BARCELONA: Boosting Accessibility and Rideshare Convenience through Efficient Local Operations in Non-optimal Areas

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***Abstract*—Barcelona's heavy investment in public transportation currently leaves little room for private ride-hailing services. However, this study proposes that Uber partner with hotels to expand its regional market share. This study examines how Uber can partner specifically with hotels to broaden its reach among tourists in the area. Using historical transportation data, hotel geolocations, and emigration/immigration/population data, we analyze areas of Barcelona to find the optimal hotels that can be used to strategically compete with public transportation. In these hotel partnerships, Uber will offer discounted rates that can compete with public transportation as a foot-in-the-door technique. This paper offers valuable insights into how Uber can gain a competitive advantage in the region by creating a new revenue stream.**

***Index Terms*—Hotel partnerships, public transportation, ride-sharing**

I. Introduction

In the status quo, Barcelona has created an extensive network for its public transportation, including buses, underground subways, railways, cableways, and more. As a result, every year, upwards of 1 billion trips are made for tourists and residents with Barcelona's public transportation [1]. Barcelona has also been promoting its public transportation by heavily regulating ride-hailing platforms, such as Uber, which hinders these platforms' financial growth [2]. Specifically, the Barcelonian government has been pushing for legislation that limits the number of licenses that can be given to drivers using ride-hailing apps like Uber, which is meant to help proliferate the city's public transportation while diminishing the growth potential of Uber [3]. To Barcelona's government, with Uber drivers operating without licenses and, in some cases, not paying taxes, Uber was, in the eyes of the government, a non-compliant taxi company. This resulted in Barcelona declaring Uber's service illegal throughout the whole country [4]. However, with a recent European Union (EU) court ruling that overturned many of the regulations placed by the Barcelonian Government, the Barcelonian tourism industry has been reopened to ride-hailing apps, such as Uber, providing access to a market with 12 million tourists [3] [5]. In fact, in 2022, around 30 million hotel stays were recorded in Barcelona, but there was only a permanent population of around 1.5 million, implying that a large proportion of people within Barcelona at any given time are tourists [6]. While residents are reliant on and well-versed in Barcelona's sprawling transportation network, many tourists will ignore public transit entirely due to language barriers or other factors. This leaves the vast majority of tourists as potential customers for ride-hailing services such as Uber.

II. Materials and Methods

A. Equations

In the following equation, N refers to the total number of people traveling to and from a district in 2017, T refers to the total number of people employed in that district, and P_{weight} is the population weight defined as the location population divided by the maximum population in that district. Gamma is the final travel coefficient for that district.1.

$$(N/T) * 100 P_{weight} = \gamma \tag{1}$$

$$(P_{District}/max(P_{District})) = P_{weight} \tag{2}$$

B. Dataset Description

The datasets utilized in this proposal were provided by the 2023 Virtual Global Hackathon. Population data describes the number of people within each neighborhood in Barcelona. Unemployment data features the number of unemployed citizens within each neighborhood in Barcelona. Immigration data includes the number of people going to and from a certain district within Barcelona. Transport data for Barcelona describes different transportation locations within the city. Bus stop data for Barcelona included the locations of bus stops within the city. All the datasets mentioned above pertain to the year 2017.

C. Feature Extraction

Features *total unemployed* and *percentage unemployed* were calculated for each district. *Total unemployed* was calculated by summing the number of people unemployed in each neighborhood within a district. *Percentage unemployed* was obtained by dividing *total unemployed* by the total population of each district. The feature *number of people to and from* is

Fig. 1. Heat map of Barcelona representing the concentration of transportation stops within each district of the city as well as the size of each district. Lighter shades of red represent a lower concentration while darker shades represent a higher concentration.

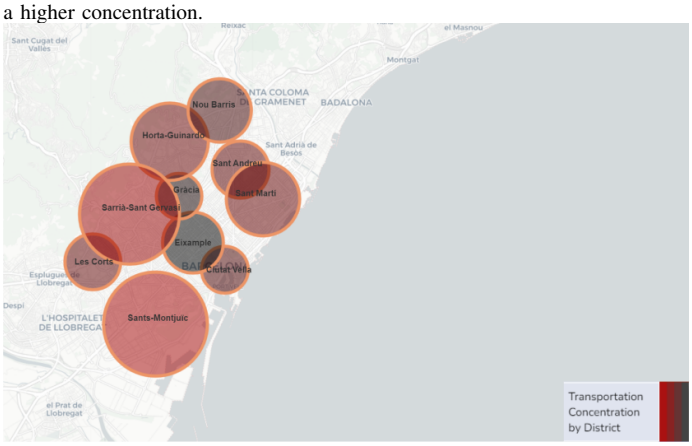
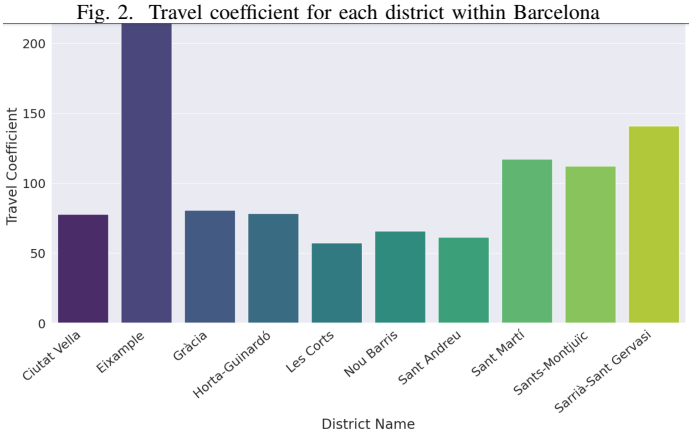


Fig. 2. Travel coefficient for each district within Barcelona



calculated by summing the total number of people traveling to and from a certain district. By using these features, a travel coefficient for each district is calculated by equation 1. This equation favors locations with a higher number of people traveling to and from the location while penalizing those with a higher number of unemployed citizens. To favor locations with a higher population, the resulting number is multiplied by a population weight factor defined by equation 2. The hotels in Eixample were found using Google Maps API as well as the googlemaps library in Python. By using the *places nearby* function in the Google Maps API, detailed info about all lodging place types within a 3km radius - approximately the radius of Eixample - of the center of Eixample was found. These hotels were then checked and filtered to make certain that all hotels were within Eixample and not in the outskirts of another district. To calculate the efficiency of driving when compared to using public transport to various locations, the five most visited attractions in Barcelona according to TripAdvisor - Basílica de la Sagrada Familia, Palace of Catalan Music, Gothic Quarter, Casa Batlló, and Park Güell - were considered. The duration of time it would take to travel from each hotel found in Eixample to each chosen attraction was calculated using the Google Maps API. Finally, to compare transit and driving durations, a *net time* was found for each hotel, where *net time* is the total time by transit subtracted by total time by driving for each hotel. Positive values for *net time* indicate higher driving efficiency and lower values for *net time* indicate lower driving efficiency. Additionally, for each trip duration calculated, the number of occurrences of driving being faster than transit and vice versa was recorded. To extract data on which of these hotels would be optimal to conduct business with, several factors were considered. The first factor considered was the number of transportation stops that were closest to a particular hotel. These totals were calculated for each hotel. Then, the time required to travel between a particular hotel and the five most popular tourist attractions was totaled for each hotel. Lastly, the number of routes, for which traveling between a given hotel and a given tourist attraction was faster by car rather than other forms of transportation, was tallied for each hotel. Each of the three collected stats for each hotel were than scaled between 0 and 1. Because we are aiming to maximize the cumulative time and number of routes, the resulting values are subtracted from 1. By doing this process, higher values are treated as smaller values and the sum of all three hotel stats can then be minimized.

Once the best district within Barcelona was found, the next step was analyzing Eixample itself. Fig. 3 analyzes hotels within the district of Eixample. Each hotel considers the number of transportation stops that are closest to it. The results are converted into a heatmap-like graph relative to transportation stops. From analyzing this graph, one can clearly see that lighter hotels are focused toward the coastline of Eixample. Hotels closer to the mainland of Barcelona are far more concentrated in terms of transportation and are not the hotels we plan on targeting.

Fig 4 continues the analysis of different hotels within Eixample. The graph uses five different landmark locations and analyzes the efficiency between the hotels and a given landmark in terms of transportation time. For example, given a hotel x and landmark y, the average time taken by car and other transportation between x and y are considered. Times in which the car provides a faster commute time are represented on the graph by ”greener” colors. Analyzing the graph, one can see that coastline hotels once again are favored compared to hotels that are more in-land.

D. Data Analysis

Repository: https://github.com/rishikanchi/FremdUGH

In order to narrow down the vast city of Barcelona to one specific district to first implement our proposal, a travel coefficient was created, since it uses population, unemployment, and immigration/emigration to uncover the most populated and employed district, both of which are key in having a large customer base for the service. Fig. 1 shows the size of each district and the concentration of transportation stops

within the respective district. However, the graph doesn't consider population or employment. Fig. 2 displays the travel coefficient for every district in Barcelona, clearly displaying Eixample as the most favorable district. Eixample has a travel coefficient of just over 200, almost doubling any other city. The district of Eixample is also the most densely populated district, creating more business for Uber.

Fig. 5 analyzes data that combines information from Fig. 3 and Fig. 4. Fig. 5 is a final representation of which hotels should be targeted in Eixample. When considering the graph, it is evident that, when considering information for each hotel, hotels near the coastline of Barcelona, and on the outskirts of the district are best for Uber to begin business with.

Fig. 6 provides a pie chart that represents the importance and necessity of Uber within Eixample. The graph shows that when traveling from a certain hotel to a certain landmark, 91 percent of times will it be faster to travel by car versus other forms of public transit. This is a crucial piece of information that shows the potential efficiency of Uber vehicles that could replace slower forms of public transit.

E. Foot-in-the-Door Technique

The foot-in-the-door technique, where a person is presented with small requests that virtually all agree to, only to be presented with a larger request, is a common technique used in sales. For example, a salesman may keep the door from shutting with his foot, giving the customer no choice but to listen to the sales pitch. In the 1966 study titled, "Compliance Without Pressure: The Foot-in-the-Door Technique.", participants were asked for a small request by telephone only to be later asked for a larger request in person. The small request was for subjects to report on the type of cleaning products they used and the larger request was for subjects to allow a researcher in their home to examine their products and usage. When compared with the control group, who were not initially approached with the phone call, the subjects who had first responded positively to the first request were 135% more likely to respond positively to the second request. [7]. When applied to Uber's presence in Barcelona, giving potential customers an initial discount acts as an initial request and makes customers more inclined to use Uber in the future.

III. Results

From our analysis, we found that the following hotels are our target hotels: Generator Barcelona, Hotel NH Barcelona Stadium, Iberostar Selection Paseo de Gracia, Hotel Best 4 Barcelona, and Hola Hostal Eixample. By partnering with these hotels, a discounted price for hotel guests to use Uber is given while simultaneously providing the hotels with more customers and profit because of this enticing price. This benefits both Uber and the hotels. To find an optimal percentage discount, we referred to a study that solicited potential newspaper subscribers [8]. The researchers in this study offered a two-week trial subscription at either full price, half, price, for free, or for free along with a gift card at a local restaurant [8]. The only trial offer that was significantly more effective than purely cold-calling potential subscribers was the 50% discount. [8]. By offering the optimal 50% discount on Uber rides for guests at the target hotels, we expect the total number of Uber rides within Barcelona to rise. However, the discount can only be used a maximum of 3 times per family staying at a target hotel (guests staying at a single hotel room). This was done so tourists will be allured by the discounted aspect of the Uber ride, but convinced to continue using Uber even after the discount fades, from the reliability, ease, and efficiency of Uber. To quantify our results with Eq 3, we calculated the total number of families (upper bound estimate which assumes that all families would be using the Uber

Fig. 3. Scatter plot/heat map of the Eixample district within Barcelona. Squares represent hotels while circles are different transportation stops described in the legend. Additionally, lighter shades of red mean that the particular hotel has fewer transportation stops nearby, while darker shades are more concentrated in terms of transportation stops.

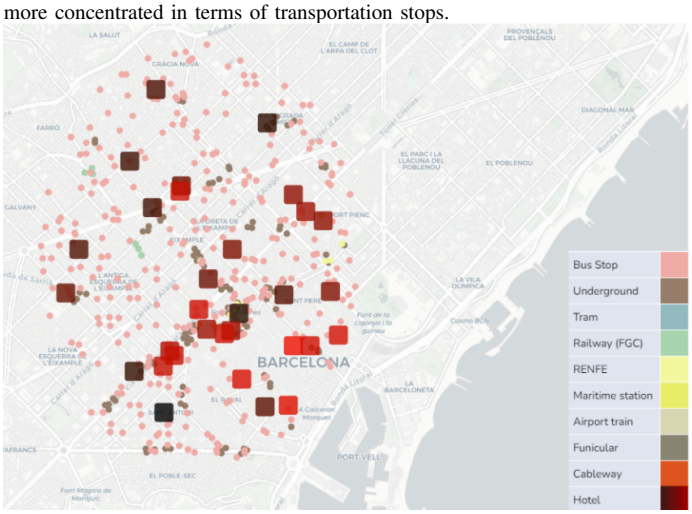


Fig. 4. Marker map of hotels in the Eixample district within Barcelona displaying the hotels' efficiency of driving compared to using public transit to go to various popular attractions in Barcelona calculated by duration. The figure displays small gray circles that represent bus and other transit stops as well as bigger circles that represent hotels, with shades closer to green representing higher driving efficiency shades closer to red representing low driving efficiency.

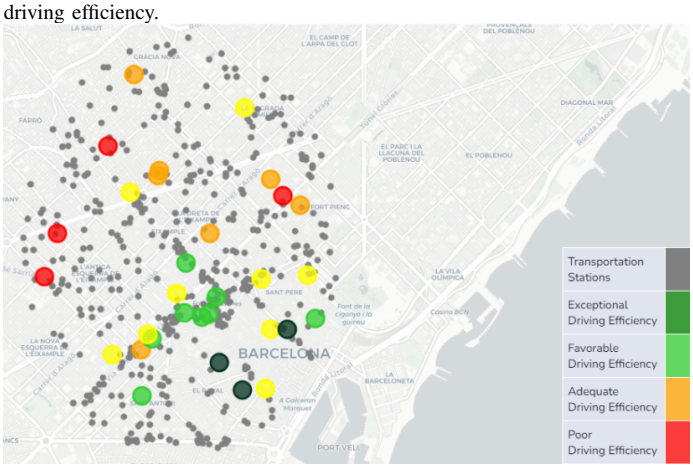


Fig. 5. Graph of hotels considered with the Eixample district. Those with red stars are hotels Uber should target.

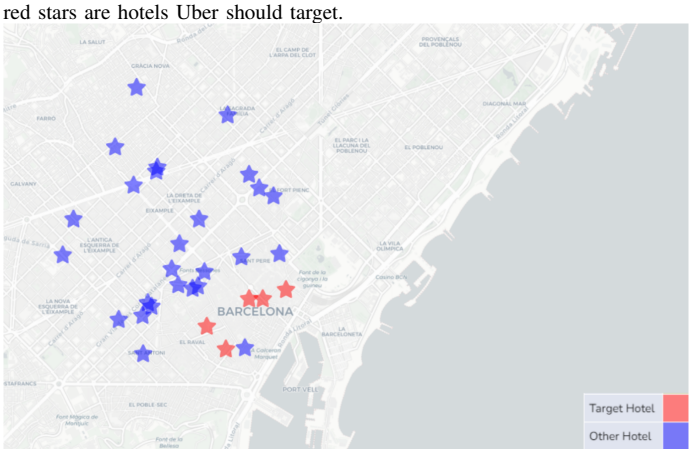
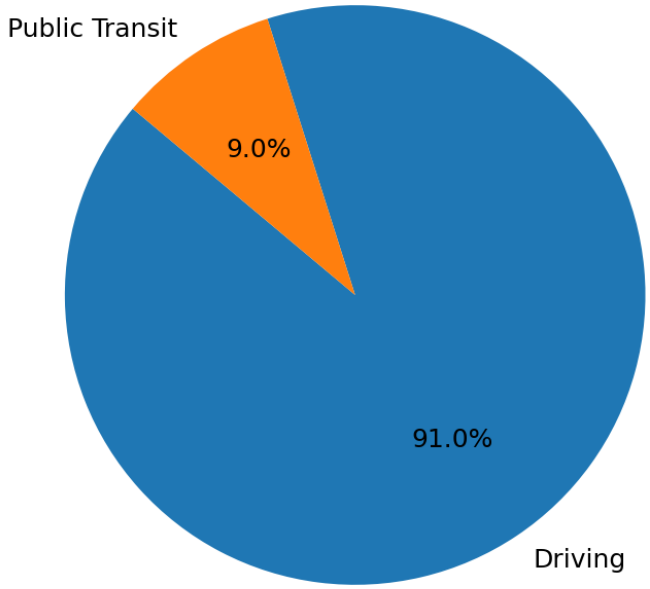


Fig. 6. Pie chart displaying the fastest mode of transportation for various trips from hotels in Eixample to popular attractions in Barcelona.



discount), N, that visit the 5 hotels per day, and multiplied that by 365 days to get a product that describes the number of families that visit the 5 target hotels in a year. Finally, that product is multiplied with T, the least number of trips we can estimate (lower bound estimate) a family to make with Uber, which is 2 trips to and from a single place within Barcelona. Equation 3 displays the total expected Uber trips from the target hotels within a year, which calculates to 464,280 trips annually. According to TripAdvisor the average cost of an Uber ride within Barcelona is €24. By multiplying the average cost of a trip at the discounted rate with the cumulative number of trips done with the target hotels, we found that this solution, at a bare minimum, will garner approximately €5,571,360 in earnings every year.

$$N_{Families} * 365_{Days} * T = Y_{Trips} \tag{3}$$

IV. Discussion

Throughout the data collection and analysis part of this project, there were several issues we encountered. For one, much of the data provided was from 2017, making conclusions about - including but not limited to - the number and location of transportation stops, population, and the unemployment rate potentially outdated. Certain locations were too far away from the districts we were considering, and those were eliminated from our data collection process. Additionally, although originally intending to use bus stop data, further research highlighted the importance of other forms of public transportation within Barcelona, such as trams, metro, and others. Therefore, in our subsequent data analysis, all forms of public transportation were considered to have a better representation of travel within Barcelona. Furthermore, an accurate estimate of the number of hotel guests was difficult to find, which is something that could be improved for a more precise estimate of potential target hotels. Due to the limitations of our technology, we were unable to find driving and transit duration to tourist attractions for more than the five attractions we utilized. If we had stronger computing power, we could have used more attractions to achieve a more accurate prediction of the hotels where it is optimal to drive instead of using transit.

Our results reveal the potential untapped market of ride-sharing in Barcelona and how Uber can partner with hotels to break into that market through offering discounts to tourists as a foot-in-the-door technique. We found target hotels for this technique by looking for hotels in Eixample, the district which we found was most optimal for Uber to begin operations in, where the duration of using public transportation to a selection of five popular tourists destinations was longer than the duration of driving to that destination. From the 31 hotels that we selected in Eixample, we narrowed down our search to the top five where the difference between the durations was the largest.

In the future, this method should be expanded to hotels across Barcelona, not just the five included in this paper.

This uniquely made solution that used data analysis to tailor-fit our implementation with Barcelona's transportation and hotel usage will see a massive increase in the number of Uber rides taken every year.

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