WIFI Hotspots in Barcelona

Operations Management - Final Project

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Outline

1. Introduction

The aim of this report is to analyze the distribution of WiFi hotspots in the city of Barcelona. More concretely, the focus is to determine potential locations where free WiFi hotspots are missing. We believe that this is an interesting subject of study as Barcelona is considered one of the world's leading tourist, economic, trade fair and cultural centers. Therefore, to maintain its reputation, the city has to keep improving the services offered to its visitors. Closely related, having free internet access has become a must nowadays, especially for travelers, whether for social network use or for the search of information. For this reason, Barcelona should offer the best WiFi experience.

The decision of determining the potential locations, will be based on the comparative analysis of existing WiFi hotspots and the potential users, both, local citizens and tourists. For this, the data used has been retrieved from "Open Data BCN database". On the one hand, the density of Barcelona's population in terms of inhabitants per unit of surface. On the other hand, the tourist housing in the city of Barcelona as a proxy of where the tourists are located. With regard to the WiFi, the data used is the WiFi access points located in various municipal amenities and public access points. There are many ways to get free internet access in the city, such as hotels or bars, but we have decided to choose "WiFi Barcelona" as those are the hotspots provided by Barcelona's city hall.

Lastly, the increasing tendency of customers demanding high quality, high service and fast delivery, involves many Operations Management decisions. For this reason, we considered that the WiFi location analysis is a suitable study subject to apply many of the concepts learned in the course. The internet access provision is considered a service, but operations strategies can also be applied in services, and not only in goods. The concrete focus of this project is a location strategy problem and design of logistic network. However, more than assignment of warehouses or distribution centers, the core here is the assignment of WiFi hotspots, which would be the equivalent of sales points for goods. All the solution proposals that will be provided will be based on basic data analysis.

2. Analysis

2.1. Variables

2.1.1. WIFI Barcelona

Barcelona has a wide spread WiFi network giving mobile access to many people on a daily basis, which is an Barcelona City Council service. Overall the city counts 590 spots distributed on 10 different districts which enable users to connect to the internet. One characteristic of the Barcelona WiFi is that it is free and does not charge any fee to the user or ask for specific access information (password, username,etc.).

Furthermore, the city's WiFi network is the biggest free one in Spain and is also on the european level one of the best. It mainly operates in municipal spaces as well as public spaces, aiming to reach citizens and tourists. Such public spaces can be for instance cultural centers and museums, libraries, bus networks, on street, sport centers, and many more.

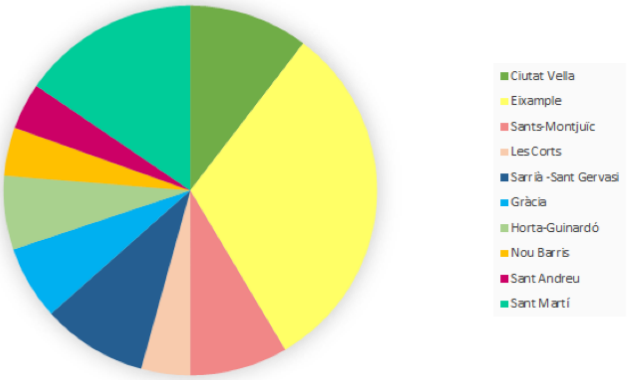


Figure 1: Amount of WiFi Hotspots

Its 590 WiFi hotspots are mostly located in Eixample, followed by Sant Marti. Even though the latter one is mostly residential, big shopping malls like "Diagonal Mar" and "Glories" could be indicators for the second largest amount of WiFi hotspots. Eixample known for being one of the top shopping areas of Barcelona, it has more to offer like Gaudi's architecture in Passeig de Gracia or the Sagrada Familia, which draws the attention of many people every day. With 10%, 8% and 9% the areas Ciutat Vella, Sants Montjuïc and Sarrià-Sant Gervasi are the ones following regarding the amount of WiFi hotspots, respectively. These areas contain among other ones the sightseeing spots Magic Fountain of Montjuïc, the Gothic Quarter, La Rambla, the Cathedral of Barcelona or also many shopping streets.

2.1.2. Tourists

Tourism is one of the main sources of revenues for the city, in 2018 Barcelona accounted for around 9.12 million tourists in hotels, in 2019 the overall number amounted to 32 million. In this analysis the tourist housings are taken into consideration to represent the distribution of tourists in the city. Thus, Eixample constitutes almost half of all tourist housings (42%), followed by Gracia (14%), Sant Marti (13%) and Sant-Montjuic (13%).

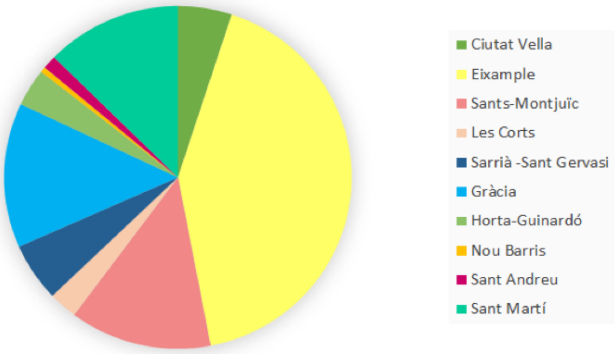


Figure 2: Amount of Tourists housings

This would mean on a yearly basis, taking the overall number of tourists in 2019 into account, that around 87.671 tourists have been every day in Barcelona with the following allocation on districts (not taking into account the seasons and standard deviations). This leads to the assumption that the city has a big potential of reaching thousands of people every day and offering services. Consequently, the theory arises that, with strategic positioning of advertising on the landing page while entering the free WiFi, the Barcelona City Council Service could charge money from companies which want publicity for their business.

	Ciutat Vella	*Eixample*	*Sants Montjuic*	*Les Corts*	*Sarria Sant Gervasi*	*Gracia*	*Horta Guinardo*	*Nou Barris*	*Sant Andreu*	*Sant Marti*
%Amount of Housings	0,05	0,42	0,13	0,03	0,06	0,14	0,04	0,01	0,01	0,13
Tourists in million (day)	4399	36789	11577	2342	4837	11971	3108	460	1116	11074

Figure 3: Tourists housings (%) and Tourists in Million (day)

2.1.3. Local citizens

In order to specify the need of local WiFi spots in different districts of Barcelona, we assume that depending on the demographic profile of the population in the city, specifically the age of the inhabitants, can be a determining variable. Therefore, the dataset was

analyzed in the first part regarding the percentage amount of inhabitants in each setted age interval per district without a dependency to the other areas, and in the second step the percentage of inhabitants in each district per age interval. The observed age intervals are 10-15 years, 16-20 years, 21-30 years, 31-40 years, 41-60 years, 61-80 years and 80 years and more. This distribution allows us to gain an overview about the demographic groups: children, teenagers, young adults/students, young adults/workers, workers, retired adults and older people.

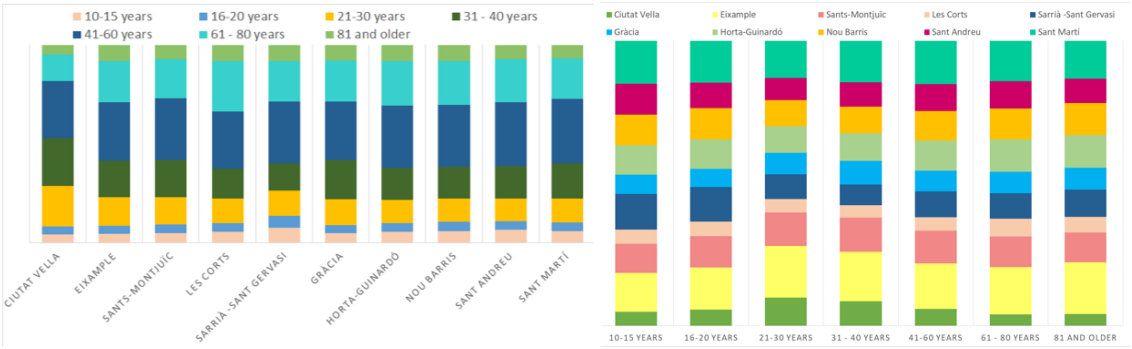


Figure 4: Frequency distribution of age category by district

Having a look on the age distribution per district, one can say that the population in Ciutat Vella is generally speaking younger than in other districts, with 53% of “10-40 years” and only 18% of “61 and older” compared to Les Corts with the smallest amount of youngsters in this age range with 37% and almost the same amount of “61 and older”, namely 34%. The group “41-60 years” has a quite equal allocation throughout all areas.

The distribution of the districts per age rates looks on the whole fairly balanced, whereby in Sarria-Sant Gervasi the percentage amount of “10-20 year” old people is higher than in the other age rates, as well as for Ciutat Vella the percentage amount of “21-40 year” old inhabitants is higher than in other ages. These observations might be due to the fact that in the north of Barcelona more families with children do live and in Ciutat Vella may be more students located.

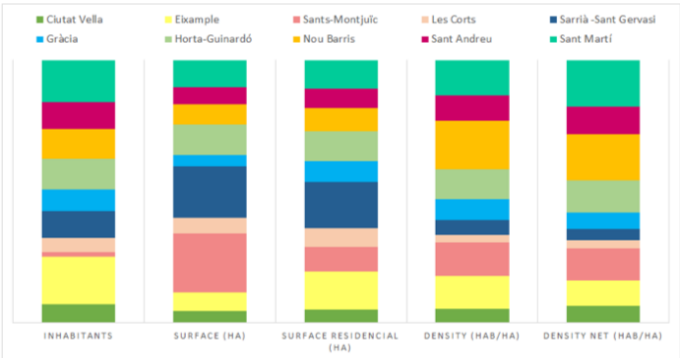


Figure 5: Inhabitants, surface and density distribution by district.

2.2. Relation between the variables

Once we have done an analysis of the variables individually, we would like to see if there is any relation among them. To do so, we have run simple correlations between the variables to see if the number of WiFi access points per district are related to the potential users in each area in terms of both, tourists and local citizens living there.

<u>WIFI hotspots and Tourist Housing</u>

Firstly, we have analyzed the relation between the WiFi hotspots per district to the number of tourists housing in the area as a proxy of where the tourists are concentrated in the city.

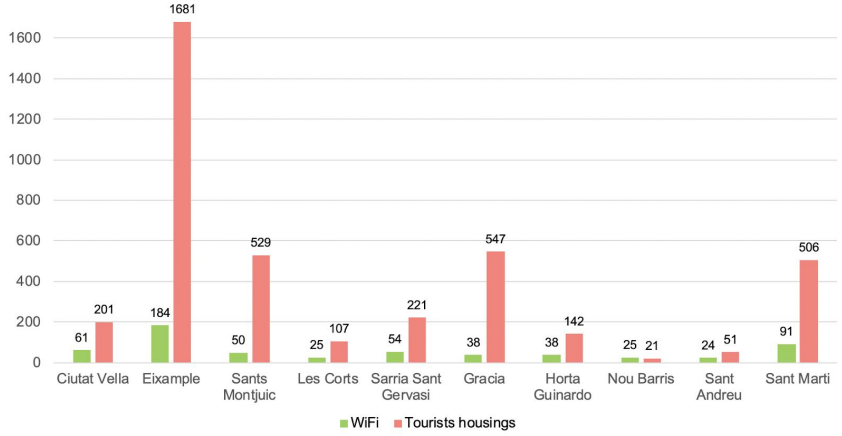
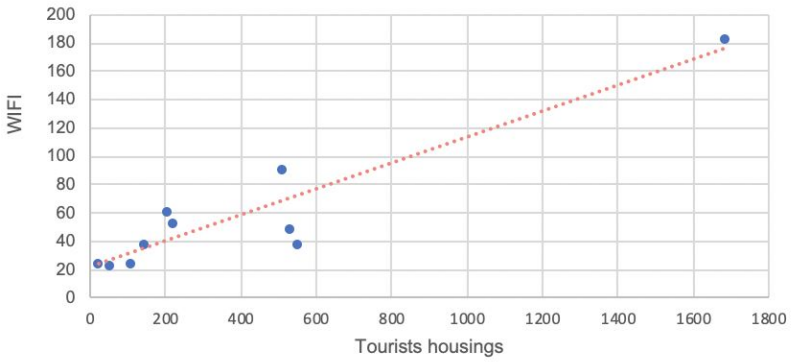


Figure 6: WiFi and Tourist housing distribution by district

From Figure 7, we can observe that there the correlation coefficient is 0,932, which indicates a highly strong positive correlation between the two variables.



	WIFI	*Tourists housings*
WIFI	1	
Tourists housings	0,931968506	1

Figure 7: Correlation Tourist Housing ~WIFI hotspots

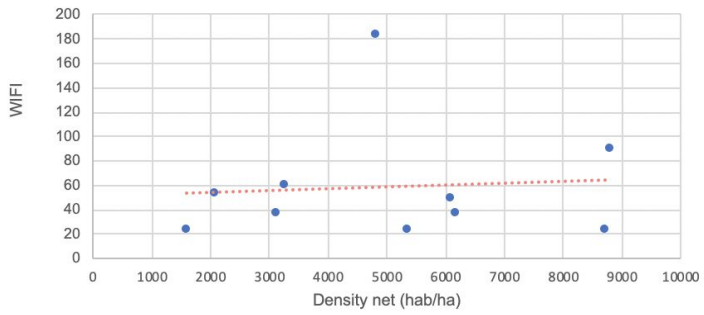
More concretely, this could be explained by the location of Barcelona's point of interests. Following the ranking of visitors of Barcelona's point of interest from 2014 to 2018 (See Figure 8), makes it evident that the location of these trendy spots from the city are located in the districts where most of the tourists book an accomodation. This ranking is led by Sagrada Familia and followed by Park Güell, FCB Museum, Barcelona Aquarium, etc.

Ranking of visitiors of Barcelona's point of interest						
	District	2014	2015	2016	2017	2018
Temple Expiatori de la Sagrada Família	Eixample	3.260.880	3.722.540	4.561.848	4.527.427	4.661.770
Park Güell	Gracia	2.598.732	2.761.436	2.958.901	3.120.733	3.136.973
Museu FC Barcelona President Núñez	Les Corts	1.530.484	1.785.903	1.947.014	1.848.198	1.730.335
L'Aquàrium de Barcelona	Ciutat Vella	1.590.420	1.549.480	1.587.828	1.626.193	1.631.108
Poble Espanyol de Montjuïc	Sants Montjuic	1.236.664	1.221.647	1.299.376	1.299.386	-
El Born Centre cultural	Ciutat Vella	1.894.400	1.486.228	1.306.230	1.190.762	1.080.079
Casa Batlló	Eixample	930.000	992.126	-	1.136.000	1.062.863
CosmoCaixa Barcelona	Sarria Sant Gervasi	739.649	733.778	757.245	884.636	1.045.961
Museu Picasso	Ciutat Vella	919.814	1.008.125	954.895	1.046.190	978.483
Palau Robert	Eixample	810.000	715.000	827.957	865.776	976.276
Fundació Catalunya. La Pedrera	Eixample	932.356	990.112	1.207.087	972.508	934.524
Museu Nacional d'Art de Catalunya (MNAC)	Sants Montjuic	718.230	717.211	820.516	866.271	891.346
CaixaFòrum Barcelona	Sants Montjuic	775.068	775.020	753.944	748.140	863.605
Castell de Montjuïc	Sants Montjuic	577.639	670.526	734.460	761.729	831.210
Museu d'Història de Barcelona	Ciutat Vella	973.034	916.517	926.571	926.184	816.989
Parc Zoològic de Barcelona	Ciutat Vella	1.057.188	1.004.069	965.292	834.885	785.992

Figure 8: Ranking of visitors of Barcelona's point of interest. Retrieved from www.barcelona.cat

WIFI hotspots and Population density

Secondly, the other potential users are the local people living in the area. This concept has been measured with the variable Density net (hab/ha), which denotes the number of inhabitants per residential surface, in hectarea units. However, the relation between WiFi and population density is practically insignificant as the correlation coefficient is 0,083.



	WIFI	*Density net (hab/ha)*
WIFI	1	
Density net (hab/ha)	0,082775396	1

Figure 9: Correlation Population density ~WiFi hotspots

Closely related, we wanted to analyze if WiFi hotspot location could have a potential relation with the inhabitants of the districts in terms of demographic characteristics, such as the age. However, the frequency distribution of the different age groups (See Figure 4) are practically similar for all districts, which present no relation to WiFi locations.

3. Solution Proposal

As analyzed in the previous points, there are already a lot of free WiFi hotspots in Barcelona. Specially, tourist places are well covered. Nevertheless, there are still some places where it would be useful to install more WiFi hotspots. Our goal is to propose one potential location. There are several methods to find potential locations but we will concentrate on the weighted method.

Weighted Method

The weighted method is a great approach to find the best location as the installation cost (tangible factors) are the same for all potential locations. Therefore, we can easily base our decision on qualitative (intangible factors).

During our research we saw that most WiFi hotspots are located in public buildings, such as cultural centers or museums. However, we found out that squares of the city are often left out. We believe they can become an oasis in the midst of urban hostility and many of them are spaces worthy to admire and enjoy. For this reason, our solution proposal is focused on squares as potential locations.

Based on different travel blogs and tourism information, the most visited squares in Barcelona are Plaça Catalunya (Eixample), Plaça Espanya (Sants Montjuïc), Plaça Sant Jaume (Ciutat Vella), Plaça Reial (Ciutat Vella), Plaça Colom (Ciutat Vella), Plaça de Sant Felip Neri (Barrio Gótico, Ciutat Vella) and Plaça del Sol (Gracia).

Figure 12: Fr. Catalunya

Figure 13: Pl. Espanya

Figure 14: Pl. St Jaume

Figure 15: Pl. Reial

Figure 16: Pl. Colom

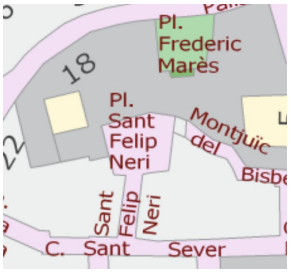


Figure 17: Pl. St. Felip Neri

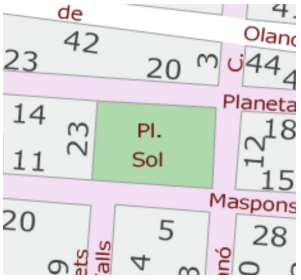


Figure 18: Pl. Sol

From the figures above, it is possible to see that there are three squares that do not have any Barcelona WiFi hotspot around, these are Plaça Reial and Plaça de San Felipe Neri in the district of Ciutat Vella and Plaça del Sol in Gracia. These places attract a lot of tourists but also locals like to gather around. They are really central and close to a lot of sights. This makes them optimal locations for new Wifi-Hotspots.

Moreover, we made a list of factors which we want to base our decision on. For us, the number of tourists is the most important decision variable. The number of POI's is related to the number of tourists. With Wifi importance we consider if the Wifi is important there or why. For example, if there are a lot of "picture points" where tourists like to upload them on social networks such as Instagram and Facebook. For our location proposal the local citizens do not play an important role but still have to be considered.

Then we gave a weight in terms of importance and developed a scale for each factor. In the following table you can see our results:

Location factor	*Weight*	*Plaça Reial*	*Plaça del Sol*	*Plaça St. Felip Neri*
Number of tourists	10	90	70	40
Number of POI's	5	40	50	30
WIFI Importance	3	70	30	40
Local citizens	2	20	60	90
Total		**1330**	1160	850
Average		55	52,5	50
Weighted Average		66,5	58	42,5

Figure 19: Weighted Method Analysis

Finally, we selected the location with the highest total score. In this case it is Plaça Reial. There are a lot of tourists which upload a lot of pictures on Instagram and the WiFi is quite important for it. More concretely, by March 2020, there are already 8,1M posts with this location. Even if there are several WiFi Hotspots at the Ramblas, the signal does not reach Plaça Reial. Together with our findings from the previous chapters, we highly recommend installing a new hotspot there.

4. Conclusions

With 590 WiFi Hotspots in 10 districts, Barcelona is already well-covered according to the internet availability. Nevertheless, and due to its importance to the city, Barcelona has to continuously develop its network. During our research we found out that there is a high relationship between the location of WiFi hotspots and the number of tourist housing and population density. Therefore, we suggested some potential locations for new hotspots in touristic places. Moreover, we used the weighted method to detect the best location among our suggestions. In the end, our best location is Plaça Reial, as there is no hotspot right now and it is an important place for tourists.

WIth regard to the limitations, it was difficult to find information about the costs for installing and operating WiFi hotspots. Therefore, our solution proposal is based on the subjective weighted method. When making the decision, the Barcelona City Council should also include the total costs for a new WiFi hotspot.

For us, analyzing the WiFi Hotspots in Barcelona was very interesting. It is the best developed network in Spain and plays an important role for its reputation. With our location proposals we hope to help them detect places where open WiFi is missing.

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6. Appendix

Appendix 1: Summary of the datasets

District	WiFi	Tourists housings
Ciutat Vella	61	201
Eixample	184	1681
Sants Montjuic	50	529
Les Corts	25	107
Sarria Sant Gervasi	54	221
Gracia	38	547
Horta Guinardo	38	142
Nou Barris	25	21
Sant Andreu	24	51
Sant Marti	91	506

District	10-15 years	16-20 years	21-30 years	31 - 40 years	41-60 years	61 - 80 years	81 and older	Sum
Ciutat Vella	4025	3785	19225	22471	27209	12459	4608	93782
Eixample	11121	9906	35526	45451	73262	50967	20294	246527
Sants Montjuic	8374	7300	22729	31348	52776	33151	11841	167519
Les Corts	4038	3395	9334	11296	21757	19239	6038	75097
Sarria Sant Gervasi	10177	8109	16864	18820	41813	27575	10766	134124
Gracia	5514	4255	14768	21937	33109	23061	8667	111311
Horta Guinardo	8463	6950	18069	25041	48662	34914	12828	154927
Nou Barris	8743	7340	17884	24355	47321	33556	12605	151804
Sant Andreu	8845	5935	15299	22472	43316	29559	9591	135017
Sant Marti	12328	9807	25354	37996	69750	43673	14862	213770

District	10-15 years	16-20 years	21-30 years	31 - 40 years	41-60 years	61 - 80 years	81 and older	Sum
Ciutat Vella	4%	4%	21%	24%	29%	13%	5%	100%
Eixample	5%	4%	14%	18%	30%	21%	8%	100%
Sants Montjuic	5%	4%	14%	19%	32%	20%	7%	100%
Les Corts	5%	5%	12%	15%	29%	26%	8%	100%
Sarria Sant Gervasi	8%	6%	13%	14%	31%	21%	8%	100%
Gracia	5%	4%	13%	20%	30%	21%	8%	100%
Horta Guinardo	5%	4%	12%	16%	31%	23%	8%	100%
Nou Barris	6%	5%	12%	16%	31%	22%	8%	100%
Sant Andreu	7%	4%	11%	17%	32%	22%	7%	100%
Sant Marti	6%	5%	12%	18%	33%	20%	7%	100%

District	Inhabitants	Surface (ha)	Surface Residencial (ha)	Density (hab/ha)	Density net (hab/ha)
Ciutat Vella	101387	436,8	129,8	942	3237
Eixample	266416	747,6	372,1	2299	4802
Sants Montjuic	23987	2294,2	249,2	2344	6060
Les Corts	82033	601,8	180,2	497	1586
Sarria Sant Gervasi	149279	2009,2	459	1047	2071
Gracia	121347	418,6	200,8	1453	3111
Horta Guinardo	168751	1194,7	294,3	2060	6151
Nou Barris	166579	804,1	232,7	3378	8703
Sant Andreu	147594	656,5	192,2	1780	5340
Sant Marti	235513	1052,4	279,7	2441	8772