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Analysis of the Real Estate Evolution over the past decade in Lisbon

A Business Intelligence approach to Smart Cities

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Dissertation proposal presented as partial requirement for
obtaining the Master's degree in Information Management

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ANALYSIS OF THE REAL ESTATE EVOLUTION OVER THE PAST DECADE IN LISBON: BUSINESS INTELLIGENCE APPROACH TO SMART CITIES

by

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Dissertation proposal presented as partial requirement for obtaining the Master's degree in
Information Management with a specialization in Knowledge Management and Business Intelligence

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ABSTRACT

The Real Estate paradigm in Lisbon has changed quite rapidly over the past ten years, with a drastic rise in tourism activity, with an increase in local settlement investment and gentrification, leading to all-time high house prices. Despite the importance of this phenomenon, there is a lack of systematic and structured research and, consequently, it is relevant to have a detailed study and thorough analysis of it, to understand what led to the fluctuations in prices as well as the differences between the pricing and types of houses between the civil parishes. To address this gap, a Design Science Research methodology was applied, with the creation of a Power BI dashboard artifact, using a Real Estate dataset (Confidencial Imobiliário) with variables such as Price per square meter, house size, and absorption time, among others. These dataset variables were intertwined with 26 study population representative variables, extracted from Census 2021, as well as 95 smart city indicators, to allow for a complete characterization of the different parishes of the Lisbon municipality, which is the study area. The results of this thorough analysis were that the smart city indicators had the biggest impact on the price of houses, amongst the civil parishes, highlighting the Culture and Commerce attributes as the ones with the highest positive correlation to the dependant variable. This study contributed to the literature of the Real Estate market study, enabling a better understanding of the characterization of each civil parish in the Lisbon municipality, allowing for the use of this study to aid in policy making and decision support on urban planning.

KEYWORDS

Real Estate; House market price; Lisbon; Smart Cities; Business Intelligence; Decision-making.

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LIST OF ABBREVIATIONS AND ACRONYMS

GIS Geographical Information System

1. INTRODUCTION

Since the second half of the 20th century, the centre of Lisbon has been through a phase of abandonment and degradation caused by rent-freezing policies. This situation was especially enforced after the 25th of April 1974 revolution, which caused the buildings' maintenance to be nearly economically impossible (Silva, 2014). In addition, with the introduction of new policies such as the support for mortgages for new houses (Mendes, 2017), the construction of non-habitational infrastructures (shopping malls, roads, and hospitals) as well as the change in needs and expectations of the population, led to a massive migration of the wealthier people to the suburbs of the city (Krähmer & Santangelo, 2018).

In addition, statistics show that people spend 85–90% of their time in buildings: working, studying, relaxing, entertaining, or living. In all cases, not only the internal but also the external environment of the buildings is important, which is directly related to the perceived and experienced quality of life (Apanaviciene et al., 2020). Today, 55% of the world's population are urban-dwelling, and as urbanization tends to exacerbate with population growth (Neves et al., 2020), this number is estimated to climb to 68% by 2015 (UNDESA, 2018).

Therefore, as time goes by, major urbanization requires new and innovative ways to manage the complexity of urban living (Rizzo, 2015). Cities will face growth, performance, competitiveness, and residents' livelihood challenges (McKinsey & Company, 2013). This way, leaders must design new strategies to enhance city performance and sustainability. Many leaders choose the pathway of transforming cities into “smart cities”, “intelligent cities,” or even “creative cities” (Ben Letaifa, 2015). Smart buildings' integration into smart cities are not the future perspectives anymore—but the actual question for today and tomorrow (Apanaviciene et al., 2020). Smart Mobility is one of the most promising topics in Smart City, as it could produce high benefits for the quality of life of almost all the city stakeholders (Benevolo et al., 2016).

With the city of Lisbon becoming more technological and sustainable, it is essential to study how that transformation impacts the Real Estate market. Although there are several studies published regarding Real Estate in smart cities (Lecomte, 2019), the study of the evolution of the Real Estate market in the city of Lisbon lacks systematic and structured research. A geolocated analysis of the city leads to a better understanding of how the services, facilities, and points of interest locations influence housing prices. This approach, combined with the Real Estate dataset specifications, allows for a detailed analysis of this sector's location, type, and price changes over the past ten years. This opens the path for predictive analysis to determine the best areas to live in and price housing evolution.

Besides the descriptive real estate indicators, for instance, price per square meter, this analysis must consider the smart city components attractive to the population, as well as the existence of public and private infrastructures from which the inhabitants can take advantage of. This way, the availability of services such as public transport, education facilities, and hospitals must also be considered since these are usually desirable additions for the general population. In addition to the social and economic state of the Lisbon municipality, it will also be possible to understand how and why the Real Estate market has changed over the past ten years and which factors influence that change. The output of this analysis is expected to contribute to the decision-making process of companies and individual buyers, regarding the choice of locations for investment, supplying them with detailed descriptions of the areas of interest, as well as providing insightful analysis to improve the city management. To sum up, in order

to achieve this goal, a time analysis of the Real Estate market in Lisbon will be conducted, while also addressing several secondary objectives: (a) Location attractiveness; (b) Cultural, educational, and health facilities; (c) Environmental conditions; (d) Local accessibility and transport systems; (e) Housing quality.

This work is organized as follows: in the next chapter, we provide a theoretical background of the topic in the study; chapter 3 contains the methodological background and data characterization and data transformations; chapter 4 comprises the analysis and the results obtained from the dashboard pages; the following chapter is the discussion of results, where conclusions are drawn; finally, in chapter 6 the conclusions are drawn, the limitations faced are exposed, and future work is proposed.

2. LITERATURE REVIEW

In order to conduct a study regarding the descriptive analysis of the Real Estate market in the city of Lisbon, there is the need to understand what the dependent variable should be, and which indicators need to be studied to explain its behaviour.

2.1 Price

The external impact of urban infrastructure assets on the housing market has caught the attention of academics all around the world. Numerous research has developed models to statistically assess the impact of public amenities on housing prices, often based on the hedonic price perspective (Wen et al., 2014). Given this, the dependent variable chosen to be studied was housing prices, intending to compare this variable in a time-series fashion, with potential influencing factors, to identify patterns and draw conclusions.

2.2 Influencing factors

As previously mentioned, in order to conduct a detailed analysis of the dependent variable, there is the need to understand which are the most influencing factors for the behavioural patterns of housing prices. In order to do that, a characterization of the urban/peri-urban areas needs to be assessed, to understand the differences in lifestyle and how that may impact the dependent variable. According to previous research, the characterization of peri-urban areas needs to be conducted by combining a multitude of disciplinary indicators (Allen, 2003). Additionally, Linder & Spear (2003) also stated that in order to produce research that is more socially relevant and real-world applicable, different types of knowledge need to be integrated into one single study. Ramos (2013) conducted a study where 19 researchers from 13 disciplinary backgrounds worked together with a 37-stakeholder panel, coming from 23 different organizational settings, in the development of an inter- and transdisciplinary process to achieve a more complete understanding of the character of and peri-urban areas. As an outcome of this session, it was concluded that six dimensions were able to define the character of peri-urban areas – Mobility, Identities and Lifestyle, Natural Elements, Land Cover, Economic Activities, and Spatial Functions.

Even though this study characterizes peri-urban areas by analysing the Lisbon Metropolitan Area, it includes the municipality of Lisbon, which is the most relevant zone of the study area, in terms of population density, economic impact and social importance. This way, in the lack of better suited literature and since our study area is a great part of the research's study area, the dimensions and indicators used in the study will be applied to this research. In the following sections, we will analyse existing literature in order to support the choice of indicators needed to explain the dependent variable.

2.2.1 Property Attributes

In addition to the price of the house, other relevant house and market indicators need to be considered. Alfiyatin et al. (2017) state that the structural makeup of the home, such as the size of the dwelling and the building, is another important factor affecting the price of a house. Another price affecting factor is the absorption rate, which Murray (2022) studied by creating a housing supply absorption rate equation, comparing the different constraints that affect the variance in absorption time, when selling a house on the market.

2.2.2 Social Attributes

Green & Hendershott (1996) study a family's willingness to buy a house, based on their age, marital status, and education level. They concluded that these variables have quite an impact on the housing demand, thus also impacting the price of Real Estate. Accordingly, Farnham et al. (2011) studies the relation between house prices and their changes in the marital statuses of the inhabitants, focusing on the divorce rate variable. By studying the social attributes of the population, it is possible to compare and segment population types inside the different urban areas, in an attempt to gather insights regarding the relation of these attributes to the differences in the price of the houses.

2.2.3 Housing Attributes

Jim & Chen (2009) conducts a hedonic assessment of private housing, which studies the residential properties of the study area, thus considering the housing attributes and characteristics, such as the number of dwellings, and the average household size, among others. It is important to understand how urban areas are characterized, when it comes to the number of buildings, dwellings, and households, as well as the number of residents per household, to understand how urbanized certain areas are and how that translates to the behaviour of the price of houses.

2.2.4 Culture Attributes

In certain urban areas, cultural heritage attracts a large number of tourists, thus leading to the rise in the price of nearby residencies. Lazrak et al. (2014) confirm this affirmation through a study of the relation between house prices and the proximity to cultural buildings, stating that residencies in these conditions are often more expensive than equivalent houses in other locations. This assumption is also supported by Ford (1989), Noonan & Krupka (2010), and Coulson & Lahr (2005), making it an important dimension of attributes to include in our analysis. Furthermore, Biagi et al. (2015) and Perić et al. (2022) conduct an analysis on the impact of tourism on the price of houses, and how most of these touristic activities occur in the city centres and cultural hotspots.

2.2.5 Education Attributes

Proximity to schools and overall education institutions is one of the most sought-after conditions when buying a house, since educational resource remains the key consideration of buyers (Wen et al., 2014). Due to accessibility, the presence of kindergarten, high school, and college institutions raises the price of nearby homes. One kindergarten within one kilometre of the community can raise home prices by 0.30 percent. When a home is less than 1 kilometre from a high school or college, its price rises by 2.737% or 0.904% (Wen et al., 2014).

2.2.6 Environment Attributes

With urban areas getting very crowded with the majority of the global population living in it, public parks, natural areas, and golf courses are examples of open spaces that may have an impact on the value of residences near those resources (Bolitzer & Netusil, 2000). Morancho (2003) also studies the link between housing prices and urban green areas, specifically analysing the distance between the house and the closest green area as well as the size of that open area.

2.2.7 Health Attributes

Regarding the influencers of house prices, hospitals have a great impact on the real estate market, due to its importance as an amenity as well as employment opportunities (Rivas et al., 2019). Additionally, Peng (2020) studies both the benefits and the constraints of living nearby healthcare facilities, which often times lead to unpleasant consequences, such as siren noises, intense traffic or lack of parking availability, making this indicator relevant to study, when combined with the prices of nearby houses.

2.2.8 Commerce Attributes

Turner (2017) discovered that in three San Francisco Bay Area districts, the presence of a number of attractions, including stores and dining establishments increases the price of surrounding homes. Additionally, Zhang et al. (2019) conducted an analysis on the effects of a shopping mall on house prices, while Nofre et al. (2018) explained the relationship between nightlife and real estate prices. Biagi et al. (2015) and Perić et al. (2022) both study the impact of tourism activities, focusing on how massively it impacts nearby housing, leading to Perić et al. (2022) even stating that local population is no longer the determinant of housing prices in European countries.

2.2.9 Mobility Attributes

So et al. (1997) estimated the influence of transportation in residential markets, specifically the availability of transport, transportation costs, travel time and convenience of transport. Dorantes et al. (2011) evaluated the effect of proximity to metro stations on housing prices, analysing the overall impact of public transportation on the dependent variable. These assumptions were also supported by Yiu & Wong (2005) and Zhou et al. (2022), whose studies also highlighted the importance of bus stops, as well as railway system accessibility, when studying the price of nearby residences.

2.2.10 Safety Attributes

As previously analysed, to be close to amenities is valued by the nearby living population. This is also true, regarding safety amenities, as confirmed by Frischtak & Mandel (2012), who analysed the relationship between the existence of police stations and the residential prices of nearby homes, while Facchetti (2021) studied the impact of police infrastructures, police performance and crime on the dependent variable. In addition to police stations, fire departments are also considered very impactful and important when it comes to overall safety in urban areas, being described by Pollack & Kaufmann (2022) as being critical facilities, when it comes to their importance as a nearby amenity, making it a potential influencer to the price of houses.

3. METHODOLOGY

3.1 Design Science Research

Design Science Research (DSR) is a methodology that seeks to enhance human knowledge by creating innovative artifacts and improve the environment in which they are instantiated (Brocke et al., 2020). Since this study aims to combine multiple data sources and undergo an in-depth analysis, with the final product being a fully dynamic and insightful PowerBI dashboard, this dissertation follows the DSR methodology. As previously mentioned, by following this methodology we intend to feed this topic with relevant literature to fill the identified gap, providing the academic community with a descriptive and characteristic tool for the urban areas to be studied.

3.2 Study Area - Lisbon

The study area for this research is the municipality of Lisbon. This city is the capital of Portugal and has an estimated population of 509,614 within its administrative limits, comprising an area of 100.05 km² (INE,2021). This is the biggest municipality in Portugal, comprising 24 civil parishes. It is located in the district of Lisbon, at the mouth of the Tagus River, having most of its parishes by the riverbed. The municipality of Lisbon can be divided into five zones, namely: the Historical Centre, Western Lisbon, Central Lisbon, Eastern Lisbon, and Northern Lisbon. As the capital of Portugal, Lisbon is a very diverse city with the highest population density and economic impact out of every municipality in the country, making it a very interesting study area.

Concerning the five different zones of Lisbon, the historic centre is the oldest, with the most tourists, cultural buildings, and overall movement. Central Lisbon, while not being part of the historical centre, is filled with domestic houses, businesses, and companies, as well as overall commerce. Western, Eastern, and Northern Lisbon are further away from the historical centre, thus having more accommodation buildings, with better mobility infrastructures and access to the city centre. Western Lisbon is comprised of Belém, Ajuda and Alcântara parishes, thus having plenty of tourist movement, also being nearby the river and the historic centre. Northern Lisbon is mostly filled with residential buildings, shops, and companies, thus having little to no tourists, as well as Eastern Lisbon, aside from Parque das Nações, which was renovated due to “Expo98”, leading to a great mass of tourists visiting its touristic attractions and modernized infrastructures.

3.3 Data Sources

According to the literature review, several relevant house prices influencing dimensions were selected. From those dimensions, and to conduct a Business Intelligence analysis on real estate transactions in Lisbon, there is the need to analyse different types of numerical and categorical data from multiple datasets that were extracted from different data sources. This way, different tables are constructed, in order to better characterize the summary statistics of these variables, which will be analysed by data source. Each variable will be characterized by the number of observations, the minimum sample value, the maximum sample value, the mean sample value, the standard deviation, the measurement unit, and a description, for a more detailed view.

3.3.1 Confidencial Imobiliário

Table 1 shows the dataset from Confidencial Imobiliário (<https://www.confidencialimobiliario.com/>) which comprises descriptive variables regarding property attributes of real estate transactions between 2007 and 2021. Absorption time, Area, and Number of Sold Dwellings are independent variables, while the Price per square meter is the dependent variable to be studied. Regarding data transformations performed on the dataset—originally, it had the data sorted by trimester inside each year. However, since there were several blank values in certain trimesters for specific variables, we applied a data cleaning technique involving the calculation of the average of the aggregation of all the trimesters in the year, sorting the variables by year, thus eliminating the “trimester” drill-down.

Summary Statistics	Obs	Min	Max	Mean	Std	MU*	Definition
Abp_Time	469	1.375	43	8.43	5.08	month	Average number of months between the placement in offer and the transaction
Area	483	50	259	107.00	29.23	m ²	Is the total surface area measured along the exterior perimeter or back of the outside walls and the axes of the walls between dwellings, including private balconies, accessory areas, and the dwelling's share of the building's communal areas
Sold Dwellings	350	60	18934	2640.64	2095.00	number	It is an estimation of the total number of houses transitioned into the market
Price	483	769	8730	2741.15	1287.27	€/m ²	Ratio between the transaction price and the private gross area

Table 1- Variable definitions and summary statistics concerning the Property attributes in the Confidencial Imobiliário dataset

*MU: Measurement Unit

3.3.2 Portuguese Census of 2021

After extracting and conducting the summary statistics analysis for the data regarding the property attributes, there was the need to combine that data with characteristics of the study area population as well as overall housing attributes of the Lisbon municipality per parish. This way, from Census 2021 (<https://censos.ine.pt/>) several statistics were extracted, analysed, and used, to combine with the property attributes and draw conclusions, such as the distribution of the civil parish's residents by Education Level, Age Group, Gender, and Civil Status (Table 2). These data categories allow for a better characterization of the study population, enabling cross-analysis with the Price per square meter.

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Definition
No Education	24	1255	5525	2949.21	1294.92	number	Number of Residents with no education
Primary School	24	983	8889	3025.79	1733.75	number	Number of Residents with 1st Cycle as maximum education level
2 ^o Cycle	24	530	4113	1546.63	823.54	number	Number of Residents with 2nd Cycle as maximum education level
3rd Cycle	24	1021	6019	2687.83	1286.31	number	Number of Residents with 3rd Cycle as maximum education level
Secondary and Post-Secondary	24	1911	7174	4170.50	1804.33	number	Number of Residents with Secondary and Post-Secondary as maximum educational level
Superior Education	24	2677	22723	8366.83	5055.42	number	Number of Residents with Bachelor+ as maximum education level
0-14 years	24	875	6790	2968.54	1449.36	number	Number of Residents aged between 0 and 14 years
15-24 years	24	845	5182	2291.75	1098.25	number	Number of Residents aged between 15 and 24 years
25-64 years	24	5627	24677	12161.71	5224.34	number	Number of Residents aged between 25 and 64 years
65+ years	24	2027	10476	5324.79	2534.17	number	Number of Residents who are 65 years old or higher
Single Men	24	2899	11511	5866.96	2449.05	number	Number of Residents who are Single Men
Married Men	24	1414	8069	3659.79	1698.96	number	Number of Residents who are Married Men
Widower	24	107	558	280.42	143.18	number	Number of Residents who are Widowers
Divorced Men	24	331	1486	786.63	327.77	number	Number of Residents who are Divorced Men
Single Women	24	2120	11966	5861.46	2591.47	number	Number of Residents who are Single Women
Married Women	24	1231	8161	3586.75	1767.33	number	Number of Residents who are Married Women
Widow	24	602	2593	1408.46	639.06	number	Number of Residents who are Widows
Divorced Women	24	448	2724	1296.33	624.32	number	Number of Residents who are Divorced Women

Table 2 - Variable definitions and summary statistics concerning the social attributes in the Portuguese Census 2021 dataset

Housing attributes in Table 3 are related to the existing residential facilities in the Lisbon municipality. This table also contains multiple variables collected to statistically measure the differences between housing attributes amongst the civil parishes. This dataset contains statistics concerning the number of dwellings, number of buildings, number of domestic households, and then the distribution of the number of households per civil parish, regarding the number of occupants.

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Definition
Dwellings	24	7525	24100	13339.29	5034.19	number	Number of Dwellings
Buildings	24	777	2953	2050.96	578.28	number	Number of Buildings
Domestic Households	24	4564	19556	10109.08	4264.09	number	Number of Domestic Households
Number of Households with 1 person	24	1992	6018	3562.21	1389.00	number	Number of Households with 1 person
Number of households with 2 people	24	1372	6267	3274.92	1444.11	number	Number of households with 2 people
Number of households with 3 people	24	560	3504	1626.75	789.51	number	Number of households with 3 people
Number of households with 4 people	24	325	2731	1109.79	587.93	number	Number of households with 4 people
Number of households with 5 or more people	24	193	1127	535.42	260.57	number	Number of households with 5 or more people

Table 3 - Variable definitions and summary statistics concerning the Housing attributes in the Portuguese Census 2021 dataset

3.3.3 Lisboa Aberta Open Data Portal

After gathering data related to the property attributes from the dwellings sold in the real estate market and gathering statistics to describe the study area population, there is a need to compile information regarding the amenities and points of interest of the Lisbon municipality, by civil parish. This way, 95 variables from seven different categories were gathered, to make the best possible description of the study area and the differences between the civil parishes. These attributes were then combined with the Price per square meter (target variable), with the objective of drawing conclusions and finding patterns that would help to understand the behaviour of the study population by civil parish.

The culture variables (see Table 4) were selected with the intent of understanding the impact of culture offerings on the Price per square meter of a civil parish. The culture attributes could be divided into monuments, and cultural buildings (museums, artistic residencies), amongst others.

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Definition
Cultural Associations	24	0	22	5.08	5.69	number	Number of Cultural Associations
Auditoriums and Amphitheatres	24	0	9	1.83	2.32	number	Number of Auditoriums and Amphitheatres
Cultural Centres	24	0	10	1.13	2.17	number	Number of Cultural Centres
Movie Theatres	24	0	4	0.58	0.91	number	Number of Movie Theatres

Art Galleries	24	0	21	3.92	4.86	number	Number of Art Galleries
Libraries, Archives and Documentation Centres	24	1	21	7.83	5.96	number	Number of Libraries, Archives and Documentation Centres
"Valmor Award" buildings	24	0	41	11.38	11.43	number	Number of "Valmor Award" buildings
Statues	24	0	49	14.96	13.70	number	Number of Statues
National Monuments and World Heritage	24	0	21	2.63	4.29	number	Number of National Monuments and World Heritage properties
Geomonuments	24	0	2	0.71	0.84	number	Number of Geomonuments
Religious Architecture buildings and Worship places	24	2	33	7.08	6.43	number	Number of Religious Architecture buildings and Worship places
Palaces	24	0	27	5.83	7.05	number	Number of Palaces
Regional Guilds	24	0	5	1.13	1.56	number	Number of Regional Guilds
Cultural Foundations	24	0	6	1.79	2.04	number	Number of Cultural Foundations
Artistic Residencies	24	0	9	1.38	2.12	number	Number of Artistic Residencies
Castles	24	0	1	0.04	0.20	number	Number of Points of Interest (POIs) - Castle

Table 4 - Variable definitions and summary statistics concerning the Culture attributes in the Lisboa Aberta Open Data Portal

In Table 5 the number of education facilities per parish is specified. The educational level and the public/private status of the institution is specified so that it is possible to ascertain if it has some impact when it comes to the Price per square meter by civil parish.

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Definition
Number of Public schools - 1st cycle	24	1	8	3.58	1.91	number	Number of Public schools - 1st cycle
Number of Private schools - 1st cycle	24	0	15	4.38	3.76	number	Number of Private schools - 1st cycle
Number of Public schools - 2nd cycle	24	0	4	1.29	1.02	number	Number of Public schools - 2nd cycle
Number of Private schools - 2nd and 3rd cycle	24	0	7	1.50	1.85	number	Number of Private schools - 2nd and 3rd cycle
Number of Public schools - 3rd cycle	24	0	5	1.88	1.45	number	Number of Public schools - 3rd cycle
Number of Public schools - pre-scholar	24	1	8	3.38	1.98	number	Number of Public schools - pre-scholar
Number of Private schools - pre-scholar	24	2	19	8.42	5.07	number	Number of Private schools - pre-scholar
Number of Public schools -	24	0	5	1.33	1.25	number	Number of Public schools - professional education

professional education							
Number of Public schools - Secondary	24	0	2	0.92	0.81	number	Number of Public schools - Secondary
Number of Private schools - Secondary	24	0	11	2.25	2.79	number	Number of Private schools - Secondary
Number of Higher education institutions	24	0	15	2.71	3.12	number	Number of Higher education institutions

Table 5 - Variable definitions and summary statistics concerning the Education attributes in the Lisboa Aberta Open Data Portal

A green environment, with trees, spacious green areas, and parks, is quite important for a good quality lifestyle. This way, six environment variables were selected to understand how this factor directly impacts the Price of housing in each parish (see Table 6).

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Description
Trees	24	543	8404	2759.21	1781.46	number	Number of Trees
Hectares of Green Area	24	149.43	1042.76	416.89	234.91	ha	Green area (ha)
Green Areas	24	39	380	148.21	98.18	number	Total number of green areas
Parks and Gardens	24	1	20	8.00	4.52	number	Number of Biggest Parks and Gardens
Lakes	24	0	5	0.83	1.31	number	Number of Lakes
Community Gardens	24	0	4	1.00	1.19	number	Number of Community Gardens

Table 6 - Variable definitions and summary statistics concerning the Environmental attributes in the Lisboa Aberta Open Data Portal

Health is one of the key factors of everyday life. This way, it is believed that proximity to health facilities and medical services providers is vital in case of an urgent need. That way, five variables were selected from the Lisboa Aberta open data portal (see Table 7), to understand where the hospitals, health centres, and pharmacies are geolocated and if and how that location affects the housing prices.

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Description
Health Centres	24	0	13	3.50	2.61	number	Number of Health Centres
Private Hospitals	24	0	4	0.67	0.99	number	Number of Private Hospitals
Public Hospitals	24	0	3	0.54	0.87	number	Number of Public Hospitals
Military Hospitals	24	0	1	0.08	0.28	number	Number of Military Hospitals
Pharmacies and Parapharmacies	24	3	22	11.08	5.13	number	Number of Pharmacies and Parapharmacies

Table 7 - Variable definitions and summary statistics concerning Health attributes in the Lisboa Aberta Open Data Portal

Commerce is a core aspect of every city. Having cafés, restaurants, banks, hotels and a full range of commerce points and utilities is very useful when considering day-to-day living, as being nearby them is essential. As such, it is important to analyse to what extent it influences the Price per square meter by civil parish. Since there are quite some commerce variables, it is necessary to divide them into different categories (see Table 8) to fully comprehend if certain areas have more or less influence on the overall cost of living in each specific civil parish.

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Description
ATM	24	0	38	7.96	8.41	number	Number of Points of Interest (POIs) - ATM
Bakery	24	0	18	3.21	4.28	number	Number of Points of Interest (POIs) - Bakery
Bank	24	1	33	11.88	8.73	number	Number of Points of Interest (POIs) - Bank
Bar	24	0	99	8.63	20.11	number	Number of Points of Interest (POIs) - Bar
Beauty Shop	24	0	11	0.63	2.21	number	Number of Points of Interest (POIs) - Beauty Shop
Bicycle Shop	24	0	3	1.04	0.93	number	Number of Points of Interest (POIs) - Bicycle Shop
Bookshop	24	0	7	1.63	1.93	number	Number of Points of Interest (POIs) - Bookshop
Butcher	24	0	5	1.04	1.31	number	Number of Points of Interest (POIs) - Butcher
Cafe	24	0	102	26.75	25.95	number	Number of Points of Interest (POIs) - Cafe
Car Dealership	24	0	12	1.21	2.92	number	Number of Points of Interest (POIs) - Car Dealership
Car Rental	24	0	5	0.75	1.30	number	Number of Points of Interest (POIs) - Car Rental
Car Wash	24	0	4	0.75	1.23	number	Number of Points of Interest (POIs) - Car Wash
Chemist	24	0	2	0.25	0.52	number	Number of Points of Interest (POIs) - Chemist
Computer Shop	24	0	3	0.46	0.82	number	Number of Points of Interest (POIs) - Computer Shop
Convenience Shop	24	0	38	5.04	7.79	number	Number of Points of Interest (POIs) - Convenience Shop
Dentist	24	0	6	0.71	1.54	number	Number of Points of Interest (POIs) - Dentist
Department Store	24	0	2	0.13	0.44	number	Number of Points of Interest (POIs) - Department Store
Fast Food	24	0	17	4.67	4.79	number	Number of Points of Interest (POIs) - Fast Food
Florist	24	0	2	0.42	0.64	number	Number of Points of Interest (POIs) - Florist
Food Court	24	0	3	0.21	0.71	number	Number of Points of Interest (POIs) - Food Court
Furniture Shop	24	0	10	0.79	2.02	number	Number of Points of Interest (POIs) - Furniture Shop
Garden Centre	24	0	1	0.04	0.20	number	Number of Points of Interest (POIs) - Garden Centre
Gift Shop	24	0	30	2.33	5.87	number	Number of Points of Interest (POIs) - Gift Shop
Golf Course	24	0	1	0.04	0.20	number	Number of Points of Interest (POIs) - Golf Course
Greengrocer	24	0	4	0.96	1.40	number	Number of Points of Interest (POIs) - Greengrocer
Guesthouse	24	0	9	1.83	2.72	number	Number of Points of Interest (POIs) - Guesthouse
Hairdresser	24	0	41	3.58	8.00	number	Number of Points of Interest (POIs) - Hairdresser
Hostel	24	0	15	2.58	4.37	number	Number of Points of Interest (POIs) - Hostel
Hotel	24	0	47	6.67	12.62	number	Number of Points of Interest (POIs) - Hotel
Jeweller	24	0	10	1.13	2.33	number	Number of Points of Interest (POIs) - Jeweller

Kiosk	24	0	7	1.88	2.20	number	Number of Points of Interest (POIs) - Kiosk
Laundry	24	0	14	1.63	2.91	number	Number of Points of Interest (POIs) - Laundry
Mall	24	0	1	0.13	0.33	number	Number of Points of Interest (POIs) - Mall
Mobile Phone Shop	24	0	10	1.08	2.22	number	Number of Points of Interest (POIs) - Mobile Phone Shop
Newsagent	24	0	8	0.71	1.65	number	Number of Points of Interest (POIs) - Newsagent
Nightclub	24	0	9	1.21	2.41	number	Number of Points of Interest (POIs) - Nightclub
Optician	24	0	8	1.08	2.06	number	Number of Points of Interest (POIs) - Optician
Post Office	24	0	5	1.88	1.20	number	Number of Points of Interest (POIs) - Post Office
Pub	24	0	9	1.00	2.22	number	Number of Points of Interest (POIs) - Pub
Restaurant	24	0	287	53.38	66.30	number	Number of Points of Interest (POIs) - Restaurant
Shoe Shop	24	0	14	1.29	2.95	number	Number of Points of Interest (POIs) - Shoe Shop
Sports centre	24	0	2	0.92	0.86	number	Number of Points of Interest (POIs) - Sports centre
Sports shop	24	0	4	0.38	0.86	number	Number of Points of Interest (POIs) - Sports shop
Stationery	24	0	5	0.63	1.11	number	Number of Points of Interest (POIs) - Stationery
Supermarket	24	2	24	7.13	5.26	number	Number of Points of Interest (POIs) - Supermarket
Toy Shop	24	0	1	0.17	0.37	number	Number of Points of Interest (POIs) - Toy Shop
Travel Agent	24	0	6	1.00	1.85	number	Number of Points of Interest (POIs) - Travel Agent
Veterinary	24	0	3	0.58	0.86	number	Number of Points of Interest (POIs) - Veterinary

Table 8 - Variable definitions and summary statistics concerning the Commerce attributes in the Lisboa Aberta Open Data Portal

Whether the civil parish is in the centre of the municipality or far from it, it is crucial to have good and reliable mobility utilities, from bus stops to metro and train stations, to river piers and airports. This way, seven mobility variables were extracted from the Lisboa Aberta open data portal so that, in conjunction with the Price per square meter variable, an analysis can be conducted to understand the impact of these indicators on the cost of housing (see Table 9).

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Description
Bus stops	24	40	155	83.46	29.25	number	Number of Bus stops
Metro stations	24	0	5	1.83	1.62	number	Number of Metro stations
Train stations	24	0	3	0.63	0.75	number	Number of Train stations
River's piers	24	0	1	0.13	0.33	number	Number of River's piers
Airports	24	0	1	0.04	0.20	number	Number of Airports
Cruise Terminals	24	0	2	0.13	0.44	number	Number of Cruise Terminals
Recreational Docks and Marinas	24	0	2	0.25	0.60	number	Number of Recreational Docks and Marinas

Table 9 - Variable definitions and summary statistics concerning the Mobility attributes in the Lisboa Aberta Open Data Portal

Although not having criminality rate data available, with the number of fire department stations and the number of police stations (see Table 10), it is possible to understand which parishes are more protected in case of an emergency and, in which case, the civil parishes with the most safety features will most likely be more quickly attended. These attribute values are then compared to the Price per square meter by civil parish.

Summary Statistics	Obs	Min	Max	Mean	Std	MU	Description
Fire Department Stations	24	0	3	0.71	0.79	number	Number of Fire Department Stations (RSB)
Police Stations	24	0	12	3.75	3.29	number	Number of Police Stations (PSP)

Table 10 - Variable definitions and summary statistics concerning the Safety and Security attributes in the Lisboa Aberta Open Data Portal

3.5 Data Transformations

After inserting the data gathered into a database and creating the data model by connecting all the tables, the next step was to adequate the data to the needs of the study. This way, multiple data transformations and new variable creations were computed in Power Query.

Firstly, the time series data from the “Confidencial Imobiliário” dataset spans from 2007 to 2021. In this study the time used was reduced to the interval from 2011 to 2020 due to poor data quality (lack of completeness), trimming the analysis to a ten-year sample, without the existence of any missing values. Since the data from the rest of the data sources is not on a yearly basis, there was no need to apply any other changes to the other datasets regarding the elimination of data.

Since the Lisboa Aberta open dataset compiled 95 variables, throughout seven categories of points of interest, there was the need for data reduction, thus leading to the aggregation into fewer variables to describe a whole category, to enable a better macro visual analysis. The following variables were aggregated, and newer variables were created:

Historical Monuments	[Number of Statues per parish] + [Number of National Monuments and World Heritage properties per parish] + [Number of Geomonuments per parish] + [Number of Religious Architecture buildings and Worship places per parish] + [Number of Palaces per parish] + [#"Number of Points of Interest (POIs) - Castle per parish"]
Cultural Buildings	[Number of Cultural Associations per parish] + [Number of Auditoriums and Amphitheatres per parish] + [Number of Cultural Centres per parish] + [Number of Movie Theatres per parish] + [Number of Art Galleries per parish] + [#"Number of Libraries, Archives and Documentation Centres per parish"] + [#"Number of ""Valmor Award"" buildings per parish"] + [Number of Regional Guilds per parish] + [Number of Cultural Foundations per parish] + [Number of Artistic Residencies per parish]
Culture	[Cultural Buildings] + [Historic Monuments]
Pre and Primary Schools	[#"Number of Private schools - pre-scholar per parish"] + [#"Number of Public schools - pre-scholar per parish"] + [#"Number of Public schools - 1st cycle per parish"] + [#"Number of Private schools - 1st cycle per parish"]
Middle Schools	[#"Number of Private schools - 2nd and 3rd cycle per parish"] + [#"Number of Public schools - 2nd cycle per parish"] + [#"Number of Public schools - 3rd cycle per parish"]
High schools	[#"Number of Private schools - Secondary per parish"] + [#"Number of Public schools - professional education per parish"] + [#"Number of Public schools - Secondary per parish"]
Schools	[Number of Higher education institutions per parish] + [Middle Schools] + [Pre and Primary Schools] + [High schools]
Green Areas	[Total number of green areas per parish] + [Number of Lakes per parish] + [Number of Biggest Parks and Gardens per parish] + [Number of Community Gardens per parish]
Hospitals	[Number of Public Hospitals per parish] + [Number of Private Hospitals per parish] + [Number of Military Hospitals per parish]
Health Institutions	[Hospitals] + [Number of Health Centres per parish]
Financial POI	[#"Number of Points of Interest (POIs) - Bank per parish"] + [#"Number of Points of Interest (POIs) - ATM per parish"]
Food Establishments	[#"Number of Points of Interest (POIs) - Bakery per parish"] + [#"Number of Points of Interest (POIs) - Cafe per parish"] + [#"Number of Points of Interest (POIs) - Fast Food per parish"] + [#"Number of Points of Interest (POIs) - Restaurant per parish"]
Nightlife	[#"Number of Points of Interest (POIs) - Bar per parish"] + [#"Number of Points of Interest (POIs) - Nightclub per parish"] + [#"Number of Points of Interest (POIs) - Pub per parish"]

Hospitality	[#"Number of Points of Interest (POIs) - Hotel per parish"] + [#"Number of Points of Interest (POIs) - Hostel per parish"] + [#"Number of Points of Interest (POIs) - Guesthouse per parish"]
General Commerce	[#"Number of Points of Interest (POIs) - Beauty Shop per parish"]+ [#"Number of Points of Interest (POIs) - Bicycle Shop per parish"]+[#"Number of Points of Interest (POIs) - Bookshop per parish"]+[#"Number of Points of Interest (POIs) - Butcher per parish"]+[#"Number of Points of Interest (POIs) - Car Dealership per parish"]+[#"Number of Points of Interest (POIs) - Car Wash per parish"]+[#"Number of Points of Interest (POIs) - Car Rental per parish"]+[#"Number of Points of Interest (POIs) - Chemist per parish"]+[#"Number of Points of Interest (POIs) - Computer Shop per parish"]+[#"Number of Points of Interest (POIs) - Convenience Shop per parish"]+[#"Number of Points of Interest (POIs) - Dentist per parish"]+[#"Number of Points of Interest (POIs) - Department Store per parish"]+[#"Number of Points of Interest (POIs) - Furniture Shop per parish"]+[#"Number of Points of Interest (POIs) - Florist per parish"]+[#"Number of Points of Interest (POIs) - Garden Centre per parish"]+[#"Number of Points of Interest (POIs) - Greengrocer per parish"]+[#"Number of Points of Interest (POIs) - Gift Shop per parish"]+[#"Number of Points of Interest (POIs) - Hairdresser per parish"]+[#"Number of Points of Interest (POIs) - Jeweller per parish"]+[#"Number of Points of Interest (POIs) - Kiosk per parish"]+[#"Number of Points of Interest (POIs) - Laundry per parish"]+[#"Number of Points of Interest (POIs) - Mall per parish"]+[#"Number of Points of Interest (POIs) - Mobile Phone Shop per parish"]+[#"Number of Points of Interest (POIs) - Newsagent per parish"]+[#"Number of Points of Interest (POIs) - Optician per parish"]+[#"Number of Points of Interest (POIs) - Post Office per parish"]+[#"Number of Points of Interest (POIs) - Shoe Shop per parish"]+[#"Number of Points of Interest (POIs) - Sports centre per parish"]+[#"Number of Points of Interest (POIs) - Stationery per parish"]+[#"Number of Points of Interest (POIs) - Supermarket per parish"]+[#"Number of Points of Interest (POIs) - Toy Shop per parish"]+[#"Number of Points of Interest (POIs) - Travel Agent per parish"]+[#"Number of Points of Interest (POIs) - Veterinary per parish"]
Commerce	[Hospitality]+ [Financial POI] + [Food Establishments] +[Nightlife]+ [General Commerce]
Mobility	[Number of Metro stations per parish] + [Number of Bus stops per parish] + [Number of Train stations per parish] + [#"Number of River's piers per parish"] + [Number of Airports per parish] + [Number of Recreational Docks and Marinas per parish] + [Number of Cruise Terminals per parish]
Safety	[Number of Fire Department Stations] + [Number of Police Stations]

Table 11 - Data Transformations

4. RESULTS

A PowerBI dashboard was created, comprising ten pages, each with a different theme. In its structure, every page has the same “Year” slider, which allows the user to choose the period to be analysed, and a chiclet slicer which allows for the selection of the civil parishes to be showcased in the visuals.

4.1 Property Attributes

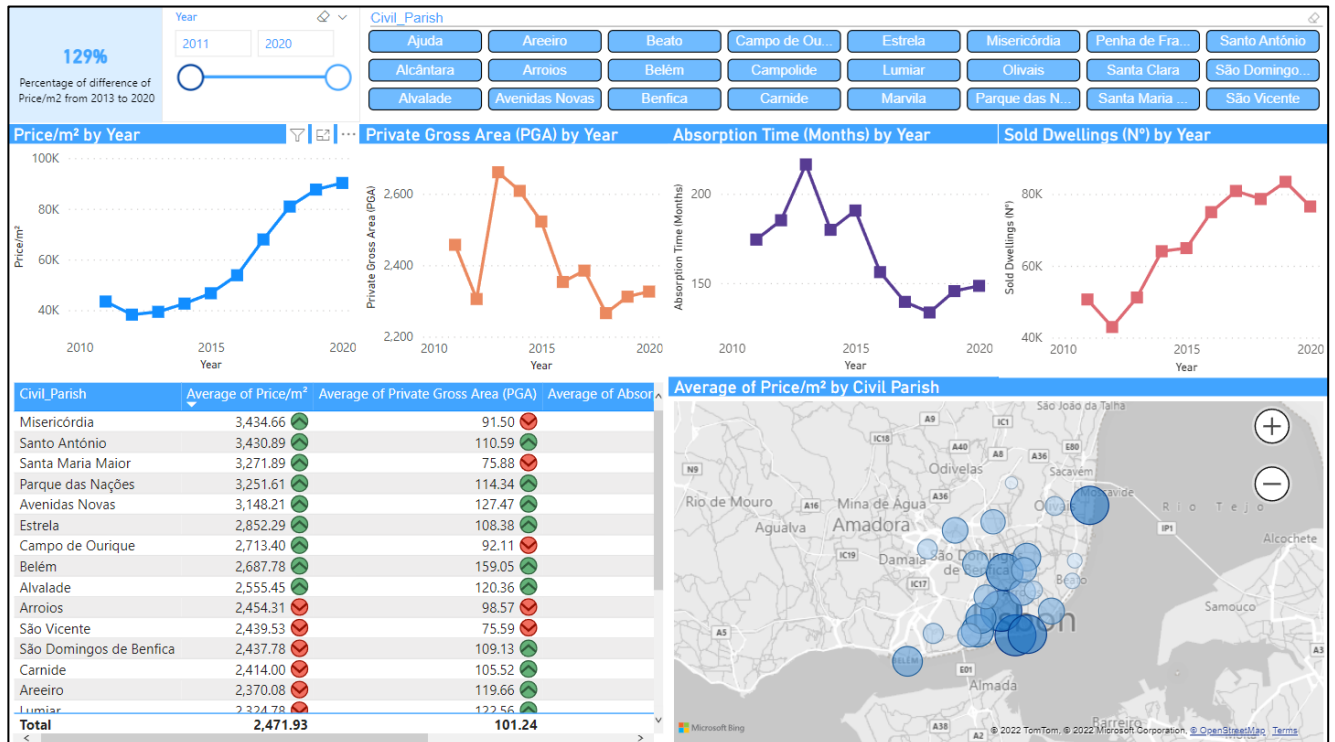


Figure 1 – Property Attributes

The first page of the PowerBI dashboard comprises information related to the Property category, most specifically the “Price/m²”, “Private Gross Area”, “Absorption Time” and “Sold Dwellings”, in a ten-year interval. As displayed in Figure 1, there is a single line plot for each of these four variables, demonstrating their evolution from 2011 to 2020. The Price/m2 shows a big overall increase between 2011 and 2020, despite the small decrease until 2013, due to the economic crisis lived in Portugal during that time period. The “Absorption Time” and “N°Sold Dwellings” variables show opposite behaviours since the more houses that are sold, the least time they stay in the market, waiting to be sold. The “Private Gross Area” variable showed a decrease in its value, which is meaningful compared to the steep increase in the Price per square meter.

Regarding the Map of the Lisbon Municipality, the bigger the bubbles and the darker the shade of blue, the higher the Price per square meter is. By visual analysis, we can see that most of the parishes with the highest prices are in the Historical Centre and Central Lisbon, with some exceptions being “Parque das Nações” and “Belém” parishes; the first due to the high level of innovation and modernization of infrastructures and cultural buildings; and the second due to the high amount of antique and prestigious cultural monuments.

On the top left corner of the page, there is a measure that compares the value of the overall Price per square meter from 2013 to 2020 in order to demonstrate the magnitude of the price increase. The table in the bottom left corner of the page contains the four variables of the property attributes, with KPI indicators, depending on whether it is higher or lower than the mean of the variable amongst the 24 parishes.

4.2 Social Attributes

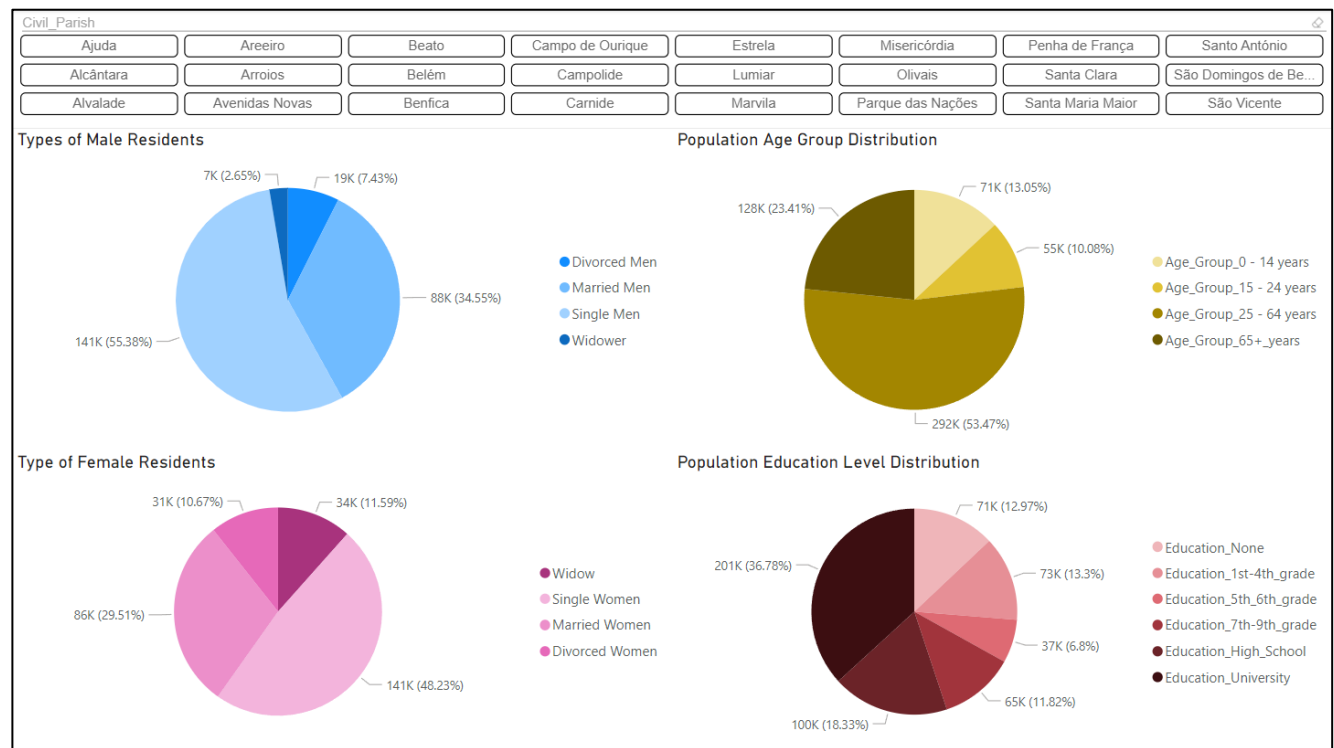


Figure 2 – Social Attributes

Regarding the Social variables, they are comprised of four pie charts characterizing the residents of the Lisbon municipality. In Figure 2, there is only a chiclet slicer for the Civil parishes since the data does not vary throughout the years. On the left-hand side, there are two analyses by Gender and Civil Status. The distribution is similar in both charts, with “Single” being the most common Civil Status, followed by “Married”. The difference is how the “Divorced” and “Widow/Widower” statuses are distributed. On the male side, “Divorced” is more than two times more common than “Widower”, whereas, on the female side, the distribution is much more balanced, with “Widow” being more common.

The yellow-themed pie chart shows the distribution of the resident population by Age Group. The most common Age group, with more than 50% of the study population, comprises the ages between 25 and 64 years and is related to the working adult population. The age group between 0 and 14 years comprises around 13% of the population, followed by the least represented age group (15-24 years old) with around 10%. Lastly, with over 23% there is the 65+ years old age group.

The last pie chart on the page characterizes the population by Education Level. As depicted in the graphic, almost 37% of the study population has some University Education. On the other hand, almost half the residents do not reach the High School Education Level.

4.3 Housing Attributes

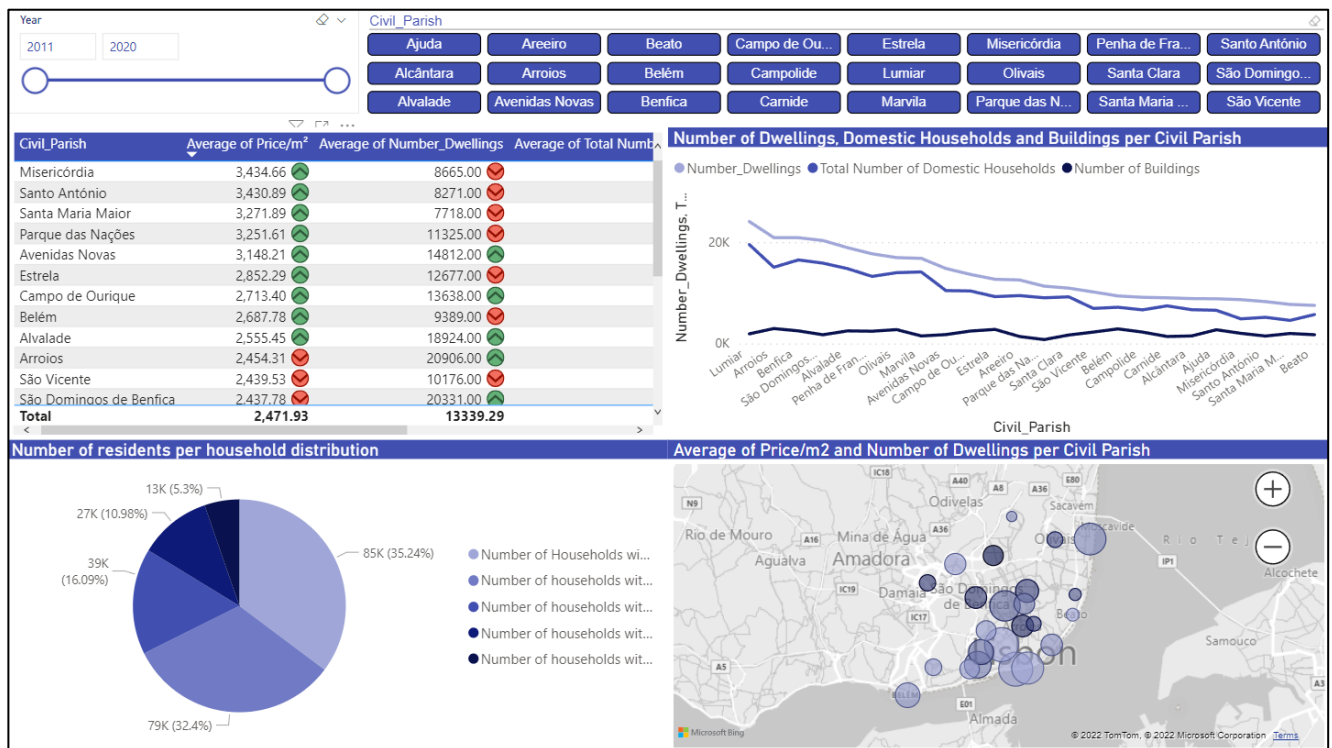


Figure 3 – Housing Attributes

As Figure 3 showcases, the housing page analyses data by comparing the Price per square meter of each parish with its housing attributes, such as the number of existing dwellings, buildings, and households per parish, as well as the distribution of the number of residents per household. On the showcased map, each parish is represented by a bubble. The size of a certain bubble is correlated with the average Price per square meter of that parish, and the higher the number of dwellings in a parish, the darker the shade of the colour. The graph results show that the parishes with the higher number of dwellings are the ones with lower Price per square meter.

The pie chart on the left of the map shows a balance between the number of households with 1 and 2 residents, representing 35.24% and 32.4% of the study population, respectively. It is also noticeable that as the number of residents per household increases, the lower occurrence of those households.

The line chart on the top of the map compares the Number of Dwellings in each parish having both the number of domestic households and the number of buildings. The first two variables are positively correlated, with the “Number of Buildings” not following the same behaviour. As also visible on the map, the parishes with the highest number of dwellings and domestic households are the parishes that are further away from the city centre, the old town, and the historical parishes.

The first visual is a table with all the variables previously mentioned in this dashboard, filtered by civil parish, having KPI indicators based on their values, compared to the overall average of that variable.

4.4 Culture Attributes

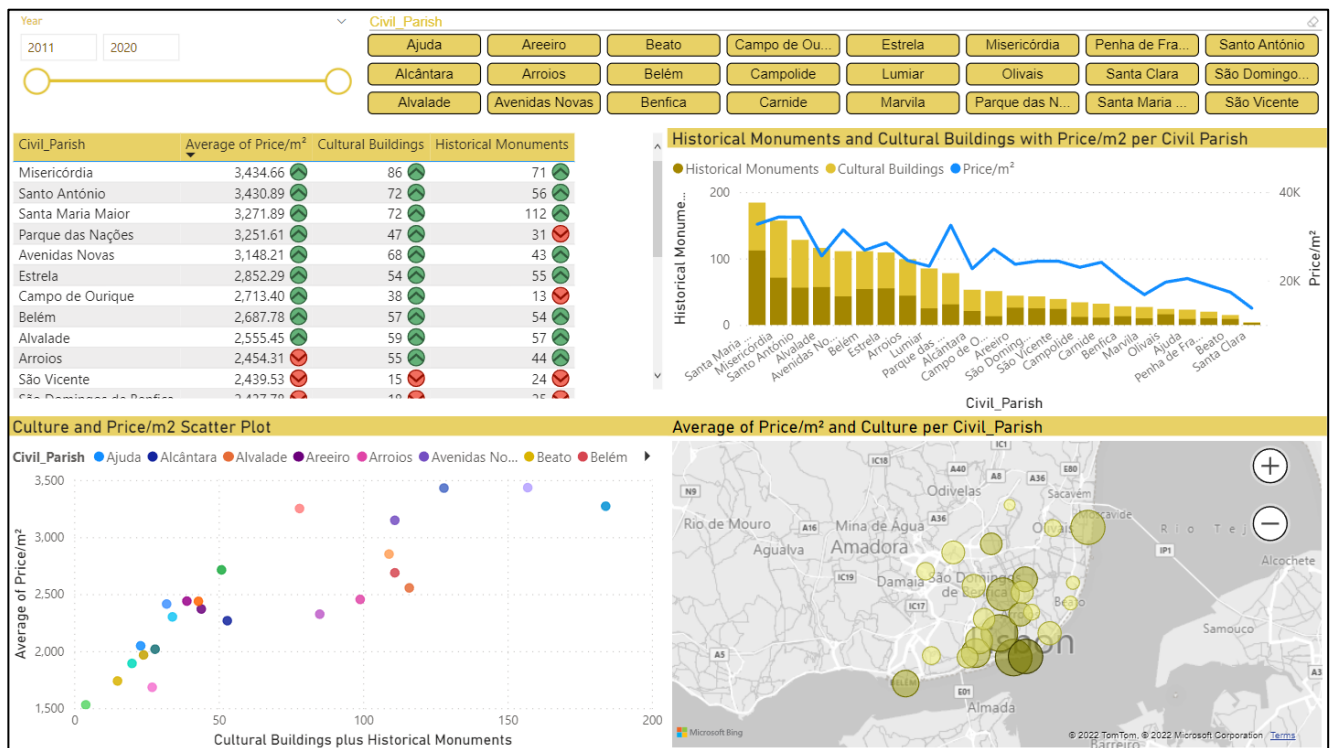


Figure 4 – Culture Attributes

The culture category brings very interesting and insightful analyses. As previously stated, for this category, two aggregate culture variables were created, comprising a set of specific variables. In the map, it is possible to observe that the civil parishes with the highest Price per square meter are also the ones with a higher number of cultural buildings and historical monuments. These parishes also belong to the historic centre and are the oldest ones. On the other hand, the further we stray from the city centre, the lower the Price per square meter and the lower the cultural levels.

This correlation between culture and Price per square meter can be visualized in the scatter plot present in the Figure 4, showing that the higher the culture indicators, the higher the Price per square meter. There is a slight exception to this norm, which is the parish of Parque das Nações, having the fourth highest Price per square meter average, while its culture indicators are standard when compared to the other parishes. The bar and line chart enables another analysis of the same data, showing the culture indicators distribution per parish and how it relates to the Price per square meter. Allowing for more numerical analysis, there is a table that shows the number of cultural buildings and historical monuments per parish, as well as the Price per square meter in those same locations, allowing for a line on line comparison with the aid of KPI icons, regulated by the average of each variable.

4.5 Education Attributes

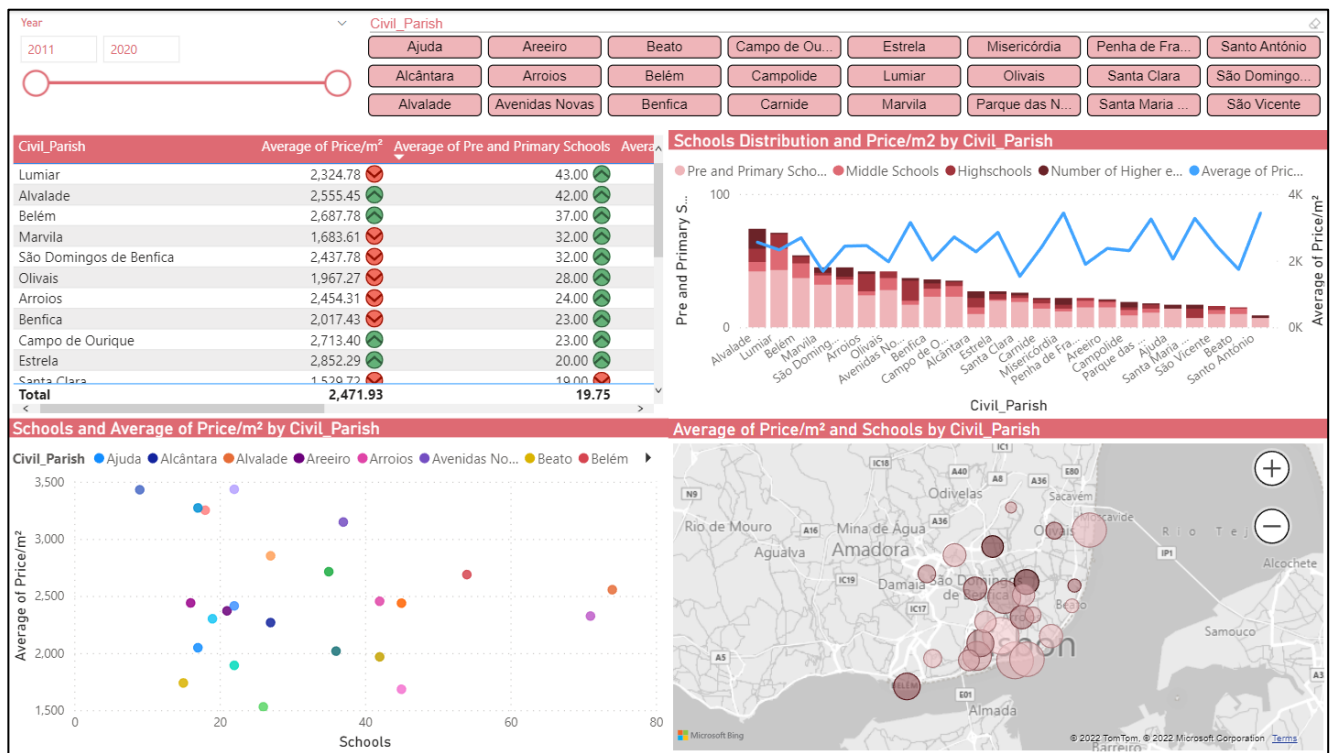


Figure 5 – Education Attributes

The education category showcases data regarding the number of schools per parish and the distribution of that number per education level and parish. The map in Figure 5 shows that there are not many schools in the historic centre, with Alvalade, Lumiar and Belém parishes on top of the school count per parish. The first two are areas with very good housing conditions, nice transportation, and good locations. It is interpretable that the north and east parts of the city have the higher number of schools, as well as Belém, with the city centre parishes having the lowest number of schools.

On the scatter plot and on the bar and line chart, it is very challenging to identify a pattern between the number of schools, their distribution, and the price per square meter. Nevertheless, in the table it is easier to numerically analyse the data, being able to identify that the parishes with the highest number of schools are, in fact, in very well-connected zones, with good transportation features, further away from the city centre; but, on the other hand, in less densely occupied parishes.

4.6 Environment Attributes

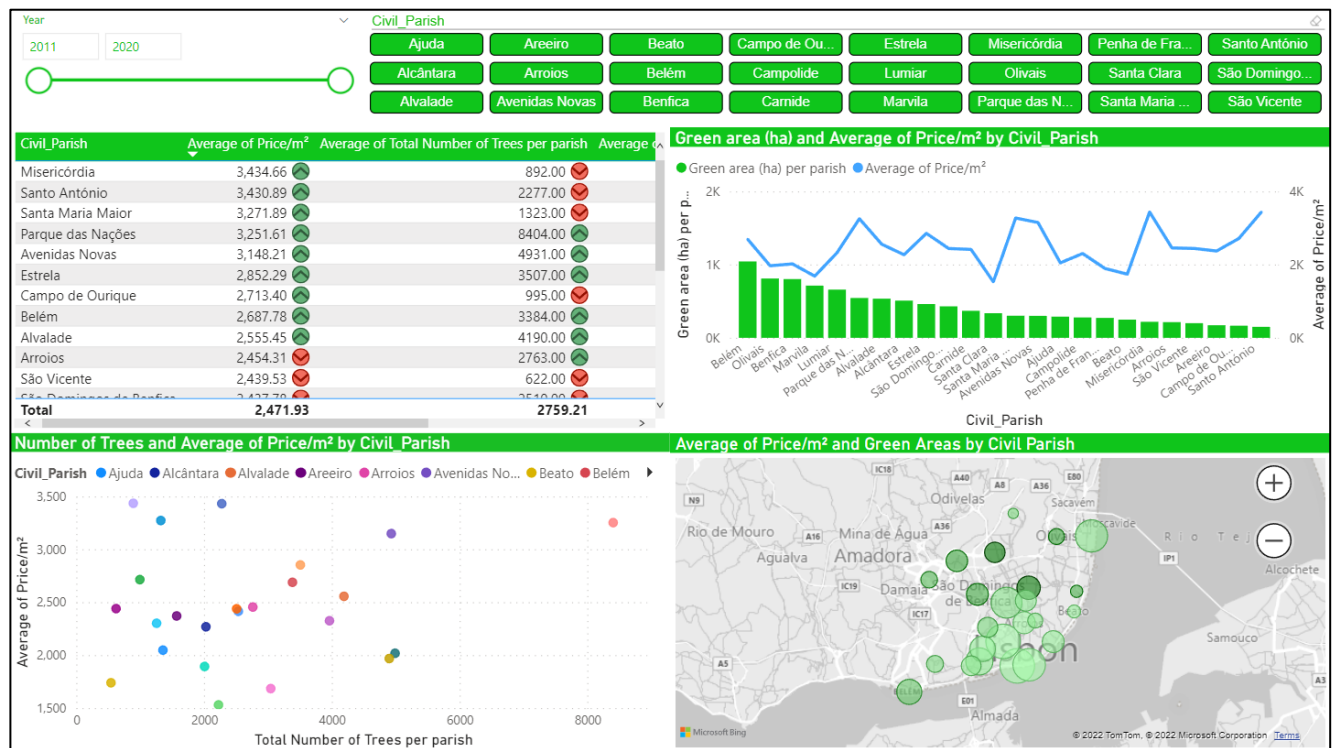


Figure 6 – Environment Attributes

Environment-wise, the different parishes in the Lisbon municipality behave very differently, depending on the analysis variable. For example, there are three visuals in Figure 6, each comparing the Price per square meter with a distinct environmental variable.

The map analyses the combination of Price per square meter and the number of green areas per civil parish. Once again, the bubble size indicates the Price per square meter, and the shade of the colour is related to the number of green areas. This way, it is interpretable that the parishes with the highest number of green areas are the ones further away from the city centre, most specifically in the north-west section of the municipality, such as Alvalade, Lumiar, São Domingos de Benfica parishes among others.

The scatter plot compares the Price per square meter variable with the number of trees. Most parishes behave similarly in the plot, outside of Parque das Nações parish, which almost doubles the second parish with the highest number of trees. The bar and line chart compares the Price per square meter variable with the number of hectares of green area per parish. The results do not show much correlation, besides the fact that the further away from the city centre and historical parishes, the bigger the number of hectares of green area.

Lastly, as in most other categories, there is a table filled with end-user numerical analyses, also accompanied by KPI indicators to measure the relation of a certain value with the average of that variable in the municipality.

4.7 Health Attributes

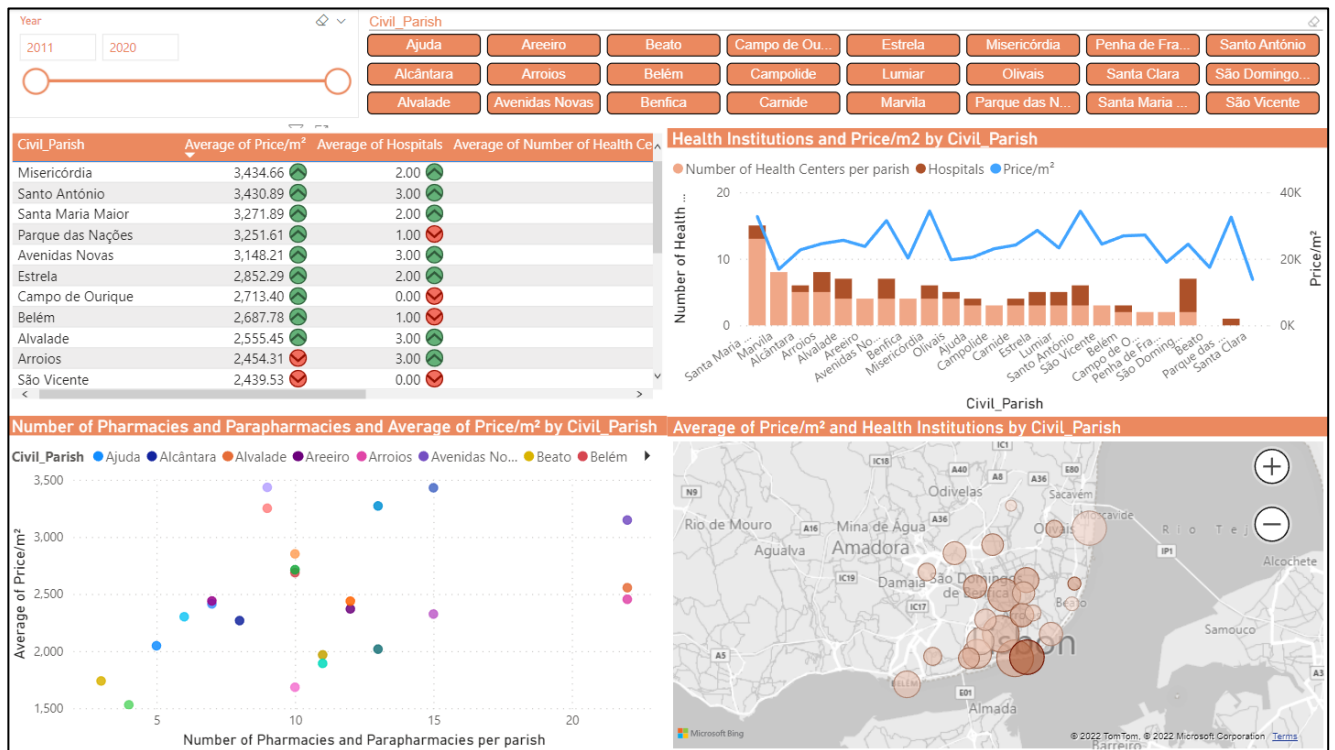


Figure 7 – Health Attributes

In the Health category, both the bar line chart and the map compare the Price per square meter with the number of health institutions on a civil parish level. Other than Santa Maria parish, which is a clear outlier, the distribution of health institutions throughout the city is quite balanced, with Beato and Santa Clara being the only parishes with no health institutions.

Relating to the number of pharmacies and parapharmacies, there is a slight positive correlation between that indicator and the Price per square meter, with Avenidas Novas parish showing a high value in both indicators. At the same time Alvalade and Arroios parishes have the most amount of Pharmacies and Parapharmacies while having a median Price per square meter. At last, there is the tabular view, with the KPI indicators, to aid in the numerical analysis.

4.8 Commerce Attributes

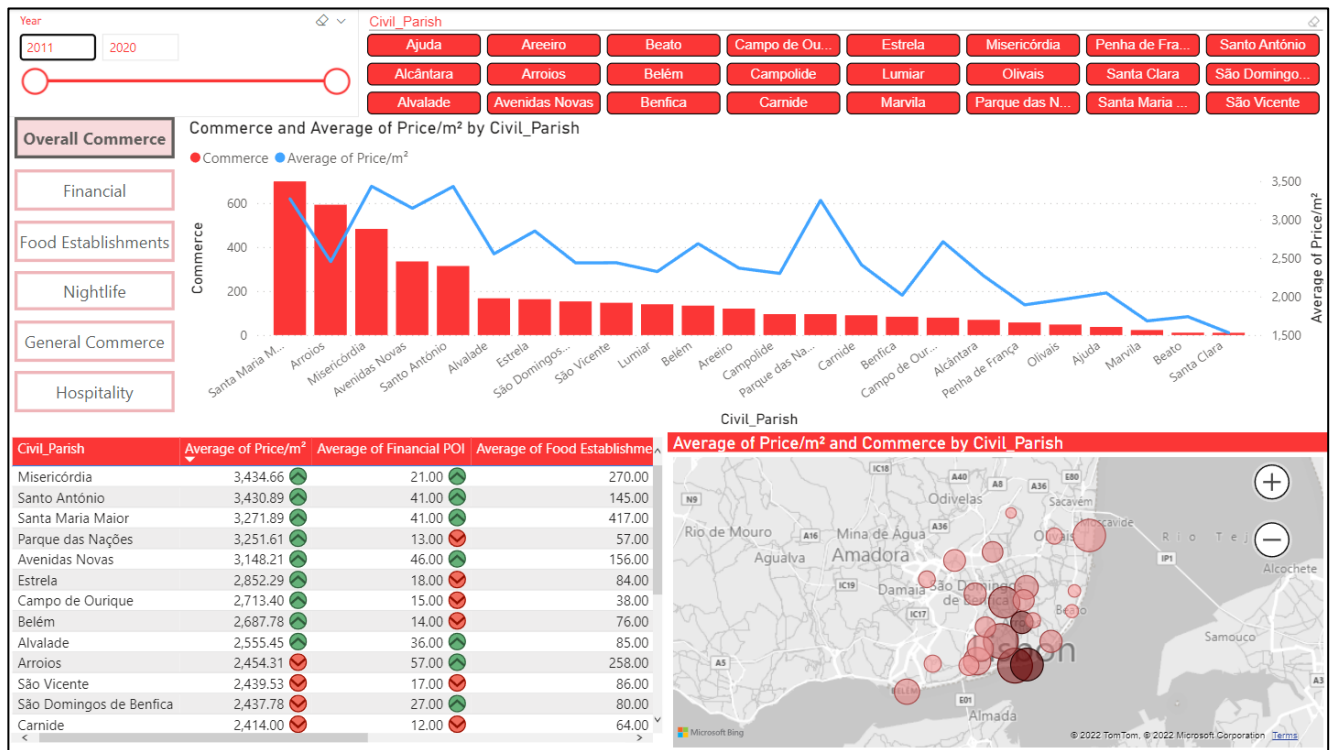


Figure 8 – Commerce Attributes

The Commerce category has a different layout compared to the remaining categories that relate the Price per square meter with Lisboa Aberta open dataset by civil parish. As displayed in Figure 8, this dashboard page has a button that updates the visuals to either analyse the overall commerce or one of the five categories individually. It is visible that the numbers of overall commerce are much higher in the city centre and the historical parishes, such as Santa Maria Maior, Misericórdia and Santo António parishes, while also having quite high values for Arroios and Avenidas Novas, which are central parishes with plenty of residents, good accessibility and a great number of companies and businesses.

The tabular view is once again used to compare the different types of commerce with the Price per square meter by civil parish, with the aid of KPI indicators regulated by the average of each variable. In the bar line chart, it is noticeable that there is a high positive correlation between the overall commerce variable and the Price per square meter, except for Parque das Nações and Campo de Ourique parishes, which showcase low levels of commerce for the existing high Price per square meter.

4.9 Mobility Attributes

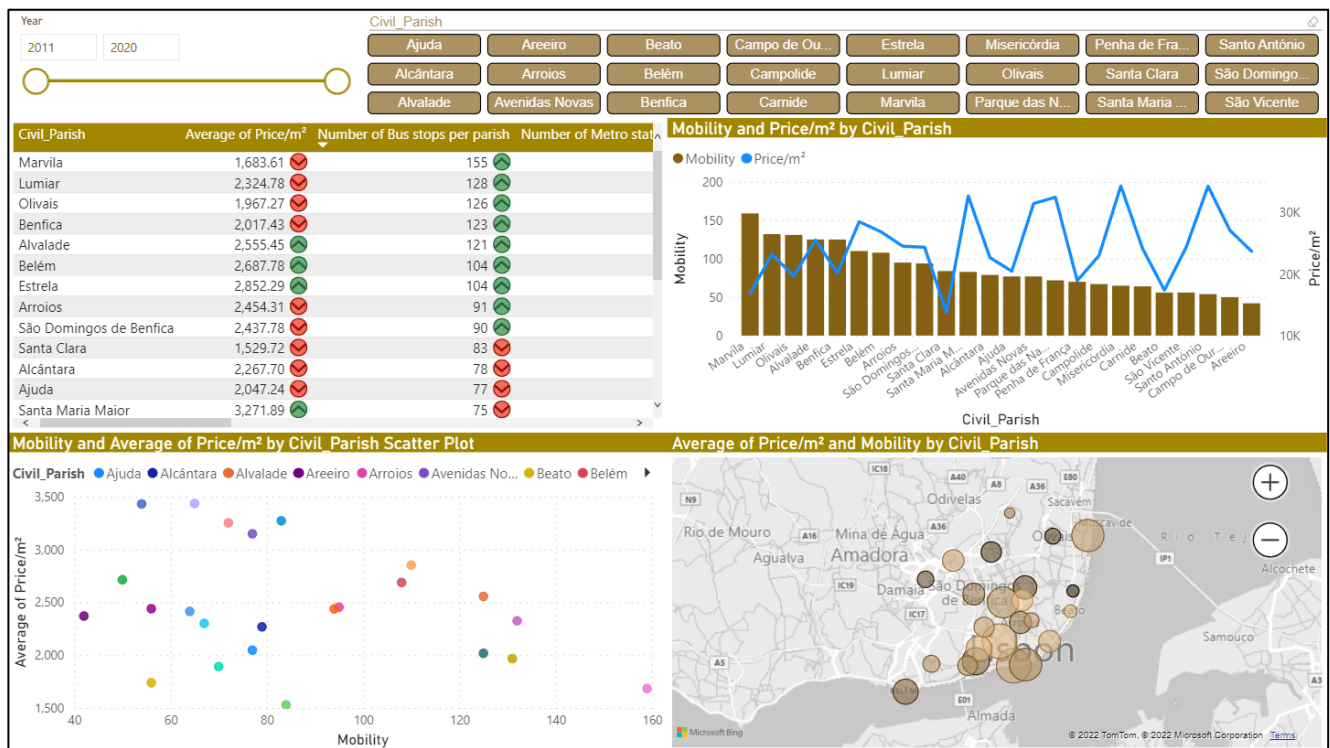


Figure 9 – Mobility Attributes

In the Mobility category, the relation between the mobility indicator and the Price per square meter is straightforward. Overall, the higher the value of the mobility indicator, the lower the Price per square meter. This is visually interpretable on the map, where we can see that the parishes with the most buildings and resident population are the ones with the most mobility options. All three visuals, besides the table, compare the mobility variable with the Price per square meter and show a negative correlation between both variables.

The table once again allows for numerical analysis, and the pattern stated before is very noticeable when comparing the Price per square meter with the number of bus stops, showing how most of the parishes that have a high number of bus stops have lower Price per square meter.

4.10 Safety Attributes

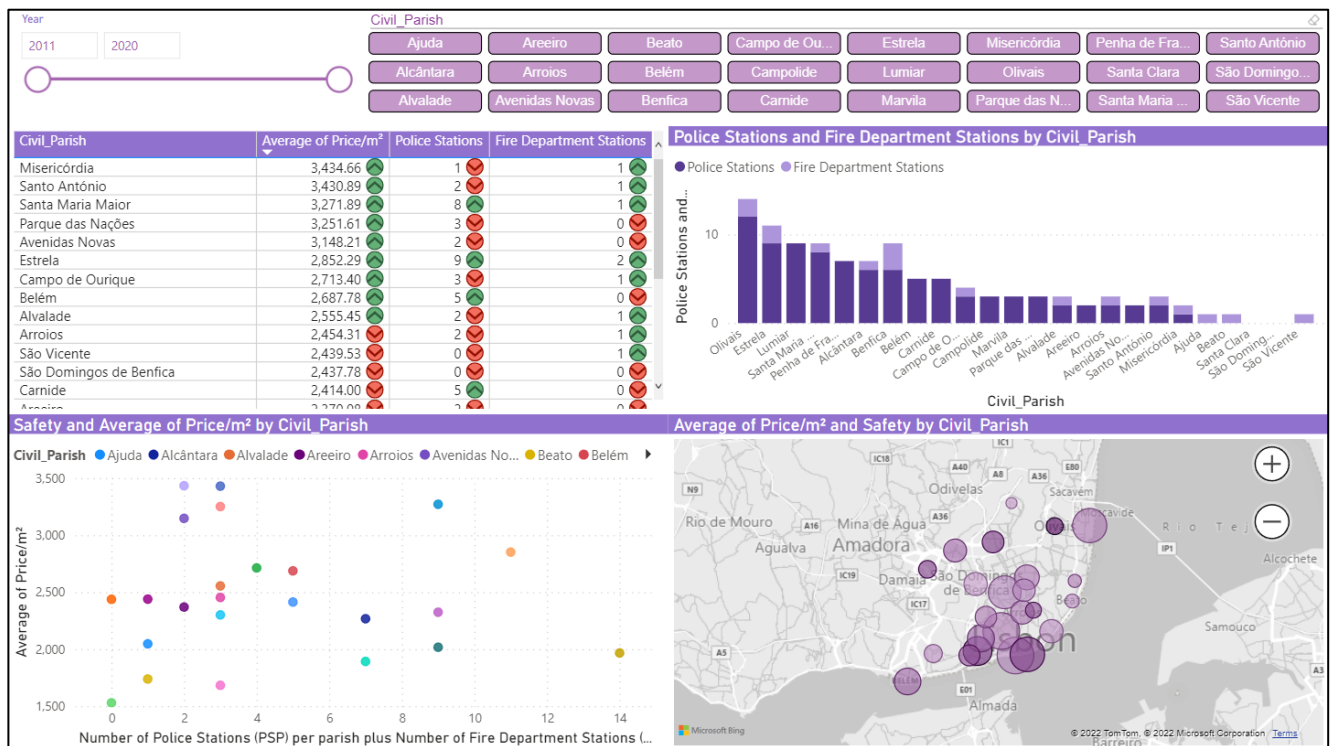


Figure 10 – Safety Attributes

The Safety category comprises the number of police stations and the number of fire stations, and as stated, not permitting a direct relation to the criminality rate.

All the visuals analyse the junction of the two variables individually. There is no direct correlation, neither through visual nor numerical analysis, between the safety indicator and the price per square meter variable. There are civil parishes with high levels of safety indicators in all areas of the city, thus not being limited by geographic location.

5. DISCUSSION

The overall Price per square meter analysis performed and the dashboard built allowed for the obtention of several insights. For example, in the property attributes category, it is visible that the Price per square meter variable negatively correlates to the Area variable, meaning the bigger houses have a cheaper Price per square meter. On the contrary, the Absorption Time variable is positively correlated to the Price per square meter, meaning that the houses with the higher Price per square meter are the ones that stay the longest on the market before being sold. On the other hand, the Number of Sold Dwellings variable does not correlate much with the Price per square meter.

The social category shows that in the municipality of Lisbon, the most common civil status is Single, followed by Married, and most residents belong to the 25 to 64 years old age group and have a college degree or higher education level. Despite this, no relevant conclusions could be drawn from comparing these attributes with the Price per square metre, at the parish level.

The housing category gives insights regarding the number of domestic households, dwellings, and buildings per civil parish, showing a positive correlation between these three variables, indicating higher values away from the Historical and city centre, in civil parishes such as Lumiar, Benfica and São Domingos de Benfica, while having the lower values on the civil parishes with the highest Price per square meter, showing that these parishes have higher surface areas with more available construction and living space. In contrast, the city centre already has limited capacity regarding new construction.

The culture category is straightforward, demonstrating a high positive correlation between the number of cultural buildings and historical monuments with the Price per square meter. The parishes of Misericórdia, Santo António and Santa Maria Maior, which are the civil parishes with the highest Price per square meter are also the ones with the highest value in this category. At the same time, Beato, Santa Clara, and Penha de França parishes which have the lowest level on the culture variables, are among the parishes with the lowest Price per square meter, which shows that this category is one of the biggest reasons why the Price per square meter is higher in the historical city centre.

The education category compares the values of the Price per square meter with the number of schools per civil parish. This analysis shows that most of the schools are further away from the city centre, in parishes with high residential education levels, while the available space for construction and the number of residents might also be influential factors.

The environment category gives insights that can be compared in terms of interpretability with the ones from the housing category. The civil parishes with the higher number of green areas and the higher number of hectares of green area are located further away from the city centre since they have more space to build parks and gardens increasing their residential attractiveness. Once again, the city centre is packed with historical and cultural monuments, as well as old buildings and households, being extremely limited when it comes to creating new green spaces.

The health category shows that the health institutions are quite well-balanced and distributed throughout the Lisbon municipality, with a large number of health centres in the historical parishes. In contrast, the bigger institutions such as hospitals, are located further away from the city centre, in parishes such as São Domingos de Benfica, Arroios, and Alvalade.

The commerce category shows a high positive correlation between the Commerce variables and the Price per square meter since the parishes with the highest amount of commercial points are located in the historical centre, where the Price per square meter is higher. In addition, the parishes of Arroios and Avenidas Novas, which are located in city centre, in very accessible areas, also have a strong correlation between the commerce variables and the Price per square meter. Arroios, Santa Maria Maior, Misericórdia, Santo António and Avenidas Novas are the five parishes with the highest number of commercial points, and with the exception of Arroios,

the other four parishes also belong to the top five parishes with the highest Price per square meter, showing the significant influence of this indicator on the study topic.

The mobility category shows quite a negative correlation between the “mobility” indicator and the Price per square meter, since the “number of bus stops” are the biggest contributor to this indicator. They are most present in the suburb parishes, further away from the city centre, and the parishes with the higher prices per square meter; once again, suburb parishes with the highest number of residents are bigger in area and need the most amount of “mobility” services.

Finally, the safety category shows that the number of police stations and fire departments is well distributed throughout the city, not showing a correlation between the Safety variables and the Price per square meter.

6. CONCLUSION

This study provides an in-depth analysis concerning the categories and variables influencing housing prices in the last decade in Lisbon raised from the body of literature. It combines property sales historical data with the socio-demographic characteristics of the resident population and more than one hundred variables from Culture, Education, Environment, Health, Commerce, Mobility, and Safety city categories, underpinning the knowledge on the topic, thus perhaps leading to a more comprehensive understanding of the evolution of the Real Estate and how the residents changed their living preferences throughout the decade. Using a Design Science Research (DSR) methodological approach, this study brings practical implications by offering an instrument — a PowerBI dashboard for gathering all the data in the study, allowing for broad, practical, visual, and easy access to the analysis for decision-making.

The main results of this study show that there is a range of categories and variables influencing the Price per square meter of a dwelling in the city of Lisbon. It also shows that throughout the years, the average Price per square meter in Lisbon rose exponentially, with Misericórdia, Santo António, Santa Maria Maior, Parque das Nações, and Avenidas Novas belonging to the top five civil parishes with the highest Price per square meter. On the social side it demonstrates that the average Lisbon resident is single, female, between the ages of 25 and 64, and has a college degree or higher. The housing results convey the fact that the further away from the historic centre, the higher the number of domestic households, dwellings, and buildings, since there is more available construction area, in bigger parishes with higher amounts of residents. Also, most households accommodate either one or two people. On the culture page, the results are evident. The Cultural analysis shows that parishes with a higher level are also the ones with the highest Price per square meter, showing a very strong correlation and influence among variables. The Education analysis shows that the parishes with a higher amount of schools are away from the city centre, where there is more available space and more residents, thus not being a high influencer category for the Price per square meter. The same is visualized in the environment category, where the parishes with the higher numbers of green areas and most hectares of green areas are the ones with greater distance from the city centre, such as Belém, Lumiar, São Domingos de Benfica, and Alvalade parishes, where the number of dwellings and overall amenities is higher, as well as the residential population. The health analysis shows that the health institutions are quite well distributed throughout city, except for a high number in the historic centre, namely Santa Maria Maior parish. The Commerce analysis shows that the parishes with the highest Price per square meter are also the ones with the highest value on commerce variables. The mobility category shows that parishes like Marvila, Lumiar, and Olivais, are the ones with the higher values on the mobility variables, most likely since they are further away from the city centre and are among the parishes with the higher number of residents. The safety category does not influence the housing prices since there is no visible correlation between the number of police stations and fire departments and the Price per square meter by civil parish. Finally, results show that the commerce and culture categories strongly influence the Price per square meter by civil parish.

This study has limitations concerning the lack of geo-localization of the dwelling transactions on the Confidential Imobiliário dataset, which was detrimental to the accuracy and pinpoint ability of the analysis performed. Another limitation relates to the fact that the Portuguese Census of 2021 data available is still provisional at the date of this study, since the final results have not been released yet, leading to uncertainty regarding the precision of the socio-demographic data. Another limitation concerns the fact that the Confidential Imobiliário dataset had data quality completeness issues concerning missing data for the years 2007 to 2010, which restrained the analysis and was not detailed in a daily or weekly fashion, thus not allowing for the application of time series data analysis and possibly the use of predictive modelling techniques.

In the future, with the proper data, the Real Estate analysis could be detailed in a daily or weekly fashion, allowing for the application of time series analysis and possibly the use of predictive modelling techniques for housing prices. This analysis may be generalized and applied to other cities, since it returns plenty of insightful results. In addition, geo-localization should be used to enable the pinpoint ability and the possible use of geospatial intelligence analysis for more accurate information supporting decision-making in the Real Estate industry, city government, or policymaking.

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