correlation test (see Table 30) showed a positive and moderate statistically significant association between the number of STTs per street segment and both the number of square meters assigned to retail and commercial uses (0.457) and their relative presence (percentage) per street (0.416). The office land uses also present a statistically significant coefficient, although more moderate. This is due to the fact that most of the administrative offices are located in historical buildings in the city centre, and also because of the location of bank offices in neuralgic areas.

Table 30. Spearman correlation test (Rho) between the number of visitor' STTs and land uses per street segment.

Land Use Variable	m² Per Street (%)	m² Per Street (Total)
Warehouse—Parking	0.097 *	0.164 ***
Residential	−0.259 ***	0.302 ***
Offices	0.271 ***	0.280 ***
Retail and commerce	0.416 ***	0.457 ***
Hospitality and leisure	0.223 ***	0.230 ***
Cultural	0.159 ***	0.162 ***
Religious	0.089 *	0.093 *
Singular buildings	0.097 *	0.100 *
Shannon index (entropy)	0.403 ***	

n = 357; *** statistically significant at 99.0% ($p < 0.01$); * statistically significant at 90.0% ($p < 0.10$).
Source: Authors' own elaboration.

Furthermore, as explained in the methods section, the Shannon index (Shannon, 1948) was calculated in order to assess the diversity and mixture of land uses. The correlation with the Shannon diversity index was also positive and moderate (0.403). This indicates that the visitors tend to be attracted by these streets with a wide variety of facilities and a higher diversity of land uses (Jansen-Verbeke 1986; Domènech *et al.* 2020b).

Finally, two stepwise linear regressions (OLS) were applied in order to determine which of the land uses are more determinant of the visitors' spatial behaviour in the historic centre of Toledo (see results in Table 31).

In the first OLS model, in which the explanatory variables were included in relative terms (% of m² with respect to the total m²), only two land uses were included as explanatory variables, since the stepwise method excluded other uses for collinearity reasons. Thus, according to the first model, the percentage of retail and commerce and the residential use are the two land uses with the highest explanatory incidence on the dependent variable (number of STT per street). Specifically, they showcased a contrary sign, reinforcing the results obtained in the Spearman correlation test.

In the second OLS model, in which the explanatory variables were expressed in absolute terms (m^2), the stepwise method kept three explicative variables, with the retail and commerce square meters being, as in the first model, the variable with the highest standardised coefficient (Std. β), followed by the singular buildings and religious uses.

Both OLS models underline that retail and commerce use is the one associated the most with the presence of visitor routes. However, the presence of religious uses and singular buildings (positively) and the residential uses (negatively) are also important explanatory variables of the spatial behaviour of visitors.

Table 31. Stepwise Ordinary Least Square (OLS) regressions with percentage of land uses per street segment (model 1) and with the number of m2 of land uses per street segment (model 2).

	Model 1 (%)		Model 2 (m^2)	
	β (Std.Dev)	Std. β	β (Std.Dev)	Std. β
Retail and commerce	2.978 (0.508)	0.294 ***	0.067 (0.009)	0.371 ***
Residential	−0.403 (0.125)	−0.162 ***		
Singular building			0.005 (0.001)	0.219 ***
Religious			0.004 (0.001)	0.133 ***
Intercept	67.125 (9.966)		34.069 (4.235)	
Diagnostic:				
R^2	0.119		0.196	
Max VIF	1.014		1.001	

n = 357; *** Statistically significant at 99.0% ($p < 0.01$).
Source: Authors' own elaboration.

The high association between the visitor spatial behaviour and the commerce use is related to the fact that commerce uses tend to be spatially located in neuralgic areas with great potential to attract demand (or with an already existing one). Hence, not only the concentration of commerce activities acts as a push factor of the spatial behaviour of visitors, but also the coexistence with other land uses with interest for sightseeing determines the visitor flows. In fact, these results are supported by the existing literature related to the particular case of Toledo (Solís *et al.* 2020; Escudero *et al.* 2018), that indicates that the commercial axes of the historic centre of Toledo concentrate most of the tourist-

related economic activities, services and facilities, and coincide with the tourist route that visitors usually follow.

7.6. Conclusions

7.6.1. Implications of our findings and main contribution to the field

This article has demonstrated that geolocated data, in particular that from big data and social media, is an undeniable and promising data source for geographical and tourism research, especially in the field of urban tourist mobilities. The article reveals that the reconstruction of visitor spatiotemporal trajectories from geotagged Flickr photos can be developed with a granularity and geographical level not addressed previously. Most of the earlier studies have concentrated on major cities (Zheng *et al.* 2012) and in natural areas (Barros *et al.* 2020; Orsi and Geneletti, 2013). This research, on the contrary, has focused on the city centre of a medium-sized historic city. In fact, previous research showcased how to identify tourist attractions and generate frequency graphs between them (Girardin *et al.* 2008; Kádár 2013; Zheng *et al.* 2012). However, none of them attempted to connect these tourist graphs/routes with the street layout.

The availability of data to develop studies on urban tourist mobility is often limited, and, therefore, this study is one more element to advance on the path of integrating the opportunities that open up the big data sources in the management of flows in touristified cities. Understanding visitors' spatial behaviour has brought new knowledge about new visions about the built environment and its uses (Anton Clavé, 2019), and, consequently, new flexible planning and management procedures could be developed. Our results have identified overflowed streets, and also shadow areas underexplored by visitors. Accordingly, the tourist sites have been classified based on the percentage of flows channelled through the streets where they are located.

In line with the study by Paül i Agustí (2018), the map of visitor flows has allowed us to see that there is a partial overlap between the Toledo official tourist map and visitor spatial behaviour. In addition, the results showcased that visitor mobility patterns tend to be concentrated in streets where the commercial and recreational uses are greater (Domènech *et al.* 2020b), especially when these are related to the provision of products and services to the tourists and, therefore, are spatially concentrated in neuralgic areas (Solís *et al.* 2020; Escudero *et al.* 2018). The results provide clues on how to manage visitor flows (Bimonte & Faralla, 2016; Lin *et al.* 2017) to protect heritage assets to serve the needs of the tourists and stakeholder communities (Seraphin *et al.* 2018; Bourdeau & Gravari-Barbas 2016). The creation of alternative routes to promote undervisited tourist sites and the suggestion of alternative locations for tourist-oriented economic activities (such as leisure or tourist information areas) could be a help to this end (Lew & McKercher, 2006). Those underused tourist sites could be earmarked for tourism promotion and marketing strategies among visitors (Zárate 2007) in order to redistribute and redirect visitor fluxes, manage overcrowding and, at the end, configure a more sustainable and competitive tourism model (Aranburu *et al.* 2016; Crouch 2011). In this regard, the influence of markers and signals in the city should be studied, since they can shape visitor spatial behaviour, distributing mobility flows towards less-visited tourist attractions (Richards 2002; Dredge 1999).

7.6.2. Limitations

The relevance of results obtained is related to the fact that by using the location, date and time associated to photos uploaded by visitors to a sharing platform, we can reconstruct detailed spatiotemporal trajectories along with the urban network. This is especially important if the limitations of the data source are considered. In the first place, there might be a bias induced by the low user penetration of image-sharing websites. Although previous studies revealed that half of the users taking photos during a trip posted them online, and the portion of those who did that on sites like Flickr was considerable (Lo *et al.*

2011), we do not have this certainty for the particular case of the historic centre of Toledo. The number of tourists and the number of Flickr users have been demonstrated to be highly correlated particularly in North American and European countries (Yuan & Medel 2016; Önder *et al.* 2014). However, considering the scale of our analysis (urban level), in future lines of research the results obtained should be cross-checked with other sources of information, such as counting sensors or video cameras, that allow us to refine the methodology used. Secondly, photographers do not consider everything equally worthy of capturing, and they are highly selective where, with whom and through which channels they communicate their activities and the places they visit (Boy & Uitermark 2017; Malik *et al.* 2015; De Waal 2014). The positive is that Flickr, as an open access repository designed to share photos of places of interest, induces less noise than other less professionalized social networks where the type of user tends to show greater self-attention rather than attention to the space visited. This allows, therefore, to identify precisely the sightseeing hotspots (Encalada *et al.* 2017; Salas-Olmedo *et al.* 2018) and approximate the tourist behaviour with higher accuracy. Linked to the previous, there is a third limitation that relates to the impossibility to gather information about the purpose of the displacements. For instance, there are some trips that might not be reflected on our spatiotemporal trajectories, such as those displacements from the parking or the train station to the city centre, or those roundtrips to the accommodation, among others. Finally, an additional drawback of this kind of data is that there is no detailed information on the demographic and socio-economic profile of the visitor, or about their previous travel experiences. To illustrate this limitation, around 50% of our sample did not include information about the country of origin of the user, a fact that limits the possibility of segmenting the reconstructed trajectories by tourist markets. Nevertheless, despite of these limitations, with our method, we have been able to reconstruct 50% of the potential visitor spatiotemporal trajectories (1048), which, at the end, represents a higher number of trajectories, at a lower cost, than those that can be obtained using other data sources (e.g., GPS devices, travel diaries, among others). However, in the present study, the fact of analysing a pedestrianised

historic centre has allowed us to reconstruct the trajectories without considering modal distributions. Thus, in centres that do not have restrictions on private vehicles it will be important to take this aspect into account.

7.6.3. Future research directions

In future lines of research, interactions between visitors and locals could be analysed (Li *et al.* 2018) and complemented with qualitative research that helps to measure the perception, of both tourists and residents, about the everyday sites of activity that are being transformed as a consequence of how visitors gaze and go places (Cechini 2016; Russo and Richards 2016). Hence, potential coexistence problems could be addressed accordingly. Furthermore, another research direction should be dedicated to exploring the potential of data from photo-sharing platforms in terms of up to what extent it is possible to detect different spatial behaviour on the basis of the origin of the tourists, considering the information provided in the profile of the users and the historical register (if available), and the type of visit undertaken, considering the potential detection of organised trips thanks to the date, time and geographical attributes of the photos.

Moreover, the reconstruction of visitor spatial behaviour following the method presented could be applied in other contexts of heritage cities in order to test the validity of the data source. Although it is true that Flickr is one of the most used platforms (Lo *et al.* 2011), especially in western countries (Önder *et al.* 2014; Yuan & Medel, 2016), the use that users make of the internet is everchanging and academia and practitioners must be up to date with new sources that can improve the analysis of mobility. The integration of different data sources, the analysis of how managers and public authorities market the destination and the evolution of the destination must be contemplated to correctly measure the mutual and reciprocal shaping between visitor behaviour and cities' characteristics (Anton Clavé 2019).

This need to be updated on the opportunities that gives us the big data for monitoring human mobility in general, and visitor mobility more specifically, gains relevance in the current context of health emergency marked by the COVID-19 pandemic. Our study shows that the data from open access repositories of geolocated photographs allow the development of agile and cost-effective analyses of the mobility of visitors. Therefore, new emerging lines of research are related to knowledge acquisition from the analysis of how the pandemic is generating a disruptive effect (or not) on mobility patterns at a local scale. This is of significant value in dense urban contexts, where a high volume of population converges and related challenges in the use of the space may emerge. In addition, the fact that international mobility has been at ground levels for some months due to global mobility restriction measures, strategies to promote locally-based tourism flows and activities have been boosted (Iaquinto 2020), which could also generate other, perhaps more intense, ways of consuming cities that deserve to be analysed.

PART III. DISCUSSION AND CONCLUSIONS

9. Discussion and conclusions

This chapter is dedicated to discussing and highlighting the main findings obtained from the results of the four research articles, to reflect on the lessons learnt and to bring to light some final remarks about future research directions

9.1. Main findings

This thesis, through the different case studies that constitute its core, has explored the urban visitors' mobilities to comprehend their spatiotemporal behaviour and identify the effects that their mobilities have on urban tourism destinations.

As shown in Table 32, the multiple studies carried out have made it possible to explore different research objectives, questions and hypotheses by means of the use of different data sources and empirical approaches. To illustrate the confirmation of the hypotheses, the main results obtained are summarised in this table.

In the first case study, the main objective has been to identify the reasons why tourists decide to move in a sustainable way at urban destinations. To do so, the case study departed from a research question aimed at deciphering the factors that push tourists to use public transport during their stay in an urban destination. The data used was collected with a survey that asked tourists that stayed overnight in the city of Tarragona whether they used public transport to travel within the city or not.

Table 32. Recall of research objectives, questions and hypotheses, data and methods and results.

Art.	Objective	Research question	Hypothesis	Data & Methods	Results	H.confirmed?
1	O1. To identify the reasons why tourists decide to move in a sustainable way at urban destinations.	RQ1. What are the factors that push tourists to use public transport during their stay in an urban destination?	H1. The mode of transport chosen to reach the destination might be highly influential on the transport choices once at destination.	Data: Surveys Methods: Logit estimations	- How tourists travel to the destination is the most decisive determinant.	✓
			H2. The tourist's socioeconomic profile could also be highly associated with the transport mode used to reach the destination.	Data: Surveys Methods: CHAID + interactions	- Transport mode used to arrive influences over the socioeconomic factors - Tailor-made strategies are required to promote sustainable transportation modes.	✓
2	O2. To explore how spatiotemporal behaviour patterns at urban destinations influence the positive economic impact of the local economy.	RQ2. To what extent the spatiotemporal behaviour of cruise tourists at a given destination acts as a determinant of their expenditure level?	H3. Different expenditure levels in the city may be related also to different spatiotemporal mobility patterns. For instance, the longer the time in the touristic areas of the city the higher the expenditure might be.	Data: Tracking GPS + surveys + GIS layers Methods: Mapping + OLS regression	- Visitors with higher per-capita expenditure spend more time onshore. - More time in places with mixed commercial and recreational uses imply higher expenditure.	✓
3	O3. To analyse how the characteristics of the built environment, and the location of places of tourist interest, shape the spatiotemporal patterns of urban tourists.	RQ3. Is there any relationship between the characteristics of the built environment and the way cruise tourists visit the city?	H4. Variables related to the syntax of the urban space, the physical attributes the presence or absence of commercial activity and the visibility of tourist points of interest could be highly related to the cruise tourist spatiotemporal behaviour in the city.	Data: Tracking GPS + GIS layers Methods: Mapping + OLS regression	- Visibility of tourist points of interest and presence of economic activity influence the spatiotemporal behaviour of visitors.	✓
4	O4. To detect flows of urban visitors' mobilities, and therefore spaces over and under visited.	RQ4. Can geotagged photographs from visitors be used to reconstruct spatiotemporal trajectories at street level?	H5. The location of mixed commercial and recreational uses might be correlated with the visitor spatial behaviour.	Data: Geolocated photos + GIS layers Methods: Mapping + OLS regression	- Visitor spatiotemporal trajectories are reconstructed along with the urban network using thousands of geotagged Flickr photos - The spatial behaviour has been used to classify the tourist sites offered on the city's official tourist map, as well as to identify the association with the land uses.	✓

Source: Author's own production

The empirical evidence obtained in this first article demonstrates the two hypotheses of research: the influence of the mode of transport chosen to reach the destination, on the transport choices once at destination (Dolnicar *et al.* 2010, Bieland *et al.* 2017, Gross & Grimm 2018: Gutiérrez & Miravet 2016b), and the association between the tourist's socioeconomic profile and the transport mode used to reach the destination.

Thus, results of the first article highlight the importance of switching tourists to more sustainable modes of transportation when travelling to the destination, since the use of alternative modes of transport from the origin to the destination encourages tourists to use PT during their stay (Peeters & Schouten 2006).

In the second case study, the main aim has been to explore how the visitors' spatiotemporal behaviour at urban destinations influences the positive economic impact of the local economy. Specifically, the case study focused on cruise tourists visiting a Mediterranean destination and the research question was related to a research gap identified in the existing literature on the topic (Ferrante *et al.* 2016): to which extent the spatiotemporal behaviour of cruise tourists acts as a determinant of their expenditure level at destination? The results of the study have demonstrated that by means of the use of GIS and GPS technologies it is possible to study accurately the spatiotemporal behaviour of cruise tourists at destination in combination with survey data in order to obtain findings of interest for destination planning and development. Specifically, the study confirmed the research hypothesis raised, about the relationship between different expenditure levels and the existence of distinct spatiotemporal mobility patterns. In fact, the results show that those tourists who invest more time in visiting the key touristic points of the city (Upper Town, Font square, and Rambla Nova and the Mediterranean Balcony) and the commercial centres are those who produce a higher per-capita expenditure. Thus, the presence of mixed commercial-use facilities in the most frequented places is a key element for boosting tourist expenditure.

The third case study analysed how the characteristics of the built environment and the location of places of tourist interest shape the spatiotemporal patterns of urban tourists. Data collected with GPS loggers have been analysed to test whether the variables related to the syntaxes of the urban space, the physical attributes, the presence or absence of commercial activity and the visibility of tourist points of interest are related to the cruise tourist spatiotemporal behaviour in the city.. Overall, this case study has demonstrated that the configurational attributes of the street network are useful for understanding the tourists' spatial behaviour. However, results also revealed that indicators referring to the visibility of tourist places and the type of economic activity are more consistent and have higher incidence. Those results are in line with previous research that confirms the importance of the relational attributes of the urban form, but pinpoint the presence of attractors as a greater explanation of pedestrian spatial behaviour (Foltête & Piombini, 2007; Mansouri & Ujang, 2016). Furthermore, the study has shown that when the space syntax indicators are used to explain cruise tourist spatial behaviour at a destination, it is important to consider not only the number of cruise tourists who walk along the streets, but also the average time that they spend in them.

Finally, in the fourth case study the main objective was about detecting flows of urban visitors' mobilities using geolocated photos uploaded on the web. This study departed from the uncertain possibility of reconstructing spatiotemporal trajectories at street level with geotagged photographs uploaded on photo-sharing repositories (i.e. Flick in this study). The results of the study revealed that the reconstruction of visitor spatiotemporal trajectories from geotagged Flickr photos can be developed with a granularity and geographical level previously not addressed: the street layout. In fact, most of the earlier studies have concentrated the identification of tourist attractions and the generation of frequency graphs between them on major cities (Zheng *et al.* 2012) and in natural areas (Barros *et al.* 2020; Orsi and Geneletti, 2013).

The availability of data to develop studies on urban tourist mobility is often limited, and, therefore, this fourth study contributes to advancing along the path of integrating the opportunities opened up by the big data sources in the management of flows and the uses of the built environments in tourist cities (Anton Clavé, 2019). The results have identified overflowed streets and shadow areas underexplored by visitors. Accordingly, the tourist sites have been classified based on the percentage of flows channelled through the streets where they are located. The map of visitor flows has allowed us to see that there is a partial overlap between the city official tourist map and visitor spatial behaviour (Paül i Agustí, 2018). In addition, the results allowed us to confirm the research hypothesis about the correlation between the visitor mobility patterns and the commercial and recreational uses (Domènech *et al.* 2020b), especially when these are related to the provision of products and services to the tourists (Solís *et al.* 2020; Escudero *et al.* 2018).

Beyond the concluding remarks derived from each article that makes up this thesis, it is important to highlight the interest of the contributions in a joint way. Thus, some reflections around the spatiotemporal behaviour of visitors and their effects on cities must be provided.

In this sense, this thesis has transversally contributed to expanding the knowledge on some of the effects caused by tourism mobility in the city and its services. Specifically, departing from the three mobility-related issues posed by Koens *et al.* (2018) and presented in Table 4 of section 2.1.2, this thesis has analysed topics related to two of them: the overcrowding of public spaces, and the impact of visitors' mobilities on the local environment. To be more precise, this thesis has shown how the spatiotemporal behaviour of visitors at urban destinations can be analysed by means of different data sources to: 1) detect mobility patterns and overcrowding on streets; 2) disentangle the factors related to urban fabric that shape urban visitors' mobilities; 3) identify the determinants of the visitors' expenditure and therefore their contribution to the

local economy; and 4) unravel the factors that push visitors to choosing sustainable modes of transport to move within the destination. Consequently, the research project highlights the need to carry out complete studies on visitors' mobilities by first detecting the visitors' mobility patterns and then implementing segmentation studies to identify how the destinations' competitiveness can be enhanced and how the environmental sustainability of the urban mobility systems can be achieved.

In this regard, although this thesis has provided new layers of evidence on the concentration of visitors' movements in reduced city areas (Aswhorth & Page 2011; Bimonte & Faralla 2016), the most important findings providing guidance to reducing the negative impact of visitors' mobilities are related to the segmentation analyses carried out. Thus, regarding environmental sustainability, the research project poses the need to analyse the factors that push visitors to use sustainable modes of transport to move within urban destinations, in order to enhance the environmental sustainability of the destination. This information is key to fostering the implementation of sustainable mobility habits among those visitors most likely to adopt these practices. Furthermore, the results suggest that having liveable urban spaces that are pleasant to walk through and well interconnected encourage active mobility, which may help to deconcentrate mobility flows (Anton Clavé 2019; Ram & Hall 2018). This configuration of walkable urban areas and the fostering of public transport use have also a direct relationship with the economic and social sustainability of the tourism activity (Koens *et al.* 2018). In fact, if city planners and tourist managers work together to reduce the dichotomization process of cities between what is mainly planned for tourists and what is left for residents, by configuring liveable and walkable cities and competitive public transport systems, the benefits for both visitors and residents are clear: the visitor's economic consumption of city services could be more balanced; the air pollution due to the emission of gases derived from private vehicle mobility would be reduced, and the overcrowding effects and so the conflicts regarding

the public use of the city spaces between residents and visitors would be reduced.

Therefore, this thesis has reinforced the existing literature through case studies that provide hints and advice on possible strategies and solutions that could increase the positive effects and reduce the adverse consequences that visitor activity generates in urban destinations.

9.2. Lessons learnt

Apart from the results obtained from the different case studies and their implications for the advancement of knowledge within the topic of the effects of spatiotemporal mobilities of visitors in cities, this dissertation contributes transversally to the existing literature on assessing the challenges and opportunities of different data sources for analysing tourism mobilities (Hardy, 2020). Therefore, this section is devoted to reflecting on the lessons learnt about the data sources that allow the analysis of visitors' mobilities, more than focusing on the learnings on visitor mobility issues already dealt with in-depth in the four case studies.

Previous studies have classified data sources as passive, active or semi-active depending on people's awareness of the georeferenced information that is being generated and the subsequent uses these data might have for research or marketing purposes (Ahas 2011; Miralles-Guasch *et al.* 2015). Therefore, traditional techniques such as surveys or direct observations have been considered predominantly active. Whilst the new location-aware technologies have been generally regarded as passive, especially in those cases where radio frequency signal technology is used (i.e. smartcards, GPS loggers, or mobile phone traces). Social media sites have been considered between active and passive (semi-active), since there is greater awareness of the type of data generated when geotagged content (posts, photos or GPS routes) is uploaded on the web by the users (Miralles-Guasch *et al.* 2015).

The literature review presented in section 2.2. on the advantages and disadvantages of each data source for analysing visitors' mobilities along with the different studies carried out by the author (both within the framework of this project and outside of it), have made it possible to design a summary table with detailed information on what each source offers. Far from classifying the data sources in the previous mentioned three categories, Table 33 is structured to systematically evaluate and compare their attributes for analysing human mobilities in general and visitors' mobilities specifically[7]. These attributes are indicated below:

- Spatial resolution (where): geographical scale to which the analysis can be performed.
- Temporal granularity (when): temporal disaggregation to which the analysis can be detailed (hourly, monthly, yearly, a specific moment in time, etc.).
- Profile identification (who): potential to detect the type of user that is being monitored.
- Reasons (why): potential to identify the motivations of the trips.
- Mean of transport used (how): capacity to reveal the mean of transport used to carry out a movement/trip.
- Number of people moving (how many): ability to compute the whole population moving in a specific territory.
- Areas through which these movements take place (by where): higher or lower geographical detail to analyse human movements.

[7] Note that in the table the colour of the symbols to evaluate the different attributes is different when the data source has been used by the author in this dissertation (green), out of the framework of this dissertation (orange), or not used by the author (black).

The objective(s) of research and the research question(s) condition the type of data source to be used. Thus, this summary table could become a useful tool for researchers in social sciences when selecting the best data source(s) based on the objectives they intend to achieve.

In the first place, the spatial resolution and the temporal granularity condition other attributes in the table such as the identification of the streets/areas through which people circulate (by where), and the transport means used to move (how). In fact, if the spatial resolution is not provided at the level of coordinates in track format and the temporal granularity does not allow monitoring mobility flows at a highly disaggregated temporal frame (e.g. time slots, days or months), the potential to analyse phenomena at a micro scale diminishes considerably (Gutiérrez, Benítez *et al.* 2020). Hence, the lower the spatial and temporal resolutions, the lower the information on the areas where the flows pass through, and the transport mode used.

As a matter of fact, having the latitude and longitude of origins and destinations of trips undertaken by tourists (during a reference week, for example) allow us to build Origin-Destination (OD) matrices, in the form of straight connections (Comito *et al.* 2016; Kádár 2013; Zheng *et al.* 2012) between places inside a specific area (e.g. intra-urban or interurban mobility). We can, furthermore, identify the most visited sites (García-Palomares *et al.* 2015; Sun *et al.* 2015). However, we cannot identify the streets through which the movements have taken place (Barros *et al.* 2020), or the transport mode used to travel. Actually, transport mode information can only be collected in three ways. First, this information can be collected through survey techniques, assuming there may be recall biases by the individuals (Miravet *et al.* 2021; Gutiérrez, Benítez *et al.* 2020). However, in the particular case of tourist surveys, they do not tend to provide information on mobility at destination. Only in very specific contexts is it possible to know the transport modes used (as is the case in the first research article in this dissertation), but without the possibility of building OD matrices. Travel diaries (mobility surveys), meanwhile, allow us to see how the

day before answering/completing them, the individuals moved through the territory.

Nevertheless, although the temporal granularity can be highly disaggregated, there is a lack of historical data from multiple days, months and/or years to allow for comparability. Secondly, inferences of the transport mode used can be implemented when precise information on the space and the time is obtained via new-location aware technologies (i.e. GPS of mobile phone traces). The speed at which the users travel, and the trajectory of the movements means it is possible to cross the mobility flows with the transportation network and estimate the transport mode used (Gutiérrez, Benítez *et al.* 2020). Third, the information can be directly extracted from a smart travel card, which allows the identification of the type of collective transport used to travel (Domènech *et al.* 2019; Gutiérrez, Domènech *et al. 2020*).

In this regard, the data update level, and hence the reliability of the data for mobility studies, relies on the period when the statistical operations are executed, which is variable and not continuous in time, or on the period when the geolocated information is collected by means of new location-aware technologies, which generally occurs on a daily and hourly basis and is reproduced in time as long as the user uses a social web site, a smartcard or a mobile phone device.

Table 33. Comparison of the characteristics of different data sources for the analysis of tourism mobilities

Statistical operation or technology		Traditional techniques						Location-aware technologies														
				Mobility survey				RFID/NFC (smartcards)			Other sensors				Social media apps							
															Geolocated content			Sport tracking apps		Dedicated smart-phone apps		
Characteristics		Census	Regis-ters	Locals	Tourists	Tourist survey	Obser-vations	Credit cards	Desti-nation cards	Travel cards	Blue-tooth	Came-ras	Parking sensor	WLAN / WIFI	*e.g.* Twitter	*e.g.* Flickr	*e.g.* Four-	*e.g.* Wikiloc	*e.g.* Strava		Mobile phone data	GPS / AGPS devices
Who	Tourists/visitors	○	○	○	●	●	⊙	●	●	◉	◉	⊙	○	●	◉	◉	●	⊙	⊙	◉	●	◉
	Workers	●	●	●	○	○	⊙	○	○	◉	○	⊙	○	○	◉	○	○	○	●	◉	●	◉
	Locals	●	●	●	○	○	⊙	●	○	◉	◉	⊙	○	●	◉	◉	○	⊙	⊙	◉	●	◉
How many	Local residents*	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉	○
	Tourists/Visitors*	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉	○
Where	National scale	●	●	●	○	●	○	●	○	○	○	○	○	○	●	●	●	●	●	○	●	○
	Regional scale	●	●	●	◉	●	○	●	●	●	○	○	○	○	●	●	●	●	●	◉	●	◉
	Municipal scale	●	◉	●	●	●	◉	●	●	●	○	○	○	○	●	●	●	●	●	●	●	◉
	Inframunicipal scale	◉	⊙	●	●	◉	●	●	●	●	⊙	◉	⊙	◉	●	●	●	●	●	●	◉	●
	Confined area	○	○	⊙	◉	⊙	●	◉	⊙	○	●	●	●	●	◉	●	●	●	●	◉	◉	●
When	Fixed date	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Yearly/monthly	○	○	◉	⊙	◉	⊙	●	●	●	◉	●	●	◉	●	●	●	●	●	●	●	⊙
	Daily/Hourly	●	●	●	●	⊙	●	●	●	●	◉	●	●	◉	●	●	●	●	●	●	●	●
By where	Major haul trip (tourists)	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉	○
	Interurban mobility	◉	◉	●	●	⊙	⊙	●	●	●	○	○	○	○	●	●	○	●	●	●	●	●
	Urban mobility	◉	⊙	●	●	⊙	◉	●	●	●	⊙	◉	○	◉	●	●	○	●	●	●	●	●
	Map-matching (street)	○	○	○	○	○	●	○	○	●	◉	●	○	⊙	⊙	◉	○	●	●	◉	⊙	●
How	By foot	○	○	●	●	◉	●	○	○	○	○	●	○	⊙	⊙	○	○	●	●	◉	○	◉
	By Bicycle	○	○	●	●	◉	●	○	○	○	○	●	○	⊙	⊙	○	○	●	●	◉	○	◉
	Motorised	○	○	●	●	◉	●	○	○	○	○	●	●	⊙	⊙	○	○	●	○	◉	●	◉
	Public transport	○	○	●	●	◉	●	○	◉	●	○	●	○	⊙	⊙	○	○	○	○	◉	●	◉
Why	Work/study	●	●	●	○	○	○	○	○	○	○	○	○	○	◉	○	○	○	●	◉	●	○
	Other purposes	○	○	○	●	◉	○	◉	◉	◉	○	○	○	○	⊙	⊙	●	●	●	⊙	◉	○

Notes: ●= *yes;* ◉= *probably yes;* ⊙=*probably not;* ○=*no;* *= Allows for the counting of tourists/locals under observation; using a specific social media app; or using a specific smart card. In the case of Twitter, barely 1% of processed tweets are geotagged (either with exact GPS coordinates or with approximate location of a place; Acronyms: WLAN (Wireless Local Area Network); RFID (Radio Frequency Identification); NFC (Near-Field Communication); AGPS (Assisted Global Positioning System); GPS (Global Positioning System).
Source: Author's own production

In second place, the identification of the type of users (locals vs visitors) and their quantification is highly conditioned by the type of data source used. In fact, most data sources do not allow counting the total number of individuals who travel across a street, visit a square, or use a certain mode of transportation. For instance, population censuses and official records are theoretically capable of recording data on an entire population. However, they leave the floating population (visitors and tourists) out of the analysis. Meanwhile, other data sources, such as travel card data, mobile phone data or social media data, require the implementation of algorithms that study user behaviour patterns to distinguish between visitors, tourists, workers or local residents (García-Palomares *et al.* 2015). In this field of machine learning, the data source that clearly has greater potential is the mobile phone data. The reasons are related to the fact that these data, apart from providing geolocated information on the mobile phone users at a highly disaggregated geographical level, they offer a continuous temporal granularity that allows us to identify the place of residence and the daily mobility patterns of the users (Calabrese et al. 2011; Mizzi et al. 2018). Moreover, the mobile phone companies can enrich the datasets crossing sociodemographic information related to the phone number, such as the gender and the age, and they can also calculate a proxy of the purpose of each trip, coupling the traces with the land uses and, therefore, identifying whether the trips are regular or sporadic (García-Albertos *et al.* 2019). Along these lines, the table also reflects whether the motivation or purpose of the trip (why) can be revealed with the different data sources.

One of the main weaknesses of the new sources of information is the unavailability of objective or subjective data provided directly by the user. For example, we do not have information that is gathered traditionally by means of surveys or census, such as the study level, the profession, the salary, or the subjective feelings at the time of developing a specific activity. To respond to these limitations, studies with big data enrich the analysis by crossing mobility data with territorial and statistical data, such as land use layers or census information. In this way, it is possible to characterise the areas through which

users move and develop activities. Furthermore, other types of analytical studies are proliferating to integrate GPS devices and accelerometer sensors in order to incorporate tourist emotions and experiences into the analysis of the spatiotemporal behaviour (Shoval *et al.* 2018a, 2018b; Grinberger *et al.* 2014; Kim & Fesenmaier 2015).

9.3. Final remarks

The last section of the thesis is dedicated to reflecting on the future research agenda in the field of tourist mobility in urban destinations. First, some considerations about the potential of data sources for studying visitors' mobilities are provided. Second, attention is given to the current challenges in visitors' mobility management in urban destinations induced by the climate change alarm and the current sanitary crisis due to the COVID-19 pandemic.

9.3.1. About the potential of data sources for the study of visitors' mobilities

Even though, traditionally, the scarcity of specific research on urban tourism in general and on spatiotemporal visitor behaviour in particular was due to data collection issues and economic cost, the current situation of increasing availability of data from location-aware technologies has also induced new methodological challenges for researchers (Hardy *et al.* 2017). These are related to data source selection, processing, and analysis. In fact, the possibilities of developing analytical studies are multiple, but the selection of one source over another, or the combination of some, varies substantially according to the research objectives and questions.

In visitor tracking studies at urban level, the use of fine-grained time and space data resolutions has gained ground compared to traditional methods (i.e. direct observation, surveys and travel diaries). In this sense, the use of GPS loggers or smartphone applications based on tracking visitors via GPS, provide very

accurate mobility data that can help understand the visitor's spatial behaviour. The main limitation of the studies using data from GPS loggers and dedicated smartphone apps to monitor visitors' mobility is related to the low sample sizes. In fact, encouraging voluntary participation is one of the main challenges facing the analytical studies of this kind.

Other limitations related to the use of GPS loggers or smartphone apps are the short battery life of the devices or their performance in highly urbanised or forested areas, which tends to be compromised. Moreover, if the aim is to obtain profile information on the subjects under study, as in the second case study in this thesis, the GPS traces must be synced with survey data, and this requires time and synthesis. Despite this, the integration of multiple sources of data to deepen the knowledge and understanding of visitors' mobility is a topic of growing interest. The incorporation of tracking technologies combined with emotional measures of human behaviour into high-resolution spatiotemporal analysis might also have great potential for improving urban planning and tourism management (Shoval *et al.* 2018a, 2018b). For instance, the fine-grained time and spatial resolution data from GPS loggers can be combined and integrated with qualitative information on the tourist collected via real-time surveying techniques (to gather information on subjective emotions), post hoc surveys (to collect data about the sociodemographic information of the visitors), or electrodermal activity sensors (to amass evidence on objective emotions) (Shoval *et al.* 2018a, 2018b; Kim & Fesenmaier, 2015). This multi-source integration represents a current and future opportunity to connect the theoretical and methodological gaps between urban research and psychology (Shoval *et al.* 2018a, 2018b).

Other sources offering detailed spatiotemporal information but not at the accuracy level of the GPS loggers, such as mobile phone traces and geolocated social media content, do not present such a hopeful future for research purposes. In fact, in most countries, obtaining mobile phone data is usually

linked to a high economic cost, whilst obtaining social media data is becoming increasingly difficult due to the tightening of applications' terms and conditions (Hardy, 2020). Furthermore, they are limited in their ability to provide sociodemographic information.

As shown in the fourth case study in this dissertation, based on the reconstruction of spatiotemporal trajectories at street level, the opportunities of geolocated social media data for assessing crowding and infrastructure use are numerous. However, changes in the usage trends of social media networks, the disappearance of certain platforms, and the loss of (free) access to these data will force researchers to look for alternative sources of data to analyse visitors' spatial behaviour.

Finally, it is important to emphasize that the combined use of various sources of information offers the opportunity to develop complex studies that enable decision-making for the planning and management of tourism activity in destinations (Anton Clavé 2019; Hardy 2020).

In fact, the identification of mobility patterns and the reasons that explain the visitors' spatiotemporal behaviour help to weave strategies and define solutions that reduce the adverse effects of tourist mobility (Ram & Hall 2018; Lew & McKercher 2006).

In this sense, it is essential that visitor tracking studies also provide practical advice and guidance on decision-making to configure more sustainable and competitive destinations (Crouch 2011; UNWTO 2019).

9.3.2. About the current challenges induced by climate change alarm and the sanitary crisis

The current pandemic situation has caused worldwide changes derived from travel restrictions, but also linked to tourist behaviour that may have important effects on the configuration of urban destinations and on the management of visitors' mobilities.

During the first months of the pandemic, the rapid interruption of world tourism activity caused a sudden change from the "overtourism" model to the "non-tourism" model (Ioannides & Gyimóthy 2020; Gössling *et al.* 2020). Global mobility restrictions triggered a huge decline in international tourism and, when national lockdown measures were reduced, local and proximity tourism was reinforced (Iaquinto 2020; Wen *et al.* 2020).

However, the fear of contagion altered the preferences of tourists and their travel patterns (Chhabra *et al.* 2020; Mackenzie & Goodnow 2020). In the first instance, tourist mobility was characterised by some types of tourism (i.e. cruise tourism, mass tourism, urban tourism, remote adventure tourism) halted to ground zero and the current uncertainty about the emergence of new variants of the COVID-19 means recovery is still slow.

Then there has been a resurgence or empowerment of short-haul tourism and leisure activities in natural and protected areas. Therefore, these dynamics have reinforced the role of the private vehicle as the main transport mode to move around the destinations. This trend has also been detected in urban destinations where the work to attract market share to public transport has been intense in recent decades and the influence of the pandemic is affecting the achievements made to date. In fact, some studies have shown how the use of private vehicles has been strengthened in global cities to the detriment of the use of collective means (i.e. bus, subway, trams) (Gutiérrez, Miravet *et al.* 2020). Consequently,

the research agenda on tourist mobility studies at destination faces the challenge of determining how tourism destinations must foster the use of sustainable transport modes (i.e., public transport and non-motorised modes) considering the perception of city users (i.e., residents and visitors).

Reducing motorised mobility, devoting more space to pedestrians and cycle lanes and fostering the use of public transport, must be part of COVID-19 recovery plans, but must also be part of the climate change mitigation and adaptation plans.

Thus, researchers and practitioners must rethink how tourist mobilities take place and how the side effects (Koens *et al.* 2018) are corrected and redirected. Accordingly, the challenges of researchers within the field of visitor tracking research are, therefore, closely related to the strategies outlined by UNWTO (2019) presented in Table 5 (section 2.1.3.).

These strategies are mainly related to the need to implement a regular monitoring of the visitors' mobilities and its effects in order to take consensual and empirically based decisions on:

1) Setting up healthy and liveable urban environments where walking is appealing and accessible to the entire population in order to deconcentrate flows and encourage a more balanced consumption of the destination's services (Anton Clavé 2019; Blečić *et al.* 2015);
2) Configuring competitive and low-carbon emission transport systems that foster multimodality (Capolongo 2020; Chhabra *et al.* 2020) and the adoption of sustainable mobility practices;
3) Establishing the bases of action for future health alert situations such as the identification of efficient strategies of mobility flow management to reduce social interaction and ultimately the risk of contagion (Zielinski & Botero 2020);

4) Involving the local community in the process of transition towards a more sustainable tourism model from which they also obtain a collective benefit;
5) Reviewing and adapting regulations when it is needed or required;
6) Improving city infrastructure and facilities to both provide a better service to their users and reduce the ecological footprint of the users' activities.

As a result of an increased number of studies dealing with these research topics, tourism destinations could increase their resilience to health and climate crises, enhance their competitiveness and increase their commitment to sustainability.

10. References

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11. Appendix

11.1. Tables and figures

Table A 1. Endogeneity corrected logit estimation results. Robust standard errors are presented in parentheses.

	Coef.	Std.Error
Intercept	-3.817	(1.897)**
Transport mode to arrive: own vehicle	Reference category	
Transport mode: plane	2.695	(1.562)*
Transport mode: public transport	3.081	(2.095)
Accommodation: hotel	Reference category	
Accommodation: second residence/apartment	0.415	(0.406)
Accommodation: camping	-0.274	(0.531)
Accommodation:other places	0.155	(0.823)
From 45 to 64 years old	Reference category	
Up to 44 years old	-0.067	(0.284)
65 years old and older	0.211	(0.466)
Duration of stay longer than 3 days	Reference category	
Duration of stay, 3 days or less	-1.639	(0.625)***
High education level (university studies)	-0.035	(0.289)
Spending at the destination: medium	Reference category	
Spending at the destination: high	0.935	(0.549)*
Spending at the destination: low	0.179	(0.431)
Spending at the destination: unknown	0.711	(0.512)
Repeater: not the first visit to Tarragona	-0.126	(0.276)
Visiting Tarragona	0.235	(0.371)
Visiting Barcelona	0.681	(0.403)*
Visiting Costa Daurada	0.829	(0.495)*
Visiting other places	0.570	(0.406)
Not visiting any place	0.321	(0.435)
Gender: male	0.032	(0.250)
Accompanied by: family with children	Reference category	
Accompanied by: family trip or partners	-0.381	(0.393)
Accompanied by: friends	-0.436	(0.621)
Accompanied by: others	-0.402	(0.464)
Season: summer	-0.218	(0.327)
Year 2015	Reference category	
Year 2014	1.295	(0.529)***
Year 2016	0.668	(0.479)
Lambda Plane	-1.321	(1.420)
Lambda PT	-0.305	(1.564)

* Significant at 10%, ** significant at 5%, *** significant at 1%.

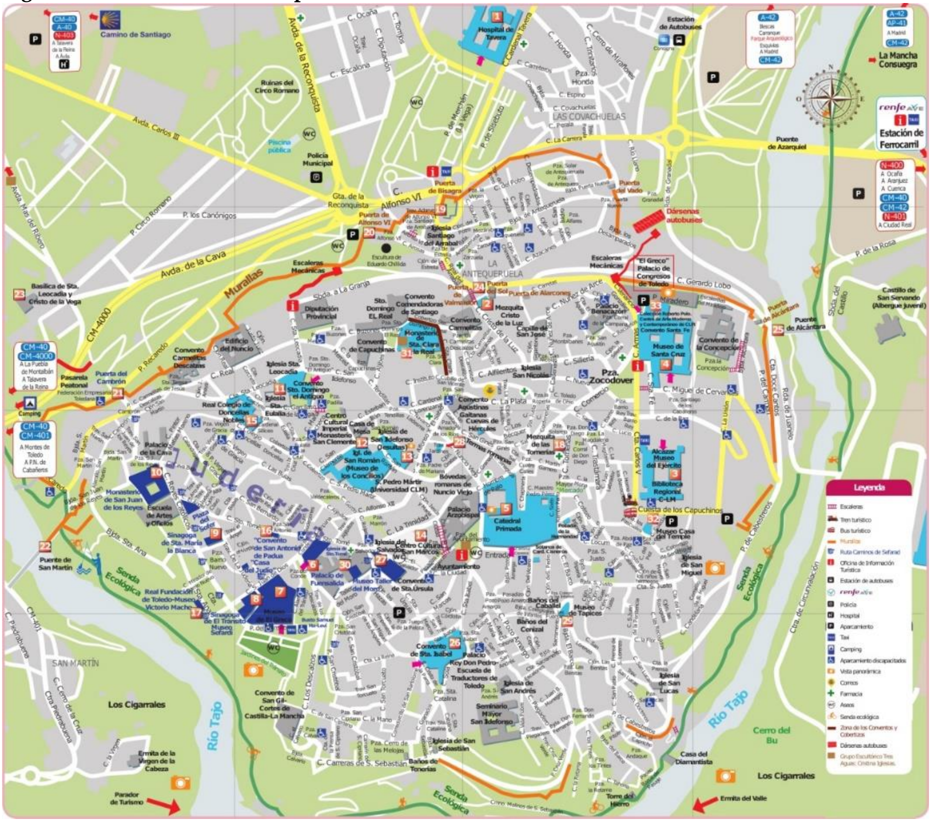
Source: Authors' own production

Table A 2. Mixed multinomial estimation. Robust standard errors are presented in parentheses.

	Plane vs. Own Car		Public Transport vs. Own Car	
	Coef.	Std.Error	Coef.	Std.Error
Intercept	-2.907	(0.771)***	-0.838	(0.536)
Origin-Spain	Reference category		Reference category	
Origin-France	0.854	(0.633)	-1.729	(0.507***
Origin-2000km	5.394	(0.445)***	0.048	(0.415)
Origin-further	6.567	(0.591)***	1.218	(0.669)*
Accommodation: hotel	Reference category		Reference category	
Accommodation: second residence/apartment	-0.698	(0.457)	0.302	(0.356)
Accommodation: camping	-3.061	(0.594)***	-4.392	(1.184)***
Accommodation:other places	-3.150	(0.908)***	-0.434	(0.657)
From 45 to 64 years old	Reference category		Reference category	
Up to 44 years old	0.420	(0.331)	0.314	(0.270)
65 years old and older	-0.551	(0.575)	0.970	(0.393)**
Duration of stay longer than 3 days	Reference category		Reference category	
Duration of stay, 3 days or less	-1.333	(0.403)***	-0.284	(0.345)
High education level (university studies)	0.697	(0.363)*	0.236	(0.253)
Spending at the destination: medium	Reference category		Reference category	
Spending at the destination: high	-0.650	(0.434)	-0.535	(0.302)*
Spending at the destination: low	0.009	(0.487)	-0.519	(0.430)
Spending at the destination: unknown	-0.448	(0.502)	-0.191	(0.418)
Repeater: not the first visit to Tarragona	0.036	(0.351)	-0.249	(0.266)
Season: summer	-0.392	(0.369)	0.088	(0.274)
Gender: male	-0.079	(0.316)	-0.337	(0.253)
Year 2015	Reference category		Reference category	
Year 2014	0.064	(0.374)	-0.205	(0.316)
Year 2016	-0.133	(0.398)	-0.206	(0.296)

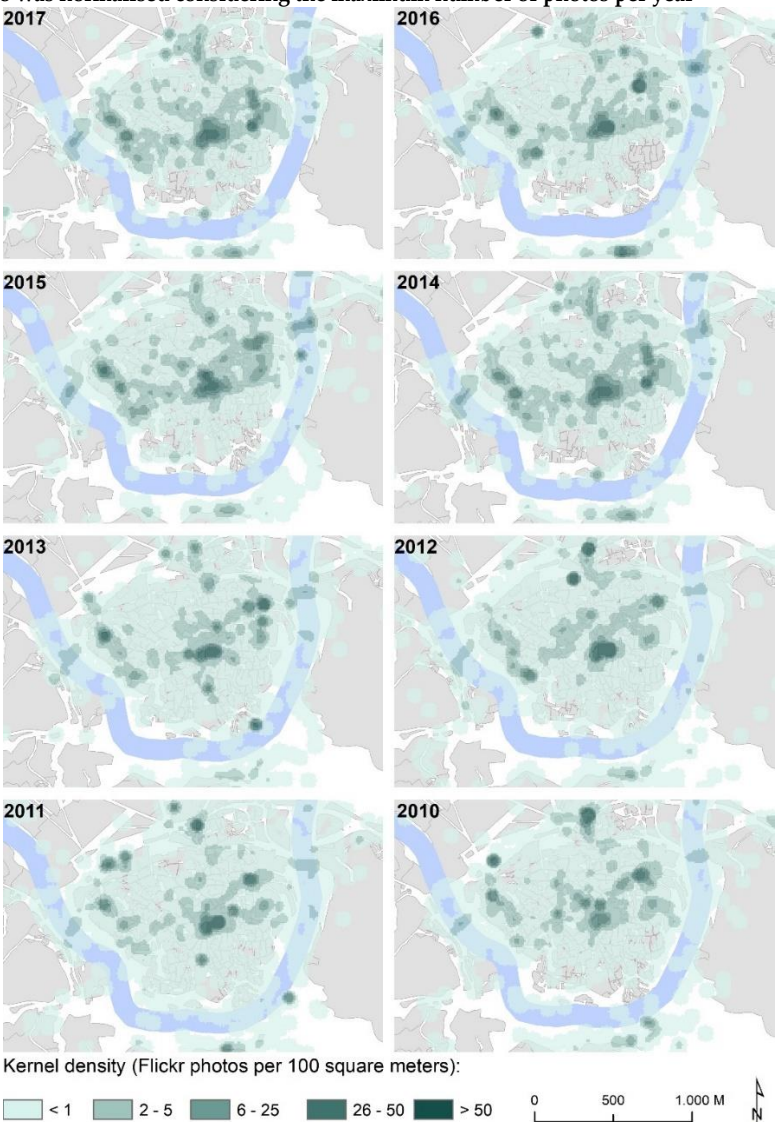
Mixed multinomial logit estimation. Robust standard errors within parenthesis. * Significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Authors' own production

Figure A 1. Official tourist map of Toledo.



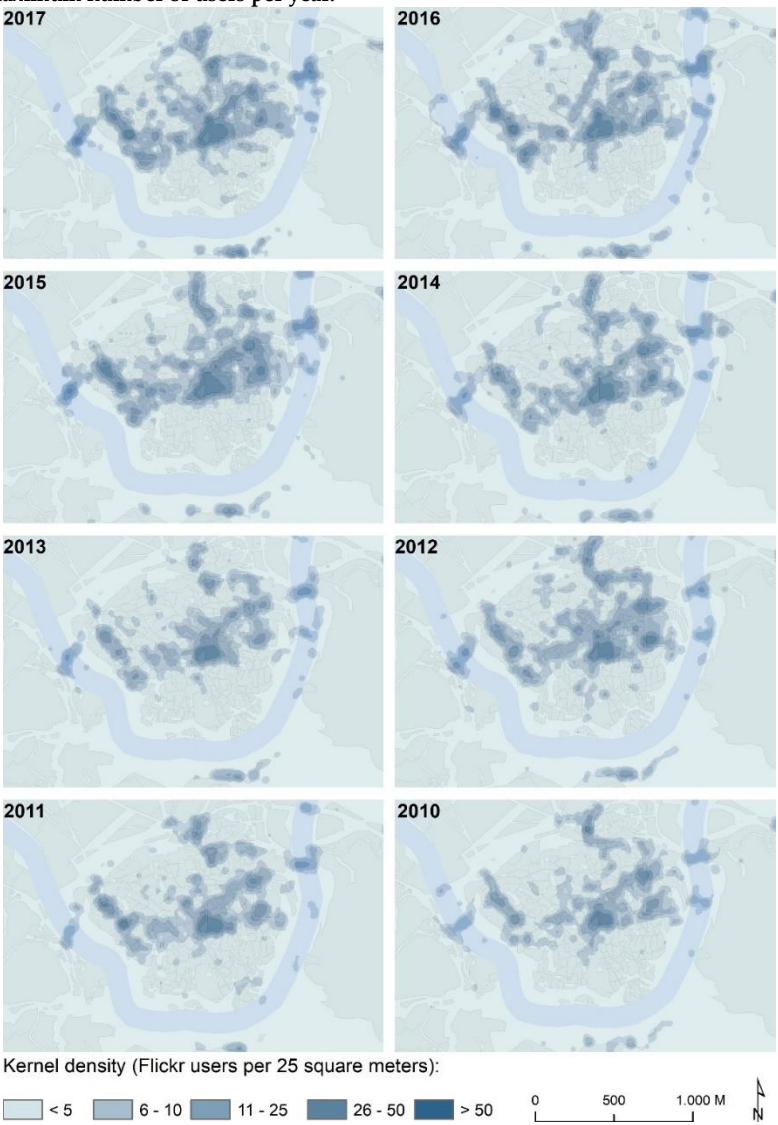
Source: https://turismo.toledo.es/.

Figure A 2. Density of Flickr photos in the historic centre of Toledo. Note: the weight of each photo was normalised considering the maximum number of photos per year



Source: Authors' own production.

Figure A 3. Density of Flickr users in the historic centre of Toledo. Note: Normalised considering the maximum number of users per year.



Source: Author's own production.

Table A 3. Number of Flickr photos and users (visitors) per year in the historic centre of Toledo.

	2010	2011	2012	2013	2014	2015	2016	2017
Number of photos	3490	3263	5289	3974	5062	4221	4843	2909
Number of users	190	228	223	238	243	214	182	153
Average - photos per user	18.4	14.3	23.7	16.7	20.8	19.7	26.6	19.0

Source: Author's own production.

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• Domènech, A. Gutiérrez, A. & Anton Clavé, A. (2020) Built environment and urban cruise tourists' mobility. Annals of Tourism Research, 81. doi: 10.1016/j.annals.2020.102889

• Domènech, A., Gutiérrez, A. & Anton Clavé, S. (2020) Cruise passengers' spatial behaviour and expenditure levels at destination. Tourism Planning and Development, 17(1), 17–36. doi: 10.1080/21568316.2019.1566169

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que el siguiente artículo del cual es coautora no ha formado parte de ninguna otra tesis doctoral, y RENUNCIA a presentarlo como tal en el futuro:

• Domènech, A., Mohino, I., & Moya-Gómez, B. (2020). Using Flickr Geotagged Photos to Estimate Visitor Trajectories in World Heritage Cities. ISPRS International Journal of Geo-Information, 9(11), 646. doi: 10.3390/ijgi9110646

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Que el siguiente artículo del cual es coautor no forma ni ha formado parte de ninguna otra tesis doctoral, y RENUNCIA a presentarlo como tal en el futuro:

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Que el artículo citado anteriormente forma parte de la tesis doctoral de Antoni Domènech Montaña y cuyo título es Exploring urban visitors' mobilities. A multi method approach. Esta tesis doctoral se realiza en la Universitat Rovira i Virgili bajo la supervisión del Dr. D. Salvador Anton Clavé y del Dr. D. Aaron Gutiérrez Palomero.

Firmado por MOYA GÓMEZ, BORJA (FIRMA) el día 02/08/2021 con un certificado emitido por AC DNIE 004

Madrid a 02 de agosto de 2021

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EXPLORING URBAN VISITORS' MOBILITIES. A MULTI-METHOD APPROACH
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