

MASTER IN MANAGEMENT OF TOURISM DESTINATIONS

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Mobile Phone Data: an experimental statistic for the tourism sector

The experience of Spain in the study of domestic tourism in the post-pandemic.

FINAL MASTER PROJECT

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Abstract

This thesis aims to show how Mobile Phone Data can be used in the tourism sector, illustrating its potential and negative sides, and becoming a relevant tool.

In the first part, I illustrate how Mobile Phone Data works, explaining how they are collected and developed and on what technology it is based. Examples of the use of this data are then shown, both in the tourist field and in other sectors.

In the second part, however, I propose two possible uses of this data concerning the study of domestic tourist flows in Spain. In the first case, I show one of the most relevant features of Mobile Phone Data, namely the degree of depth that can be reached in the analysis. To do this, I built an index that shows how each province reacted differently in terms of domestic tourist arrivals, taking into consideration the 3 summer months, from 2020 to 2022, using the summer of 2019 as a point of comparison. To show the versatility of this data, this comparison was also made between larger geographical areas, united by geographical, economic, or demographic characteristics.

In the second case, however, I illustrate an interesting use of this data aimed at the analysis of tourist flows leaving a certain area, in this case, Madrid. Analyzing, therefore, how these flows have changed in the distribution over the three summers after the covid.

Keywords: Domestic tourism, Mobile Phone Data, Transition Index, Experimental Statistic

1. Mobile phone data: a new way to collect information in the tourism sector?

1.1 What does the tourism sector need?

Tourism is a complex subject, composed of several flakes, and it touches different topics, creating many links with other subjects, and this peculiarity increases the complexity of the tourism sector.

Analyzing, knowing, and understanding are key elements to work in tourism. Some numerous indexes and data allow you to analyze and simplify this intricate world. For instance, the most known indicators are the number of tourists visiting a place in a specific period, the number of overnights in a place in a specific period, or the average stay registered in a place in a specific period.

A big problem related to these indicators is the reliability of data, it's very complex to find all data, especially related to tourist inflow and outflow. If we consider that most of the data available to us come from surveys, which therefore do not represent the entire population, but only a small percentage, the data's representativeness can be considered another problem.

Another important criticism is represented by the black market, it plays an important role in this game; all data generated from this market are not considered in the official dataset. In the same way, all visitors that move from one place to another staying in friend's houses are not counted as well. So, when we work with official data, we know that they are only partial.

This complexity has been augmented by several factors, such as the easiness to move across boundaries and countries. So, developing new ways to collect full data is required.

A new way to operate can be introduced in a brief time. This new way is based on mobile phone data (MPD), provided by mobile phone companies. This way to collect data identifies a resident in his home country as a traveler based on the position of his mobile phone.

The biggest aim of this paper is to show how this experimental way of collecting data can be a relevant tool for people that work in tourism and must manage tourism destinations. Through the case of domestic tourism transition after the pandemic in Spain (Spain is seriously testing the introduction of MPD as a tool to collect data), this thesis wants to demonstrate several advantages of using this type of data to analyze and understand better tourism phenomena, among which, one of the most important is to provide a real tracking of almost the entire population (contrary to what happens with the data obtained from surveys). Since it is experimental, account must be taken of certain problems or disadvantages which will be explained below.

So, the interdisciplinarity of tourism requires high transversality. This experimental system of collecting data lends itself to this ability. Many uses could be based on this system. From a cartographic point of view, for example, using these data, maps could be created that could represent the exchange between flows in and out of a given province, with a degree of precision, both quantitative and qualitative, that you would not get with the normal data at our disposal.

Before starting to explain how MPD works, it needs to say that INE (the Spanish national statistic institute) is working seriously on Mobile Phone data, and a lot of information and literature about it is provided by INE.

1.2 Statistical measurement using mobile phone positioning: how does it work?

The first step is understanding how this experimental statistic is built. According to the INE press release (May 2022), the information source for this new way to collect tourism data is the aggregate data provided by Spain's three biggest mobile phone operators.

One of the INE's duties is to redact the ETR (Encuesta de Turismo de Residentes), a three-month paper, which aims to estimate the total number of travels made by people who live in Spain as residents, within and outside of national boundaries. This statistical survey distinguishes between

the several characteristics of these trips, such as the socio-economic traits of travelers. The data for this search is provided by a personal survey based on a sample of 8.200 families. Doing this work requires a lot of costs, and the results are not so representative.

So, in this scenery, INE has started collaborating with mobile operators to collect data through this experimental way, hoping to decrease cost and improve quality simultaneously.

This methodology associated with domestic tourism put the focus on three variables:

- Number of tourists
- Overnights
- Average duration of stay

Collecting data about these three variables could be significant to study bigger phenomenon:

- Where visitors come from and which destination they have visited within Spanish boundaries
- Patterns in terms of tourism flows associated with different destinations.

Thus, MPD requires complex processes. Starting from the collection of mobile phone signals, these signals must be transformed to make them compatible with the tourism sector's needs, then the last step is the development of algorithms through which it's possible making the data useful for final purposes. This complex journey is carried on thanks to the collaboration between INE and Spain's three biggest mobile operators.

1.2.1 Mobile network

Without a mobile network collecting this data wouldn't be possible. Thus, the first step is to understand how these data are counted. Mobile phones send and receive low-power radio signals,

which are received by antennas attached to mobile phone base stations. These base stations are linked to the rest of the mobile phone network.¹

The mobile phone's position is estimated by antennas, thus, in certain cases, it can be that the position is not extremely accurate, it depends on how many antennas are in the area, the more the concentration of the antennas is, the greater the tracking is accurate. Each antenna covers a particular area, receiving all mobile phones' signals from that area.

1.2.2 Basic concept

According to the INE Technical project², this experimental statistic aims to enhance the ETR, going deeper geographically and improving time efficiency. All this information that we got from mobile phone positions doesn't allow us to get qualitative variables about travels or travelers, in other words, we don't know which type of accommodation they've used, the purpose of travel, and so on. These aspects can be added by the ETR, where we can collect more qualitative information thanks to surveys.

To understand better MPD, it's very relevant to be sure to know exactly the meaning of basic concepts that made this statistic:

- Journey: generally, it means a trip that must be longer than one day and less than one year, outside your resident area. Ultimately, the traveler must return to the origin point. From a statistical point of view, it is considered as a journey when a mobile phone was picked up between 22:00 and 6:00 in a municipality other than that of residence, provided that the same mobile phone is also detected the following day after 6:00. The journey ends when the phone is picked up between 22:00 and 6:00 in the residence municipality.

¹ Irune.Penagaricano@amta.org.au. (2020, April 8). *How mobile networks work - AMTA | The Voice of the Australian Mobile Telecommunications Industry*. AMTA | the Voice of the Australian Mobile Telecommunications Industry. <https://amta.org.au/1041-2/#:~:text=Mobile%20phones%20work%20by%20sending,as%20mobile%20phone%20base%20stations>

² INE. (2022b, July). *Medición del turismo interno a partir de la posición de los teléfonos móviles: Proyecto técnico*. INE. https://www.ine.es/experimental/turismo_moviles/exp_moviles_turismo_interno.pdf

- Overnight: in the tourism sector, it is related to the number of nights that a person spends in a destination. For this experimental statistic, the overnight is made by the total number of nights spent in the same municipality, following the same rules explained in the paragraph above.
- Daily trip: a journey that is long more than three hours but without overnight. From this experimental statistic, daily trips are not considered.

All these data are received by INE from each mobile operator. INE doesn't have sensitive information about people, all the data are aggregated and there isn't personal information.

1.2.3 Indicators and their Development

The data received monthly by INE, sent by telephone operators, are raw data that are filtered and transformed to better respond to the institution's needs. Since the 3 major mobile operators don't cover 100% of the population, INE has developed correction factors to cover the entire population. These factors change for each province, and thanks to them it's possible to estimate all three variables considered (Number of tourists, overnights, and medium stay) as if they had mobile phone data from the entire population.³

1.2.4 Where is possible to find this experimental data?

The relevance of this project is evident looking at [INE's](#). An entire section is dedicated to this experimental way to collect and use data for the tourism sector. The full project is related to outbound and inbound flows as well. On the website, different sections are available, each one about different analyses, such as outbound flow data, inbound flow data, and internal flow data.

Unloading full datasets, maps, graphs, and other material is possible.

³ INE. (2022b, July). Medición del turismo interno a partir de la posición de los teléfonos móviles: Proyecto técnico. INE. https://www.ine.es/experimental/turismo_moviles/exp_moviles_turismo_interno.pdf

1.3 Advantages and disadvantages of using MPD to study tourism flows

1.3.1 Advantages and Goals

As we've already seen, INE is working on a new way to develop and analyze tourism flows to improve the understanding related to tourism phenomena. We've already talked shortly about some advantages this experimental statistic can bring to tourism. Using mobile tracking allows us to go deeper geographically, making an incredibly detailed analysis possible. In the second part of this paper, we'll see how this data can provide detailed information at the province level. But, thanks to this data, we can go deeper, working with the municipality data level as well. According to Grassini and Dugheri (2021), MPD could be more useful in analyzing domestic tourism rather than international one. That's why, MPD can detect visitors that use non-official accommodations, which are more popular among domestic visitors. International travelers tend to prefer official accommodations, which is also counted by traditional surveys. For that reason, by studying internal flows with MPD, we could notice bigger differences with traditional statistical results.

As it's clear, this degree of deepness makes it possible to study tourist flows and movement, which wouldn't be possible to study with normal data. In addition, working with these data is faster than normal one. As we have seen with INE experience, they can share data every three months. In this way, we could always work with the latest and updated data, getting a more realistic representation of reality.

Another advantage of using MPD is that you can track visitors' journeys, understanding details you couldn't catch about their path across the country.

The degree of deepness and the pace of development make these data a great tool for tourism operators, to study, manage and plan tourism destinations at every level.

Another aspect to consider is money-related. Making surveys can be awfully expensive in terms of money and time. Thus, mobile positioning data is not just faster and more detailed, but it's also cheaper than the traditional method, especially over a long period.

Using this statistic, INE wants to provide a rapid and highly detailed estimate of the number of residents in Spain who travel to a province other than the province of residency⁴. This project has been thought to implement the existing ETR, the previously mentioned survey, which INE has used for several years.

INE's purpose for the long term is to mix these 2 statistical operations, keeping the speed and the granularity of mobile phone data with the qualitative details about tourists' trips of the ETR.

1.3.2 Disadvantages and problems

Moving to the dark side of this data, being experimental means that there are some critical points to face. Firstly, the granularity can be both a positive and negative side at the same time. As it's explained in the INE press release (May 2022), a traveler with two smartphones may be counted twice, as he was 2 different people. Another problem could be related to areas where antennas cover less, the accuracy may not be high. Especially boundary areas may represent a problem. If the coverage by antennas is low, the margin of error of the tracking can be some kilometers.

Even if nowadays each of us has a smartphone, people who travel without one are not considered in this statistic.

Another relevant question is related to the privacy of travelers. Despite mobile phone data provided by phone operators doesn't contain personal information, privacy is still a critical point that needs to be managed specifically.

We are still in an experimental phase so that new criticism may come out in the future.

⁴ -INE. (2022, May). Measurement of interprovincial domestic tourism using mobile phone positioning. *Instituto Nacional De Estadística*. https://www.ine.es/en/prensa/experimental_moviles_turismo_interno_en.pdf

1.4 Smartphone Tracking's previous uses

This technology is not a newcomer. To be fair, INE's use is an ambitious project, but previously this data was used in tourism, and not only. Thanks to its precision, smartphone tracking has been useful for facing overcrowding problems and mass-tourism destinations.

1.4.1 Mobile phone tracking for managing mass tourism destinations

Over-tourism and overcrowded destinations are real problems for the tourism industry and not only. Venice and Barcelona are two well-known examples where MPD has been used to handle this type of situation, both very overcrowded destinations. Just a couple of weeks before the Covid explosion, Venice officials used mobile phone data combined with cameras and sensors, with the end to collecting a clear picture of how many people visited the city in that period (they did this experiment during the carnival period, one of the busiest periods of the year).

According to Brady (2020), the Tourism Councilor of Venice said that had become necessary to manage efficiently these overcrowded situations and that these new tools are particularly useful to do it, in real-time and with a high degree of precision.

A similar solution has also been tested in Barcelona, trying to manage the most popular area of the city: the Sagrada Familia. Working with IoT (Internet of Things) and Big Data, Barcelona tried to find a solution to over-tourism, improving citizens' quality of life and tourists' experience. Thanks to a complex system of cameras, sensors, mobile phone data, and other technological tools, they have tried to map and understand travelers' behavior to better organize the city's tourism offer.

1.4.2 Mobility control through mobile phone data

But one of the most significant previous uses of this data has been made always by INE. The National Institute of Statistics had already used mobile phone positioning to improve the Population and Houses Censuses. This work is made every ten years and for the last time (2021) has been used mobile phone position data. Specifically related to the mobility part, mobile phone data has been especially useful to provide a clearer view. According to INE technical project (December 2020),

this study has proposed an analysis of the suitability of this new way to get statistical information. Again, data were provided by the three largest telephone operators in Spain.

A geographical unit called "INE mobility area" has been created to ensure an adequate presence of users in each area. The total number of these areas was 3,214. Based on this geographical basis, three statistical matrices were constructed:

- Daily mobility matrix: 4 days have been selected and a mobility index has been built between all areas, covering these 4 days.
- Matrix day and night population: the aim is to collect information about the floating population.
- Seasonal population matrix: which aims to provide an overnights area for all telephones present in Spain for certain dates.

This first experience has played a huge role in order to push INE to invest more in this statistic.

1.4.3 Estonian experience

According to Raun et al. (2016), Estonians also experienced mobile phone tracking. In this paper, the authors have developed a methodology for measuring visitors' flows using space-time tracking data. They have pointed out that mobile phone-based tracking technologies allow us to study tourism better and more precisely than traditional methods. That's why spatial and temporary dimensions are better and faster represented, the tracking periods are longer, and GPS tracking enables tourism operators to follow travelers' journeys. In this example, it has been used a different methodology to collect data. Since this research was focused on foreign tourists that came to the country, it has been used the roaming of foreign mobile phones to track and count visitors.

1.4.4 The controversial case of Florence

According to Grassini and Dugheri (2021), in 2017 the Statistical department of the Metropolitan City of Florence experimented with the use of MPD to quantify the number of residents. The biggest concern was about tourists and daily visitors, being Florence one of the most popular

destinations in Italy. The experiment has been conducted together with Vodafone, a popular mobile phone operator, similarly at the INE's case. There have been distinguished 4 groups: residents, commuters (residents outside of Florence but that visit it regularly), Italian visitors, and foreign visitors. Since Vodafone isn't used by all, Vodafone has developed an algorithm to report MPD data to the population.

Looking at the results resumed in the table above (Table 1), it's evident that the MPD time pattern is quite the same as the traditional data one. But, focusing on numbers, we can see that related to the Italian visitors, the ones counted by mobile phone are higher than the traditional ones. This is why visitors from foreign countries tend to prefer traditional accommodations, which are covered with statistical surveys as well. In contrast, Italian tourists use a lot of non-traditional accommodations (friends' houses, second houses, black market, and so on). So, all these hidden people are counted only using MPD. This reasoning can be done also by talking about people who live in the city without being officially registered, and this point is one of the most important functionalities of MPD according to Grassini and Dugheri (2021).

Time	Italian OD	Italian MPD	Italian MPD/OD	Foreign MPD	Foreign OD	Foreign MPD/OD	Total OD	Total MPD
May-16	182,435	537,664	2.95	714,189	864,838	1.21	896,624	1,402,502
Jun-16	186,383	587,400	3.15	686,642	838,890	1.22	873,025	1,426,290
Jul-16	145,003	415,617	2.87	811,144	889,266	1.10	956,147	1,304,883
Aug-16	143,196	294,779	2.06	762,087	833,590	1.09	905,283	1,128,369
Sep-16	164,211	454,350	2.77	728,235	795,750	1.09	892,446	1,250,100

Figure 1- Metropolitan City of Florence: number of tourists' overnight stays from accommodation data (Official Data: OD) and MPD. Processing of Vodafone data by the Municipal Statistics Office of the Metropolitan City of Florence

2. MPD application to a case study: Domestic Tourism Transition in Spain after Covid-19's shock

This section of the thesis will show concrete applications of Mobile Phone Data, with the final goal to collect relevant information to understand tourism flows, trends, travelers' behaviors, and so on. We will see how MPD can be used in several circumstances and for different purposes.

In the first part, after a brief explanation of domestic tourism in terms of tool against the pandemic shock, we will observe my studies made on MPD about Spain's domestic market. The first one is about the resilience that each province had after the Covid's coming, where I built an indicator with MPD that shows how provinces reacted differently. The second one is a comparison between patterns and the rest of the country, using the same indicator but applied to bigger areas. The last one is a study of Madrid's outflows, where thanks to MPD, I studied how these outflows changed in the last four summers.

2.1 Domestic Tourism in Spain

Starting from the analysis of domestic tourism resilience literature, we can see that most of the papers are closely related to resilience during the pandemic peak. One of the purposes of this thesis is to illustrate, using MPD, the transition of Spanish domestic tourism following the shock caused by Covid, to analyze if there have been structural changes within internal demand behavior.

2.1.1 A quick review of Spain's domestic tourism situation before and after the Covid peak

Spain, one of the most important tourist countries in the world, has been hit hard during the pandemic. The paper written by Mayor and Boto-García (2022), shows how different Spain's provinces have reacted in diverse ways during the first semester after the become of Covid. The document points out the relevance of domestic tourism in order to cope with the drop in

international one. They have found that domestic demand resilience is positively related to high pre-pandemic domestic demand. In other words, provinces that were more attractive for domestic tourism better resist the pandemic. For the same reason, provinces that were more focused on the international market have not been able to cope with domestic demand. Mayor and Boto-García work has been made only considering the hotel industry. So, it takes into consideration only partial data. As we'll see in the following pages, thanks to smartphone data we could explain better these changes and these phenomena.

Knowing exactly how domestic tourism has helped to relieve the tourism market crash would be extremely helpful to understand how destinations should rethink its relevance. Although domestic tourism is a recognized key driver globally for the tourism industry, accounting for 73% of total expenditure in travel and tourism in 2017 (WTTC, 2018); most destinations or tourism operators still prefer international flows, which is often associated with higher spending capacities and better branding (Arbulú et al., 2021).

According to Arbalú et al. (2021), domestic tourism has a lot of advantages. For instance, it is more sustainable from the locals' point of view. In fact, domestic tourists tend to purchase more likely local products/services, supporting small scales enterprises and host communities.

Domestic travel includes visiting friends/parents, and it creates tourism flows in different areas, even including not popular ones. The work of Arbalú et al. (2021) has tried to calculate the weight of the redistribution of outbound demand in the domestic market due to the impossibility to travel outside Spain.

In doing this, they used traditional data collected by INE, which doesn't take into account several forms of domestic travelers, such as all the people don't stay in traditional and registered accommodations. This could have created a partially true analysis, which could be improved using MPD.

2.1.2 Domestic tourism, a tool against the pandemic or a radical change in travelers?

Covid's quickness and deepness have allowed it to hit our society strongly and unexpectedly. Like other economic fields, tourism wasn't ready to react to this type of event. But, as we've seen, not all destinations have had the same reaction. Some of them have been hit harder than others.

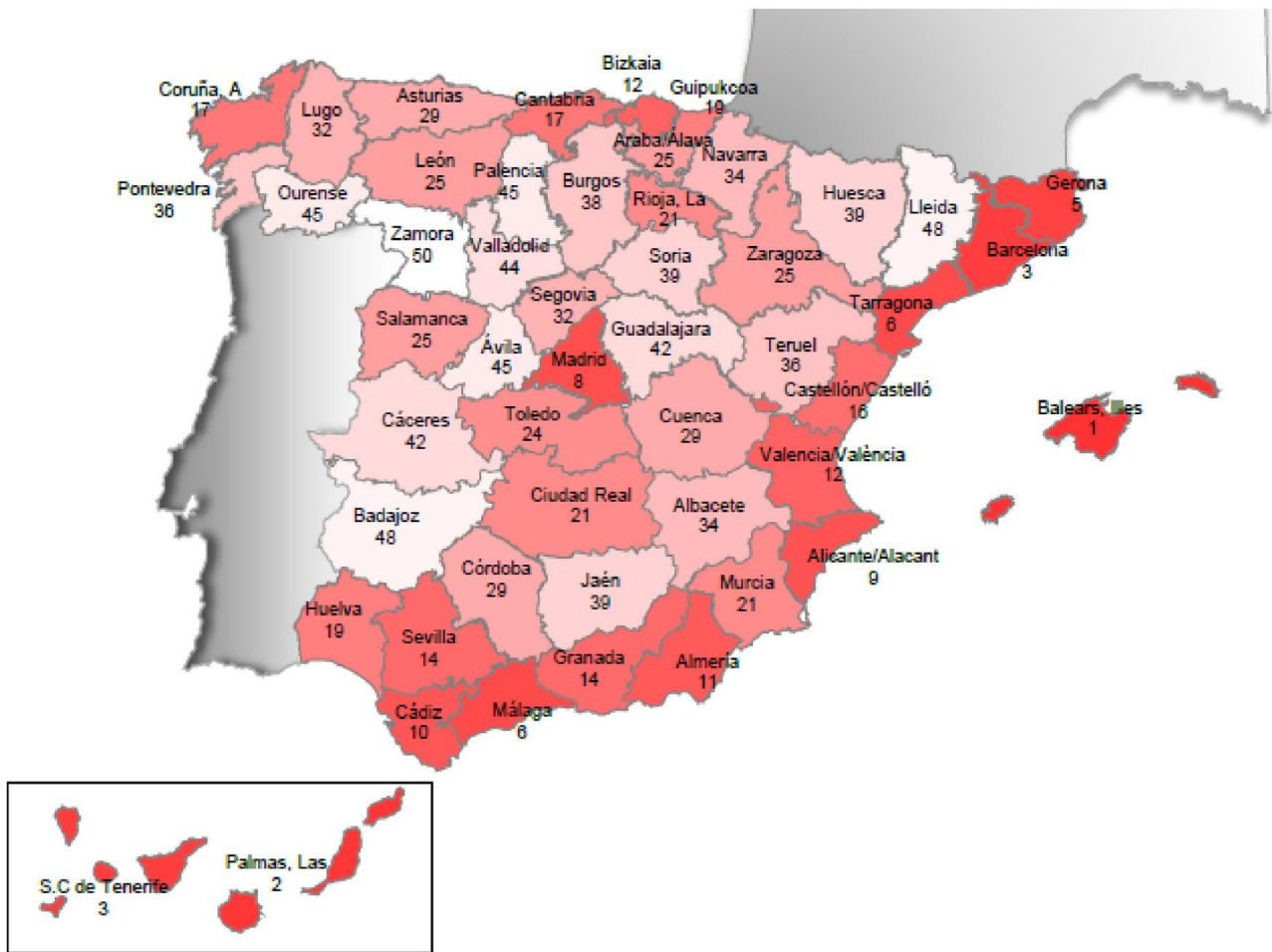
Certainly, the explanation of this difference is not univocal, the reasons are many. For sure, the first element is the degree of dependence on tourism, destinations that were totally dependent on the tourism sector have been brutally damaged by the pandemic. Other relevant elements can be seasonality, and the type of tourism/tourist facilities present on the territory, without obviously forgetting the enormous incidence of the epidemiological situation, which has been different between one destination and another, also at a provincial level. In addition to all these elements, there is another relevant one, the domestic market. Due to mobility restrictions established in some periods, domestic markets have played a significant role in keeping alive tourism destinations.⁵

Thanks to this last aspect, we can explain better differences between destinations in terms of registered tourism flows during Covid-time.

The domestic market has been used, mixed with other factors, to build a Tourism Vulnerability Index to COVID-19 among Spain's provinces (Duro et al., 2021). This work has been done in the middle of the pandemic. So, its purpose was to develop an index that could predict and explain which provinces would suffer the most. Therefore, applying this index to the Spanish provinces, the authors highlighted which of them were more likely to suffer the effects of the pandemic.

As we can see in Map 1, the provinces most at risk are those with high seasonality, a strong tendency to international tourism (and a poor predisposition to domestic one), and accommodation facilities more geared to mass tourism.

⁵ Duro, J. A., Perez-Laborda, A., Turrión-Prats, J., & Fernández, M. F. (2021). Covid-19 and tourism vulnerability. *Tourism Management Perspectives*, 38, 100819. <https://doi.org/10.1016/j.tmp.2021.100819>

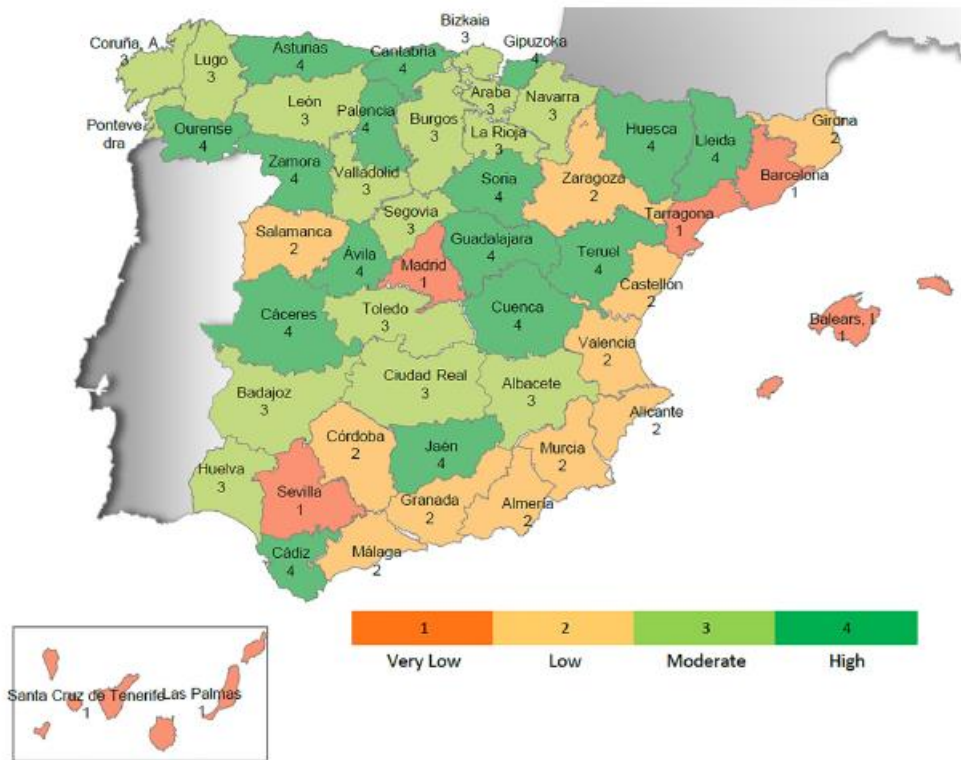


Map 1- The Spanish provincial map of TVI-COVID for the Spanish provinces. Credit: (Duro et al., 2021)

Later in this paper, we will analyze how domestic tourism has been developed in each province. To do this was used MPD, creating a resilience index that shows the trend of tourist arrivals from the domestic market, using as the reference year 2019 and using only the 3 summer months. So, in the following part, we will see if Map.1 will be confirmed or not by maps developed with MPD.

Another proof of the importance of domestic tourism is provided by the work of Duro et al. (2022). In this paper, the authors have pointed out which provinces reacted better during the summer of 2020 to Covid shock, comparing overnights of summer 2020 with average summer overnights from 2015 to 2019. This calculation has considered foreign visitors as well, especially in the average overnights (as we know during the summer of 2020 the international visitors were near zero).

Duro et al.'s work aimed to investigate why there have been so many differences in tourism resilience among Spain's provinces. They built a map, showing how each province has registered different situations in terms of overnights.



Map 2- Resilience across Spain's provinces. Credits: Duro et al. (2022).

As we can see in Map 2, the provinces located on the Mediterranean coast, and the islands, are the ones that have been most accused of the advent of the pandemic. This is perfectly in line with what we can see in Map 1, where a resilience index was assumed, always based on data from hotels.

In the next chapters, we will see how this scenario will change thanks to the use of Mobile Phone Data, which guarantees a much more complete and precise representation of reality.

2.1.3 Domestic Tourism: experiences from Other Countries

Before entering the specific part of this thesis, where we'll see how domestic tourism has impacted Spain's tourism sector before, during, and after the Covid peak using Mobile Phone Data as a

principal source, it might be useful to check how domestic demand has been involved in other countries strategies.

A first point of view is given by Nyikana and Bama (2023), these authors have conducted qualitative research in South Africa to understand how domestic tourism has been significant during the pandemic. South Africa has been developing its domestic tourism market since 1996 with the NTSS (National Tourism Sector Strategy). Even before Covid, actions were taken to distribute tourist resources throughout the territory.

This attention to the domestic market was accentuated by the arrival of covid. The Department of Tourism has implemented recovery strategies that focus heavily on national tourism.

As reported by the SAT (South African Tourism) report (2021b), the number of journeys made within national borders fell by 40% compared to 2019 during 2020. Despite this, the domestic tourism market of 2020 generated a total revenue 21% higher than in 2019, with an increase of 102% in the average spending of domestic tourists compared to the previous year.

The South African experience is great evidence of how important is to develop the domestic market in the same way as the international one.

The literature is full of studies that demonstrate how domestic tourism has been relevant in contrasting the pandemic's negative effects. This topic is full of different shades to focus on, from a social point of view, studying the behaviors of domestic tourists, to an economic one. Very often, these sides are studied together. An example is from Costa Rica, where Calderón et al. (2021) have conducted a study aimed to analyze the behavior of domestic tourism in Costa Rica after the lockdown.

Another piece of evidence is from Volgger et al. (2021), where it was compared different marketing strategies in the domestic tourism market, to see which one the best is to encourage tourists to visit the country during the pandemic. The study was conducted in Australia.

The 3 examples described above are only a small part of all existing literature concerning the effects of covid and domestic tourism during the pandemic. These articles, like most similar studies, use qualitative sources (like surveys) or quantitative ones, like traditional statistics provided by national agencies. The result is a partial view of reality, traditional statistics and surveys are not able to represent the whole population and neither a high percentage.

In this context, Mobile Phone Data could offer a great and supporting hand, to create a complete scenery of reality.

2.2 Domestic tourism transition in Spain: a new perspective provided by Mobile Phone Data

In the first part of this paper, it was explained what Mobile Phone Data is exactly, its origin, how it is built, and its potential advantages and disadvantages. Then, it was introduced a possible application field for MPD in the tourism sector: Mobile Phone Data can be useful to track and manage big tourist flows, with a high degree of precision and deepness. MPD is particularly useful in tracking domestic tourist flows, due to their characteristics, they tend to use more hidden accommodations or hidden ways to travel within national boundaries.

2.2.1 Transition Index: Methodology

Now, in this section, it's explained the indicator built with MPD, which shows how domestic tourism flows have changed due to the Covid-19 shock, across Spanish provinces. All data was downloaded from INE.⁶

The data are referred only to the three summer months, from 2019 to 2022. As the origin point of tourist flows, it wasn't distinguished, it was considered the national total amount. Regarding

⁶ Spanish Statistical Office. *Experimental statistics. Main menu.* INE. https://www.ine.es/experimental/turismo_moviles/experimental_turismo_moviles_interior.htm?L=1

destinations, it was used at the provincial level, even though the degree of deepness allowed by MPD is bigger.

So, it was created a “Transition Index” (TI), comparing the total number of tourist arrivals for each province, keeping 2019 as a reference point. So, for example, for each province it was compared the total number of arrivals in the three months of summer of 2020, with 2019 one, and so on for each year. The same index was developed using other two variables: overnights and average medium stay, but to make the study easier and clearer, only the index about the total number of arrivals will be used, which is already significant by itself. If the TI is over 1, it means that the province has received more tourist arrivals in that year than in 2019.

In doing that, the first objective is to analyze how domestic tourism flows have developed due to Covid-19. This is possible thanks to MPD’s high precision rate. To better represent the results, maps were created, using different shades of color. Thus, in the next section, I’m going to explain this data, using maps to illustrate better the results.

The maps realized with the data provided by mobile phones, therefore, represent an index relative to the relationship between the domestic tourist flows of the year considered, compared to the same period in 2019. Consequently, the provinces with the highest TI do not necessarily correspond with those with the highest absolute numbers of tourist arrivals.

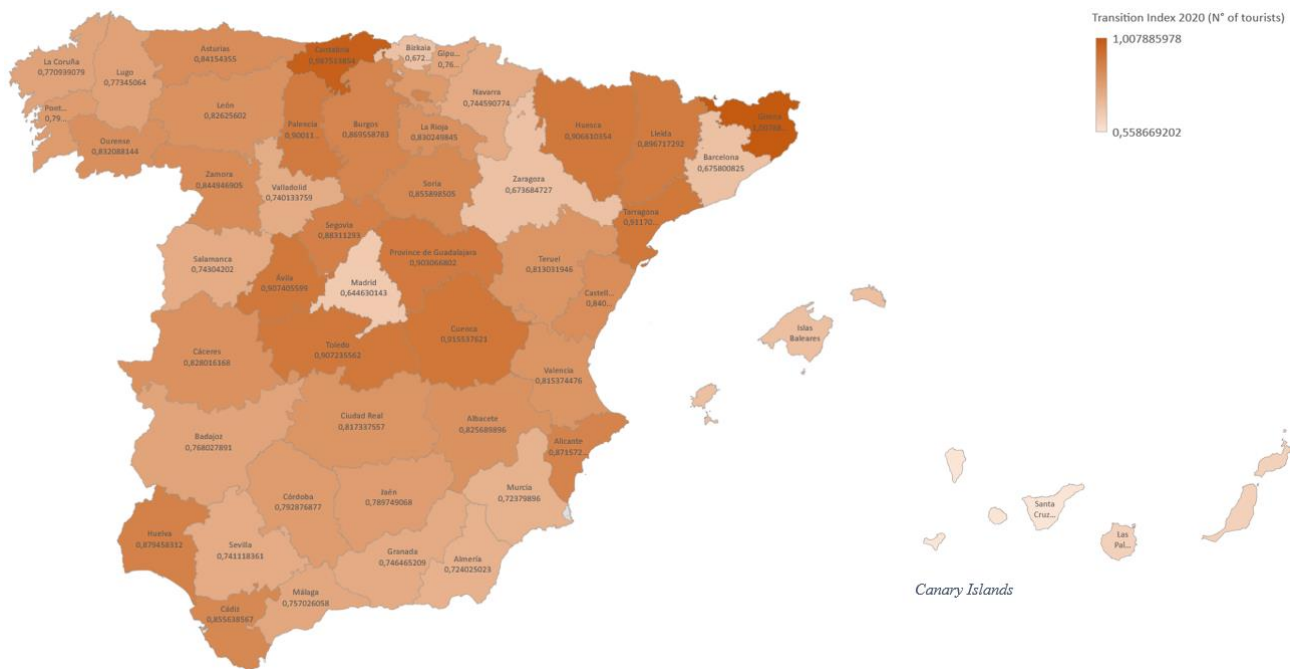
And finally, a clarification regarding the provinces of Ceuta and Melilla, these provinces haven’t been considered in this analysis. Their position and their situation do not make them particularly relevant to the purpose of this thesis. On the contrary, their involvement would have made comparisons between other provinces more difficult.

2.2.2 Transition Index: Results and Explanations

The Transition Index represents a clear and easy example of how MPD can be applied to the tourism sector. It is a simple way to study if and how much tourism flows have changed with Covid, during the summer months.

TI of Summer 2020

In Map 3, we can see the first map of TI for the summer of 2020. As we well know, 2020 has probably been the worst summer for the tourism sector. The international market basically disappeared; thus, the weight of the tourism economy has been carried out totally from the domestic market.



Map 3- Transition Index Map (N° of tourists, 2020). Credit: My elaboration.

So, looking at Map 3, we can point out different elements. Madrid, Barcelona, and Zaragoza were one of the most hit provinces in 2020, especially the capital was hit very strongly by Covid consequences. Even Canary Islands and Balearic Islands have seen dropping their arrivals, probably

due to their position, they are reachable easily by plane, and in 2020 traveling by plane was difficult.

The provinces that better replied to the pandemic, in terms of tourist arrivals were Girona (the only one with a positive increase) and Cantabria.

The general trend for the 2020 summer was negative, with an average TI around 0,81, but not that much, especially in certain provinces located in the north and the center of the country.

To better understand the potential of MPD, we can establish a comparison between MPD results and ETR results, obviously looking at the same period. Table 1 shows the total number of domestic tourist arrivals and TI or TITD for both MPD and ETR, both at the regional level. The differences, in terms of TI and, TI TD are evident, with a difference that often is around 10%. The most striking cases, where the difference between the two indices reaches more than 20% concern the Balearic Islands and the Canary Islands. This enormous difference can be explained by the different abilities of the two types of data collection to represent reality: the MPD has recorded a real decrease (the islands have been penalized more for the position, especially the first year of covid) while the ETR was less precise. In general, the indicator based on traditional data provides higher values than the one processed with MPD, which may indicate that existing studies based on traditional data overstate resilience.

Looking at general numbers, in the third quarter of 2020, ETR counted 44.628.688 trips. Referring to the same period, Mobile Phone Data counted 49.704.120. Thus, the difference between traditional statistical approximations available in ETR is slightly different from MPD.

In ETR, it is distinguished by regional and autonomous cities level, so the degree of deepness is not the same as MPD. Looking at the report about the third quarter of 2020, on a total of 44.628.688 trips, the main destinations for Spanish inhabitants were Andalucía, Cataluña, and Comunidad

Valenciana.⁷ Thus, considering only ETR, it may seem that Cataluña has reacted well to the Covid threat. Instead, using MPD we know that Barcelona province has been very hit by the pandemic, while the opposite situation occurred with the province of Girona. Lleida and Tarragona stay in a middle situation, they had a decrease in tourists, but slight compared to that in Barcelona.

Trying to build a Transition Index with traditional data (TITD), comparing 2020 data with 2019 one, we see that Andalusia has around 0,84. But, as we can see in Fig. 3, this conclusion is not totally correct. Huelva and Cadiz are the only provinces with a similar TI made with MPD. Other provinces of the Andalusia region have lower TI. Thus, also for Andalusia, MPD can offer a deeper view, that can complete information provided by ETR.

If we move the focus to the middle of the map, we can see that Madrid has one of the worst TI. But, looking at the provinces that surround Madrid, we notice a decent situation. Toledo, Cuenca, and Guadalajara are part of the Castilla-La Mancha region; Avila and Segovia are part of the Castilla y Leon region. Looking at the map, these 5 provinces have a TI of around 0,90; and that's pretty high. Castilla y La Mancha and Castilla y Leon have respectively of around 0,95 and 0,89 of TITD (calculated with traditional data taken by ETR). Thus, in this case, both TI and TITD, are similar, especially considering other provinces of these two regions. Moving to the north, Cantabria was the best province in terms of the Transition Index, according to MPD. The reasons beyond this difference between Cantabria and nearby provinces can be a lot.

The relevant point for this thesis is to underline how MPD can be useful to make evident trends or phenomena, stimulating a deeper analysis, and involving linked fields. Later, we will talk about possible uses in this way, comparing different areas according to their characteristics.

⁷ INE. (2020b, December 23). Residents Travel Survey (ETR/FAMILITUR). *Third Quarter Year 2020*. https://www.ine.es/en/daco/daco42/etr/etr0320_en.pdf

2020 MPD	N° of Tourists (MPD)	N° of Tourists (ETR)	TI (MPD)	TI (ETR)
Andalusia	9.724.749	9.268.410	79,52%	84,40%
Cataluña	7.819.032	6.107.141	87,47%	85,53%
Comunitat Valenciana	5.718.429	5.747.469	84,78%	76,49%
Castilla y León	5.242.849	4.695.376	84,47%	89,04%
Castilla - La Mancha	4.370.489	2.921.949	88,42%	95,06%
Galicia	3.025.153	2.707.298	78,73%	79,06%
Canarias	586.827	1.784.749	59,30%	78,90%
Cantabria	1.614.439	1.533.210	98,75%	99,57%
Madrid, Comunidad de	2.814.666	1.509.266	64,46%	58,01%
Aragón	1.825.974	1.494.747	80,33%	77,81%
Asturias, Principado de	1.082.549	1.435.352	84,15%	81,56%
Murcia, Región de	861.991	1.108.350	72,38%	86,40%
Extremadura	1.233.241	1.101.132	80,04%	90,03%
Balears, Illes	819.093	1.091.246	67,84%	85,00%
País Vasco	1.729.570	993.347	73,15%	82,11%
Navarra, Comunidad Foral de	656.015	699.161	74,46%	86,22%
Rioja, La	531.423	418.828	83,02%	87,57%

Table 1- MPD vs ETR data, a regional perspective of the 2020 summer. Credit: my elaboration

To resume, in this first map, we can see the first and basic use of Mobile Phone Data applied to the tourism sector. About the summer of 2020, the first one with the pandemic and with restrictions related to it, the data appear similar, at least at the regional level, to the traditional one.

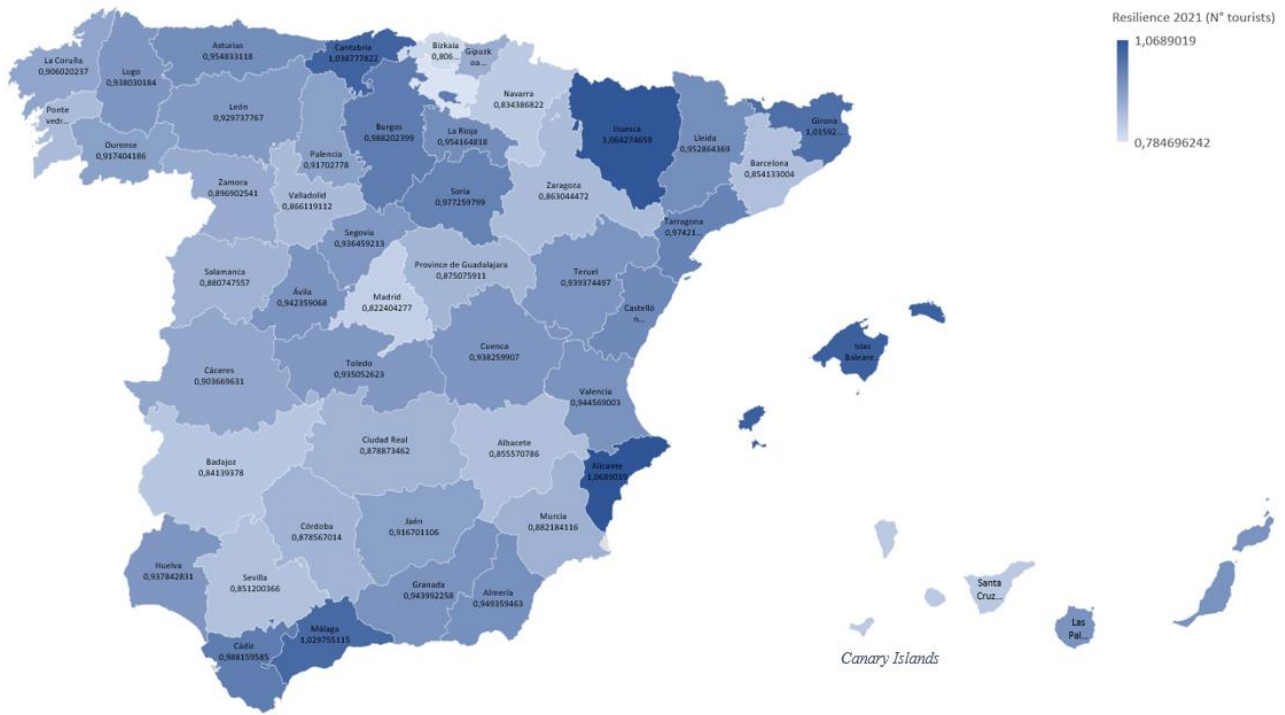
Going in-depth, MPD starts to show its utility, to better represent reality, showing differences between provinces, and even between municipalities.

After this first approach, and comparison between MPD and the traditional statistics of the ETR, we have seen differences between MPD's results and ETR ones, and it is obvious because they come from two different sources, one is an almost complete and direct representation of the population, the other one is a sample. However, these differences should not be too high, otherwise, there may be problems with the reliability of the data.

TI of Summer 2021

Map 4 represents the Transition Index related to the summer of 2021. The 2021 summer was particular, after a year and a half of Covid, people wanted to travel and move, but the pandemic situation was still there with new clusters that came out every week.

So, on one hand, there was the willingness of people to travel, but on the other one, there was a climate of uncertainty that made it very difficult to organize trips.



Map 4- Transition Index Map (N° of tourists, 2021). Credit: My elaboration.

This two-sided situation is reflected in Map 4, where the general trend is better than the previous summer, but there are still some difficulties in some areas. As proof of this general improvement, the average TI for the 2021 summer is around 0,93, the previous one was around 0,81, so even looking at the data, there has been a sensitive improvement.

Also in 2021, Madrid, Barcelona, and Zaragoza were very hit in terms of the total number of domestic tourists received. Their TI is lower than the general average. Girona and Cantabria are still among the best provinces with TI over the average.

Keeping an eye on last year as a reference, we can see several provinces that have improved their arrivals, and consequently their TI. Probably, the most evident reality is the Balearic Islands, which have switched from a 0,67 TI to a 1,05, almost double, becoming one of the provinces with the best

Transition Index. In the same way, even Huesca and Alicante have increased greatly, with a Transition Index over 1. In Andalusia, Malaga has had a significant increase in tourist arrivals during the 2021 summer, overpassing the pre-Covid level as well.

Thus, the 2021 summer appears, in general, better than the previous one, with more provinces with a TI over 1 and a higher average. Looking at Map 4, it's obvious that most of the provinces have registered lower arrivals than in 2019, despite the 6 provinces with higher results.

After analyzing the summer of 2020 and 2021, we can already say that the MPD (combined with other existing statistical research methodologies) could be very useful for operators in the sector and for many factors:

- Using MPD, we can describe better spatial and geographical phenomena. We can go in-depth, with incredible precision that allows us to notice some shades, which would have been impossible to catch with normal statistics.
- Identifying and understanding how different areas behave differently allows tour operators to investigate more precisely the motivations behind these differences.
- The degree of geographical and spatial detail allows, therefore, to study and develop increasingly detailed and differentiated programs, to conduct a joint growth that adapts to the differences of individual areas.

Also, for the 2021 summer, making a comparison with ETR data related to the same period can indicate more clearly the difference. Table 2 shows the data for the summer of 2021, even for the summer of 2021, the differences between the data are quite clear. Again, for this summer, the two indices often have a difference greater than 10%. The Canaries have similar values for both sides, while the Balearics have two totally different values, the TITD (ETR) is much higher than the TI, although both are higher than the 1. Also, for the summer of 2021, we can see that ETR data is generally higher.

Looking at ETR data for the 2021 summer, Spain residents have done 53,839,454 trips within Country boundaries.⁸ The total number of domestic tourists collected by MPD is quite higher, it's 57.329.001. Thus, for the 2021 summer, MPD has probably detected all travelers that used non-official accommodation, who haven't been considered by the ETR algorithm based on surveys.

According to the ETR report, the three most visited regions by domestic tourists were Andalusia, Cataluña, and Comunidad Valenciana, the same three of 2020. Comparing the 2021 official data with the 2019 official data, the Andalusia TITD is 1,04, the Cataluña one is 1,08, and the Comunidad Valenciana one is 0,99. According to these data, therefore, it might seem that the first two regions recorded an increase in domestic tourist flow in the summer of 2021, compared to that of 2019.

Instead, looking at Map 4, we can see that the situation described by TI processed with MPD is different. Starting from Andalusia, the only province that has a TI over 1 is Malaga, other provinces have lower indexes. Thus, the average TI for Andalusia is 0,96. This is clear evidence of how MPD reality can be different from the picture drawn by traditional statistics.

Moving to Cataluña, the average TI is 0,95, where only Girona has an index over 1. Again, MPD makes evident a different situation.

In the third region, the Comunidad Valenciana, TI and TITD are slightly different, the first one is a bit over 1, and the second is around 0,99. But thanks to MPD, we know that only Alicante has an index over 1, while the other two provinces, Valencia and Castellon have it lower.

After comparing the data of the provinces with the best ratio, we can propose the same comparison even for the less virtuous provinces. For example, taking into consideration the numbers provided by the ETR reports, Madrid would have a TITD of 0.92, while according to MPD, the index is 0.82. Being Madrid is both a province and a region, it allows a direct comparison between the ETR data and MPD.

⁸ INE. (2021b, December 22). Residents Travel Survey (ETR/FAMILITUR). *Third Quarter Year 2021*. https://www.ine.es/en/daco/daco42/etr/etr0321_en.pdf

In the final part of the thesis, Madrid will be at the center of a further analysis that will show, even more in detail, the potential that Mobile Phone Data has, and how useful it can be for the tourist world and especially for those who work there.

2021 MPD	N° of Tourists (MPD)	N° of Tourists (ETR)	TI% (MPD)	TI% (ETR)
Andalusia	11.719.997	11.425.135	95,83%	104,04%
Cataluña	8.508.100	7.685.798	95,18%	107,64%
Comunitat Valenciana	6.795.981	7.055.689	100,76%	93,90%
Castilla y León	5.769.271	4.773.968	92,96%	90,53%
Castilla - La Mancha	4.473.953	3.011.896	90,52%	97,98%
Galicia	3.444.335	3.520.573	89,64%	102,81%
Canarias	886.095	1.931.607	89,54%	85,40%
Cantabria	1.698.248	1.622.671	103,88%	105,38%
Madrid, Comunidad de	3.590.886	2.384.936	82,24%	91,67%
Aragón	2.190.664	2.129.446	96,38%	110,86%
Asturias, Principado de	1.228.283	1.457.673	95,48%	82,82%
Murcia, Región de	1.050.616	1.182.246	88,22%	92,16%
Extremadura	1.348.182	1.338.422	87,50%	109,43%
Balears, Illes	1.262.581	1.839.802	104,58%	143,31%
País Vasco	1.960.635	1.198.179	82,92%	99,04%
Navarra, Comunidad Foral de	735.129	708.161	83,44%	87,33%
Rioja, La	610.738	546.751	95,42%	114,32%

Table 2- MPD vs ETR data, a regional perspective of the 2021 summer. Credit: my elaboration

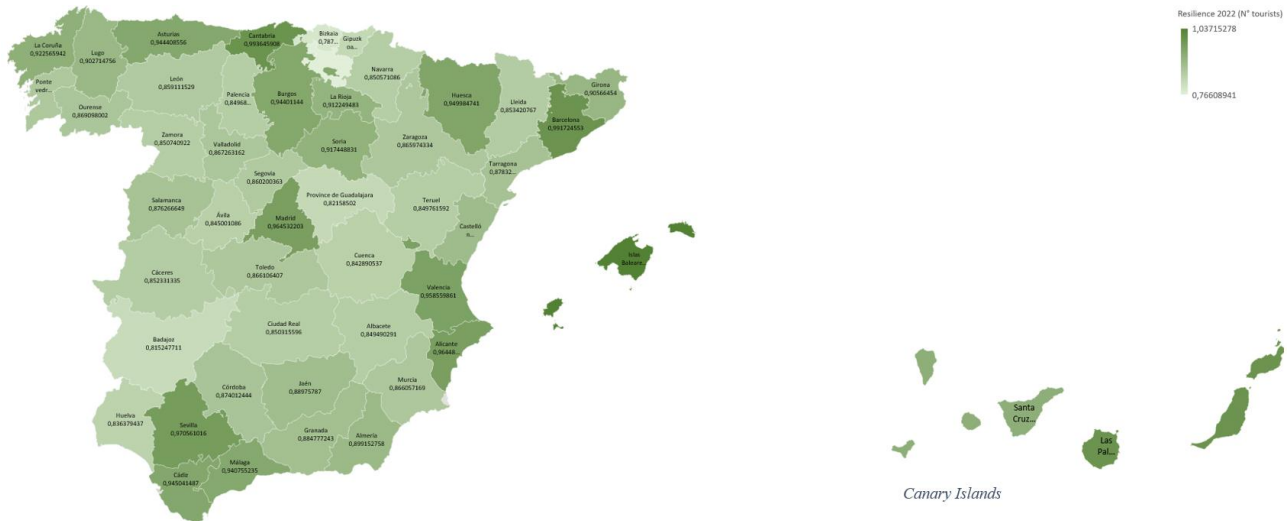
Thus, also in this second map, we have understood how MPD can provide a different point of view, probably more accurately geographically speaking. Traditional statistics based on surveys need to be developed through an algorithm to represent the entire population, it would be impossible to get direct information using surveys and covering the population at the same time. In this context, Mobile Phone Data can add accuracy, covering directly more people, and the probability of making a mistake is lower.

TI of Summer 2022

Map 5 shows the last summer that has been considered in this analysis. In 2022, the pandemic situation was different from the previous two years. It can be said that the summer of 2022 was the

first period, since the advent of Covid, where an almost total return to the pre-pandemic normality was observed.

Since there have been no more restrictions on freedom of movement, international tourism has also resumed involving large flows of people.



Map 5- Transition Index Map (N° of tourists, 2022). Credit: My elaboration

Before analyzing some provinces, starting from the general trend. In 2022 summer, according to MPD and the TI map (map.5), the average TI was around 0,91. So, comparing it with the previous ones, in 2021 it was 0,93, and in 2020 it was 0,81, we see a slight decrease compared with the 2021 summer.

This little difference can be explained by what is written above, so it can be caused by the increase in the international market. So, probably, in 2022 more Spanish went to foreign countries, instead of staying in Spain.

This feeling is confirmed by the ETR report about 2022: through the summer, Spanish residents did 56,768,382 trips, of which 50,656,762 were within Spanish boundaries.⁹ There have been over 3 million domestic tourist arrivals less than in 2021. Even looking at the total number of domestic tourist arrivals registered by MPD, the 2022 summer data is lower than in 2021, 55.688.392 against

⁹ INE. (2022b, December 22). Residents Travel Survey (ETR/FAMILITUR). *Third Quarter Year 2022*. https://www.ine.es/en/daco/daco42/etr/etr0322_en.pdf

57.329.001. However, as of 2022, the data taken from mobile phones recorded 5 million more domestic tourists than traditional data. Table 3 illustrates a comparison between MPD and ETR, looking at the total number of domestic tourist arrivals registered and TI (TITD). While in the previous two summers, ETR data were found to be higher than MPD data, in the latter this phenomenon appears to have subsided. To underline how the situation of the Balearic Islands still presents much higher numbers with the ETR (similar case also for the País Vasco and Aragon).

2022 MPD	N° of Tourists (MPD)	N° of Tourists (ETR)	% (MPD)	% (ETR)
Andalusia	11.176.922	9.690.833	91,39%	88,24%
Cataluña	8.188.907	7.554.144	91,61%	105,80%
Comunitat Valenciana	6.380.781	6.813.039	94,60%	90,67%
Castilla y León	5.427.490	4.568.686	87,45%	86,63%
Castilla - La Mancha	4.196.057	2.754.434	84,89%	89,61%
Galicia	3.421.738	3.668.007	89,05%	107,12%
Canarias	951.574	1.941.694	96,16%	85,84%
Cantabria	1.624.464	1.452.070	99,36%	94,30%
Madrid, Comunidad de	4.211.463	2.115.915	96,45%	81,33%
Aragón	2.035.974	2.334.808	89,57%	121,55%
Asturias, Principado de	1.214.873	1.579.287	94,44%	89,73%
Murcia, Región de	1.031.410	1.239.069	86,61%	96,59%
Extremadura	1.286.938	955.475	83,53%	78,12%
Balears, Illes	1.252.195	1.727.491	103,72%	134,56%
País Vasco	1.877.199	1.212.337	79,39%	100,21%
Navarra, Comunidad Foral de	749.388	518.537	85,06%	63,95%
Rioja, La	583.909	493.935	91,22%	103,28%

Table 3- MPD vs ETR data, a regional perspective of the 2022 summer. Credit: my elaboration

Now, talking about Map 5, the biggest difference from other maps is the situation in Madrid and Barcelona. In 2020 and 2021, these 2 provinces were among those with the worst situation.

But, in the summer of 2022, these two provinces came back almost to the pre-pandemic level of domestic tourism. Barcelona has a TI of 0,99, while Madrid one is 0,96, much better than the 2021 indexes, which were respectively 0,85 and 0,82. Surely, the reasons behind this phenomenon are many, from the resumption of business trips to the progressive and almost reached return to

normality, which has allowed very popular destinations (and problematic in Covid perspective) to return to vogue among travelers.

Keeping the attention on the 2022 TI, we see that only the Balearic Islands have a TI over 1, other provinces have an index lower than 1. It means that if we directly compare the n° of internal tourist arrivals for each province in 2022 with the same variable related to 2019, only the Balearic Islands received more tourists last summer than the 2019 summer.

But not only Madrid and Barcelona have seen a sensitive increase in their arrivals from the domestic market. Even provinces like Sevilla, Valencia, and the Canary Islands have a better TI than the 2021 ones. Basically, in 2022, the most popular destinations received more domestic tourists, bordering on pre-Covid levels.

This data is very interesting to understand if the shock caused by covid has permanently changed the places and destinations preferred by Spanish residents. In fact, in 2021, there were 6 provinces with TI greater than 1, with Madrid, Barcelona, and other famous provinces mentioned above well below pre-covid levels. This could have predicted a possible lasting change in the tastes and preferences of Spanish travelers.

Instead, the reality described by the 2022 data distances this idea. It will be interesting to continue to follow the evolution of the situation in the coming years, to understand if the stop last summer is due to a series of factors (such as the return to international travel) or if indeed, the data found in 2021 were the latest aftermath of the pandemic, and that therefore nothing has changed radically. The data obtained from mobile phones, therefore, can be very useful in the coming years, to continue to follow and monitor with precision and detail, future domestic movements.

In conclusion, in this paragraph, we have seen how a first use of MPD can be relevant for tourist operators and destination managers.

Working with the data of only three years, and referring only to the summer months, it was, however, possible to highlight and understand relevant information, only by processing a simple index.

In the final part of this paper, as already written above, further possible advantages (and possible problems) of this experimental statistic will be shown. First, the data will be compared, not more than the individual provinces, but more extensive areas, to understand how the MPD can also give information on geographical areas other than the convention, uniting territories based on morphological, social, and so on.

Finally, we will show the data from an analysis of the tourist flows leaving the province of Madrid to the other 49 examined so far, to understand if there have been changes in their distribution.

2.3 Mobile Phone Data: patterns analysis in Spain

In the previous part, we analyzed the Transition Index of Spain's provinces for the last three summers (2020, 2021, 2022). The aim was to see how the domestic market had changed after the Covid shock, showing at the same time one of the possible uses of MPD in the tourism sector.

In this paragraph, it is shown another use of MPD related to tourism, always linked with the analysis of TI, but related to the comparison of pattern areas.

If in the previous analysis, we viewed the transition index province by province, now we are going to use an average of this indicator to compare wider geographical areas, grouped according to reasons, morphological, geographical, and economic.

Therefore, in these analyses two averages of the transition index will be used: one concerning the pattern, the other realized between all the remaining provinces.

2.3.1 Green Spain vs other provinces

The first pattern that has been analyzed is the one called Green Spain (GS). Green Spain is a real and concrete brand, which involves Asturias, Cantabria, La Coruña, Lugo, Ourense, Pontevedra, Araba, Bizkaia, and Gipuzkoa (using regional level: Asturias, Cantabria, Galicia, and Euskadi).

Nature is the focal point of this brand, thus, it might think that, in Covid times, where social distancing was an extremely relevant factor, such a destination could be extremely attractive to tourists. Instead, as MPD data shows, this was not.

Starting from 2020 summer, in Figure 6, we can see graphically the two TI: the Green Spain one is 0,816327869793503, the other one represents other provinces, and it is 0,809270342642896.



Map 6- Transition Index Average: comparison between Green Spain vs. Other Provinces (N° of tourists, 2020). Credit: My elaboration

The darker part represents Green Spain, while the lighter one represents the rest of the provinces. The difference between the two averages is slight, but in 2020 summer, we can say that the Green Spain trend was a bit better than the general one.

To better understand the evolution of these trends, we can move to observe the 2021 summer, looking at Map 7.



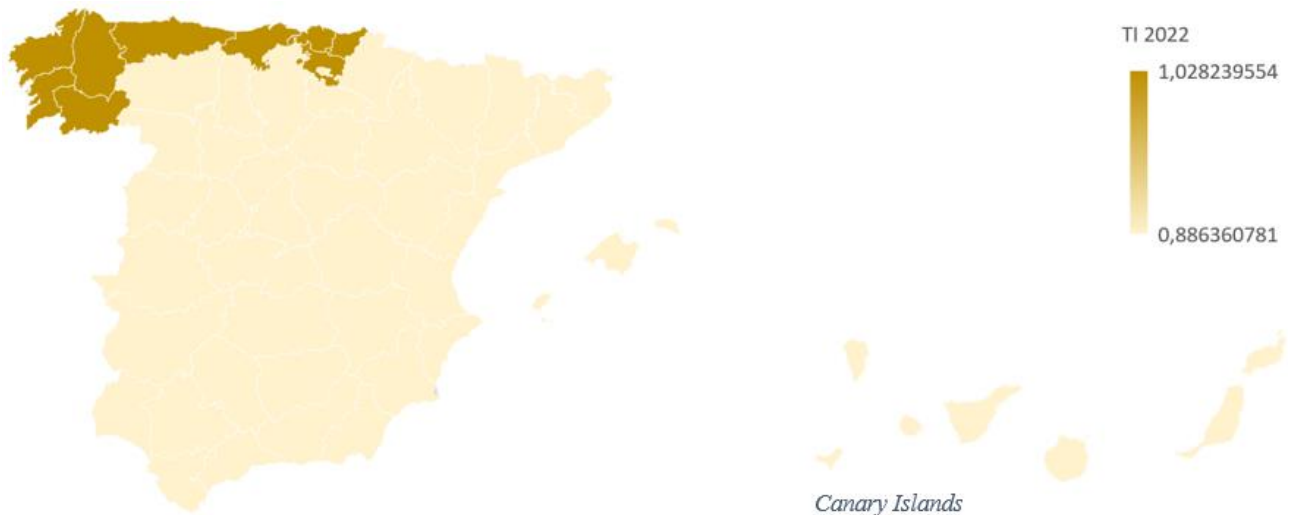
Map 7- Transition Index Average: comparison between Green Spain vs. Other Provinces (N° of tourists, 2021). Credit: My elaboration

As it is shown, in 2021 Green Spain had a lower TI. There has been, therefore, a reversal of trend. Generally, in 2021, tourist flows improved, and more people restarted traveling. So, both averages increased rather than 2020.

In 2022, the situation changed significantly. As we can see in Map 8, the trend came back as the one of the 2020 summer but with a higher gap. During the three summers, Green Spain registered a better TI during the first and the last one. In the other one, its average TI was lower than the rest of the country.

This scenery doesn't change if we look at the same pattern using TITD, in other words, a TI made with ETR data. Starting from the 2020 summer, with traditional data, GS had a TITD of 0,84, which is higher rather than the one for the rest of the country, which was 0,79.

This trend changes looking at 2021 data, where Green Spain's TITD was 0,98 and that of the rest of the country was about 1.



Map 8- Transition Index Average: comparison between Green Spain vs. Other Provinces (N° of tourists, 2022). Credit: My elaboration

In 2022, the trend changes again, Green Spain TITD was around 1, and the other one was 0,93. Thus, with traditional statistics taken from ETR reports, Green Spain had better Transition indexes related to 2020 and 2022.

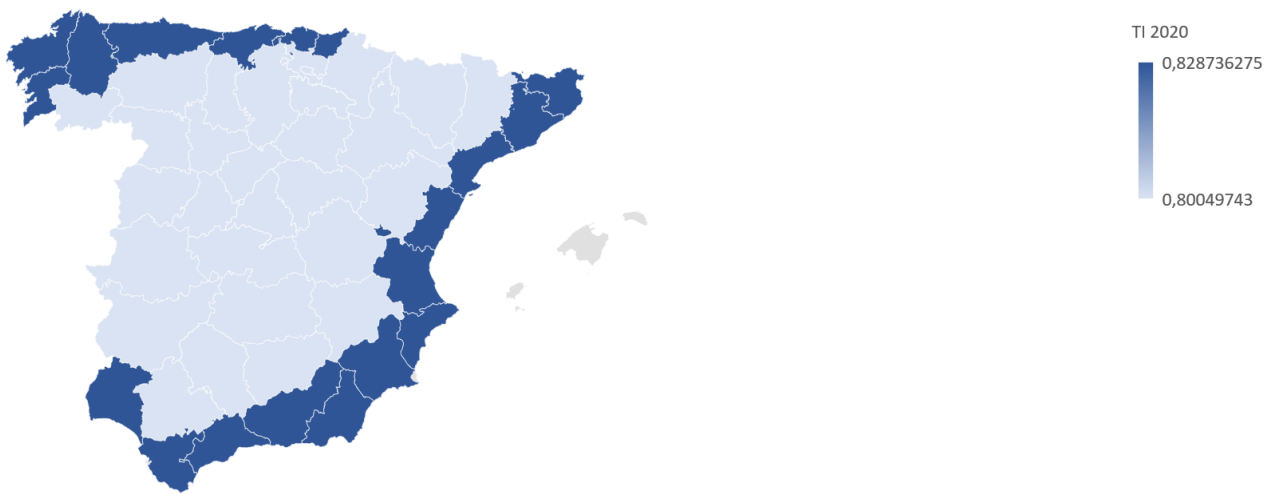
In this case, the two realities described by MPD and ETR data are the same in terms of trend, but they appear different in terms of the weight of values.

2.3.2 Coastal Provinces vs other provinces

The second pattern that has been analyzed is about coastal provinces: Girona, Barcelona, Tarragona, Castellon, Valencia, Alicante, Murcia, Almeria, Granada, Malaga, Cadiz, Huelva, Pontevedra, Asturias, Cantabria, La Coruña, Lugo, Bizkaia, and Gipuzkoa.

The Balearic Islands and Canary Islands have not been considered because as islands, they have different characteristics, for instance just different reachability.

Looking at Map 9, it's shown the summer of 2020 averages of coastal provinces and other provinces. The difference between the two values is noteworthy, showing that the coastal provinces had a smaller decrease than those of the hinterland.



Map 9- Transition Index Average: comparison between Coastal Provinces vs. Other Provinces (N° of tourists, 2020). Credit: My elaboration

As before, it's very helpful going on with the analysis, moving to the following summer, the 2021 one. Map 10 illustrates how the hierarchy has not changed, with a significant gap increasing.



Map 10- Transition Index Average: comparison between Coastal Provinces vs. Other Provinces (N° of tourists, 2021). Credit: My elaboration

It seems clear that provinces located on the coast have been able to better resist Covid shock, as data confirms. That's confirmed also by data related to the 2022 summer shown in Map 11.



Map 11- Transition Index Average: comparison between Coastal Provinces vs. Other Provinces (N° of tourists, 2022). Credit: My elaboration

This last map confirms the previous ones, coastal provinces have had a better Transition Index for all the summers. It means that provinces on the coast, on average, lost fewer domestic tourists than other provinces, always keeping the summer of 2019 as a reference. Of course, it must be remembered that the period considered concerns the 3 summer months, so the coastal provinces are more favored.

Here, making a comparison with ETR data is more difficult. The latter is only available at the regional level, and the division at the provincial level that we have adopted for the analysis does not allow regrouping the MPD data at the regional level to compare them.

In conclusion, this comparison has shown a clear situation: since the summer of 2020, the coastal provinces have recorded an average value greater than that of the inland provinces. The same phenomenon was repeated in the following summer.

Using averages, you lose the degree of detail that this new type of statistics makes possible. So, although the coastal provinces have had a higher average than the others for two summers out of three, there have been individual cases, such as the province of Barcelona, which has individually represented a completely different reality. But this also serves to provide a more complete picture of how MPD can be used for various purposes, at various levels and at different times, thus serving as

an extremely important tool to understand, predict and plan tourist destinations, and in general for the tourism sector.

2.3.3 The three most populated regions (at province levels) vs others

The first pattern analyzed was about a real brand, the second one was about a geographical common characteristic, and now, the third one is about a demographic characteristic. In this paragraph, we will see the two different behaviors of the three most populated regions, but keeping the province level, and the others. The provinces located in the most three populated regions are Madrid, Barcelona, Tarragona, Girona, Lleida, Malaga, Sevilla, Cordoba, Cadiz, Almeria, Huelva, Granada, and Jàen (Madrid, Cataluña, and Andalusia).

This comparison can be very interesting, especially in the first two summers after Covid, when tourists saw crowded destinations badly. Now, moving to data and maps, in Map 12 we can see the difference between the average TI of provinces located in the three most populated regions and the average TI of others, in the summer of 2020.



Map 12- Transition Index Average: comparison between Provinces located in the three most populated regions vs. Other Provinces (N° of tourists, 2020). Credit: My elaboration

The difference between the two values is notable. According to data, other provinces had a slightly better TI than provinces located in the most populated regions, this confirms that, at least for the first summer after the pandemic, the most populous localities have lost more tourist flows than the rest of the country.

The situation changes moving to the following summer, resumed in Map 13.



Map 13- Transition Index Average: comparison between Provinces located in the three most populated regions vs. Other Provinces (N° of tourists, 2021). Credit: My elaboration

In 2021, the provinces of Madrid, Cataluña, and Andalusia registered a high average Transition Index, around 0,93, which was pretty much the same as the rest of the country. Although the hierarchy was not changed, both groups analyzed registered, more or less, the same TI.

This map, therefore, highlights how although the pandemic situation was still in place, the provinces located in the most populated regions received domestic tourism flows that were closer to those pre-Covid. This trend was confirmed the following summer, as can be seen in Map 14, where provinces located in the most three populated regions registered a higher TI than the rest of the country.



Map 14- Transition Index Average: comparison between Provinces located in the three most populated regions vs. Other Provinces (N° of tourists, 2022). Credit: My elaboration

To give a more complete analysis, we can check data from ETR as well, building, in the same way, an average Transition Index for each group, using traditional statistics (TITD).

The following indexes have been directly developed using ETR reports (2019b, 2020b, 2021b, 2022b). Keeping 2019 data as the reference, in the 2020 summer the average TITD of Andalusia, Cataluña, and Madrid was around 0,81, while the average TITD related to the rest of the country was 0,84. So for this first summer after Covid, the gap between the two groups was more pronounced with ETR data than MPD.

Moving to the 2021 summer, the average TITD provided by ETR data shows a different situation than MPD results, with an average TITD of 1,04 for the group of Andalusia, Cataluña, and Madrid, and with an average TITD of 0,98. Recalling TI made with MPD, they were respectively 0,932 and 0,935.

In 2022, the average TITD for the three regions was 0,93, slightly lower than the rest of the country, which was 0,94. Thus, the ETR report about that summer gives us a framework opposed to that painted by the MPD.

Again, MPD and ETR data give different TI (or TITD), showing dissimilar scenarios qualitatively and quantitatively talking.

The continuous contrast between the results derived from official statistics and those of mobile phones must be used to obtain a more accurate and true-to-reality context, as much as possible. Based on these initial analyses, it would be desirable to continue experimenting with MPD related to the tourism sector, trying to understand how the latter can be used in a coordinated manner with the methodologies already in use.

In the last part of this paper, it will be shown another very significant characteristic of MPD. It will be analyzed outflows from Madrid, to understand if there have been significant changes after Covid shock.

2.4 Outflows from Madrid Analyzed by Mobile Phone Data

In paragraph 2.2, an analysis was made of the inflows for each Spanish province and their change following the advent of Covid. Then, an index was built, with reference to 2019, to assess how the arrivals of domestic tourism have changed in the 3 summers following the outbreak of the pandemic.

In this section, we are going to observe the opposite, we are going to see the outflows from the province of Madrid to others. To do this, we aren't going to use an index, but we are going to use percentages. For each year, from 2019 to 2022, we are going to analyze the 3 summer months, calculating the total number of outflows from Madrid for each summer, and then showing which provinces received the most tourists from Madrid.

Starting from 2019, Figure 15 shows the distribution of outflows from Madrid toward other provinces.



Map 15- Distribution of Outflows from Madrid, summer of 2019. Credit: my elaboration.

The summer of 2019 represents the starting point for this analysis as well. In the three summer months, according to MPD provided by INE¹⁰, there have been 12.436.748 travelers that left Madrid to reach another province. The main destination was Toledo, which received around 11,08% of total outflows from the capital, probably due to its proximity. The second province was Alicante with 8,04%, Alicante has been the preferred maritime destination for residents of Madrid. Subsequently, we find two other provinces bordering Madrid, Guadalajara, and Avila, respectively with 6.26% and 6.13%. Then follows Valencia with 4.70% (a second province on the sea), and Segovia with 4.66% (another neighboring province). Malaga and Cadiz received a similar number of travelers, 3,50% and 3,28%. To conclude, we find Asturias with 2,99%, the only provinces from the north, and Cuenca with 2,75% of total outflows from Madrid.

As for the islands, the Canaries received fewer tourists than the Balearic Islands, Las Palmas got 0.85% while Santa Cruz de Tenerife only 0.60%, and the Balearic Islands received 1.94% of the tourist flows leaving Madrid.

Provinces such as Caceres (2,74%), Ciudad Real (2,60%), Murcia (2,41%), and Castellon (2,45%) received more flows than Barcelona (2,03%). The rest of the provinces received flows of around

¹⁰ Spanish Statistical Office. (n.d.). *Experimental statistics. Main menu.* INE. https://www.ine.es/experimental/turismo_moviles/experimental_turismo_moviles_interior.htm?L=1

1% or less. The worst province was Lleida, which received only 0,19% of outflows coming from Madrid, Teruel was close with only 0,22%. In general, apart from Barcelona, Catalonia has been visited little by residents in Madrid (Tarragona 0,67%, Girona 0,47%). So, talking only about coastal provinces, Alicante and Valencia were the first choice, followed by Andalusia, with Malaga and Cadiz.

Predictably, in the summer of 2020, the number of tourists coming from Madrid was lower than in 2019, with 10.241.044 detected travelers. Figure 16 illustrates that the first destination remained Toledo with 12,49%, a plus of almost 1,5 percent on the previous summer. The second one was again Alicante with 8,32%, which reconfirms again as the first coastal province for Madrid's residents.



Map 16- Distribution of Outflows from Madrid, summer of 2020. Credit: my elaboration.

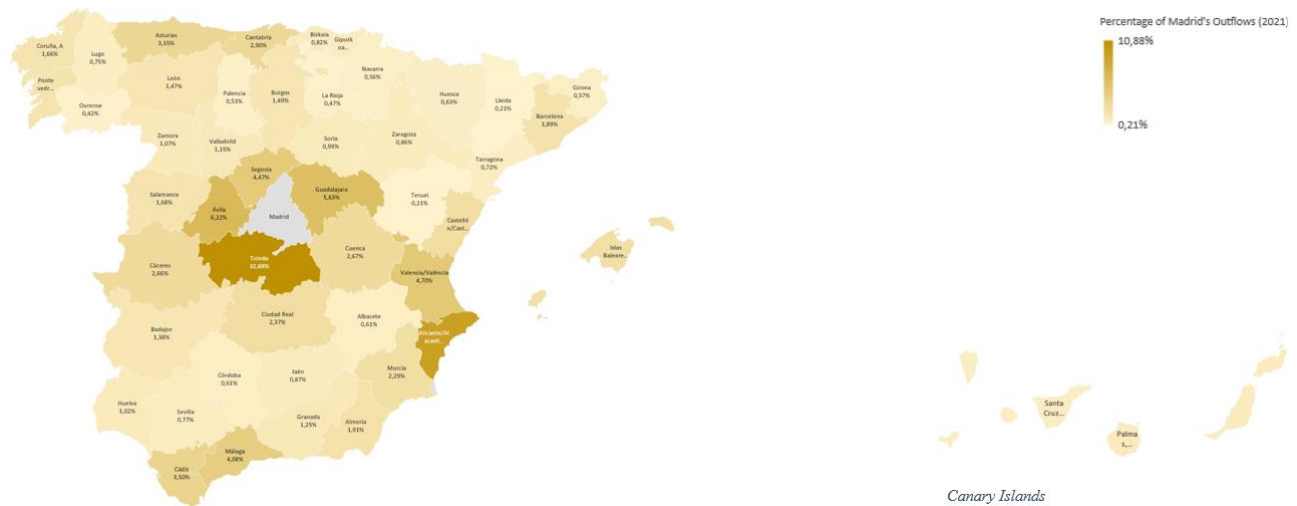
The provinces that surround Madrid were visited more, Avila, Guadalajara, and Segovia have respectively received 7,09%, 7,01%, and 5,24%. This growth of flows to the neighboring provinces has been probably a consequence of Covid. The climate of uncertainty that characterized the summer of 2020, has led many people to move and move in the areas surrounding their residences.

Valencia has kept more or less the same percentage, with a 4,58%, remaining the second coastal province hit by Madrid outflows. Then, we find Malaga with one percentage point less than Valencia. Asturias increased a bit its market share, reaching 3,33%. Finally, we find Cadiz with 3,14% and Cuenca with 3,03%.

The situation regarding the islands remained almost unchanged since the previous year, with the Balearics receiving more tourists (1.73%) than the Canaries (0.72% for Las Palmas and 0.54% for Santa Cruz de Tenerife). Barcelona registered fewer arrivals than in 2019 (1,12%), while provinces such as Caceres (2,87%), Ciudad Real (2,54%), and Murcia (2,22%), have been on the same level. Castellon's arrivals dropped by almost 0,50% (2,08%). The rest of the provinces received a little percentage of tourist flows, from 1,5% to 0,60%. Also for the 2020 summer, the worst province was Lleida (0,15%) Teruel had a very similar situation (0,19%). But, in general, Cataluña had low values (Tarragona 0,44% and Girona 0,34%), the same pattern as the year before.

In the 2020 summer, we saw how Covid changed the distribution of the outflows, making easier proximity tourism despite faraway destinations.

Continuing with the analysis, we move on to the summer of 2021, graphically represented in Figure 17. The total number of outflows from Madrid was 11.955.650, there was an increase rather than in 2020 of over 1.500.000.



Map 17- Distribution of Outflows from Madrid, summer of 2021. Credit: my elaboration.

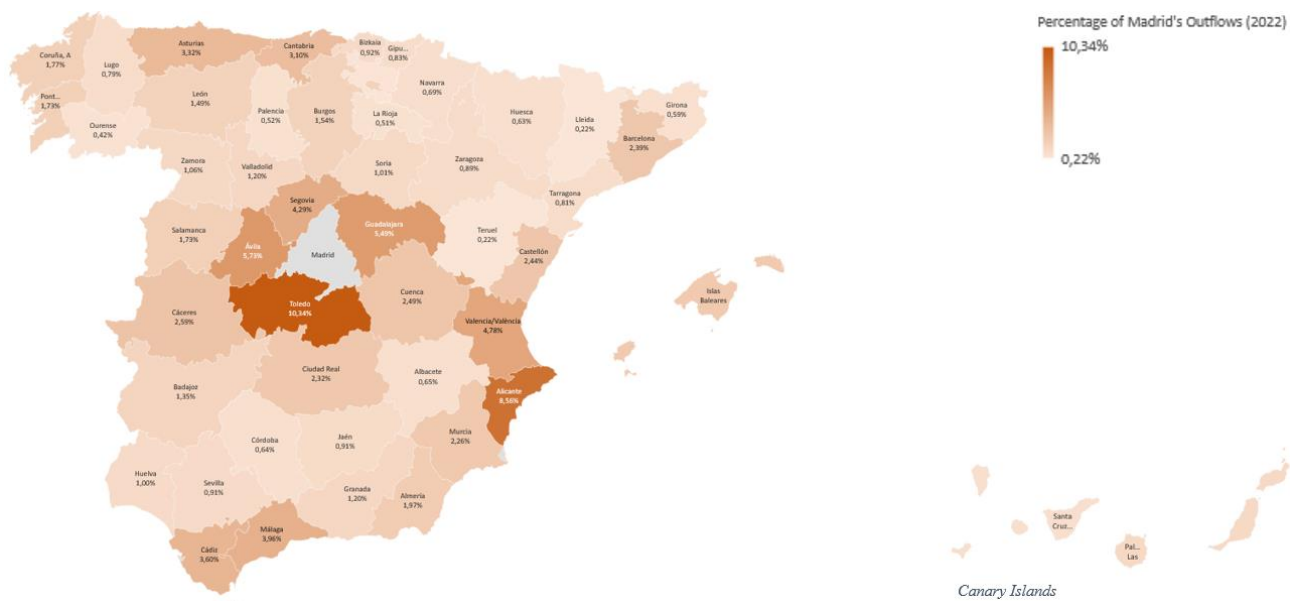
For the third consecutive summer, Toledo was the most visited province by Madrid’s residents, with 10,88% of the total outflows from the capital. As in the previous two summers, after Toledo there is Alicante, but in 2021 its percentage increased rather than previous years, reaching 9,03%. After the peak of summer 2020, Avila, Guadalajara, and Segovia returned on 2019 values, respectively with 6,22%, 5,63%, and 4,47%. Probably, the improvement of the pandemic situation has brought greater peace of mind in the population, which then has resumed to move to provinces further away from the country of origin. Valencia remained the second most visited coastal province, with 4,70%. Then, we find again the two Andalusia provinces, Malaga and Cadiz, with 4,08% and 3,50%. Asturias maintained more or less its percentage, with 3,15%. Lastly, we find a new entry, the province of Cantabria, with 2,90%, another province from the north.

Moving to other provinces, the hierarchies of the islands remained the same, but with higher percentages for all. The Balearics remain the most beaten (2.15%), while in the Canaries, Las Palmas (0.92%) received more arrivals than Santa Cruz de Tenerife (0.68%).

For the third summer, Ciudad Real (2,37%), Caceres (2,66%), and Murcia (2,29%) registered similar values higher than Barcelona (1,89%). Other provinces registered values in a range between 1,60% and 0,60%, more or less. The worst province for the third year was Lleida, but this time it

tied with Teruel, both 0,21%. The low values trend of Cataluña continued for 2021 as well, (Tarragona 0,67% and Girona 0,47%).

The last analyzed summer is 2022, graphically resumed in Figure 18. The total number of people that left Madrid was a bit lower than the previous summer, it was 11.326.753, a decrease of more than 500.000.



Map 18- Distribution of Outflows from Madrid, summer of 2022. Credit: my elaboration.

If in the summer of 2021, the provinces around Madrid had returned to the pre-Covid level, in 2022 they lost further tourist flows coming from the capital, recording the lowest distribution percentages between the 4 summers analyzed. Anyway, Toledo remained the first visited province, receiving the 10,34% of the total tourist outflows coming from Madrid in the 2022 summer. Alicante, with 8,56%, was the second most visited province, it has kept this position since 2019. Then, we find Avila, Guadalajara, and Segovia, other neighboring provinces, which recorded a drop in arrivals from Madrid, respectively with 5,73%, 5,49%, and 4,29%. In the middle, it was placed Valencia, with 4,78%. Malaga, Cadiz, Asturias, and Cantabria have increased their market share, capturing, probably, a part of the flow that was no longer received by the neighboring provinces mentioned above.

The two Andalusia provinces totalized around 3,96% (Malaga) and 3,60% (Cadiz). Asturias and Cantabria, the provinces of the north, were around 3,32% and 3,10%.

For the fourth year in a row, the Balearic Islands (2,17%) got more tourists from Madrid than the Canary Islands (Las Palmas 1,01% and Santa Cruz de Tenerife 0,66%). The worst province was Lleida, even this year together with Teruel, both 0,22%. In Catalonia, the same situation has occurred as in previous years, so except for Barcelona, the other provinces have received only a small percentage of tourist flows from Madrid.

In conclusion, there haven't been significant changes in these four summers. There was an increase in proximity flows in 2020, which came back suddenly to a pre-pandemic level in 2021. Since 2019, the provinces of the north, Asturias and Cantabria have gained more and more market share, with constant growth. About islands, the hierarchy never changed, with the Balearic Islands that have always been preferred over the Canary Islands, but both increased their percentages, reaching the peak, in the summer of 2022. The provinces that have been most hit by outflows from Madrid are located nearby, such as Toledo, which was the most visited for all four summers, but also Guadalajara, Avila, and Segovia. Having analyzed summer months, Alicante has been surely the first coastal province visited by residents in Madrid, and the second one considering all provinces, for all four summers. With Alicante, Valencia has received a good level of tourist flow, making the Comunidad Valenciana the first coastal region for Madrid inhabitants. It is followed by Andalusia, thanks to Malaga and Cadiz, both have been visited with constant values for all four years. The region with the worst tourist flow from Madrid has been Cataluña, for all 4 summers Lleida has been the province with the lowest percentage of tourists from the capital, and Tarragona and Girona had low percentages as well. A bit better was done by Barcelona, but not enough to compensate others. If in 2021 there was a return to a pre-pandemic level, in 2022 there was a little change in the distribution. The neighboring provinces lost a few tourist flows in favor of faraway provinces.

Through this analysis, we have seen how MPD can be used to analyze in depth a tourism destination, such as a region, a province, or even a municipality. MPD makes it possible to build a clear frame of tourist inflows and outflows, linking destinations, origin points, and destination points.

Conclusion

In the first part of this thesis, we have seen how MPD works, illustrating advantages and possible problems. Being an experimental statistic, new problems can come out during its use. We have seen how Mobile Phone Data can offer help to Tourism, helping manage tourism's complexity.

Then, it has been illustrated previous uses of MPD, in the tourist fields and others. Venice and Barcelona experienced, on a small scale and mixed with other technologies, how mobile tracking can be useful to collect insight into tourism phenomena. Previous uses were tested by Florence and Spain as well but in a different field. These two subjects analyzed Mobile Phone Data to understand residents' mobility. Spain is advancing its project to improve the methodology for population census. In the latter census, it implemented the use of MPD.

Describing functionalities, characteristics, and previous uses, the first huge advantage of using MPD came out, it is the availability time of data. Traditional data can take over a year to be available, while MPD is available after only two months. It is clear how the availability of MPD can make all the difference, allowing people to analyze phenomena almost in real time.

The second part of the paper has shown two possible uses of MPD in the tourism field. It was conducted an analysis, where Spanish provinces have been compared through their Transition Index (an indicator that shows how domestic tourism changed across summers, keeping the 2019 one as a reference). First, this comparison was made among all provinces (apart from Ceuta and Melilla) and across the summer months of 2020, 2021, and 2022. Then, it was compared patterns against the rest of the country. These comparisons pointed out one possible use of MPD applied to the tourism world. The high flexibility ensures the use of MPD facilitates the study of tourist phenomena; it allows you to personalize your research using data only about areas that you are interested in. In describing and showing the results obtained from Mobile Phone Data, we used data traditionally in use, those taken from ETRs, to understand the differences between these two approaches. I found that the TI made with data taken from ETR is generally more optimistic than the one made with

MPD. Whereas, at the level of absolute numbers recorded, MPD has always recorded more tourist arrivals (deriving from the internal market) than those present in the ETR reports. This probably means that MPD shows more precisely tourism flows than ETR, in terms of absolute numbers and quality of values. Anyway, despite the differences, the general frame drawn by the two methodologies must be, more or less, the same. The differences must exist because the two methodologies use different ways to collect data: MPD is a direct collection of the data through the mobile phone signal, instead, the ETR is a calculation based on surveys that cover directly only a small percentage of the population. But the final result needs to be similar, in a contrary case, there would be something wrong.

In the last part of the thesis, I took into analysis the tourist outflows from Madrid to other provinces, always keeping the three summer months as a reference period. This analysis explains another possible use of MPD data in the tourism field. It was shown how helpful can be to track the tourist outflows from a certain origin point to several destinations, looking at the same period, aiming to collect detailed and helpful information, which could be significant for different purposes.

The two advantages described and shown in this paper are useful to demonstrate a significant peculiarity of using MPD, that is the incredible geographic accuracy, which can still be very high at the municipal level as well. It wasn't possible to go so deep into this thesis, MPD's municipal data is available but it needs a lot of time and a specific program to be managed efficiently.

After having analyzed tourist inflows and outflows, MPD data allows you to cross these flows, building a model that shows inflows and outflows from and to specific destinations, which can be a region, a province, or a municipality, all without losing geographical accuracy.

All the uses presented in this thesis aim to study something that has already happened, with the purpose to collect information, knowing better certain phenomena, developing strategies, and so on.

But MPD could be used in another way, it could be used to build a Gravity Model, with the end to analyze and identify patterns and changes in tourism flows, and maybe trying to predict possible future evolution of them.

Our results seem to indicate that MPD is a sensible way to collect data on tourism flows. Therefore, future research might use this data to study many tourism phenomena. For example, a promising study might consider MPD data to estimate a gravity model for Spanish destinations with high geographical detail. In a similar spirit, Carta and Rodriguez (2022) used non-traditional data based on credit cards to estimate a gravity model for Spanish provinces. However, the author did not explore the high level of geographical detail that MPD data allows.

MPD can be used as well with other technologies or with other subjects: for instance, it can be used in marketing or in studying spatial and urban evolution of spaces and places.

So, in conclusion, this thesis shows some of the potentials that MPD could have if applied seriously to the world of tourism. Its involvement is still low, and more research is needed, but MPD should start to be considered in the analysis and study of tourism phenomena.

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