The Effects of Cultural Heritage on Residential Property Values:
Evidence from Lisbon, Portugal

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Abstract

This paper examines the impact of historic amenities on residential housing prices in the city of Lisbon, Portugal. Our study is directed towards identifying spatial variation of amenity values for churches, palaces, lithic (stone) architecture, and other historic amenities through the housing market and making use of both global and local spatial hedonic models.

Our empirical evidence reveals that different types of historic and landmark amenities provide different housing premiums. While having a local non-landmark church within 100 meters increases housing prices by around 3.9%, higher concentrations of non-landmark churches within 1000 meters yield negative effects in the order of 0.1% on housing prices with landmark churches having a greater negative impact around 3.4%. In contrast, higher concentration of both landmark and non-landmark lithic structures positively influence housing prices in the order of 2.9% and 0.7% respectively.

Global estimates indicate a negative effect of protected zones, however this significance is lost when accounting for heterogeneity within these areas. We see that the designation of historic zones may counteract negative effects on property values of nearby neglected buildings in historic neighborhoods by setting additional regulations ensuring that dilapidated buildings do not damage the city's beauty or erode its historic heritage.

Further, our results from a Ridge Geographically Weighted Regression specification indicate the presence of spatial non-stationarity in the effects of different historic amenities across the city of Lisbon with varying between historic and more modern areas.

Keywords: Spatial hedonic models, Historic amenities

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1. Introduction

Historic cities all over the world are identifiable by their iconic historic buildings and monuments, which are a testimony to the city's history as a whole. This is particularly evident in European capitals such as Paris with the Eiffel Tower, the ancient structures and edifices of Rome, the Acropolis of Athens, or the Manueline and Moorish styled monasteries, towers, and castle in Lisbon.

Residents of such cities value the aesthetic and cultural significance of these immovable cultural heritage goods and sites creating demand for living spaces in their proximity (Van Duijn and Rouwendal 2012, Koster et al. 2015) and increasing the value of real estate in these urban markets (Glaeser et al. 2001, Carlino and Saiz 2008). When these unique and irreplaceable historic amenities are concentrated in historic city cores, as in many European cities, higher income households are pulled to the city center (Brueckner et al. 1999, Koster et al. 2015). In addition, these high amenity areas attract the creative class who are direct producers of cultural capital, increasing the areas attractiveness and commanding further housing premiums (Florida and Mellander 2010).

Cultural heritage is also an important backbone of many economic sectors including tourism and travel, which are significant drivers of economic activity. Both domestic and international tourists are major visitors to historic heritage places. In addition to climate, quality of public services, crime levels and cultural or environmental amenities, the stock and quality of historic amenities are essential elements in attracting visitors to a city. In 2007, for example, tourism and travel generated €9.5 billion in Lisbon representing 4.8% of gross domestic product and employing 9.8% of the working population (World Travel and Tourism Council 2007). In November 2014 tourism revenue in Lisbon attributed to lodging produced €45.8 million (Instituto Nacional de Estatistica 2015).

Agencies and organizations whose mission it is to protect and preserve historic and culturally important buildings and monuments from pollution, development and even use by the public must compete nevertheless for needed resources with other social goals such as health, education or even social housing. Furthermore, given limited resources, priorities must be set among competing preservation and restoration goals.[1] Therefore, an estimate of the economic value of alternative cultural heritage goods and sites is of great importance.

A key question is the extent to which different types of tangible immovable cultural heritage are capitalized into nearby residential property values, and the resulting effect on the value of neighboring properties and property tax collection. Estimates of the effect of cultural heritage and in particular historic monuments, on the value of nearby real estate would be of use to provide not only an idea of the general public's preferences but also to inform decisions over the level of funding of cultural heritage and over conflicting urban planning goals which may arise, for example, from the need to

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[1] According to an analysis of the Portuguese public budgets for culture (Augusto Mateus and Associados 2010), resources devoted to heritage preservation and valorization increased from 33% in 2000 to 36% in 2008 within the budget of the Portuguese Ministry of Culture.

convert urban land into new business development and the desire to preserve the charm of historic urban areas.

It is well establish that the price of real estate is determined by the bundle of structural and locational amenities it displays. If a household values cultural heritage goods and sites then the household chooses a housing unit for which the willingness to pay for an increase in cultural heritage equals the marginal implicit price of purchasing that increase. However, households may be willing to pay different prices for different cultural heritage goods depending on their generated net benefits and on their accessibility. Consequently, the capitalization of cultural heritage into real estate values should not only differ across space but also across heritage categories.

For instance, non-landmark monuments such as neighborhood fountains, statues or even local churches are local cultural heritage, which generate values only for those who live in very close proximity to the amenity. While such a good might generate both use and non-use values for residents of the neighborhood and/or visitors to that part of the city, we would not expect large values for residents who live at some distance from that location.[2] Therefore, it is likely that most of the benefits (value) of such type of tangible immovable cultural heritage be captured through the local housing market.

In contrast, landmark monuments are likely to be national cultural heritage and as such hold some importance not just for the residents of a city but also for all citizens in the country. In this case, we would expect that the value of such monuments do not decrease as fast as we move away from them and that the importance of its non-use value component be more significant compared to a non-landmark monument. This in turn suggests that the real estate market provides a lower bound for the estimated total value of such historic amenities, reflecting mostly its local use benefits (or disamenities). One may also think of some landmarks as global cultural heritage goods, some of which having even been designated as world heritage sites such as the Cathedral of Notre-Dame and the Eiffel Tower in Paris, the Monastery of Jerónimo sand Tower of Belém in Lisbon or the Historic Center of Rome with its Colosseum and Arch of Constantine, just to name a few.

We thus raise the following two questions: What are the effects of proximity and concentration of tangible immovable cultural heritage on urban residential markets? Does the household’s marginal willingness to pay for urban amenities, and in particular historic immovable amenities, vary across different categories of cultural heritage and over space?

Our study addresses these previous questions by identifying the variation of values for a broad set of urban historic amenities and the value of protected historic areas (hereafter “protected zones”) in

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[2] The total value of historic heritage can be decomposed into use and non-use values. The use value includes not only the direct benefits of visiting, living or working in a heritage place but also indirect benefits associated with community image, aesthetically quality and social interaction. On the other hand, the non-use value includes a variety of intangible benefits that do not require a person to actually visit the heritage place. People may value the simple existence of the place as well as the option to visit a heritage place, although they may not have immediate plans to visit it. In addition, a person may also value the chance to bequeath a heritage place to future generations, as part of a shared cultural legacy.

the housing market of Lisbon, Portugal. We define urban historic amenities in accordance with the UNESCO definition of cultural heritage, representing the legacy of physical infrastructures (thus, tangible and immovable) inherited from past eras that are aesthetically pleasing to current residents, hold historic and architectural significance and are bestowed for the benefit of future generations.[3] The historic amenities of interest in this study are categorized as either churches, palaces, lithic (stone) structures, or other historic amenities greater than 50 years old with landmark amenities and world heritage sites (which are themselves landmarks) within each group highlighted. For example, the iconic Castle of St. Jorge is a landmark lithic structure while the Monastery of Jerónimos is a world heritage (and landmark) church. Our protected zones are defined as the union of all areas in Lisbon where there exists (i) a designated monument; (ii) a 50 meter buffer around a designated monument; or (iii) a listed special protected area. The reference for protected zones in Lisbon comes from the *Câmara Municipal de Lisboa* Urban Plan.

We first develop an analytical urban model that includes herd behavior to discuss the effects that historic amenities have on residential property values. This theoretical framework emphasizes the importance of spatial heterogeneity in amenities in the formation of property values and sets the stage for the empirical component of this study providing the foundation for the choice of variables and model specification. We then use a standard hedonic model to estimate the amenity values of proximity to different categories of historic amenities, cultural heritage concentration and historic protected zones. Results indicate significant spatial autocorrelation in the residuals, and thus a spatial error model is implement as indicated by specification tests and the AIC criteria. There are benefits to modeling this behaviour through spatial hedonic models with reduced sum of squared errors of prediction up to 4% relative to traditional Ordinary Least Squares (OLS) models. Further, we extend the analysis to a local Ridge Geographically Weighted Regression (RGWR) model to investigate spatial non-stationarity and generate local estimates for individual historic amenities and general categories of monuments either non-landmark, landmark or world heritage sites.

Our results show that different types of historic heritage have different premiums in the residential housing market. We see no significant global effect when isolating the impact of proximity to world heritage sites with consistent effects from proximity and concentration of landmark and non-landmark amenities. While proximity to landmark and non-landmark amenities increase prices by approximately 0.01% for every meter, higher concentrations of landmark amenities within 1000 meters has a positive impact of 0.9% while higher concentrations of non-landmarks have a negative impact of 0.1%.

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[3] According to UNESCO cultural heritage encompasses several main categories of heritage namely tangible movable culture (such as books, works of art, and coins), tangible immovable culture (such as buildings, monuments and archeological sites), tangible underwater culture (shipwrecks, underwater ruins and cities), intangible culture (such as folklore, oral traditions, performing arts and rituals) and natural heritage (including culturally significant landscapes, and biodiversity). In our study we focus only on tangible immovable culture.

In general, we see a pattern of strong positive price effects for higher concentrations within 50 meters, however this effect is reversed with negative, yet weaker, effects coming from higher concentrations of amenities at 1000 meters. This concentration of monuments informs on the ensemble effect of historic amenities.

Finer disaggregation by amenity type reveals however that while having a local non-landmark church within 100 meters increases housing prices by around 3.9%, higher concentrations of non-landmark churches within 1000 meters yield negative effects in the order of 0.1% on housing prices with landmark churches having a greater negative impact around 3.4%. In contrast, higher concentration of both landmark and non-landmark lithic structures positively influence housing prices in the order of 2.9% and 0.7% respectively. The effects from different types of landmark amenities are consistently stronger than their non-landmark counterparts.

While global results indicate a negative effect from being located in a protected zone of 1.6%, this effect is removed when accounting for spatial dependence in the data or by the inclusion of interaction effects which capture the heterogeneity of locations within these protected zones themselves.

Our empirical evidence also highlights the capacity of the RGWR model in explaining price differentials over space for proximity to historic amenities. Our results reveal in general a concentration of positive price effects for proximity to different types of historic amenities in the historic CBD of *Baixa*. The magnitudes of values, particularly for churches, located in this CBD have nevertheless a limited range about zero with strong magnitudes located outside *Baixa*. This may be explained because historic amenities are disproportionally clustered at this historic CBD, an area of the city that has also an elegance and regularity of architectural style that most other areas of Lisbon do not have.

In contrast, along the Tagus River to the west of *Baixa* and towards Belém, there are stronger positive price effects for lithic and other historic amenities. Compared to the primary CBD where there is high population density, the smaller localized amenities along the river draw in fewer visitors to the area, which already has little touristic traffic. From this we establish that spatial non-stationarity exists in the data and global estimates may mask relevant localized effects.

The remainder of this paper is structured as follows. Section 2 reviews the existing literature. Section 3 develops our analytical model and section 4 describes the study region and presents our data. Then, section 5 presents our empirical strategy for assessing the impacts of proximity to historic amenities and protected zones on housing prices. Section 6 discusses the results from our traditional OLS model, global spatial model and local ridge geographical weighted regression. Finally, section 7 offers conclusions.

2. Existing Studies

There is already a large body of literature that has sought to identify the degree to which heritage values contribute to the price of residential properties and whether or not listing of such properties (i.e. seeking to ensure the maintenance of the dwelling's heritage characteristics) affects property values by applying the hedonic pricing technique.These studies reveal that when dwellings or places receive heritage designation, there are positive housing benefits through the intrinsic benefits from owning heritage properties and further potential tax exemptions as well as positive spillovers to nearby properties (Asabere et al. 1994, Coulson and Leichenko 2001, Deodhar 2004, Cebula 2009, Coulson and Lahr 2005, Ahlfeldt et al. 2012, Van Duijn and Rouwendal 2012, Koster et al. 2015). Some studies even show that higher income households prefer to reside in heritage zones and listed heritage buildings, (Koster et al. 2015).Yet, there is also some evidence that there may be negative effects from stringent regulatory frameworks and limitations on alterations or maintenance associated to heritage designation (Asabere et al. 1994).

In contrast, empirical studies focusing on the effects of proximity and/or concentration of historic monuments on property values are quite scarce, in part due to the high level of spatially detailed data required. To our knowledge, the few existing studies have focused on specific types of immovable cultural heritage such as churches and places of worships (Do et al. 1994, Carroll et al. 1996, Brandt et al. 2014) or examined global average effects of a pool of historic monuments (Lazrak et al. 2014).

Our study adds to this latter set of empirical studies by conducting both global and local spatial analyses of the amenity values of broad categories of historic monuments and types of cultural heritage clusters namely with landmark status. In particular, we use global spatial regression techniques to account for spatial autocorrelation and locally weighted regression techniques to allow the housing hedonic parameters to vary over space. This latter technique better represents micro-market realities and the importance of location as a prime determinant of housing prices. Finally, we also provide a theoretical foundation for variable choice and the need to account for spatial dependence in our model of residential housing prices.

Focusing specifically on the impact of proximity to churches, Do et al. (1994) estimate that houses closest to churches have decreased prices, however Carroll et al. (1996) using a similar strategy find a positive relationship. Both studies were conducted prior to the widespread use of spatial modeling techniques, and therefore ignore potentially important spatial autocorrelation in the data in which housing prices near each other are similar in price.

Although introducing distance or concentration of historic amenities in the standard OLS model provides a measure of their impact, not accounting for spatial dependence in the data when using housing prices may lead to biased and inefficient results. Brandt et al. (2014) add to the discussion from the previous decades on valuing the effects to churches and places of worships by accounting for such spatial dependence. The authors estimate a 4.8% housing premium for a location within 100 to 200 meters distance of a place of worship. This effect remains significant and positive even after a building has lost its religious affiliation, indicating that households place value on buildings themselves for non-religious purposes potentially for architectural or cultural significance.

Moro et al. (2013) collected data on historic and cultural sites in Dublin to estimate the effect on housing prices of proximity to these sites. Similar to what we do in our study, the sites were classified into broad categories to measure the effect of distance to the nearest historic building, church, Martello tower, archaeological site, and a residual grouping of monuments (memorials, gardens and obelisks). The authors test many specifications and in general find that increasing the distance to the nearest historic building has a negative effect on housing prices in the range of 0.07%. Yet, the authors do not test or account for spatial dependence in housing prices, and further consider only the global individual effect of each group separately without controlling for proximity to all other categories of cultural and historic amenities. Within categories, there is no distinction between individual sites or the relative prominence of each site in terms of landmark status.

More recently, Lazrak et al. (2014) obtain improvements upon the results of a standard hedonic model by accounting for the spatial dependence both in their dependent variable and error term. Heritage and cultural amenities are considered all listed monuments which include registered architectural, religious, industrial and UNESCO heritage sites. The authors are able to study the internal effect of heritage designation on a property, the external effect of heritage density of an area, and the effect of being located in a historically protected area of the city. When accounting for the spatial dependence of the data, the estimated direct effect of heritage designation is 23.8%. The indirect effect for an additional monument within a 50 meter radius is 0.28%. When estimating the premium for being located in a protected historic district, the authors find a significant value of 26.4%. These results assume that different categories of monuments all have the same effect and estimates the average effect of historic and cultural heritage.

Comparatively fewer studies have employed GWR techniques for the valuation of urban amenities such as is done in our research. These localized modeling techniques are argued to be better suited for local policy decisions with heterogeneity across neighborhoods not accounted for in global models (Ali et al. 2007). Bitter et al. (2007), Cellmer (2012) and Yu (2007) estimate geographically weighted models on the standard set of housing characteristics and find significant spatial variation in housing prices across space and improvements in using localized techniques. In terms of valuing amenities through the housing market Cho et al. (2006), Cho et al. (2008) and Nilsson (2014) use the GWR techniques to value open spaces and natural amenities via property prices.

3. Analytical Model

Model Assumptions

We assume a representative household in a small open monocentric city. The city is open in the sense that households are perfectly mobile within and between cities. In equilibrium, the utility level does not vary across location. The city is small and one of many with utility level determined in the national markets, and exogenous to the city. Further, households are assumed to rent housing services from absentee landlords.

The household decision model conforms to some of the basic assumptions of the standard monocentric city model, including a central business district (CBD) and commuting costs that depend on the residence-to-CBD distance. Thus, the relative positions of all locations in the city are described by a single variable x, equal to the distance to the CBD. In addition, we assume that residential houses are also characterized by the level of urban amenities associated with a specific location (e.g. view, open space, historic monument), $A(x, x_a)$. For simplicity we assume the CBD to be located at $x = 0$ and the urban amenity to be located at $x_a$with $x_a > 0$. Households take the level of urban amenities as given when choosing residential locations.

Households have preferences defined over urban amenities at their dwelling sites, A, housing services, Q, and the consumption of a composite non-housing numéraire good, C. Specifically, the household utility function is assumed to be:

$$U = u(Q, C) + \varphi(A) \tag{3.1}$$

where $u(\cdot)$ is utility from non-amenity goods and quasi-concave, and $\varphi(\cdot)$ is utility from urban amenities and concave. The urban amenity function is represented as follows:[4]

$$A = \frac{\tilde{A}}{N} f(x_a, x) \tag{3.2}$$

where $\tilde{A}$ represents the urban amenity capacity, N is the external consuming group size and $f(x_a, x)$ is a distance function that captures how far the household is located from the urban amenity. For simplicity, we assume that congestion effects associated with the urban amenity come from external (non-resident) visitors N.

Letting income be y and commuting cost per mile t, disposable income at distance x is given by $y - tx$. Households consume housing with a rental price of R and a composite good with unit price, and have the following budget constraint:

$$y - tx = QR + C \tag{3.3}$$

Households maximize utility 3.1 with respect to budget constraint 3.3 by choosing x, C, Q and taking urban amenities as given. The first order conditions for the maximization problem yield the optimal choices of housing services and non-housing goods as:

$$C^*(y, t, R, x) \text{ and } Q^*(y, t, R, x) \tag{3.4}$$

Substituting these ordinary demand functions back into 3.1 yields the indirect utility function. In a spatial market equilibrium households must have no incentive to relocate. Thus in equilibrium households must attain the same exogenous level of utility $\bar{V}$, regardless of their location in the city.

$$V\left(y, t, R, x, \tilde{A}, N, x_a\right) = \bar{V} \tag{3.5}$$

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[4] Exogenous urban amenities are modeled generally here. Brueckner, et al. (1999) categorize exogenous urban amenities to include both historic (urban infrastructure from past eras) and natural (topographical features). Empirically this research focuses on historic amenities.

Equation 3.5 implicitly defines the households rental bid price function for housing as:

$$R(y, t, x, \tilde{A}, N, x_a, \bar{V}) \tag{3.6}$$

The expression in 3.6 represents the price households are willing to pay for a unit of rental housing services at location x. When rents vary by 3.6 across the city, household utilities are identical across locations and households have no incentive to relocate.

To the extent that our model allows spatial variation in urban amenities, the spatial pattern of housing rents emerging from our model is more complicated than in the standard monocentric city model. In particular the willingness to pay for rental housing may no longer be a monotonically decreasing function from the CBD as seen in 3.7 since households may be willing to sacrifice proximity to the workplace for local urban amenities:

$$\frac{\partial R(y, t, x, A, \bar{V})}{\partial x} = \frac{1}{Q}\left\{-t + \frac{\tilde{A}}{N}\frac{\varphi_A f_x}{u_C}\right\} \lesseqgtr 0 \tag{3.7}$$

From Rental Price to Property Value

If the residential market works in accordance with conventional economic theory then the price of a house should be such that buyers are indifferent between renting and owing. Note however that rents are determined in the residential market for space use, not in the asset market for ownership. Equation 3.6 thus captures the fundamental forces driving residential rents. On the other hand when investors acquire an asset (real estate property), they are actually acquiring a current and future income stream. In a frictionless market, residential rents should cover the user cost of a property such that:

$$R_t = (i_t + d_t + m_t)P_{x,t} - \left[E_t\left(P_{x,t+1}\right) - P_{x,t}\right] \tag{3.8}$$

where i, is the interest rate, d, depreciation, and maintenance costs, m. Expected capital gains (or losses) are represented by the expected change in property value P_x between periods for investor at location x.

Rearranging 3.8 gives the equation for residential housing price in period t for investor x. This price is driven by the imputed rent, interest rate, depreciation rate, and maintenance as well as from expected price in the following period.[5] For simplicity, we have that in equilibrium imputed rents are equal to market rents.

$$P_{x,t} = \frac{R_t}{1 + i_t + d_t + m_t} + \frac{E_t\left(P_{x,t+1}\right)}{1 + i_t + d_t + m_t} \tag{3.9}$$

Following Hott (2009) and Franco and Cutter (2015), we assume that an investor's expectation regarding the future property price depends on both social and non-social signals. Informational influence affects expectations of real estate price appreciation if investors look to others in deciding

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[5] Imputed rents are defined as the implicit rent for home owners which account for the fundaments of rent – interests, depreciation, and maintenance.

whether or not their real estate purchase will generate capital appreciation. In this sense, we can write the expectation regarding future price as:

$$E_t\left(P_{x,t+1}\right) = (1-\lambda)E_t\left\{\sum_{j=1}^{\infty}\frac{R_{t+j}}{\prod_{n=1}^{j}(1+i_{t+n}+d_{t+n}+m_{t+n})}\right\} + \lambda P_{-x,t} \tag{3.10}$$

where λ captures the magnitude of the information spillovers and weight that an investor x places on the value of all neighboring properties $P_{-x,t}$ at time t. The investor's expectation of their property value in the following period is the weighted sum of his expected stream of future rents and current value of neighboring properties.

Finally, inserting 3.10 back into 3.9 we get the representative residential property price for investor x at time t as:

$$\begin{aligned} P_{x,t} = & \frac{R_t}{1+i_t+d_t+m_t} + E_t\left\{\sum_{j=1}^{\infty}\frac{R_{t+j}}{\prod_{n=0}^{j}(1+i_{t+n}+d_{t+n}+m_{t+n})}\right\} \\ & + \lambda\left\{\frac{P_{-x,t}}{1+i_t+d_t+m_t} - E_t\left\{\sum_{j=1}^{\infty}\frac{R_{t+j}}{\prod_{n=0}^{j}(1+i_{t+n}+d_{t+n}+m_{t+n})}\right\}\right\} \end{aligned} \tag{3.11}$$

According to 3.11 residential property prices can divert from their fundamental value because of a herding behavior. The fundamental price of a residential real estate property is driven by present and expected future residential rents, interest rates, depreciation, maintenance, and the price of neighboring residential real estate. However, the presence of this herding behavior ($\lambda > 0$) may create a positive feedback effect between the attractiveness of a property and its price.

If $\frac{P_{-x,t}}{1+i_t+d_t+m_t} > E_t\left\{\sum_{j=1}^{\infty}\frac{R_{t+j}}{\prod_{n=0}^{j}(1+i_{t+n}+d_{t+n}+m_{t+n})}\right\}$ then the excess return from this price externality is positive, which pushes the price of a residential property higher. Alternatively if the opposite holds, there is a negative price externality. The weight parameter λ captures the strength of this externality. This in turn implies that real estate markets are not fully efficient and autocorrelation in price inflation should be accounted for in studies that examine the determinants of real estate prices. Equation 3.11 therefore sets the stage for the empirical analysis of residential property values and location desirability within Lisbon.

4. The study region and data

4.1. Study Region

Our study area is the European capital city of Lisbon, Portugal, the largest city in the country with a 2007 population (corresponding to the year for which housing data is available) of 552,118 and slightly over 2 million residing in the greater metropolitan area.[6]

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[6] Population defined as the total sum of individuals of all ages residing within the city limits of Lisbon.

Lisbon is a city situated in a region of seismic activity and built on seven hills near the mouth of the Tagus River, which runs from the Iberian Peninsula to the Atlantic Ocean where the city is located. Perched on the edge of the Atlantic Ocean, Lisbon is therefore one of the rare Western European cities that faces the ocean and uses water as an element that defines the city. Fearless navigators embarked from here in the 15th and 16th centuries to sail unknown waters and chart new lands, and the legacy of this golden Age of Discovery underpins much of the city's culture and heritage. The city also enjoys a subtropical-Mediterranean climate with mild winters and long, warm summers.

Areas in Portugal are broadly organized into *freguesias* or civil parishes, and in 2007 the city had 53 of such formal divisions covering its 100.05 km^2 area.[7] However, locals mostly refer to the different areas of Lisbon in terms of *bairros*. Though the so-called *bairros* have no formal political boundaries and are usually defined by locals as a set of historic neighborhoods with both social and historical significance characterized by common architectural, cultural and historic features, tempered by a strong influence of local perception over their history. Areas such as *Alfama*, *Bairro Alto*, *Mouraria*, *Bica*, *Graça* and *Madragoa* are clear *bairros* for the people of Lisbon. In Lisbon, *bairros* can be found both in older historic areas and also in newer developments, which speaks to the human dimension attached to the terminology.

The primary CBD of Lisbon, known as *Baixa Pombalina* or simply *Baixa*, is located in the downtown core bordered by the Tagus in the south. This part of the city was completely rebuilt after the 1755 earthquake by the Marquês de Pombal. The planned layout, greatly different from what one can observe in the more ancient neighborhoods, is a testimony to the ideas of the Enlightenment. While this central area serves as the main employment center and historic central hub of the city, in 1998 Lisbon leveraged it's hosting of the World Expo to redevelop a previously idle industrial area into a secondary CBD. This area, known as *Parque das Nações* (Park of the Nations) or "Expo", is now a highly active commercial/business and residential area of the city located further inland along the river.

The city is serviced by the Lisbon Portela international airport located in the north, which is the main international transportation hub. Further, there are two international train stations, one in each CBD, linking Lisbon to destinations in Spain and France. Two bridges also connect the city to municipalities and motorways on the south of the Tagus river. The 25th of April Bridge (named so to commemorate the Carnation Revolution of 1974, which ended the dictatorship period), inaugurated in 1966 and bearing resemblance to the famous Golden Gate Bridge in San Francisco, connects Lisbon with the Setúbal peninsula across the river. The bridge is situated between *Baixa* and the mouth of the river in the western *bairro* of *Alcântara*. To alleviate the congestion of having a singular river crossing the Vasco da Gama Bridge, currently the longest bridge in Europe, was opened in 1998 and

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[7] In 2012 the municipal council approved the reorganization from 53 *freguesias* to 24, however recent Census 2011 methodology makes uses the former classification of 53.

is located in the Expo area. While the Vasco da Gama Bridge averages over 50,000 cars a day, the 25th of April Bridge boasts approximately 150,000 cars a day. North of the 25th of April Bridge is located the Monsanto Forest Park, the largest open space in the city covering an area of 10 km^2 and approximately 10% of the city's area.

Though many buildings were destroyed in the Great Earthquake of 1755, Lisbon maintains a rich history, and its historic buildings and cobblestone streets are juxtaposed against the newer buildings of modern Lisbon. Furthermore, the city has a wide variety of historic amenities representing Portuguese culture and history throughout the centuries. These amenities were primarily erected in the historic downtown core and concentrated along the river, a pattern seen in many European capital cities. Overall, we can identify twelve landmarks of prominence within the city due to their historic, architectural and touristic significance, which are thought to generate non-use values for non-residents outside of Lisbon in addition to the locals. Included among these landmarks are the Castle of St. Jorge, the National Pantheon and the two UNESCO World Heritage Sites, the Belém Tower and Jerónimos Monastery, which are further regarded as having an important global value to the common heritage of humanity.

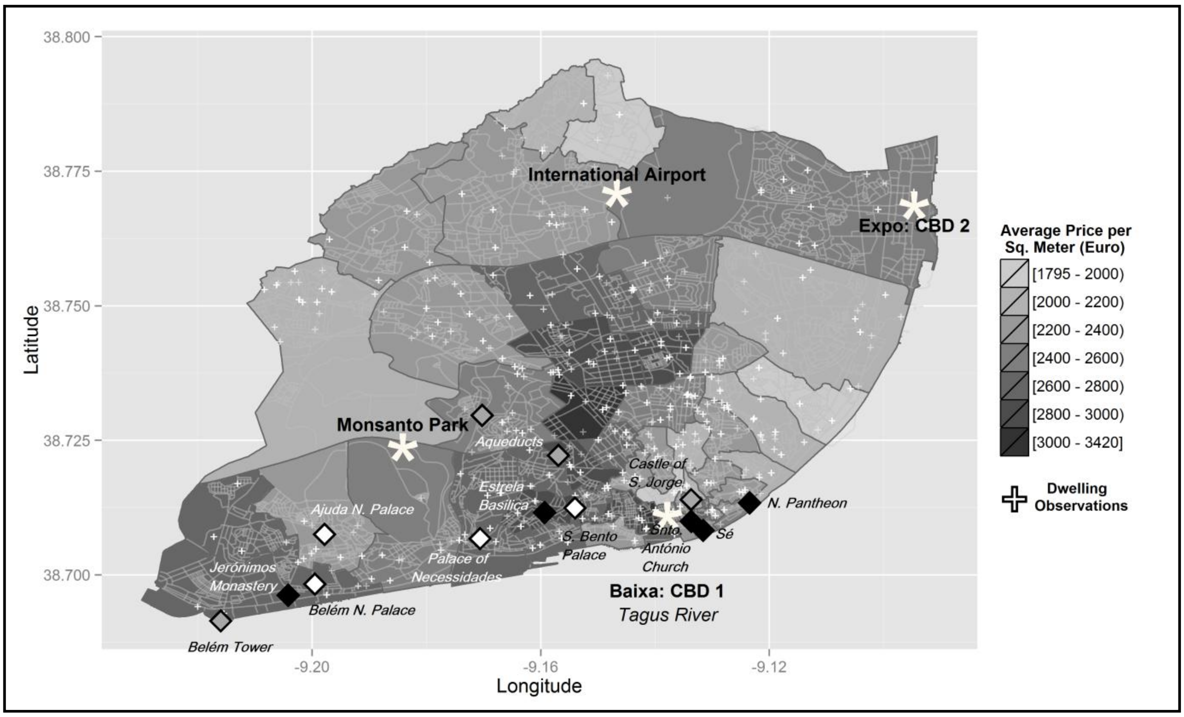
The Castle of St. Jorge is the most recognized of Lisbon's major attractions crowning one of the hills overlooking the city. It is located near *Alfama*, the oldest *bairro* of the city characterized by its traditionally narrow streets and Moorish influence. Nearby is the Romanesque styled Lisbon Cathedral, or *Sé* of Lisbon, which holds the Archdiocese of the city and is located in the *Castelo* area of *Baixa.* Along with the National Pantheon and its grand central dome, which houses the tombs of outstanding Portuguese figures, these historic landmarks stand out among Lisbon's primary CBD landscape.

West of the historical *Baixa* along the river in the Belém area are the Monument to the Discoveries and Lisbon's two UNESCO world heritage sites: Jerónimos Monastery and the Belém Tower. The 16th-century Jerónimos Monastery is one of the great landmarks of Portugal, built to honor Vasco da Gama's epic 1498 voyage to India. This monument is as much a symbol of the wealth of the Age of Discovery as it is a house of worship. Not far from this monastery is another emblematic symbol of Portugal's extraordinary Age of Discovery during the 16th century, the Belém Tower. Squat in the shallow waters near the mouth of the Tagus River, the tower originally served as a fortress situated in the middle of the river (the watercourse has shifted over the years) and represents the highpoint of decorative Manueline architecture. Its ornate façade is adorned with fanciful maritime motifs - twisted rope and armillary spheres carved out of stone.

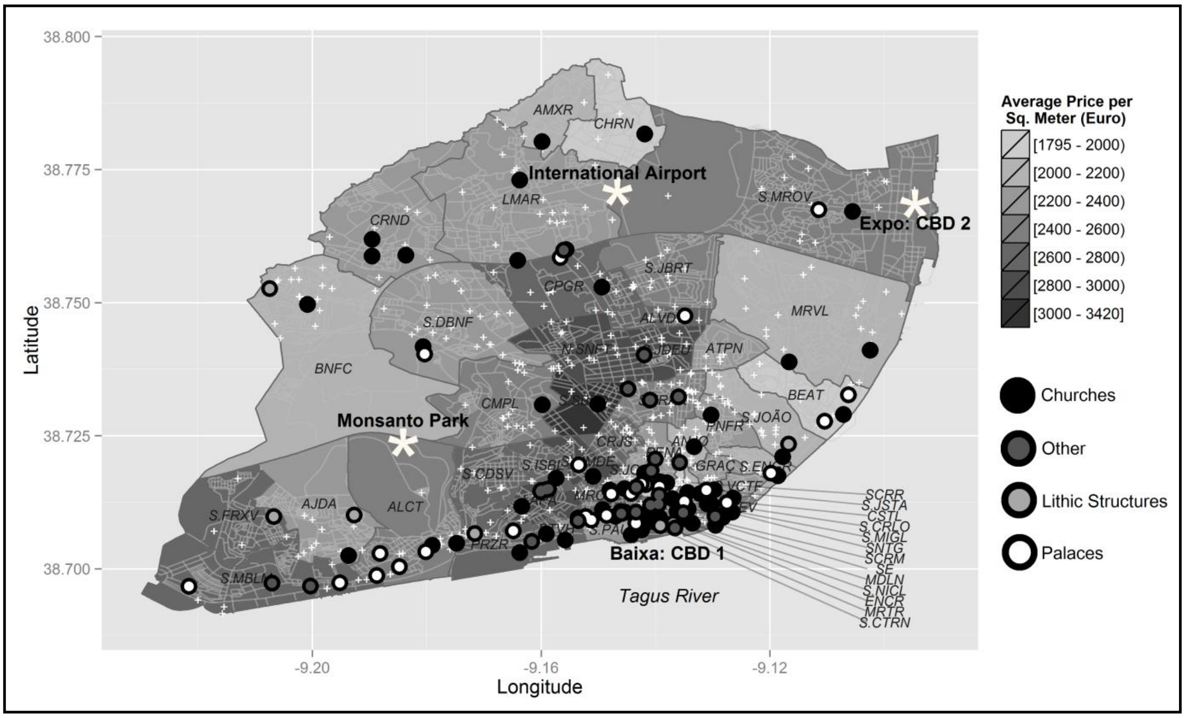
The Monument to the Discoveries is also located on the river bank near to the Belém Tower. It was conceived in 1939 as a temporary beacon during the Portuguese World Fair opening in 1940. The monument was demolished a couple of years after the closure of the exhibition. The monument we see today is an exact replica of the original one, built in 1960 on the occasion of the 500th anniversary of the death of the Infant D. Henrique (Henry the Navigator). The monument is built in the shape of a caravel, showing Henry the Navigator at the prow overlooking the Tagus and holding a smaller caravel. The monument features many other relevant heroes of the Portuguese maritime expansion history such as Vasco da Gama, Pedro Álvares Cabral who discovered Brazil in 1500 and Fernão de Magalhães, known for the first circumnavigation of the Earth. Figure 1 highlights the important geographical features of Lisbon and the location of historic amenities in the city.

***Figure 1.* Historic Amenities: Lisbon, Portugal**

Panel A: Landmarks

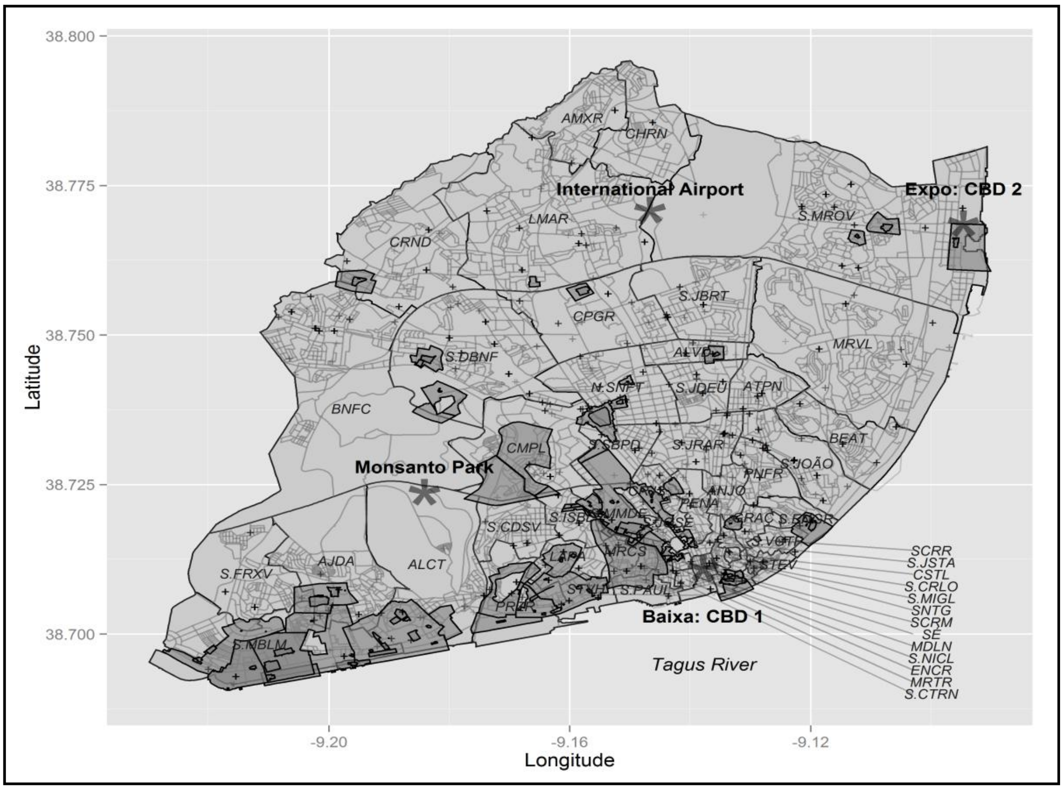


Panel B: Non-Landmarks



Within the city are also located areas with special protected zone designation, including both designated monuments and surrounding green spaces and related areas relevant for historic or cultural reasons. The national department for culture and heritage, the *Direção-Geral do Patrimonio Cultural,* manages the designation of all protected zones and monuments, which are accompanied by a 50 meter protective buffer zone. Such areas have the goals of ensuring the preservation of the landscape and the visual integration of designated properties including green spaces and related areas that are relevant to this context. The locations of these protected zones are represented in figure 2.

Figure 2.**Protected Zones: Lisbon, Portugal**



4.2. Data

According to equation 3.11, equilibrium residential property value of a dwelling is not only influenced by the set of structural attributes associated to the dwelling, but also by its neighborhood and geographic characteristics, accessibility characteristics, and proximity to local public amenities including the historic amenities of interest. This guides the selection of variables for the estimation of the empirical model.

Residential property data for 2007 in the city of Lisbon is obtained from *Confidencial Imobiliário*, a Portuguese organization providing information and statistics regarding the Portuguese real estate market. Observations without appropriate data for geo-coding were removed. The database contains the asking bid price and price per square meter of the property, a vector of structural characteristics (area, parking, view, and other features) and location characteristics (partial address, zip code, *freguesia*) for 11,708 two-bedroom apartment dwellings in the city.[8] The data were geo-coded, which allows for the assignment of each house to any spatially aggregate administrative district (such as a *freguesia* or city blocks). Geo-coding is also needed for the computation of an interpolated air quality value at the location of each housing unit (at the *freguesia* level) as well as to create spatial accessibility measures.

The locations of dwelling observations are illustrated in figure 1. The highest observation densities are found in the former *freguesias* of *São Miguel* and *Socorro*, both located in the primary CBD of *Baixa*. Average housing bid prices are highest in the former civil parish of *Mártires*, also located in the primary CBD.[9] From figure 1, this *freguesia* has also high bid prices per square meter of living space. All 53 *freguesias* are represented by housing observations with the lowest density of 2.44 observations per hectare in the *freguesia* of *Marvila*.

We further constructed a geo-coded database of categorized historic amenities in Lisbon. Urban historic amenities are defined in accordance with the UNESCO definition of tangible and immovable cultural heritage. The final historic amenities of interest in this study are categorized as churches, palaces, lithic (stone) structures, or other historic amenities (e.g. statues, fountains, funiculars) greater than 50 years old with landmark amenities within each group highlighted.[10]

From the collection of all historic amenities in the city we focus solely on those providing an external effect rather than analyzing residential premiums for properties with heritage designation. Buildings with official heritage designation (due to their façades or historic importance) are excluded from being considered a historic amenity and include theaters, cinemas, hotels, shops, transport stations, museums, hospitals and schools. These structures serve a dual purpose providing additional services to the community and are controlled for in their own respect. Further exclusions include churches or palaces that have been abandoned or become derelict. The final total includes 173 historic amenities: 74 churches, 33 palaces, 14 lithic structures, and 52 other. The collection is built and categorized from various sources including *Câmara Municipal de Lisboa*, the Portuguese Ministry of Culture - *Instituto de Gestão do Património Arquitectónico e Arqueológico,* and the *Instituto da Habitação e da Reabilitação Urbana*. A full list of all historic amenities is located in table A1 of the Appendix.

Using ArcMap 10.2 geo-referenced shape files of dwellings, historic amenities, and local public goods were created. These were imported to R 3.1.2 to develop measures of local amenities for each dwelling. In particular, we generated distances to individual historic amenities to determine a

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[8] Although transaction prices are favored we are limited to using asking bid prices, which may introduce a positive bias in the results. This bias is consistent across all observations, and estimation results remain meaningful.

[9] *Mártires* was one of the oldest civil parishes dating to 1147. Despite having less than 400 inhabitants at the time in an area of 0.10 km^2, the parish housed important historic amenities such as the Lisbon Opera House - Teatro Nacional de Sao Carlos (from 1793), the Basilica de Nossa Senhora dos Martires from the 18th century, the St. Francis Convent (today's Lisbon's School of Fine Arts), the Convent of Boa Hora where was installed a court in the 19th century and the statue of the Portuguese Poet Fernando Pessoa in Largo do Chiado. At the administrative reorganization of Lisbon on December 8, 2012 this parish was amalgamated with others to become part of the parish Santa Maria Maior.

[10] Prior to 1964.

dwellings proximity to alternative groupings of these amenities. This includes distance to the nearest monument overall, the nearest mutually exclusive landmark, non-landmark, or world heritage site, or the nearest historic amenity type of church, palace, lithic structures or others. We also calculated historic heritage concentration for varying buffer distances surrounding a dwelling location (50, 100 and 1000 meters).

Within each *freguesia*, further divisions were used for the collection of Census 2011 data at the city block level. The city block serves as the primary unit of analysis for neighborhood level variables including population density, socio-demographic variables on education level and age, and variables related to the stock of buildings including the percentage of non-residential buildings, percentage of vacant buildings, and percentage of buildings built in different decades since 1919. We further include the stock of neglected and dilapidated buildings within 1000 meters of our housing observations using data obtained from *Câmara Municipal de Lisboa*. On average, each *freguesia*is composed of 69 city blocks with *Castelo* in the heart of the primary CBD having the smallest of 9 and *Santa Maria dos Olivais* having the largest of 278. In total Lisbon is divided into 3,623 city blocks, of which our observations fall into 307 unique ones.

Local urban amenities in Lisbon are obtained through the *Lisbon City Service Development Kit API* providing the geo-coded locations of different categories of amenities in the city. Using these locations, we then calculate distances to control for proximity to employment centers, airport, health and education locales, fitness centers and stadiums, train stations, shopping centers, art amenities (which include galleries and museums) and culture amenities (which include libraries, theatres, auditoriums, and cinemas). Endogeneity is expected due to potential causal relationship between housing prices and the location of art and culture amenities.[11] Without an appropriate instrument, we include only those arts and culture amenities established at least ten years prior to the listing of dwellings in 2007 with arts and culture amenities built or established after 1997 excluded. We further control for the number of open spaces within given buffers and proximity to the nearest open space as a proxy for overall availability of green spaces in the neighborhood.

Maps from *Câmara Municipal de Lisboa* used for urban planning provide the location of freeways, metro stations (prior to 2007), bridges, viewpoints and regions in the city of high seismic risk or risk of flooding.[12] Further variables are constructed based on proximity to these urban features. The location of protected zones are also obtained from such maps and used to determined dwelling observations located in such areas. As the city of Lisbon sits atop seven hills, the city elevation profile and the altitude of dwelling observations is obtained using ArcGIS Online maps with further interactions between a dwelling's elevation above sea level and proximity to city viewpoints. In

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[11] Although housing prices may be influenced by proximity to these amenities, developers and owners may wish to situate their businesses in areas of high housing prices.

[12] Seismic risk is determined by soil quality throughout the city.

particular, we are able to determine the focal point of each viewpoint and whether they overlook the Tagus River, a general view of the city, or have a full 360 degree view.

Additionally, average income at the *freguesia* level comes from the Ministry of Finance and obtained via *Câmara Municipal de Lisboa.* Average income in this respect is based on IRS tax submissions for the 2007 year.

Data on air pollution comes from *Agência Portuguesa do Ambiente* (QualAr – data on air quality). In particular, air pollution in the form of PM^{10} particulates is obtained from air quality monitoring stations located across the city. This form of air pollution has been shown to be associated with increases in respiratory disease and use of asthma medication (Pope III et al. 1991). As the location of these stations are not aligned with any administrative boundaries, the values of particulates are interpolated from the point locations of the stations to the midpoint locations of the *freguesias*. Moreover, in order to obtain sufficient variability (particulates measures are highly seasonal as well as spatially heterogeneous), we chose the average of the daily maximum for the worst quarter in 2007, derived from the hourly readings for all six stations.

Metadata for all variables included in the analysis, as well as descriptive statistics, are presented in table A2 and A3 of the Appendix.

5. Empirical Methodology

The empirical approach used in this paper employs three econometric models emphasizing the role of location in real estate analysis and exploring the impact and sources of variation of historic heritage concentration and proximity as capitalized into residential property prices. In the first class of models, locational effects are expressed through traditional proximity variables (such as distance to nearest local amenity, historic amenity, or CBD) and through concentrations within buffers of different radii around each dwelling observation (e.g. concentration of palaces in a buffer of 50 meters) in a standard OLS hedonic pricing model. With our second class of models we extend the standard OLS specifications and aim to remove any potential spatial effects by using a spatial regression. While the former two models capture the global effects of proximity to and concentration of historic heritage, our third class of models adopts and extend to local RGWR techniques to explore the variation in the values for individual monuments and categories of monuments over space. This latter spatial model is used in real estate markets to capture localized variations and mitigate potential bias by unobserved factors. Next, we briefly describe each of these three models.

5.1 Standard Hedonic Pricing Model

Hedonic models decompose the price of residential properties into its value bearing characteristics. The general form of a non-spatial linear regression analysis can be expressed as follows:

$$P = \beta_0 + S\beta_1 + B\beta_2 + D\beta_3 + H\beta_4 + \varepsilon \tag{5.1}$$

where housing price, P, for an observation is influenced by a vector of structural characteristics of the dwelling, S, neighborhood attributes, B, measures of accessibility to local urban amenities such as the CBD, D, and the variables of interest, H, which represent proximity or concentration of historic amenities or location in a protected zone. The error term ε is classical, following a normal distribution with zero mean and constant variance.

The method of OLS estimation is referred to as a Best Linear Unbiased Estimator (BLUE), estimating all β's in 5.1 by minimizing the sum of squared prediction errors, hence, least squares. The linear regression model 5.1 is also known as the OLS model. Based on 5.1 we can identify the average marginal effects of a residential property's differentiated characteristics on its price.

However, from our analytical model when investors take into account the value of neighboring properties and herding behavior exists $(\lambda > 0)$ spatial dependence occurs in the model and the property value function deviates from its fundamental price. This implies that housing prices are not randomly distributed across a city and similarly valued homes cluster together. The baseline OLS specification in 5.1 does not account for these effects and assumes that outcomes for different observations are independent of each other. When observations have specific locations in relation to each other, such as dwellings in a city, the independence assumption is strong and the OLS model must be extended to explicitly incorporate spatial dependence. This underlying spatial dependence must be tested empirically and corrected if present.

The hedonic model of residential property prices 5.1 can be extended to account for spatial dependence either through a spatially lagged dependent housing price variable or through the error, whereby error terms for different observations exhibit correlation over space. If spatial dependence exists in the data then OLS estimates suffer some important caveats in the form of biased or inefficient estimates.

Explicitly, house pricing techniques involve looking at the price of comparable dwellings in the neighborhood such that a dwellings listing price or assessment value is determined in part by the value of neighboring dwellings through a signaling mechanism, for instance due to uncertainties regarding the value of neighborhood characteristics. This signaling mechanism is used quite often by realtors, developers and other agents in the real estate market. This in turn implies a direct spatial relationship between property values in the sense that the price of one house will hence influence the price of other houses located relatively near, and vice-verse. In the case where we omit spatially lagged housing prices, the classical OLS assumptions are violated with correlation between the error term, which captures the omitted variable, and the regressors. Estimates for the remaining regressors therefore will be biased and inconsistent (Anselin 1998).

Alternatively, omitted or unobserved variables such as outdoor maintenance expenditures or public perception of certain areas in a city may be correlated in space through an externality mechanism, which in turn can influence property prices in a particular neighborhood. Under Gauss-Markov assumptions the covariance between error terms must be zero, and when this unobservable spatial dependence between housing prices is present, this assumption is violated. With positive spatially autocorrelated errors, OLS tends to underestimate standard errors in hedonic regressions. If these unobserved amenities are correlated with neighborhood housing prices, OLS also yields biased coefficient estimates.

In other words, OLS results in the presence of a spatially-lagged dependent variable are biased and inconsistent and, in the presence of a spatial residual autocorrelation are inefficient and asymptotically consistent.

OLS Regression Diagnostic

The Jarque-Bera test is used to examine the normality of the distribution of the errors. The null hypothesis of the Jarque-Bera test is a joint hypothesis of the skewness being zero and the excess kurtosis being zero. If there is no empirical evidence to reject the null hypothesis, then the test indicates non-normal distribution of the error term. Since the tests of variance and spatial dependence are conditioned upon a normal distribution, one should be cautious to interpret the test results.

When multicollinearity is present in the data, OLS estimators are imprecisely estimated. If the goal is to understand how the various regressors impact the dependent variable, then the presence of multicollinearity introduces major problems. Detection of multicollinearity can be done by examining the value of the Condition Number (CN), the criteria for which to signify serious multicollinearity are arbitrary, with the value 30 often quoted. The Variance Inflation Factor (VIF) can also be used to quantify the severity of multicollinearity. As a rule of thumb if any of the VIF values exceeds 5 or 10, it implies that the associated regression coefficients are poorly estimated due to multicollinearity. Remedial measures such as dropping one or several predictor variables or, if none of the predictor variables can be dropped the use of alternative methods of estimation such as Ridge Regression and Principal Component Regression, help to solve the problem of multicollinearity.

A test of the variance of the error term as the BLUE requires homoskedastic, or constant error, variance. If the error terms do not have constant variance, they are said to be heteroskedastic. Measurement errors, subpopulation differences, interaction effects or model misspecifications can produce heteroskedasticity. The White and the Breusch-Pagan tests can diagnose for such a problem, both of which focus on smoothly changing variances for the disturbances. Low probabilities of these tests point to existence of heteroskedasticity which may occur when the error variance is affected by spatial dependence in the data. Therefore, it is also important to conduct further diagnostic tests for spatial dependence.

Spatial Weight Matrix

Let N represent the number of observations in our dataset. The $N \times N$ spatial weight matrix $\mathbb{W}$ describes for each observation in the sample which other nearby observations may be considered as its neighbors - i.e. which observations in proximity have an influence, and the level of intensity of this influence. This matrix is nevertheless a priori fixed and its elements take the following values:

$$w_{ij} = \begin{cases} 0 & \text{if } i = j \\ f(w) & \text{if } i \neq j \end{cases} \tag{5.2}$$

where$f(w)$ represents the neighbor weighting function.

The most common weighting schemes involve specifying criteria for defining neighbors in terms of the k-nearest neighbors (each house has exactly k neighbors) or within a given bandwidth radius r around the point. If an observation falls within a given distance or set of nearest neighbors (as determined by distance) they are identified as neighbors.[13] For each dwelling, the set of neighbors increases as the radius r or the number of k neighbors enlarges, but even more for houses located in dense areas than in dispersed housing locations. An observation set of neighbors, as represented by the rows of w_{ij}, are standardized so that there are proportional weights for observations which do not have the same number of neighbors. A spatially lagged variable can therefore be represented as a linear combination of weighted neighboring values.

With respect to the intensity of interaction between two observations, the two most commonly used spatial patterns are the contiguity pattern and the distance based pattern. In the contiguity spatial matrix, $w_{ij} = 1$ if i and j are neighbors. In the distance based specification, either the inverse distance or the inverse squared distance values the interaction between the neighbors i and j. The distance based specification means a decreasing interaction between dwelling i and its farther neighbors j whereas the contiguity specification means a constant interaction for all neighboring houses j wherever they are located.

The structure of the spatial weight matrix is fundamental to define the spillover mechanism. If we fail to choose a proper weight function, the result and effect of spatial analysis will not be satisfying and convincing, and the calculation may even be distorted (Chen, 2009).

In the spatial analysis literature, it is assumed that the choice of $\mathbb{W}$ is at the discretion of the researcher, but some ad-hoc critics are often underlined. To match the real story is the best way to address this problem. In our case, the household behavior we attempt to describe guides this procedure. For example, if the household gives more importance to the information from closer houses than from farther ones, then a distance based specificationis better. If the importance of information strongly decreases with distance then the inverse squared distance is a better choice. If the

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[13] This contrasts with how for example urban planners usually define neighborhoods. In general, neighborhoods are defined as areas impacted by the same effect because they are exposed to the same risk (e.g. flood, noise) or because they benefit from the same measures of preservation, either patrimonial or environmental. Therefore, with spatial dependence, one house can be located in a neighborhood whereas its neighbors (connected houses) are located in nearby but different neighborhoods.

household considers information from all neighboring houses as important then a contiguity specification is best. The size of the neighbors' set (the value of the radius r or the number k) is questioned too. For the distance based specifications the value of r or k has less consequence, because of decreasing interactions, than for the contiguity specification. In the latter case, a maximum value for r or k can be based on a pragmatic size for the prospection area. As such, we specify four kinds of weight function to test for spatial dependence and extend the standard OLS models.

We adopt a binary weighting scheme to assign a value of 1 to indicate neighbors based on the 100 nearest dwellings and all dwellings within a radius of 500 meters. Within a 500 meter radius, a dwelling has on average 400 additional dwellings which are considered neighbors. This distance covers a handful of city blocks and is a reasonable distance to define a neighborhood in which local amenities such as grocery stores are located. Specifying the 100 nearest dwellings allows for a tighter definition of neighbors and based on the dispersion of observations in the city, corresponds to dwellings located within a few streets of each other. Distance matrices weight this relationship based on dwelling proximity. We specify inverse and inverse squared weight matrices which assert that prices of dwellings which are closer have a higher influence and more weight on a given dwellings value. For these distance based weight matrices, we impose the same cut-off of 500 meters after which point properties have no effect on a dwellings price.

For symmetric weight matrices based on neighbors within 500 meters and the inverse and inverse squared distance within 500 meters, we use the Cholesky decomposition algorithm for sparse matrices to obtain numerical solutions for the coefficient and standard error estimates of the estimated spatial models. When working with the non-symmetric nearest 100-neighbors matrix, we use the LU factorization method. Table 1 summarizes the properties of the 11,708×11,708 spatial weights.

***Table 1.* Spatial Weight Matrices**

	Description	Number of locations	Number of nonzero links	Percentage nonzero weights	Average number of links
SW1:	Inverse distance for all properties within 500 m	11,708	4,682,292	3.415	399.92
SW2:	Inverse distance squared for all properties within 500 m	11,708	4,682,292	3.415	399.92
SW3:	All properties within 500 m	11,708	4,682,292	3.415	399.92
SW4:	100 Nearest Neighbors	11,708	1,170,800	0.854	100

Using the weight matrices specified in Table 1, a spatially lagged variable $\mathbb{W}P$ can be defined as a weighted average of neighboring observations with non-neighbors having a weight of zero, such that:

$$\mathbb{W}Y = \sum_{j=1}^{N} w_{ij} p_i \tag{5.3}$$

where w_{ij} are the respective weights of the matrix $\mathbb{W}$. In a similar fashion, this can be applied to OLS residuals to model a spatial autoregressive process in the residuals such that unobserved correlation is present over space.

Global Moran's I and Lagrange Multiplier Tests

The Moran's I measures spatial autocorrelation (feature similarity) based on both feature locations and feature values simultaneously. This tool evaluates whether the pattern expressed is clustered, dispersed, or random. This statistic can thus be applied to test spatial autocorrelation in the dependent variable or the estimated residuals of the OLS model. In general, the values of Moran's I range from +1 meaning strong positive spatial autocorrelation, to 0 meaning a random pattern to -1 indicating strong negative spatial autocorrelation. However, without looking at statistical significance one has no basis for knowing if the observed pattern is just one of many possible versions of random.

In the case of the global spatial autocorrelation analysis, the null hypothesis states that there is no spatial clustering of the values associated with the geographic feature in the study area. In other words, the global autocorrelation analysis involves the study of the entire region pattern and generally asks the question as to whether the pattern displays clustering or not. When the p-value is small and the absolute value of the Z-score is large enough that it falls outside of the desired confidence level, the null hypothesis can be rejected. If the null hypothesis is rejected, two possible interpretations arise. If the index value is greater than 0, the feature exhibits a clustered pattern. If the value is less than 0, the feature exhibits a dispersed pattern. Note, however, that the global Moran's I gives no guidance regarding whether these clusters consist of locations with high or low values or where these clusters are located. Specifically, the global Moran's I statistic for autocorrelation takes the form:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij} \, (p_i - \bar{p})(p_j - \bar{p})}{\sum_i (p_i - \bar{p})^2} \tag{5.4}$$

where w_{ij} are the elements of the spatial weight matrix, which captures the social and economic spillover mechanism across space, with the value in each cell quantifying the hypothesized strength of interaction between location pair i and j. Here p_i represents the location specific values of price (or residuals) which is compared against the average value $\bar{p}$. A Z-score for the Moran's I statisticcan be computed as $Z = \frac{I - E(I)}{\sqrt{V(I)}}$, where $E(I)$ is the mean and $V(I)$ is the variance, given the null hypothesis of no clustering. The null hypothesis of no clustering is thus rejected with a p-value < 0.05 if the estimated Z-score is larger than 1.64 or with a p-value < 0.01 if the Z-score is larger than 2.33.

The cause of spatial dependence is unspecified in the Moran's I test, and Lagrange Multiplier (LM) tests and their robust versions are based on well-structured hypotheses to indicate whether this dependence is due to an omitted spatial lag of the dependent variable or an underlying spatial pattern not accounted for in the error term.

Under a normality assumption on the residuals from the OLS model, the LM-error statistic tests the null hypothesis of no significant spatial error autocorrelation, while the LM-lag statistic tests the null hypothesis of no spatial autocorrelation in the dependent variable. If both hypotheses are rejected, one considers which value of the test statistics is largest. As an alternative or supplement to this, the robust tests can be used. The robust LM error test corrects for the presence of local spatial lag dependence. The LM error test assumes the absence of this kind of autocorrelation. Similarly, the robust LM lag corrects for presence of local spatial error dependence. These tests inform on the appropriate specification of the spatial model with final selection based on these statistics, the AIC criterion, variable significance and economic reasoning.

5.2. Global Spatial Models

The general spatial hedonic form can be expressed as follows:

$$P = \beta_0 + \sum_{k=1}^{m} \beta_k z_k + \rho_{lag} \mathbb{W}P + \varepsilon \tag{5.5}$$

$$\varepsilon = \rho_{err} \mathbb{W}\varepsilon + u \ ; \qquad u \sim iid(\mathbf{0}, \sigma^2 \mathrm{I_n}) \tag{5.6}$$

where the m regressors z capture the effects on housing prices attributed to dwelling characteristics, S, neighborhood attributes, B, accessibility, D, and historic amenities, H. We account for spatial dependence by incorporating either the spatially lagged dependent variable $\mathbb{W}P$ with respective coefficient ρ_{lag} or by modeling the original OLS error term ε as an autoregressive error term where we account for spatial correlation attributed to $\mathbb{W}\varepsilon$ with respective coefficient ρ_{err}. Under this specification u follows the classical error term assumptions. When $\rho_{lag} = 0$ we have a spatial error specification and with $\rho_{err} = 0$, the spatial autoregressive specification. When conducting respective LM tests the hypothesis being tested is the significance of these parameters.

The values of ρ_{err} and β_k can be simultaneously estimated by the maximum likelihood method. The spatial lag model (obtaining the values of ρ_{lag} and β_k) can also be estimated by the maximum likelihood. Regarding the measures of fit, the adjusted R^2 is not applicable, and the proper measures are now both the AIC and the SC.

To the extent that implicit price values will vary with different spatial weight matrices either in terms of neighbor designs or in terms of the size of the neighbors' set, we have conducted a robustness analysis. Our robustness analysis helped to identify whether the choice of particular $\mathbb{W}$ matrices induces some discordant results and provided empirical guidelines to be discussed with realistic features. Moreover, the selection of the appropriate specification may be sensitive to the spatial weight configurations. In that case, the robustness analysis helped to identify the specification that most frequently occurs and that will be used to calculate the proper implicit prices for housing and cultural heritage attributes.

5.3. Local Spatial Model

The OLS and spatial hedonic models are limited to estimating average global effects that historic amenities have on housing prices without accounting for potential spatial heterogeneity in the data. Global models assume a singular urban housing market, while in practice this assumption of spatial stationarity is rigid and it is likely that effects vary depending on location in a city. The effect of historic amenities in a historically rich downtown core may be different than the effect of historic amenities near the city limits.

Using nonparametric GWR models, we explore spatial non-stationarity by allowing for the estimation of coefficients at each location (observation) i using a weighted sub-sample of the data. This yields estimated effects attributed to each observed property value with regressor parameters varying across space (Brunsdon et al. 1996, Helbich et al. 2014, McMillen and Redfearn 2010). Such models capture the localized effect on residential housing prices attributed to specific historic amenities.

Geographically weighted parameter estimation uses the generalized method of moments framework where the coefficients are estimated at each observation i as

$$\widehat{\beta}_i = (Z' \mathbb{W}_i Z)^{-1}(Z' \mathbb{W}_i P) \tag{5.7}$$

Here a decaying Gaussian function is used to obtain the entries of the individual $N \times N$ spatial weight matrix $\mathbb{W}_i$ for each observation, weighing respective neighbors based on distance between observations and the optimal bandwidth for neighbor inclusion. Each $\mathbb{W}_i$ is a diagonal matrix with weights between observation i and j along the diagonal and obtained by:

$$w_{ij} = exp\left[-\frac{1}{2}\left(\frac{d_{ij}}{h}\right)^2\right] \tag{5.8}$$

where$h$ is the optimal bandwidth window over which the local estimates of the coefficients are estimated and used to weight the distance between observations, d_{ij}. This optimal bandwidth is computed using cross validation and is adaptive in the sense that at each location the optimal number of nearest neighbors is used for local estimation.[14] While a fixed bandwidth imposes a given radius globally across the entire sample within which observations are considered neighbors, the adaptive bandwidth accounts for potential local clustering and non-random spatial distribution of the observations in using the number of nearest neighbors and is thus the preferred procedure for our local estimates. There is a tradeoff between a small bandwidth that may give higher variance in the estimated local coefficients while a large bandwidth may yield biased results.

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[14] The selection criterion is to take the bandwidth that minimizes the cross validation statistic: the sum of each observed value minus the fitted value omitting the observed value evaluated at the given bandwidth.

Global and Local Multicollinearity

Although the VIF may indicate no multicollinearity at the global level, there may be important localized multicollinearity impacting the model. The condition number is estimated locally at each observation and tests the numerical inversion of the matrix $Z'\mathbb{W}_iZ$. The condition number is evaluated as the ratio of the largest singular value $\sqrt{e_{max}}$ (square root of the eigenvalue) to the smallest singular value $\sqrt{e_{min}}$ of these matrices. While under perfect multicollinearity this value would be infinite (with an eigenvalue equal to 0), numerical values above 30 indicate potential issues in obtaining robust estimates for $\hat{\beta}$ from inverting this matrix.

The effect of multicollinearity is amplified when estimating localized regressions due to the smaller spatial sample used for estimates, and if spatial heterogeneity exists within the data some locations may exhibit local multicollinearity while others do not (Wheeler and Tiefelsdorf 2005). This effect is especially true in models with many dummy (or count) variables where a smaller sample and variation across predictors may lead to linear dependence in at least one $Z'\mathbb{W}_iZ$ matrix across all locations i.

Global models must be re-specified for geographically weighted regressions when there are many of these variables measured in such a way that there is little variation in the values they take (such as dummies, counts, or percentages). Given a localized subset of these variables, it is possible that two or more have identical values for each observation (e.g. a localized set of neighbors are all non-new dwellings and have no pool). At a local level there is a higher risk that at least one location will have perfect multicollinearity yielding at least one singular design matrix across observations.

Standard geographically weighted regression models are extended by introducing ridge regression techniques to manage multicollinearity (Wheeler 2007). Here a small bias to the diagonal (ridge) of the $Z'\mathbb{W}_iZ$ matrix is included to increase the difference between the diagonal elements of this matrix and the off-diagonal elements, which represent the co-variation between predictors. The resulting estimates have the form:

$$\widehat{\beta_i} = (Z'\mathbb{W}_iZ + \varepsilon\mathbb{I}_i)^{-1}(Z'\mathbb{W}_iP) \tag{5.9}$$

where now eigenvalues are $e + \varepsilon$, and the condition number is the ratio of the largest singular value $\sqrt{e_{max} + \varepsilon}$ to the smallest singular value $\sqrt{e_{min} + \varepsilon}$. Therefore, the ε can be estimated at each location in such a way as to ensure local CN's less than or equal to the target threshold of 30, which has been suggested as the upper limit below which the results of the numerical inversion of the matrix are reliable and multicollinearity is not a concern.

6. Estimation Results and interpretation for historic amenities evaluations

In this section we present the results of the global baseline OLS and spatial hedonic models along with the results of testing for spatial dependence in our data. We extend our analysis to ridge geographically weighted regression techniques to examine spatial patterns of our main estimated coefficients of interest.

We refer to a model in which the parameter estimates for every observation in the sample are identical as a global model. If the parameter estimates are allowed to vary across the study area such that every observation has its own separate set of parameter estimates, we have a local model.

Historic amenities are introduced according to two attributes. First, we differentiate between churches, lithic structures, palaces or other historic amenities, and second we highlight prominent landmark sites within each category which are assumed to have different impacts due to their size and significance to the city of Lisbon. Additionally, we isolate the effect due to the two UNESCO world heritage sites. To capture different impacts we estimate our models with distance to nearest amenities as well as the number of amenities within buffer zones to capture ensemble effects from the concentration of historic amenities. Using the location of protected zones in Lisbon, we further capture the effect of living in these areas on housing prices.

6.1 Diagnostic tests for the global models

Multicollinearity and Heteroskedasticity Diagnostics

At the global level, measuring distance to historic amenities may potentially introduce multicollinearity between predictor variables as determined by the VIF. An important control included in all models is the distance to the primary historic CBD, *Baixa*, and introducing measures for distance to historic amenities are problematic with many of these amenities, especially landmarks, located in this area as seen in figure 1. As such, models capturing the effect of proximity to historic amenities are limited in the level of disaggregation possible, with disaggregation by types of landmarks and world heritage sites introducing multicollinearity and therefore excluded from the analysis.

VIF estimates indicate no multicollinearity in the concentration of historic amenities, with all statistics below the threshold value of 10.[15] While some variables, namely distance to the primary and secondary CBD as well as those used in creating interaction terms, have VIF levels above the threshold of 10, these are all control variables from which we are not interested in making inferences and thus have no impact on the performance of the model. Since multicollinearity only affects the standard error of variables with high VIF values, estimates and standard errors obtained for the historic amenity variables of interest remain suitable for analysis.

Results from the Breusch-Pagan test indicates the presence of heteroskedasticity in the OLS residuals, and thus robust standard errors are reported.

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[15] Full VIF estimates available upon request.

Tests for Spatial Dependence

Spatial analysis is extended to three OLS models capturing varying impacts of historic amenities: (1) protected zones; (2) concentration of landmark and non-landmark historic amenities disaggregated by type; and (3) proximity to types of historic amenities.

Results from the Breusch-Godfrey test on the residuals of each OLS model suggest the presence of residual autocorrelation.[16] These results indicate some underlying relationship influencing the data, and further extensions to spatial analysis are justified. From our discussion in section 5, under the presence of a spatial process in the data, the results from the OLS models may be biased and inefficient. Table 2 summarizes our test statistics of spatial dependence. The definition of each of the four weight matrices used in our robustness checks can be found in table 1 in section 5.

Table 2.**Test Statistics of Spatial Dependence**

	Global Moran's I (Dependent)	Z-score (Dependent)	Global Moran's I (Residuals)	Z-score (Residuals)	LM Error	LM Lag	Rob. LM Error	Rob. LM Lag
Protected Zones								
SW1	0.2664***	55.00	0.0312***	7.25	52.74***	37.9***	31.14***	16.29***
SW2	0.2736***	30.62	0.0370***	4.56	22.64***	31.18***	5.195**	13.73***
SW3	0.2269***	211.00	0.0158***	22.80	217.8***	26.94***	207.2***	16.4***
SW4	0.2383***	194.40	0.0121***	15.23	110.8***	252.3***	21.59***	163.1***
Protected Zones (Interactions)								
SW1	0.2664***	55.00	0.0301***	18.08	218.1***	38.08***	196.5***	16.50***
SW2	0.2736***	30.62	0.0412***	8.83	63.02***	41.11***	37.47***	15.56***
SW3	0.2269***	211.00	0.0154***	22.83	205.0***	25.35***	195.1***	15.47***
SW4	0.2383***	194.40	0.0116***	15.36	90.71***	247.9***	11.86***	169.1***
Historic Amenity Concentration								
SW1	0.2664***	55.00	0.0279***	6.62	41.58***	33.92***	23.4***	15.74***
SW2	0.2736***	30.62	0.0333***	4.18	18.36***	27.69***	3.701*	13.04***
SW3	0.2269***	211.00	0.0129***	19.71	143.4***	23.81***	135.2***	15.67***
SW4	0.2383***	194.40	0.0099***	13.29	73.32***	208.2***	10.01***	144.9***
Historic Amenity Proximity								
SW1	0.2664***	55.00	0.0272***	6.47	39.82***	32.83***	22.29***	15.3***
SW2	0.2736***	30.62	0.0327***	4.11	17.8***	26.99***	3.546*	12.74***
SW3	0.2269***	211.00	0.0122***	18.83	127.6***	23.54***	119.9***	15.87***
SW4	0.2383***	194.40	0.0100***	13.37	73.95***	223.1***	8.483***	157.6***

*Notes: ***Significance at 1 p.c. level; **Significance at 5 p.c. level; *Significance at 10 p.c. level.*

The Global Moran's I tests the whole study area for spatial autocorrelation, assuming the spatial process is the same at all locations. Our results indicate a significant positive spatial autocorrelation ($I > 0$) in the dependent variable, indicating that similarly priced dwellings are more clustered

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[16] Under the null hypothesis of no serial autocorrelation both Durbin-Watson and Breusch-Godfrey tests examine the structure of the residuals, however D-W tests only a first order autoregressive process of the residuals appropriate for time series while B-G tests higher order autocorrelation in a more general setting which may capture residual dependence in observations across space and not necessarily time sequential.

together than would be under a random spatial pattern. Moreover, the Moran's I test for residuals yield the same conclusion. We reject the null hypothesis of no spatial clustering and conclude on positive spatial autocorrelation. The Z-score for Moran I residual autocorrelation is consistently well above 2.33 across all OLS models and spatial weights, which implies rejecting the null hypothesis of no residual autocorrelation at a 99% confidence level. Although this provides an indication of spatial correlation, we have further conduct the LM tests.

The LM diagnostics treat the standard OLS model as the restricted model (null hypothesis), and the spatial model as the unrestricted model (alternative hypothesis). Thus, the LM diagnostic can effectively consider the difference between spatial and non-spatial models as a result of unobserved variables (Anselin and Rey 1991). The headline finding is that with all LM and robust LM statistics significant across all weight matrices, both the spatial error and spatial autoregressive (lag) models are appropriate for further analysis with the preferred model to be chosen based on AIC and variable significance criteria from the estimated models. We thus estimate each type of model under the varying weight matrices.

Spatial Lag versus Spatial Error Models

Across specifications, spatial hedonic models improve over OLS models with decreases of up to 4% in the residual sum of squares (SSE). As expected, coefficient estimates for spatial parameters both from spatial error (ρ_{err}) and spatial autoregressive (ρ_{lag}) specifications are significant and indicate positive spatial relationships between the lag dependent variable and the error component respectively. Comparing the spatial models against their baseline OLS, results from the Likelihood Ratio and Wald test are consistent with the global Moran's I and LM tests and indicate significant spatial dependence across specifications.

Significant variables under the OLS specification remain so under the spatial models with consistent magnitudes across specifications with different weight matrices. Using the AIC model selection criteria, all spatial models outperform their OLS counterpart and further all have reduced SSE. In general, spatial error models are preferred over the spatial autoregressive specifications under the alternative weight matrices. Based on the combination of LM tests, AIC, and variable significance, the preferred model is the spatial error specification under the inverse distance spatial weight (SW1) and subsequent analysis and comparisons focus on this model. Table 3 summarizes the AIC and SSE values as well as the LR and Wald test estimates for the alternative estimated spatial models under the weight matrix SW1.[17]

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[17] Full results on all the spatial error and spatial lag models tested under the weight matrices defined in session 5 can be obtained upon request from the authors.

***Table 3.* Global OLS and Spatial Error under SW1 Diagnostics**

	N	Global Adj. R^2	AIC	SSE	Rho Err	Rho Lag	Wald Statistic	LR Statistic
Protected Zones								
OLS	11,708	0.6598	-2926.7	528.35	-	-	-	-
Sp. Error	11,708	-	-2974.4	525.08	0.120	-	54.7***	49.6***
Protected Zones (Interactions)								
OLS	11,708	0.66006	-2930.5	527.73	-	-	-	-
Sp. Error	11,708	-	-3091.7	517.55	0.444	-	185.0***	163.7***
Historic Amenity Concentration								
OLS	11,708	0.66174	-2977.8	524.61	-	-	-	-
Sp. Error	11,708	-	-3015.9	521.96	0.109	-	37.9***	40.1***
Historic Amenity Proximity								
OLS	11,708	0.6612	-2971.8	526.05	-	-	-	-
Sp. Error	11,708	-	-3008	523.53	0.106	-	30.8***	38.1***

*Notes: ***Significance at 1 p.c. level; **Significance at 5 p.c. level; *Significance at 10 p.c. level.*

6.2. Global Models Results

OLS and spatial error results for being located in a protected zone, proximity to historic amenities and historic amenity concentration are found in table 4 with complete list of estimated coefficients presented in table A4 in theAppendix.[18] In addition to historic amenities, we report the effects of environmental amenities and architectural ambiance capturing the overall locational ambiance which complement historic amenities. Further, we report impacts from elevation, view, flooding and seismic hazards which are specific to the geographic of city.

***Table 4.* Global OLS and Spatial Error Results**

Variables	OLS		OLS with Interaction		Spatial Error		Spatial Error with Interaction	
	Coeff.	(Std. err.)	Coeff.	(Std. err.)	Coeff.	(Std. err.)	Coeff.	(Std. err.)
Protected Zones								
Accessibility to CBD's								
log(Dist. to Baixa)	-0.12852***	(0.012)	-0.13222***	(0.013)	-0.12749***	(0.014)	-0.12580***	(0.020)
log(Dist. to Expo)	-0.09321***	(0.013)	-0.08608***	(0.014)	-0.09443***	(0.014)	-0.07831***	(0.021)
Environmental Amenities								
log(Dist. to Nearest Open Space)	-0.22159***	(0.061)	-0.24350***	(0.063)	-0.22154***	(0.067)	-0.28329***	(0.092)
Count of Open Spaces 50 m	0.03497***	(0.012)	0.02057	(0.014)	0.03163**	(0.013)	0.0141	(0.015)
Count of Open Spaces 200 m	-0.02323***	(0.004)	-0.02282***	(0.005)	-0.02212***	(0.004)	-0.01719***	(0.005)
Count of Open Spaces 500 m	0.00663***	(0.001)	0.00784***	(0.001)	0.00639***	(0.001)	0.00535***	(0.001)
Count of Open Spaces 1000 m	0.00180***	(0.000)	0.00182***	(0.000)	0.00181***	(0.004)	0.00177***	(0.004)
log(Dist. to Freeway)	0.17527*	(0.097)	0.17888*	(0.100)	0.16025	(0.107)	0.15077	(0.151)
log(PM10 Particulates)	-0.60572***	(0.171)	-0.66647***	(0.173)	-0.62153***	(0.187)	-0.77595***	(0.248)

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[18] In an attempt to capture potentially important neighborhood effects, interaction terms between our definitions of historic amenities and population density, distance to CBD's, distance to open space, distance to metro and *freguesia* level average income were estimated. These interactions however introduced variance inflation factors exceeding the threshold for the variables of interest, compromising their interpretation. As such we removed these interaction variables from our model. Additional OLS and spatial model results available upon request.

log(PM10 Particulates)*log(Dist. to Nearest Open Space)	0.05959***	(0.016)	0.06491***	(0.017)	0.05951***	(0.018)	0.07520***	(0.025)
log(PM10 Particulates)*log(Dist. to Freeway)	0.05160***	(0.019)	0.05610***	(0.020)	0.05382**	(0.021)	0.06139**	(0.029)
Architectural Ambiance								
log(% Buildings built pre 1919)	0.00384***	(0.0005)	0.00389***	(0.0005)	0.00384***	(0.0006)	0.00352***	(0.0007)
log(% Buildings built 1919 to 1945)	-0.00193***	(0.0005)	-0.00194***	(0.0005)	-0.00202***	(0.0006)	-0.00233***	(0.0008)
log(% Buildings built 1946 to 1960)	0.00213***	(0.0005)	0.00207***	(0.0005)	0.00215***	(0.0005)	0.00233***	(0.0007)
Natural Hazard Risk								
High Flood Risk Dummy	-0.05111***	(0.0096)	-0.04948***	(0.0098)	-0.05044***	(0.0105)	-0.04298***	(0.0140)
High Seismic Risk Dummy	-0.00837	(0.0072)	-0.00803	(0.0073)	-0.00898	(0.0080)	-0.01141	(0.0110)
Views								
log(Dist. to Viewpoint)	0.05990***	(0.02201	0.06036***	(0.0224)	0.06203**	(0.0243)	0.07534**	(0.0342)
log(Elevation)	0.07327**	(0.03315	0.07103**	(0.0339)	0.07645**	(0.0365)	0.09261*	(0.0512)
log(Dist. to Viewpoint)*log(Elevation)	-0.01153**	(0.0055)	-0.01120**	(0.0056)	-0.01210**	(0.0060)	-0.01518*	(0.0085)
Historic amenities								
Protected Zone Dummy	-0.01637*	(0.009)	-0.03114	(0.0231)	-0.01501	(0.0098)	-0.04873	(0.0336)
Protected Zone Dummy*No. of Dilapidated Buildings 1000 m			0.00026*	(0.0001)			0.00035*	(0.0001)
Protected Zone Dummy*No. of Open Spaces 50 m			0.08838**	(0.0361)			0.05343	(0.0413)
Historic Amenity Concentration								
Accessibility to CBD's								
log(Dist. to Baixa)	-0.12297***	(0.013)			-0.12243***	(0.0144)		
log(Dist. to Expo)	-0.12135***	(0.014)			-0.12009***	(0.0154)		
Environmental Amenities								
log(Dist. to Nearest Open Space)	-0.15821**	(0.063)			-0.16812**	(0.0673)		
Count of Open Spaces 50 m	0.03043**	(0.014)			0.02826*	(0.0148)		
Count of Open Spaces 200 m	-0.02316***	(0.004)			-0.02179***	(0.0048)		
Count of Open Spaces 500 m	0.00831***	(0.001)			0.00812***	(0.0018)		
Count of Open Spaces 1000 m	0.00169***	(0.0004)			0.00171***	(0.0004)		
log(Dist. to Freeway)	0.21717**	(0.101)			0.20729*	(0.1102)		
log(PM10 Particulates)	-0.45952***	(0.169)			-0.48822***	(0.1833)		
log(PM10 Particulates)*log(Dist. to Nearest Open Space)	0.04062**	(0.017)			0.04337**	(0.0187)		
log(PM10 Particulates)*log(Dist. to Freeway)	0.04527**	(0.019)			0.04719**	(0.0212)		
Architectural Ambiance								
log(% Buildings built pre 1919)	0.00330***	(0.001)			0.00333***	(0.0006)		
log(% Buildings built 1919 to 1945)	-0.00159***	(0.001)			-0.00166***	(0.0006)		
log(% Buildings built 1946 to 1960)	0.00167***	(0.001)			0.00168***	(0.0005)		
Natural Hazard Risk								
High Flood Risk Dummy	-0.05434***	(0.009)			-0.05327***	(0.0107)		
High Seismic Risk Dummy	0.00764	(0.007)			0.0053	(0.0080)		
Views								
log(Dist. to Viewpoint)	0.03256	(0.022)			0.03594	(0.0244)		
log(Elevation)	0.027	(0.033)			0.03307	(0.0367)		
log(Dist. to Viewpoint)*log(Elevation)	-0.00433	(0.005)			-0.00533	(0.0061)		
Historic amenities								
Count of Landmark Church 100m	0.04393	(0.035)			0.04561	(0.0351)		
Count of Landmark Church 1000m	-0.03441***	(0.007)			-0.03448***	(0.0074)		

Count of Non-Landmark Church 50m	-0.00006	(0.061)	0.0057	(0.0625)
Count of Non-Landmark Church 100m	0.03999**	(0.017)	0.04244**	(0.0180)
Count of Non-Landmark Church 1000m	-0.00110***	(0.0003)	-0.00092**	(0.0003)
Count of Landmark Palace 50m	0.021	(0.041)	0.01606	(0.0408)
Count of Landmark Palace 1000m	-0.00204	(0.005)	-0.00048	(0.0057)
Count of Non-Landmark Palace 50m	0.09237	(0.072)	0.0902	(0.0720)
Count of Non-Landmark Palace 100m	-0.04642	(0.049)	-0.04183	(0.0492)
Count of Non-Landmark Palace 1000m	-0.00162	(0.001)	-0.00178	(0.0011)
Count of Landmark Lithic 50m	-0.08701	(0.063)	-0.08058	(0.0636)
Count of Landmark Lithic 1000m	0.03205***	(0.009)	0.02963***	(0.0096)
Count of Non-Landmark Lithic 50m	0.04198	(0.032)	0.04953	(0.0331)
Count of Non-Landmark Lithic 1000m	0.00623	(0.004)	0.00707*	(0.0041)
Count of Non-Landmark Other 50m	0.05710**	(0.026)	0.05886**	(0.0276)
Count of Non-Landmark Other 100m	-0.04451***	(0.017)	-0.04395**	(0.0176)
Count of Non-Landmark Other 1000m	-0.00087*	(0.0004)	-0.00093*	(0.0004)
Historic Amenity Proximity				
Accessibility to CBD's				
log(Dist. to Baixa)	-0.08972***	(0.013)	-0.09032***	(0.0152)
log(Dist. to Expo)	-0.13886***	(0.015)	-0.13774***	(0.0172)
Environmental Amenities				
log(Dist. to Nearest Open Space)	-0.21159***	(0.064)	-0.21200***	(0.0695)
Count of Open Spaces 50 m	0.03147**	(0.012)	0.02911**	(0.0131)
Count of Open Spaces 200 m	-0.02544***	(0.004)	-0.02407***	(0.0046)
Count of Open Spaces 500 m	0.00623***	(0.001)	0.00608***	(0.0017)
Count of Open Spaces 1000 m	0.00183***	(0.000)	0.00184***	(0.0004)
log(Dist. to Freeway)	0.07342	(0.100)	0.06409	(0.1089)
log(PM10 Particulates)	-0.59421***	(0.173)	-0.60905***	(0.1875)
log(PM10 Particulates)*log(Dist. to Nearest Open Space)	0.05780***	(0.017)	0.05784***	(0.0193)
log(PM10 Particulates)*log(Dist. to Freeway)	0.05386***	(0.019)	0.05558***	(0.0212)
Architectural Ambiance and Neighborhood				
log(% Buildings built pre 1919)	0.00358***	(0.001)	0.00360***	(0.0006)
log(% Buildings built 1919 to 1945)	-0.00140**	(0.001)	-0.00150**	(0.0006)
log(% Buildings built 1946 to 1960)	0.00186***	(0.001)	0.00190***	(0.0005)
Natural Hazard Risk				
High Flood Risk Dummy	-0.05703***	(0.009)	-0.05619***	(0.010)
High Seismic Risk Dummy	-0.00852	(0.007)	-0.00918	(0.007)
Views				
log(Dist. to Viewpoint)	0.02762	(0.022)	0.03147	(0.024)
log(Elevation)	0.02701	(0.033)	0.03271	(0.036)
log(Dist. to Viewpoint)*log(Elevation)	-0.00396	(0.005)	-0.00493	(0.006)
Historic amenities				
log(Dist. to Nearest Church)	-0.00035	(0.004)	-0.00058	(0.004)
log(Dist. to Nearest Palace)	0.0007	(0.004)	0.00063	(0.005)
log(Dist. to Nearest Lithic)	-0.01026*	(0.006)	-0.01012	(0.006)
log(Dist. to Nearest Other)	-0.03462***	(0.004)	-0.03355***	(0.005)

Notes: ****Significance at 1 p.c. level; **Significance at 5 p.c. level; *Significance at 10 p.c. level.*

Hedonic price results based on OLS

OLS specifications with log dependent price variable and log continuous variables are used to capture the non-linearity exhibited by the analytical property value function from equation 3.11. This specification is preferred over linear, log-linear, and log-linear models with squared covariates.

All OLS models have adjusted R^2 values in the order of 0.66 such that the variables chosen explain 66% of the variation in dwelling prices in Lisbon as seen in table 3. Across all specifications, structural, neighborhood and accessibility coefficients are consistent with expectations. Area is the most significant driver with a positive elasticity of housing price to area of 0.78 such that a 1% change in area of the dwelling on average increase the price of a dwelling by 0.78%. Other amenities contribute positively to the value of dwellings with the biggest drivers including whether the house is new, increasing prices by 0.15%, whether there is air conditioning, increasing prices by 0.14%, and whether there is a pool, increasing prices by 0.12%.

In terms of neighborhood building characteristics, dwellings are negatively influenced by the number of neglected and dilapidated buildings within a 1000 meter radius by approximate 0.08%, while higher percentages of non-residential buildings in a city block, which proxies the level of mixed use of a neighborhood, increases prices by 0.002%. Neglected buildings are not only unsightly and more susceptible to fires but may attract unwanted activity in the form of squatters or usages for illicit purposes, signaling lower quality neighborhoods. Additionally, increasing population density has the effect of reducing property values by approximately 0.01% while areas with higher average income increase prices by 0.17%, as one would expect.

Housing prices decrease when moving farther away from both the primary and secondary CBD with a slightly stronger effect coming from the historic primary CBD ranging around 0.13% and an approximate 0.10% decrease for each meter further from the secondary CBD. Further, prices increase significantly by 0.05% as we move away from the airport. A possible explanation for this result may be the associated noise and pollution that is stronger the closer a dwelling is to large airports. Similarly, proximity to the nearest freeway, which are associated with road noise and pollution, have a negative impact on housing prices in the range of 0.21%. As one of the most important means of transportation in the city, results indicate that living within 100 meters of a metro station is valued positively.

Environmental amenities are capitalized into dwelling prices with a positive impact due to proximity to an open space and negative price effects due to increased levels of PM^{10} pollution particulates. Yet our results also reveal that the amenity value of proximity to open spaces falls as the level of PM^{10} pollution increases. In contrast, the amenity value of being located farther away from a freeway increases as the level of PM^{10} pollution increases. This result may be explained by the fact that most of this type of pollution in Lisbon is generated by road traffic.

Lacking complete data to control for the age of individual dwellings, the percentage of buildings built in different time periods at the city block level is used. The stock of buildings built prior to 1919 as well as those built between 1946 to 1960, 1961 to 1970 and 1981 to 1990 have a positive effect increasing prices in the range of 0.001%. This reflects that buildings from different eras and with different stylistic, architectural, historic and quality characteristics of these eras are valued differently.

Being located in a protected zone of the city has a negative impact on housing prices in the range of 1.6%. Protected zones are designated so due to their historic significance and pleasant ambience which may attract non-residents and visitors to these areas, increasing congestion. Further, given the goal of preserving the character of these zones, regulations may exist on the modification or alteration of dwellings, limiting a homeowner's ability to manage their own property.

Our OLS results suggest that concentration of historic amenities, measured by means of the number of existing monuments at a certain radius from a dwelling, affects residential prices differently depending on type and density. In addition, historic amenities located in direct proximity (50 meters) of a dwelling tend to have a positive price effect, however as we increase the concentration of different types of amenities within broader radii (1000 meters) the effect reverses and there is a negative, although weaker in magnitude, price effect on dwellings. While having a monument at a 50 meter radius of a dwelling has a positive effect around 4.5%, higher concentrations of monuments within 1000 meters has a negative yet small impact around 0.12%.

Non-landmark amenities have a similar effect in close proximity eliciting a premium of 4.7% within 50 meters, with higher concentrations of these non-landmark within 1000 meters having a negative impact of 0.1%. Correspondingly, but in contrast, landmark amenities located in 1000 meter radius have a positive effect of 0.9%. Within 1000 meters of any dwelling there may potentially be over 50 non-landmark amenities, the variety of which may draw in and attract various groups of non-residents. Given the dispersion of landmark amenities across the city there can be at most 4 within 1000 meters at any dwelling location. Being located near unique landmark amenities while not being exposed to the high clustering of many landmarks together may explain the differential effects between non-landmark and landmark amenities. When isolating the effect of world heritage sites, we see no significant effect from these amenities while the effect of the remaining landmarks and non-landmarks have magnitudes in the same range.

When disaggregating by different categories of historic amenities, not all types elicit the same effects. We find that although the existence of a church nearby has a positive effect on housing prices, higher concentration of churches impact prices negatively. Non-landmark churches within 100 meters increase housing prices by around 3.9% while higher concentration of such churches in 1000 meters decrease prices by 0.1%. Similarly, increased landmark churches within 1000 meters has a stronger negative effect decreasing prices by 3.4%. The effect due to landmark churches dominates given their size, prominence and cultural significance in relation to non-landmark churches which are in general much smaller and less ornate. With a highly Roman Catholic population, non-landmark churches serve the local community with weekly services and congregations which may explain the positive price effect. Landmark churches, while also providing religious services, tend to draw in much larger crowds and further cater to tourists and non-residential visitors.

Comparatively palaces and other historic amenities have a positive price effect at 50 meters of 12% and 9%, however higher concentrations at 1000 meters have a reduced negative effect of 0.2% and 0.1% respectively. The local effects of these amenities are stronger than the effect of churches. While churches may be attributed with increased congestion and bell tolling during services, palaces and other historic amenities are primarily aesthetic and may not attract as many non-residents to the area. Similarly, landmark lithic structures (Castle of St. Jorge, Belém Tower, and the Aqueducts) have a positive price effect of 3% within 1000 meters.

Although palaces in general have a positive effect on housing prices, when disaggregated into landmark and non-landmark palaces, there is no significant effect. This suggests that the public's general perception regarding palaces is regardless of whether a palace is considered a landmark or not. In general, higher concentrations of palaces are valued for their common architectural traits and surrounding open space and not for their size or grandeur.

In terms of proximity to historic amenities, monuments in general have a positive price effect. As distance to the nearest monument decreases, residential prices increase by approximately 0.01% per meter. There is little difference in the effect of landmark and non-landmark amenities both increasing prices by similar magnitudes to monuments overall. Similar to models of concentration, we see no effect when isolating world heritage sites.

Both lithic and other historic amenities have a positive effect on prices in the range of 0.01% and 0.03% respectively. This complements the measures of concentration which reveals that these amenities located within 50 meters are capitalized into housing prices. Although we estimate a model of proximity to historic amenity types classified as landmark and non-landmark amenities, the variance inflation due to landmark amenities do not allow us to make inferences confidently regarding these effects.

Spatial Error Results under SW1

In general, estimates from the spatial specification decrease in magnitude in comparison to their OLS counterparts and corrects potential biases and inefficient standard errors of the estimates by controlling for spatial dependence in the error term.

Under the spatial model, dwelling characteristics remain significant and positively influence housing prices. Although *freguesia* level average income remains significant, its effect decreases among all spatial specifications indicating that spatial dependence captures some of the neighborhood quality effect which is signalled by income. Similar decreases in magnitude are seen in the negative effects due to higher neighborhood population density.

Regarding the risk of natural hazards, it is interesting to report that flooding risk consistently has a significant and negative effect on housing prices in the order of 5% across specifications after accounting for spatial dependence. Although not significant, seismic risk in general tends to still have a negative effect on housing prices. A possible explanation is that while flooding incidents are frequent every year and well publicized, earthquakes even if frequent, are very subtle with larger ones quite rare. As a result, housing prices in Lisbon do not seem to capitalize seismic hazards from building collapse and fire hazards, reflecting only geographic differences in flooding risk even after removing the effects of spatial autocorrelation.

The amenity value of proximity to a scenic viewpoint maintains a negative and significant impact on housing prices when accounting for a dwellings location in a protected zone of about 0.06% after accounting for spatial dependence. This is perhaps due to pedestrian congestion from both tourists and locals with many viewpoints simultaneously acting as an alternative to the local nightlife with kiosks and patios serving food and drink until late in the evening. In contrast, housing prices rise as elevation increases by 0.07% since higher elevations are associated with some type of view. Yet, the amenity value from being located farther from a scenic viewpoint rises as elevation of the dwelling increases and this interaction effect is still significant.

Even after controlling for spatial dependence we still see positive and significant global spatial coefficients associated with buildings from different eras. This reveals that the market values different historic architectural features, which are themselves a testimony of the past and its influence on Lisbon's built heritage. The external effect from higher concentrations of buildings from different eras of Lisbon's history are found to have significant effects, with buildings built prior to 1919 generating a premium of 0.001% and those built between 1946 and 1960 generating a premium of 0.003%.

In addition, proximity to arts amenities and proximity to culture amenities continue to have contrasting impacts on housing prices. While being located closer to arts amenities has a positive impact of 0.01%, being located closer to culture amenities decreases housing prices by approximately the same magnitude.

Accessibility variables which are influenced by spatial dependence follow economic intuition, with decreasing prices moving from the primary and secondary CBD's in the order of 0.12%, and increasing prices moving from the airport of 0.06%. Note, nevertheless, that the importance of the significant spatial effects of proximity to *Baixa* and Expo vary across our three main specification models the same way as in the OLS model. Specifically, as we move from capturing historic amenities through protected zones to heritage concentration at certain radii to cultural heritage proximity in meters, the importance of being located near *Baixa* decreases (from 0.127% to 0.122% to 0.090%) while the importance of being located near Expo increases (from 0.094% to 0.120% to 0.137%). This is actually in accordance with the fact that *Baixa* is not only the main hub of historic amenities but it is simultaneously an important shopping and banking district in the city. As finer and more disaggregated measurements of historic amenities are included, the more disentangled these two effects can be traced in the model.

Switching the focus onto the historic amenity coefficients, we find that when including protected zones and distance to *Baixa* while controlling for spatial dependence, the effect of protected zones diminish and becomes insignificant, suggesting that a significant effect under the global OLS model may incorrectly attribute a negative effect to protected zones due to the underlying spatial relation. Under the global spatial hedonic models, there is no evidence that protected zones significantly impact housing prices in Lisbon. It is interesting to note nevertheless that the spatial global effect, though insignificant, is still negative.

While a protected zone provides guarantees that surrounding properties will not be demolished and replaced, or their exteriors modified in ways that are not in harmony with the historic character and integrity of neighborhoods, this type of zoning curtails a homeowner's property rights, which may negatively impact housing values. In the case of Lisbon, this problem was compounded not only by the ownership system, mostly vertical, but also by the existence of rent control laws (abolished only in 2012), which greatly contributed to the lack of investment and under keeping of the housing stock in historic areas and elsewhere in the city. Over the last 20 years, the city of Lisbon and other Portuguese public agencies related to the rehabilitation of the urban housing stock and preservation of historical buildings, have provided public grants and other fiscal advantages to homeowners/landlords wishing to restore or rehabilitate their properties within such districts in attempt to incentivise investment, renewal and gentrification of historic areas in *Baixa*.[19]

Even though the vast majority of Lisbon's protected zones house a disproportional amount of buildings and landscapes that have special architectural, social and historic interests compared to other locations in the city, some protected zones even overlap with districts that carry a prominent status because of the landmark monuments within their boundaries and history. As such, these latter protected zones may carry more prestige than that conveyed by simple local designation.[20]

It is interesting to note then, that negative price discounts are still observed in spatial models of protected zones, but because the effect is not statistically significant we cannot infer that the disadvantages stemming from restrictions on property rights and past housing regulations are largely balanced by the positive effects from preserving the charm of these neighborhoods and from the

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[19] Examples of specific programs that have been put into place to incentivize the rehabilitation of dilapidated and degraded housing stock in historic city cores and in other parts of urban areas include the *Regime Especial de Comparticipação e Recuperação de Imoveis Arrendados* (RECRIA since 1988), the *Regime de Apoio a Recuperação Habitacional em Areas Urbanas Antigas* (REHABITA since 1996) and the *Regime Especial de Comparticipação e Financiamento de Prédios Urbano sem Regime de Propriedade Horizontal* (RECRIPH since 1996). These incentives have been adjusted over the years but due to their scarce positive outcomes, the government has recently merged all of them into one single program to ensure that their goals would be better attained and better financial support would be provided.

[20] For example, *Baixa Pombalina* was placed on Portugal's tentative list of potential World Heritage Sites on 7 December 2004, which declares it superior to the planned areas in Edinburgh, Turin and London. In particular, the submission states that the plans for the reconstruction of London after the Great Fire in 1666 "does not implement overall principles" like those achieved in the Pombaline. After the earthquake of 1755, the new buildings incorporated a set of features intended to supply them with adequate seismic behavior, enabling them to resist horizontal loads and to dissipate a considerable amount of energy. Among these measures the so-called “Gaiola” (the Cage) stands out and it is based on a set of timber members embedded along the inner face of the main stone masonry facade walls. *Baixa Pombalina* is an example of an outstanding anti-seismic construction system, which was a step beyond its time.

public fiscal incentives to rehabilitate housing units in historic zones. Further, we cannot state that residential values in protected zones are lower compared to zones without this designation.

It is also worth pointing out that protected zones in *Baixa Pombalina* are replete with architectural marvels post-earthquake from the 18th-century onward, aesthetically pleasing sets and wide streets and avenues. In contrast, inland inner-city protected zones north of *Baixa* namely in the *bairros* of *Bica, Alfama* and *Castelo* are characterized by dense housing stock of low quality and very long narrow streets inherited from Medieval eras. These areas are also known for their lack of parking and social facilities. As these two examples illustrate, some protected zones may have a set of other locational attributes not valued by the market despite the historic characteristics, which make these areas worthy of designation. This, in turn, would imply that the market valuation of residing in protected zones may differ across space. Two remarks are therefore in order. First, the choice of protected zones and therefore, which parts of Lisbon are worth preserving may be correlated with unobserved location attributes, which may have biased the previous OLS coefficient on protected zones. Second, the global spatial coefficient related to protected zones may still be biased if there is difference in unobserved housing quality or in the level of stringency of local preservation ordinances in these zones. As such, global spatial estimates may still mask variations in historic amenity values across the city.

Including interaction effects with protected zones indicate that unobservable location effects may be responsible for driving the significance of the effect under the OLS specification (first specification in table 4). By including interactions with the number of dilapidated dwellings within 1000 meters and open space buffers at 50 meters, OLS results for the impact of protected zones on housing prices are no longer significant. Yet, these OLS interaction coefficient estimates are positive and significant suggesting that being located in a protected zone attenuates the disamenity value associated with blight and increases the amenity value of very localized green surroundings. Thus, historic ambience and open space seem to be complementary goods. After controlling for spatial dependence in the error term, significant interactions of protected zones and open space buffers at 50 meters are no longer significant, though a positive and significant value for the interaction between protected zones and dilapidated dwellings within 1000 meters remains. This is an interesting result since it seems to suggest that this zoning regulation may reduce the negative effects of concentration of neglected buildings on property values by creating an incentive for rehabilitation in these areas and by setting regulations that ensure that these chronic eyesores do not damage city’s beauty or erode its historic heritage.[21]

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[21] There are several fiscal incentives and grants to incentive maintenance and rehabilitation of buildings in protected zones. However, if a property owner fails to maintain his building(s) and allows neglect and severe deterioration to occur, that property owner can be cited by the city of Lisbon to totally or partially demolish the building by neglect. Once such a citation is issued, the property owner must correct the violations. If the property owner fails to cooperate, the property owner may be assessed a fine for every day he is in violation of the citation. Through this process, the

Results when disaggregating by type of historic amenities are in line with the conclusions from OLS estimation and show that different categories elicit different effects on housing prices. It is thus important to take into account the heterogeneity of historic amenities when conducting such analysis. Spatial results indicate that higher concentrations of landmark and non-landmark churches in a 1000 meter radius have a negative impact on prices, with landmark churches having a greater effect.

Locally (within 100 meters) the use value of a non-landmark church is significant at around 4% with residents valuing the accessibility to a congregation point. This contrast between the effects of churches locally (within 100 meters) versus the larger radius of 1000 is potentially due to congestion effects that are generated by churches. Churches provide active services to the communities and are a localized meeting point drawing in both residents and non-residents for weekly mass, weddings, and funerals. Although having a church nearby may be a benefit to residents, additional non-landmark or landmark churches in the area beyond the first serve little purpose to residents and may in fact have negative externalities with the tolling of church bells and high activity during services. With more activity occurring around landmark churches, which additionally draw in tourist and those not in the congregation, this negative impact on price is more pronounced.

Whereas churches actively provide services to the public, lithic and other historic amenities are primarily aspects of pure aesthetics with little non-use value to non-local residents. When controlling for spatial dependence, we see that non-landmark lithic structures elicit a positive effect on housing prices, an effect which is not captured under the standard OLS specification. Higher concentration of both landmark and non-landmark lithic structures therefore positively influence housing prices in the order of 2.9% and 0.7% respectively. As expected, the effect from landmark lithic structures is larger in magnitude reflecting the fact that landmark amenities have a greater non-use value to not only residents of the area, but also to other residents in the city and abroad.

Even in controlling for spatial dependence, we see no significant effect from the disaggregation of landmark and non-landmark palaces. For other historic amenities however, the local effect of having higher concentrations within 50 meters is positive but, similarly to the baseline OLS specification, higher concentrations of these amenities in 100 or 1000 meters has a negative effect. While housing prices capitalize a positive effect from being in an area with historic amenities, too many of these amenities in the broader area may be reflective of historic areas which are dense with historic amenities and attractive to non-residents.

In terms of proximity to historic amenities, other historic amenities consistently have a positive effect on housing prices in the range of 3.3%. When controlling for spatial dependence, this magnitude is slightly lower than under the baseline specification. Although the effect of proximity to

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city works to address the problem of blighted properties in the local historic zones by getting property owners to act responsibly and perform minimal maintenance of their properties.

lithic structures in general had a positive impact on housing prices in the baseline model, this effect is removed when estimating the spatial models.

In summary, our global results seem to attest the causal evidence that many residents in Lisbon appreciate living in proximity to historic amenities, green areas, appreciate having neighborhood historic amenities that have mostly localized uses, and appreciate architectural ambience and nice views either of the Tagus river or of historical sites. However, residents do not really want to live nearby scenic viewpoints, protected zones or even in areas with high density of historic amenities possibly because of the disamenities associated with these locations. To the extent that heritage status and designation is likely to be positively correlated with unobserved characteristics of surrounding neighborhoods, it is also important to take spatial correlation into account when one wants to efficiently estimate the coefficients of the model. Moreover, our global results also seem to suggest that greening programs can either magnify the amenities or attenuate the negative effects of historic monuments in some cases, and reduce the negative housing price effects from PM^{10} pollution. In addition, historic ambience and open space seem to be complements in Lisbon and further, designation of historic zones seems to counteract the negative effects on property values of neglected buildings in historic neighborhoods by setting additional regulations that ensure that these chronic eyesores do not damage city's beauty or erode its historic heritage.

6.3. Geographic Weighted Ridge Regression Results

In this section we explore the assumption that the effect of historic amenities on housing prices remain constant across location in the city. We complement the analysis of global effects of historic amenities by estimating localized Ridge GWR models. It should be nevertheless emphasized that our GWR analyses are exploratory and we do not use them to make hard inferences regarding the exact magnitudes but rather to discuss the patterns present. Table 5 presents the results of our tests for spatial dependence, collineariety and spatial variability for various specifications of RGWR models.

When estimating GWR models we remove all dummy and count variables from the baseline OLS specifications due to their limited variability and because these would create problems with local collinearity. We further look only at specifications with proximity to nearest historic amenities.[22] In order to reduce the model to the appropriate variables, we remove dwelling characteristic dummy variables, counts of open spaces in given buffers, and measure the distance to the nearest metro station rather than concentration of surrounding stations. This specification is left only with continuous variables including housing area, the most significant dwelling characteristic.

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[22] With a log-log specification we estimate the price elasticity of distance to historic amenities.

***Table 5.* RGWR Collineariety Diagnostics**

	Optimal Bandwidth	SSE	Condition No.	Condition No. Unconstrained			B-P	Rho Err	Moran's I (Residuals)
				25th Percentile	Median	90th Percentile			
Monument Proximity									
OLS	-	640.7	-	-	-	-	442.1***	-	0.04896***
Sp. Error	-	616.7	-	-	-	-	420.9***	0.55501***	-0.00518
RGWR	399	563.2	30	30,342.4	116,127	2,863,488	-	-	-0.00678
Landmark, Non-Landmarks, World Heritage Proximity									
OLS	-	638.6	-	-	-	-	447.6***	-	0.05736***
Sp. Error	-	628.6	-	-	-	-	442.3***	0.18709***	-0.00419
RGWR	413	563.9	30	66,005.6	195,588	2,963,185	-	-	0.00174
Historic Amenity Proximity by Type									
OLS	-	637.6	-	-	-	-	456.2***	-	0.05574***
Sp. Error	-	628.2	-	-	-	-	447.9***	0.18266***	-0.00393
RGWR	399	562.4	30	34,891.7	129,302	3,000,275	-	-	0.00072

Notes: ****Significance at 1 p.c. level; **Significance at 5 p.c. level; *Significance at 10 p.c. level.*

Additionally, following Wheeler (2007) we implemented a ridge regression version of GWR to address the problem of local collinearity. Ridge regression was designed specifically to reduce collinearity effects by penalizing the size of regression coefficients and decreasing the influence in the model of variables with relatively small variance in the design matrix. From table 5 our condition numbers are all equal to 30 and the maximum value of the variance-decomposition proportions of individual variables located in table 6 are in general less than 0.5, suggesting therefore that local collinearity is not preventing the marginal inference on the spatial pattern of regression coefficients. The matrix in equation 5.9 results in 11,708 coefficients for each parameter.[23]

Respective global OLS and spatial models are re-estimated under the new specifications so that comparisons can be made across models. With the preference for a spatial error specification using the inverse weight matrix in the previous section, we re-estimate global spatial hedonic models under this specification. Our OLS values for the variance-decomposition proportions in our OLS model in table 6 also reveal no collinearity issues.[24]

We estimate different specifications focusing on the proximity to monuments in general, proximity to mutually exclusive landmark, non-landmark, and world heritage site, and proximity to the nearest church, palace, lithic structure or other historic amenities. Across models, there is an improvement in the RGWR models over the traditional OLS model with lower sum of squared errors,

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[23] There is a modest increase in computational complexity to include the ridge regression parameter in GWR. The main computational burden in the GWR version implemented here is the CV estimation of the kernel bandwidth. The number of calculations in the CV estimation is dominated by the calculation of the kernel weights and matrix inverse for the regression coefficients at each location.

[24] Global Moran's I tests of the dependent variable and residuals indicate significant positive spatial autocorrelation and LM tests with the inverse distance weight matrix indicate significant LM and robust LM test statistics for spatial autoregressive and error models. Our VIFs analyses also reveal that we do not have problems of global collinearity. The full set results on the tests for spatial dependence and global VIFs for the new analyses can be provided from authors upon request.

indicating that the local models gain statistical improvements over the standard global OLS models. The smaller this measure, the closer the fit of the RGWR model to the observed data. The Moran's I statistic on residuals is positive and significant at 1% level for the OLS, while this statistic is insignificant for both the Spatial Error and RGWR models. This means that the OLS results have not accounted for spatial dependence in the data, while in the case of the spatial models (global and local) no significant spatial autocorrelation in the residuals exists. Moreover, in the particular case of the RGWR, our result on the Moran's I also indicates that the inclusion of the coefficient penalization did not significantly affected the spatial autocorrelation model in the model residuals.

The index of spatial variation measures the relative variability across locations in the coefficient estimates between the OLS and localized model.[25] We impose the criteria that values greater than 1.5 indicate strong spatial variation in the localized estimated coefficient. This threshold is exceeded for all historic amenities of interests, and is consistently high across estimates of all coefficients with significant variation in the distribution of building ages and measures of dwelling distance to local amenities and CBD's. The effect due to world heritage sites has the least spatial variation and is consistently high, reflecting the global nature of these historic amenities which have non-use values much broader than other historic amenities. This spatial non-stationarity present in local estimates is masked when using global techniques. Overall, the results from our test for spatial variability validates the use of a GWR model for the analysis of this data.

***Table 6.* RGWR Results**

	OLS	**Spatial Error (SW1)**	**Geographically Weighted Regression**			**Index of Spatial Variation**	**Max. V-D P**	
			25th Percentile	**Median**	**90th Percentile**		**OLS**	**GWR**
Monument Proximity								
Monuments	-0.00239	-0.0005	-0.03322	-0.01069	0.06236	15.33	0.255	0.255
Ridge Parameter	-	-	0.21292	0.21682	0.22892	-	-	-
Landmark, Non-Landmarks, World Heritage Proximity								
Landmarks	0.00637	0.00804	-0.02305	0.00176	0.02476	4.92	0.31	0.657
Non-Landmarks	-0.005	-0.0049	-0.02376	-0.0019	0.09504	6.12	0.163	0.269
World Heritage Sites	0.08686***	0.08040***	0.08418	0.17448	0.52115	1.78	0.476	0.998
Ridge Parameter	-	-	0.21843	0.22219	0.23406	-	-	-
Historic Amenity Proximity by Type								
Nearest Church	0.01386***	0.01229**	-0.00777	0.01535	0.11116	12.18	0.283	0.250
Nearest Palace	0.01002**	0.01074**	-0.01273	0.00888	0.04942	12.26	0.203	0.380
Nearest Lithic	-0.00139	-0.00156	-0.04897	-0.0257	0.02608	8.83	0.259	0.553
Nearest Other	-0.03159***	-0.03007***	-0.03437	-0.01463	0.04724	11.07	0.286	0.655
Ridge Parameter	-	-	0.22105	0.22486	0.23658	-	-	-

Notes: ****Significance at 1 p.c. level; **Significance at 5 p.c. level; *Significance at 10 p.c. level.*

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[25] The Index of Spatial Variance is estimated as the standard deviation of all local estimated parameters as a fraction of the standard error of the OLS estimator. Values higher than 1.5 suggest a strong variation in the local parameters relative to the OLS parameters.

RGWR estimates for historic amenities impacts

For brevity, RGWR estimates in table 6 are reported by their quantile range. The estimated results of the new global models are also presented in table 6.

Under the baseline OLS specification proximity to world heritage sites, churches and palaces have a negative price effect with prices increasing as we move farther from these amenities, while other historic amenities have a positive price effect increasing with decreasing proximity. These effects remain when controlling for global spatial dependence. Though the larger the bandwidth the more the RGWR model parameters approach their global values, in the case of historic amenities our RGWR results show that marginal effects varies significantly within Lisbon. For example the coefficient value of the 25th percentile for proximity to the nearest historic monument equals -0.03322 and the value at the 90th percentile is equal to 0.06236. To have a better understanding of the overall impacts of historic amenities from our RGWR model we have also computed the distribution of the results. Table 7 presents those results.

From this table, the distribution of the RGWR results with high proportions of positive elasticities for world heritage sites, churches and palaces. Consistent with the global models, lithic and other historic amenities in general have RGWR results of negative elasticities indicating increasing prices as we move closer to such amenities.

***Table 7*. Distribution of RGWR Results**

	Min	Max	Mean	Median	Pos./Neg.	1 S.D. of 0
Monument Proximity						
Monuments	-0.1491	0.2821	0.0003	-0.0107	0.51	86.26%
Landmark, Non-Landmarks, World Heritage Proximity						
Landmarks	-0.3314	0.1369	-0.0063	0.0018	1.07	86.64%
Non-Landmarks	-0.2038	0.2891	0.0121	-0.0019	0.87	74.53%
World Heritage Sites	-0.0732	1.1220	0.2275	0.1745	42.04	57.73%
Historic Amenity Proximity by Type						
Church	-0.1251	0.2640	0.0297	0.0154	2.11	72.82%
Palace	-0.1189	0.1802	0.0137	0.0089	1.74	83.75%
Lithic	-0.1476	0.1590	-0.0238	-0.0257	0.46	64.69%
Other	-0.1776	0.4115	-0.0096	-0.0146	0.57	85.88%

Spatial patterns in historic amenity values

From figure 3 there is a pattern of positive price effects for monuments in the historic primary CBD where the bulk of historic amenities are located with slight changes towards a negative price effect as we move towards the secondary CBD, Expo, where there is much fewer historic amenities. Landmark amenities tend to have a negative impact on price (with positive elasticities) nearer to the landmarks and in the primary CBD, whereas in contrast non-landmark amenities tend to have a more positive price effect in the historic CBD of *Baixa* with decreasing effects as we move towards the secondary CBD in Expo. The effect of landmark amenities towards the city limit and towards the airport tend to become positive. This may indicate that landmark amenities are valued broadly for their non-use benefits by residents in the city, however location in close proximity to landmarks located in the historic CBD and area of Bélem (which is West of *Baixa*) may carry a negative effect with high levels of non-residential visitors to these sites.

In general, the effect of world heritage sites in their direct proximity is largely insignificant with magnitudes close to zero. Moving towards the peripherals however, there are negative price effects for areas more north towards the airport. The global significance of world heritage sites is driven by these areas of strong negative price effects and large areas of localized effects close to zero.

The effect of proximity to churches varies over space ranging from a 0.12% increase in prices for increased proximity to a 0.26% decrease for increased proximity depending on church location and clusters. In areas where churches are sparsely located there is a pattern of moderate positive price effects compared to the CBD where there are many more churches. Churches, which are the most numerous of any historic amenity, tend to have a positive price effect in the area of Bélem and the old historic area of *Alfama* (which is located north of *Baixa*).

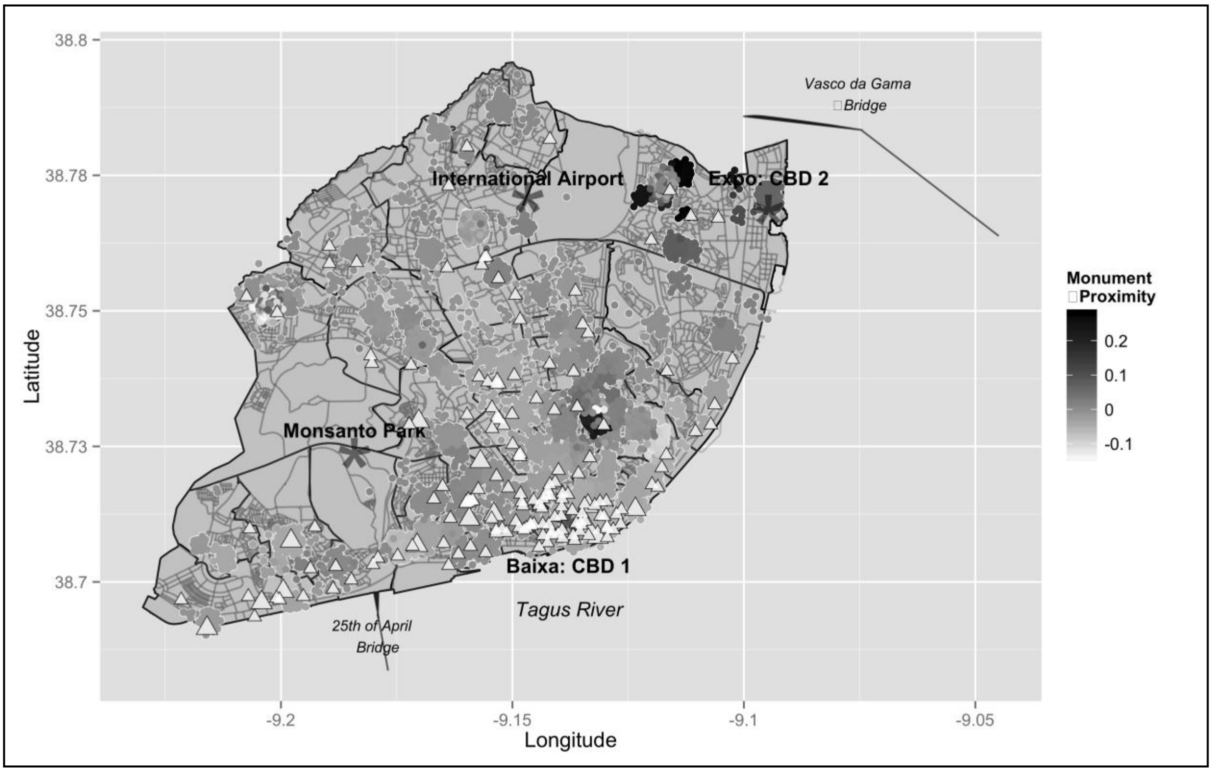
Just behind these historic areas of *Alfama* and *Castelo,* where the Castle of St. Jorge is located, there are strong positive price effects coming from palaces and lithic structures. While this area is quite historic, there are few palaces and lithic structures located in this densely packed neighborhood. Other historic amenities, which are all non-landmarks, tend to have a positive impact on housing prices. As we move west towards the area of Bélem, where there are less other historic amenities and more churches, palaces and lithic structures, this effect becomes negative.

Further, lithic structures (ranging from a negative effect of 0.14% to a positive effect of 0.15%) and other historic amenities (ranging from a negative effect of 0.17% to a positive effect of 0.41%) have areas of strong positive price effects as we move west along the river towards the 25th of April Bridge and Bélem. This area, outside of the crowded CBD, has relatively less non-residential visitors.

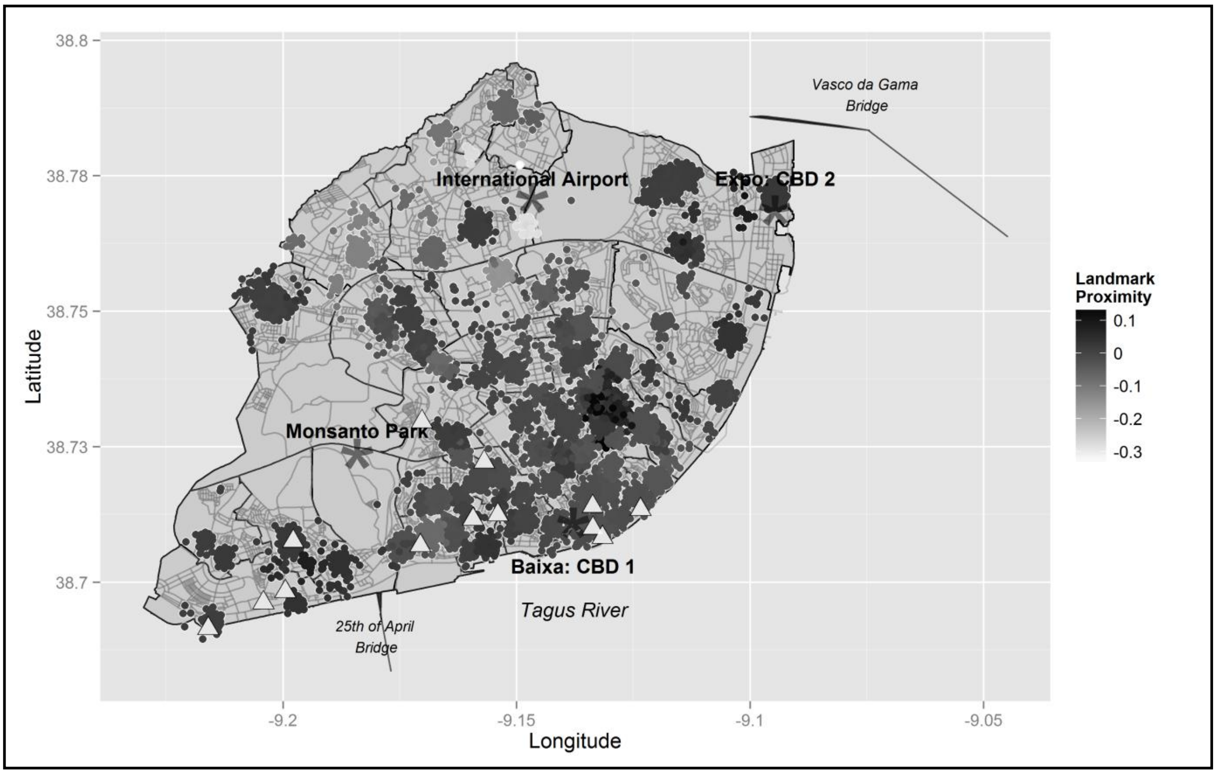
Palaces which are primarily located along the river just outside of the downtown core tend to have a slight positive effects on the cluster of dwellings in direct proximity. Outside the CBD in the *São Bento* area where the landmark São Bento Palace is located and there few of either churches or lithic structures, there is a positive marginal impact for being located closer to any type of palace. This corresponds to the localized use value of such amenities which are valued by neighborhood residents however less so by residents who live further. This spatial variation is not captured in global models and extensions to localized estimation techniques allow for more appropriate analysis of this effect.

Figure 3. **RGWR Spatial Variation**

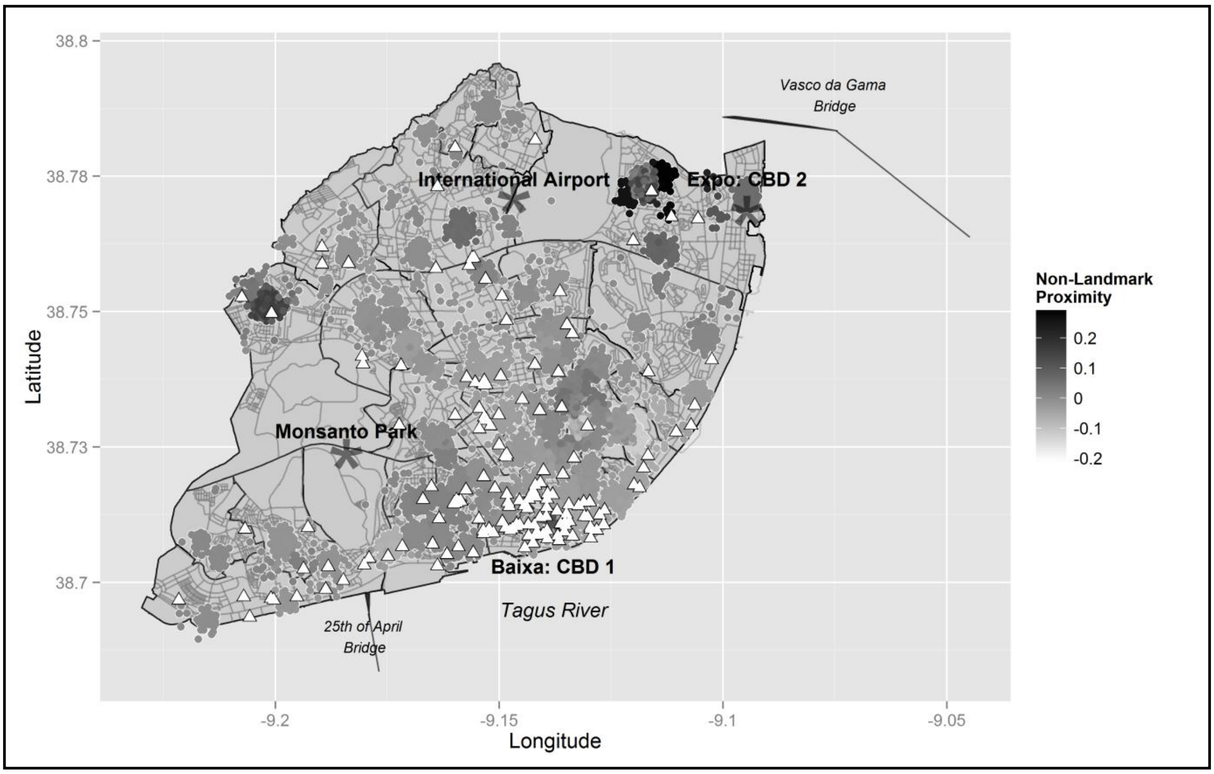
Panel A: AllMonuments



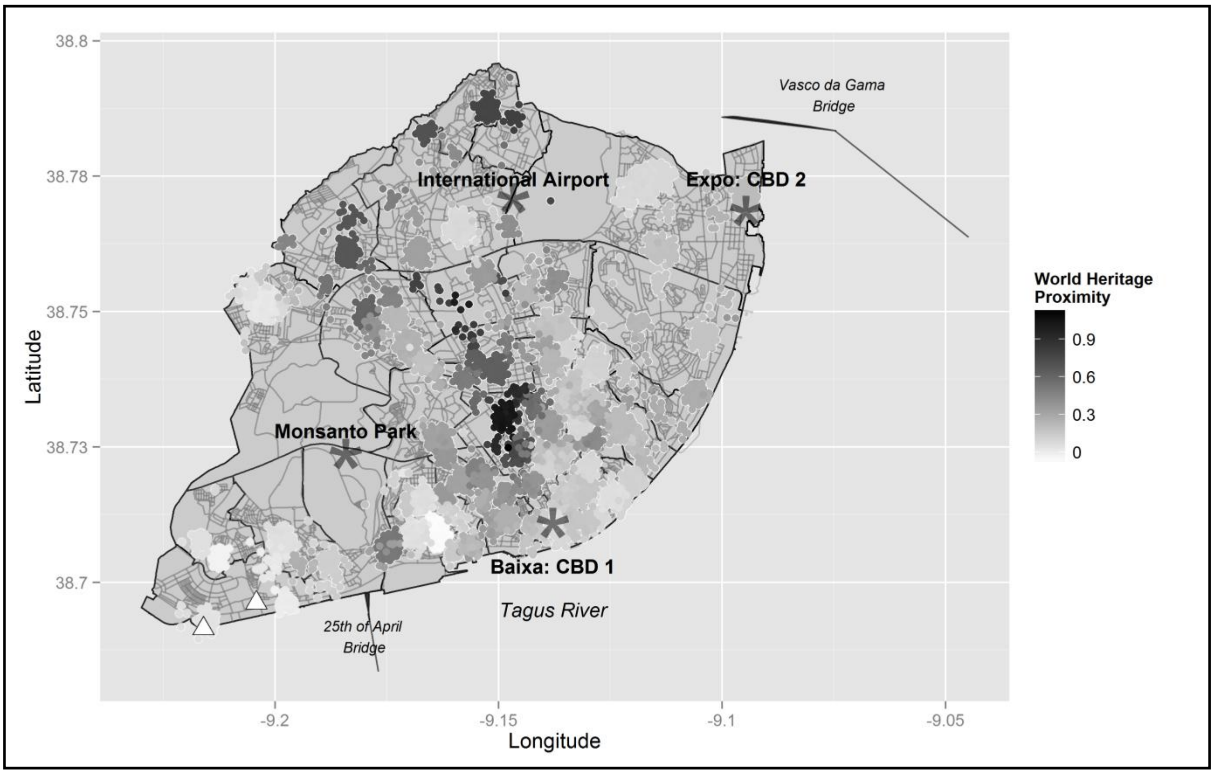
Panel B: Landmarks



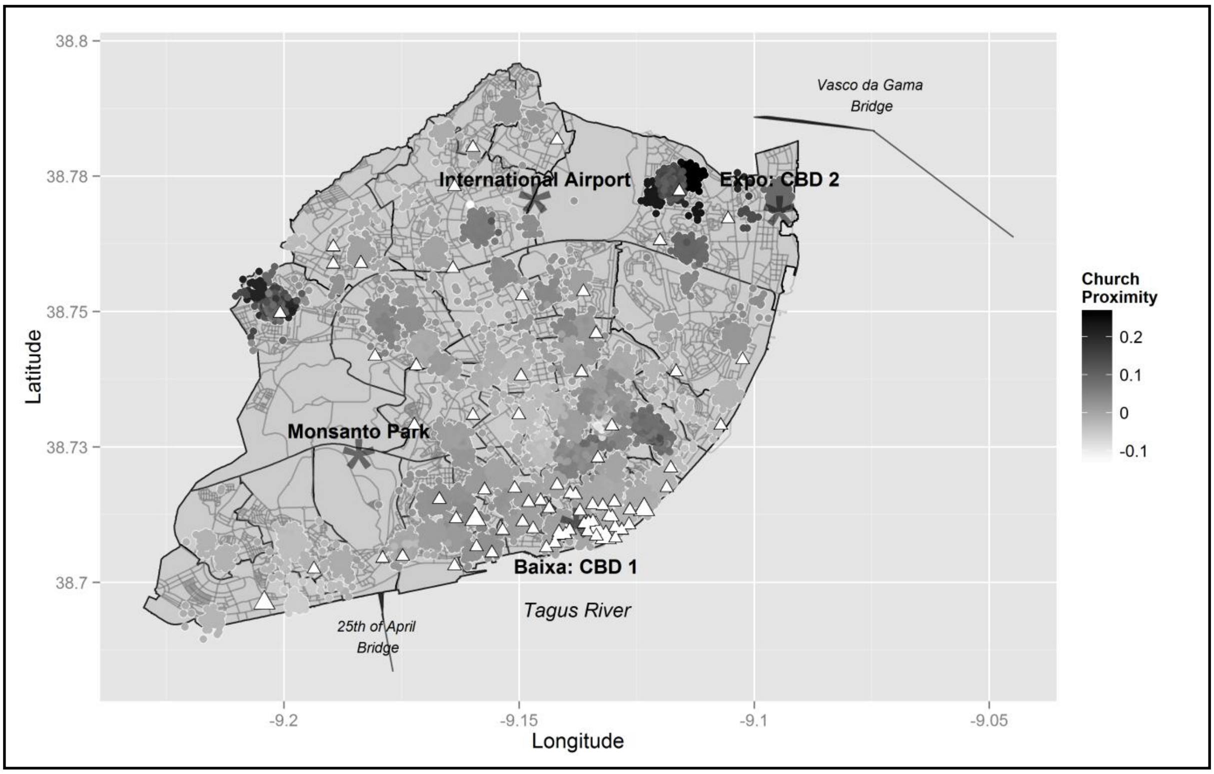
Panel C: Non-Landmarks



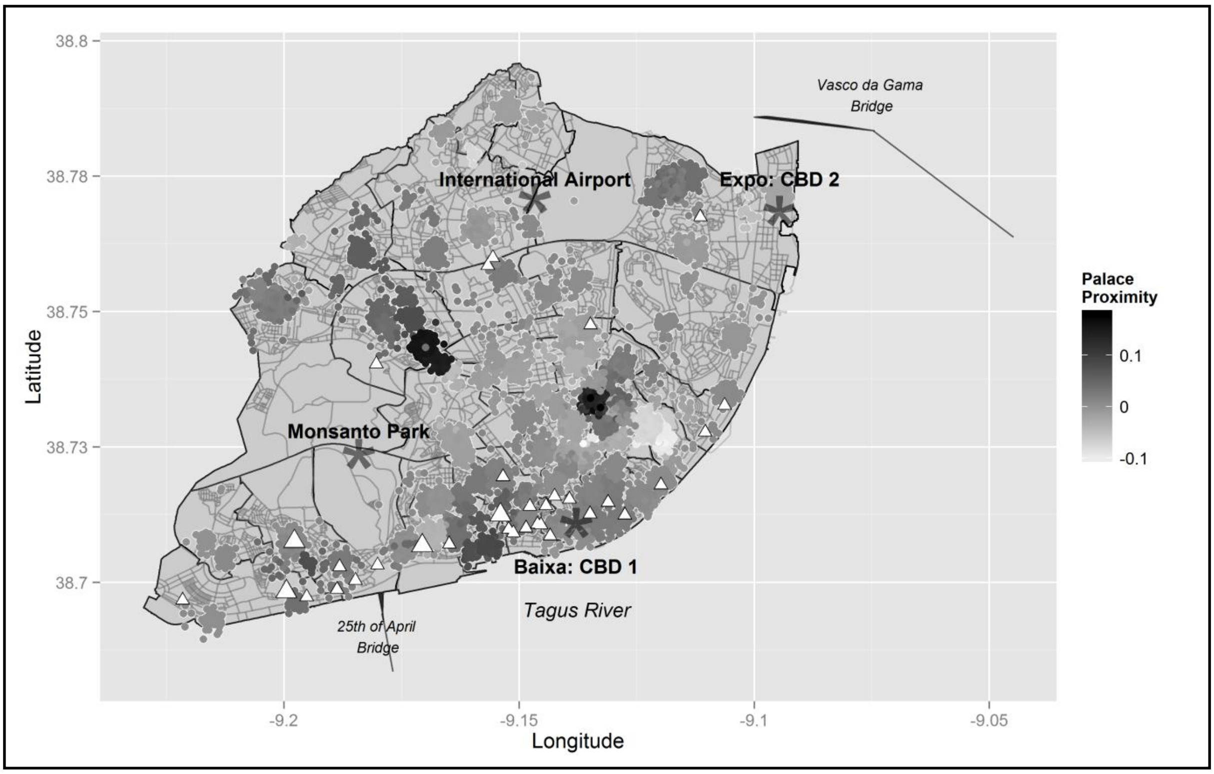
Panel D: World Heritage Sites



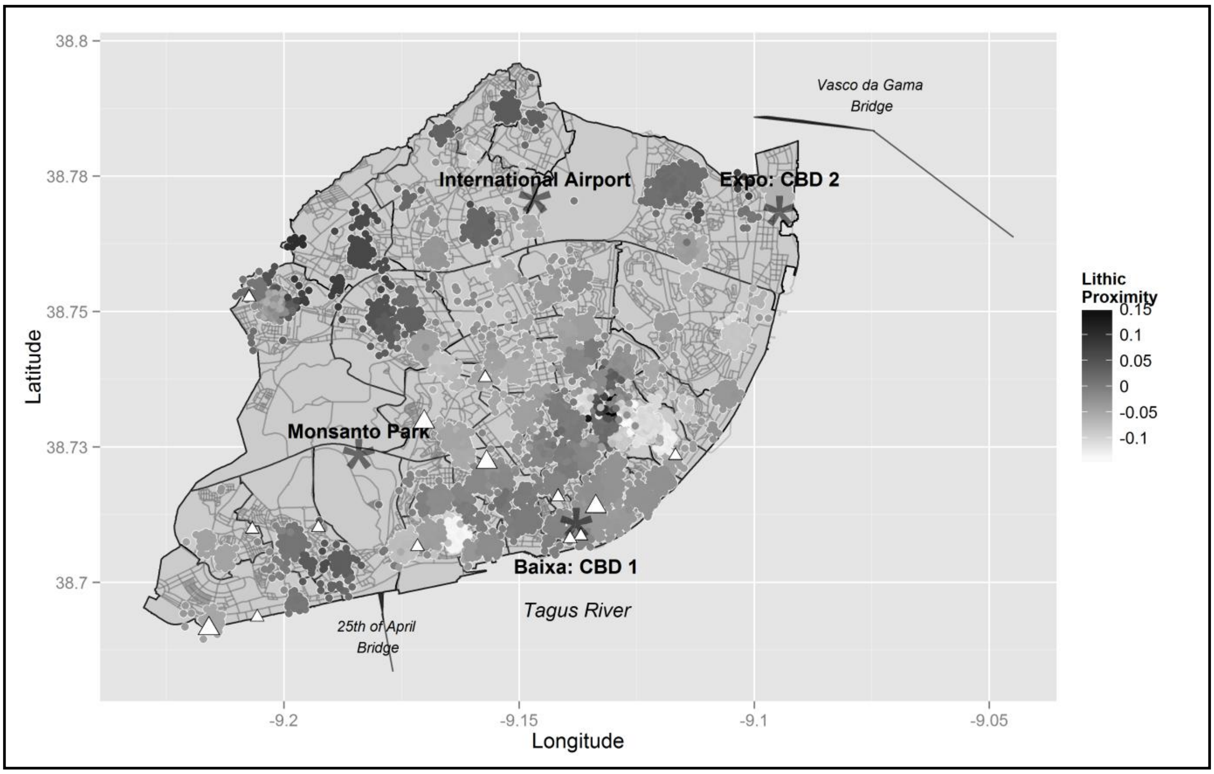
Panel E: All Churches



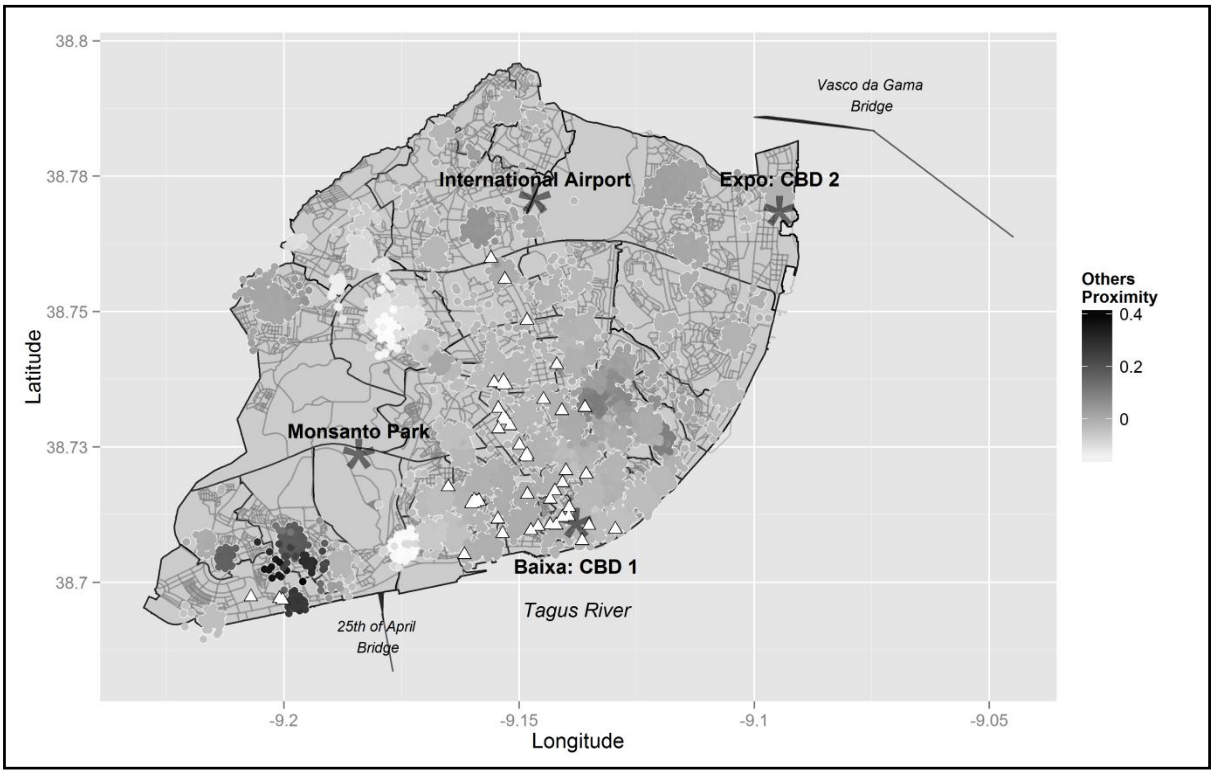
Panel F: All Palaces



Panel G: All Lithic



Panel H: All Others



7. Conclusion

This research has determined the effects on the residential housing market caused by concentration and proximity to historic amenities. These effects however are not constant when disaggregating by different types of historic amenities as well as landmarks compared to non-landmark amenities. The impacts on the housing market due to these amenities exhibit spatial non-stationarity with variation in the local effects compared to global effects.

From a policy perspective, these findings highlight the importance of conceptualizing the amenity value not just in terms of structural characteristics but how those characteristics interact with or are conditioned by social, economic and other local contextual features. By disaggregating landmarks by different types, we obtain finer information on the different influences that historic amenities have on the residential urban housing market. With municipal policies directed at specific urban neighborhoods or areas, localized models may capture these finer effects when compared to global models for the entire city. While global effects indicate a significant negative impact of protected zones, when accounting for the heterogeneity of these areas this effect disappears. We see that the designation of historic protected zones may counteract the negative effects on property values of nearby neglected buildings in historic neighborhoods by setting additional regulations ensuring that dilapidated buildings do not damage the city's beauty or erode its historic heritage.

In the sense of usage, we find in general that direct proximity to historic amenities tend to have a positive price effect, while higher concentrations of these amenities in a broader radius have weaker negative effects. While being located in direct proximity to a historic amenity is capitalized into dwelling premiums, higher concentrations may attract increasing non-residents to the area. Our results indicate that historic ambience and open space are complements in Lisbon suggesting also that greening policies that increase open space areas near historic monuments and sites and within protected zones can add additional premiums to property values.

As expected, landmark historic amenities have a stronger magnitude owing to their broader non-use value not only to local residents but to others located in the city. We do not find however any significant impacts attribute to world heritage sites in the city.

These results imply that when deciding on historic amenity investment and preservation, local governments must take into consideration that the resulting effects of such policies will impact dwellings closer to the amenity more than residents living further away. Under a constrained budget, investment decisions on the preservation and maintenance of historic amenities should target those with the highest potential spill-over effects. If these investments are valued through the housing market and increases housing prices, especially from landmark amenities which have effects of much larger magnitudes, there is an important discussion and analysis to be done regarding increases in property tax revenues while balancing gentrification.

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Appendix

Table A1. Historic Amenities of Lisbon

Churches: *Churches (Igreja); Chapels (Capela); Convent (Convento); Monastery (Mosteiro)*		
Basilica da Estrela	**Mosteiro dos Jeronimos**	**Panteao Nacional**
Se Patriarcal	Igreja de Santo António	Igreja de Chelas
Igreja de Sao Tiago e Sao Martinho	Igreja Paroquial do Castelo	Igreja Paroquial de Santa Justa e Rufina
Igreja Paroquial de Santa Justa	Igreja Paroquial da Graca	Igreja Paroquial do Lumiar
Igreja Paroquial de Sao Nicolau e Sao Juliao	Igreja Paroquial de Carnide	Igreja Paroquial dos Olivais
Igreja de Sao Joao da Praca	Igreja da Luz	Igreja Paroquial da Madalena
Igreja de Nossa Senhora do Loreto	Mosteiro de Nossa Senhora da Piedade da Esperanca	Igreja Paroquial da Ameixoeira
Igreja Paroquial de Nossa Senhora do Socorro	Igreja Paroquial de Sao Cristovao	Igreja de Sao Jose
Igreja Paroquial de Sao Paulo	Igreja Paroquial do Campo Grande	Igreja Paroquial de Sao Vicente de Fora
Igreja de Nossa Senhora da Quietacao	Capela de São Sebastião da Mouraria	Convento de Santos-o-Novo
Igreja Paroquial de Sao Mamede	Convento de Nossa Senhora dos Remedios	Igreja Paroquial das Merces
Convento de Sao Domingos de Benfica	Igreja Paroquial da Penha de Franca	Igreja Paroquial de Telheiras
Mosteiro de Santa Teresa de Jesus	Igreja Paroquial de Sao Sebastiao da Pedreira	Igreja Paroquial de Santa Catarina
Igreja Paroquial de Marvila	Igreja Paroquial do Beato	Igreja Paroquial do Sacramento
Igreja Paroquial de Sao Miguel	Convento de Sao Pedro de Alcantara	Igreja Paroquial da Charneca
Igreja Paroquial da Encarnacao	Igreja Paroquial de Santos-o-Velho	Igreja Paroquial da Pena
Igreja do Menino Deus	Igreja Paroquial de Santo Estevao	Igreja Paroquial de Santa Engracia
Igreja Paroquial de Santa Isabel	Igreja Paroquial de Benfica	Igreja Paroquial da Ajuda
Igreja do Corpo Santo	Igreja Paroquial dos Anjos	Igreja Paroquial de Sao Francisco de Paula
Igreja Paroquial dos Martires	Igreja Paroquial de Alcantara	Igreja de Nossa Senhora das Dores
Igreja Paroquial de Campolide	Mosteiro de Nossa Senhora da Conceicao dos Cardais	Mosteiro de Nossa Senhora da Encarnacao
Mosteiro de Corpus Christi	Igreja Paroquial de Sao Joao de Brito	Igreja Paroquial de Santo Eugenio
Igreja Paroquial de Fatima	Igreja Paroquial de Santo Condestavel	Igreja Paroquial de Sao Joao de Deus
Igreja Paroquial de Olivais Sul	Igreja de São Roque	Igreja Paroquial de Sao Vicente de Paulo
Igreja Paroquial de Sao Domingos de Benfica	Igreja Paroquial de Santa Joana Princesa	
Palaces: *Palaces (Palácio); Mansions (Palacete); Nobel Houses (Solar/ Casa)*		
Palácio Nacional da Ajuda	**Assembleia da Republica**	**Palácio Nacional de Belém**
Palácio das Necessidades	Palacete dos Viscondes e Condes dos Olivais e Penha-Longa	Palácio Ratton
Solar da Quinta dos Lagares d'El-Rei	Palácio dos Condes de Almada	Palácio dos Condes de Figueira
Palácio de Xabregas	Palácio do Marquês de Tancos	Palácio dos Almadas
Palácio Sabugosa	Palácio de Santo Estêvão	Palácio do Conde de Vimioso
Palácio marqueses de Fronteira	Palácio das Chagas	Palácio da Flor da Murta
Palácio Foz	Palácio Burnay	Palácio Palha
Casa da Quinta da Pimenta	Palácio Ludovice	Casa da Junqueira
Palácio de Santa Catarina	Palácio Valada-Azambuja	Palácio do Marquês de Angeja
Palácio dos Duques de Lafões	Casa da Fonte do Anjo	Palacete na Rua de Pedrouços, 97 a 99
Palácio do Barão de Quintela e Conde de Farrobo	Palácio Palmela	Palacete na Rua Jau

Stone/ Lithic Architecture: *Towers (Torres); Arches (Arcos); Windmills (Moinho); Columns (Pelourinho);*		
Aqueduto das Águas Livres	**Castelo de São Jorge**	**Torre de São Vicente de Belém**
Pelourinho de Lisboa	Forte de Santa Apolónia	Obelisco Aquático
Moinhos do Casalinho da Ajuda	Moinhos do Caramão da Ajuda	Arco Triunfal da Rua Augusta
Portas de Benfica	Aos Restauradores de 1640	Padrão dos Descobrimentos
Arco de São Bento		
Other Historic Amenities: Statues (*Estátuas);* Monuments *(Monumentos);*Fountains *(Chafariz);* Funicular *(Elevador);* Crosses *(Cruzeiro)*		
Estátuas Lusitanas de Montalegre	Padrão do Campo Pequeno	Cruzeiro das Laranjeiras
Chafariz D'El Rei	Cruzeiro de Arroios	
Lápides das Pedras Negras	Chafariz da Esperança	Chafariz de Carmo
Neptuno	Chafariz das Janelas Verdes	D. José I
Chafariz do Desterro	Luís de Camões	D. Pedro IV
Figura masculina com cão (sem título)	Figura masculina com leão (sem título)	Ascensor do Lavra
Ascensor da Glória	Ascensor da Bica	Campo dos Mártires da Pátria
Elevador de Santa Justa	Afonso de Albuquerque	Duque de Saldanha
Cavador	Actor Taborda	Guardadora de Patos/ A Filha de Rei Guardando Patos
Maria da Fonte	Despertar	França Borges
Monumento ao Povo e aos Heróis da Guerra Peninsular	Figura feminina (sem título)	Marquês de Pombal
A Dor	A Arte A Ciencia	Rosa Araújo
Figuras femininas (sem título)	La Grande Sauterelle	Antero de Quental
Figura feminina com veado (sem título)	Mulher Vendo-se ao Espelho	Figura feminina (sem título)
Vento Garroa	Figura feminina (sem título)	Figura feminina com cavalo (sem título)
Figura feminina (sem título)	O Segredo	A Família
Estátua de Alexandre Herculano	Estátua de Almeida Garrett	Estátua de António Feliciano de Castilho
Monumento ao poeta Chiado	Adamastor	

** Landmark historic amenities indicated in* ***bold***

Table A2. **Descriptive Statistics**

Variables	**N**	**Mean**	**St. Dev,**	**Min**	**Max**
Dependent					
Price	11,708	12.152	0.365	10.463	13.911
Structural					
log(Area)	11,708	4.407	0.265	3.219	5.481
New Dummy	11,708	0.179	0.383	0	1
View of Tagus Dummy	11,708	0.062	0.241	0	1
Pool Dummy	11,708	0.007	0.086	0	1
Parking Dummy	11,708	0.114	0.318	0	1
Fireplace Dummy	11,708	0.025	0.156	0	1
Double Windows Dummy	11,708	0.207	0.405	0	1
Air Conditioning Dummy	11,708	0.119	0.323	0	1
Elevator Dummy	11,708	0.228	0.42	0	1
Accessibility					

log(Dist. to Baixa)	11,708	8.142	0.696	4.191	9.118
log(Dist. to Expo)	11,708	8.826	0.466	7.254	9.6
log(Dist. to Airport)	11,708	8.349	0.502	6.378	9.273
log(Dist. to Nearest Cultural Amenity)	11,708	6.082	0.863	3.213	8.337
log(Dist. to Nearest Arts Amenity)	11,708	6.563	0.928	2.668	7.826
log(Dist. to Nearest Public Parking)	11,708	5.8	1.063	2.129	8.019
log(Dist. to Nearest Train Station)	11,708	6.827	0.868	0.101	8.536
Count of Metro Stations 100 m	11,708	0.061	0.239	0	1
log(Dist. to 25th April Bridge)	11,708	8.499	0.566	6.352	9.292
log(Dist. to Nearest Fitness Amenity)	11,708	6.406	0.538	4.261	7.69
log(Dist. to Nearest School)	11,708	5.085	0.729	1.499	6.907
log(Dist. to Nearest University)	11,708	6.162	0.819	3.239	7.825
log(Dist. to Nearest Health Amenity)	11,708	5.021	0.706	2.395	7.134
log(Dist. to Nearest Hospital)	11,708	6.481	1.091	1.885	8.069
log(Dist. to Nearest Shopping Center)	11,708	6.259	1.052	2.636	8.694
log(Dist. to Nearest Security Amenity)	11,708	6.351	0.604	2.797	7.552
log(Dist. to Nearest Fire station)	11,708	6.821	0.664	3.339	8.231
log(Dist. to Nearest Cemetery)	11,708	6.998	0.83	3.089	8.107
log(Dist. to Freeway)	11,708	6.934	0.894	-1.067	8.319
log(Dist. to Stadium)	11,708	7.313	0.64	1.474	8.425
Environmental Amenities					
log(Dist. to Nearest Open Space)	11,708	5.615	0.94	2.37	7.145
Count of Open Spaces 50 m	11,708	0.035	0.187	0	2
Count of Open Spaces 200 m	11,708	0.433	0.586	0	4
Count of Open Spaces 500 m	11,708	2.617	1.626	0	8
Count of Open Spaces 1000 m	11,708	9.415	6.847	0	18
log(PM10 Particulates)	11,708	3.614	0.246	3.165	4.153
Architectural Ambiance					
log(% Buildings built pre 1919)	11,708	-4.354	6.705	-19.105	4.605
log(% Buildings built 1919 to 1945)	11,708	-3.475	6.523	-19.571	4.605
log(% Buildings built 1946 to 1960)	11,708	-3.574	6.525	-19.085	4.605
log(% Buildings built 1961 to 1970)	11,708	-5.472	6.158	-17.982	4.605
log(% Buildings built 1981 to 1990)	11,708	-7.644	4.908	-17.066	4.605
log(% Buildings built 1991 to 1995)	11,708	-7.845	4.693	-18.412	4.605
log(% Buildings built 1996 to 2000)	11,708	-8.322	4.175	-17.824	4.605
log(% Non-Residential Buildings)	11,708	-6.32	5.756	-19.665	4.605
log(% Vacant Buildings)	11,708	1.962	5.144	-14.417	4.605
Count of Dilapidated Buildings 1000 m	11,708	100.063	76.905	3	353
log(Average Freguesia Income)	11,708	10.186	0.311	9.27	10.819
log(Population Density)	11,708	-4.47	0.934	-11.657	-2.35
log(% Population w. Superior Education)	11,708	2.189	2.887	-17.026	4.5
log(% Population under 19)	11,708	2.353	2.156	-15.974	4.123
log(% Population over 65)	11,708	2.991	1.032	-13.449	4.605
Natural Hazard Risk					
High Flood Risk Dummy	11,708	0.144	0.351	0	1
High Seismic Risk Dummy	11,708	0.462	0.499	0	1
Views					
log(Dist. to Viewpoint)	11,708	6.293	0.94	2.21	7.688

log(Elevation)	11,708	4.005	0.808	0	4.963
Historic amenities					
Protected Zone Dummy	11,708	0.143	0.35	0	1
Count of Landmark Church 100m	11,708	0.004	0.061	0	1
Count of Landmark Church 1000m	11,708	0.309	0.539	0	3
Count of Non-Landmark Church 50m	11,708	0.002	0.039	0	1
Count of Non-Landmark Church 100m	11,708	0.019	0.147	0	2
Count of Non-Landmark Church 1000m	11,708	8.702	7.966	0	27
Count of Landmark Palace 50m	11,708	0.003	0.051	0	1
Count of Landmark Palace 1000m	11,708	0.526	0.744	0	2
Count of Non-Landmark Palace 50m	11,708	0.001	0.038	0	2
Count of Non-Landmark Palace 100m	11,708	0.003	0.057	0	2
Count of Non-Landmark Palace 1000m	11,708	2.123	2.783	0	11
Count of Landmark Lithic 50m	11,708	0.001	0.032	0	1
Count of Landmark Lithic 1000m	11,708	0.107	0.321	0	2
Count of Non-Landmark Lithic 50m	11,708	0.006	0.076	0	1
Count of Non-Landmark Lithic 1000m	11,708	0.705	0.78	0	3
Count of Non-Landmark Other 50m	11,708	0.013	0.115	0	1
Count of Non-Landmark Other 100m	11,708	0.038	0.203	0	2
Count of Non-Landmark Other 1000m	11,708	5.562	6.105	0	20
log(Dist. to Nearest Church)	11,708	5.894	0.791	1.979	7.754
log(Dist. to Nearest Palace)	11,708	6.632	0.941	3.723	8.218
log(Dist. to Nearest Lithic)	11,708	7.086	0.916	2.471	8.726
log(Dist. to Nearest Other)	11,708	6.855	1.07	1.028	8.577

Table A3. **Variable Description**

Variable Description	**Units**	**Source**
Dependent		
Price: Listing price of two bedroom dwellings (€2007)	Euro	Confidencial Imobiliário
Structural		
Area: Square meters of living area	m2	Confidencial Imobiliário
New or used dwelling	Dummy	Confidencial Imobiliário
View of Tagus River	Dummy	Confidencial Imobiliário
Existence of a pool	Dummy	Confidencial Imobiliário
Existence of parking space	Dummy	Confidencial Imobiliário
Existence of fireplace	Dummy	Confidencial Imobiliário
Existence of double windows	Dummy	Confidencial Imobiliário
Existence of air conditioning	Dummy	Confidencial Imobiliário
Existence of elevator	Dummy	Confidencial Imobiliário
Accessibility		
Distance to Baixa; Primary CBD	m	GIS Calculation
Distance to Parque das Nações (Expo); Secondary CBD	m	GIS Calculation
Distance to Lisbon Portela international airport	m	GIS Calculation
Distance to nearest cultural amenity	m	GIS Calculation
Distance to nearest arts amenity	m	GIS Calculation

Distance to nearest public parking	m	GIS Calculation
Distance to nearest train station	m	GIS Calculation
Number of metro stations within 100 m	Count	GIS Calculation
Distance to the 25th of April Bridge	m	GIS Calculation
Distance to nearest fitness area: sports centres, track fields, swimming pools, sports fields	m	GIS Calculation
Distance to nearest public or private school	m	GIS Calculation
Distance to nearest university or college	m	GIS Calculation
Distance health centre, clinic, or pharmacy	m	GIS Calculation
Distance to nearest public or private hospital	m	GIS Calculation
Distance to nearest shopping centre	m	GIS Calculation
Distance to nearest security amenity (police station)	m	GIS Calculation
Distance to nearest fire station	m	GIS Calculation
Distance to nearest cemetery	m	GIS Calculation
Distance to nearest freeway	m	GIS Calculation
Distance to nearest sporting stadium	m	GIS Calculation
Environmental Amenities		
Distance to nearest open space	m	GIS Calculation
Count of open space within 50 m	Count	GIS Calculation
Count of open space within 200 m	Count	GIS Calculation
Count of open space within 500 m	Count	GIS Calculation
Count of open space within 1000 m	Count	GIS Calculation
Freguesia level concentration of pm10 particulates	Concentration	GIS Calculation
Architectural Ambiance and Neighborhood		
Per cent of buildings constructed prior to 1919	Percent	Census 2011
Per cent of buildings constructed 1919-1945	Percent	Census 2011
Per cent of buildings constructed 1946-1960	Percent	Census 2011
Per cent of buildings constructed 1961-1970	Percent	Census 2011
Per cent of buildings constructed 1981-1990	Percent	Census 2011
Per cent of buildings constructed 1991-1995	Percent	Census 2011
Per cent of buildings constructed 1996- 2000	Percent	Census 2011
Per cent of non-residential buildings	Percent	Census 2011
Per cent of vacant dwellings	Percent	Census 2011
Count of dilapidated buildings within 1000 m	Count	GIS Calculation
Average income at the Freguesia level	Euro	Câmara Municipal de Lisboa
Subsection population density	Resident/ m2	Census 2011
Per cent of population with superior education	Percent	Census 2011
Per cent of population less than 19 years old	Percent	Census 2011
Per cent of population over 65 years old	Percent	Census 2011
Natural Hazard Risk		
Located in area of high flooding risk	Dummy	GIS Calculation
Located in area with high potential seismic damage	Dummy	GIS Calculation
Views		
Distance to the nearest viewpoint over the city, river, or with 360 degree view	m	GIS Calculation
Elevation: Dwelling altitude	m	GIS Calculation
Historic amenities		
Protected Zone: Located in historically protected area of the city	Dummy	GIS Calculation
Count of Landmark Church 100 m	Count	GIS Calculation
Count of Landmark Church 1000 m	Count	GIS Calculation

Count of Non-Landmark Church 50 m	Count	GIS Calculation
Count of Non-Landmark Church 100 m	Count	GIS Calculation
Count of Non-Landmark Church 1000 m	Count	GIS Calculation
Count of Landmark Palace 50 m	Count	GIS Calculation
Count of Landmark Palace 1000 m	Count	GIS Calculation
Count of Non-Landmark Palace 50 m	Count	GIS Calculation
Count of Non-Landmark Palace 100 m	Count	GIS Calculation
Count of Non-Landmark Palace 1000 m	Count	GIS Calculation
Count of Landmark Lithic 50 m	Count	GIS Calculation
Count of Landmark Lithic 1000 m	Count	GIS Calculation
Count of Non-Landmark Lithic 50 m	Count	GIS Calculation
Count of Non-Landmark Lithic 1000 m	Count	GIS Calculation
Count of Non-Landmark Other 50 m	Count	GIS Calculation
Count of Non-Landmark Other 100 m	Count	GIS Calculation
Count of Non-Landmark Other 1000 m	Count	GIS Calculation
Distance to nearest church	m	GIS Calculation
Distance to nearest palace	m	GIS Calculation
Distance to nearest lithic structure	m	GIS Calculation
Distance to nearest other historic amenity	m	GIS Calculation

Table A4. **Global OLS and Spatial Error Results**

Variables	**OLS**		**OLS with Interaction**		**Spatial Error**		**Spatial Error with Interaction**	
	Coeff. (Std. err.)		**Coeff. (Std. err.)**		**Coeff. (Std. err.)**		**Coeff. (Std. err.)**	
Protected Zones								
Structural								
log(Area)	0.78392***	(0.008)	0.78188***	(0.008)	0.78150***	(0.008)	0.77391***	(0.008)
New Dummy	0.15605***	(0.005)	0.15638***	(0.005)	0.15532***	(0.005)	0.15495***	(0.005)
View of Tagus Dummy	0.06021***	(0.008)	0.06077***	(0.008)	0.06023***	(0.008)	0.06174***	(0.008)
Pool Dummy	0.11954***	(0.023)	0.12059***	(0.023)	0.11969***	(0.023)	0.11475***	(0.023)
Parking Dummy	0.06936***	(0.007)	0.06892***	(0.007)	0.06921***	(0.007)	0.07027***	(0.007)
Fireplace Dummy	0.02938**	(0.013)	0.02963**	(0.013)	0.02919**	(0.012)	0.02935**	(0.012)
Double Windows Dummy	0.01524***	(0.005)	0.01466***	(0.005)	0.01549***	(0.005)	0.01605***	(0.005)
Air Conditioning Dummy	0.14390***	(0.006)	0.14379***	(0.006)	0.14108***	(0.006)	0.13755***	(0.006)
Elevator Dummy	0.01726***	(0.005)	0.01756***	(0.005)	0.01652***	(0.005)	0.01368**	(0.005)
Accessibility								
log(Dist. to Baixa)	-0.12852***	(0.012)	-0.13222***	(0.013)	-0.12749***	(0.014)	-0.12580***	(0.020)
log(Dist. to Expo)	-0.09321***	(0.013)	-0.08608***	(0.014)	-0.09443***	(0.014)	-0.07831***	(0.021)
log(Dist. to Airport)	0.03682***	(0.013)	0.03462**	(0.013)	0.03510**	(0.015)	0.0211	(0.021)
log(Dist. to Nearest Cultural Amenity)	0.02400***	(0.004)	0.02478***	(0.004)	0.02397***	(0.005)	0.02321***	(0.007)
log(Dist. to Nearest Arts Amenity)	-0.01546***	(0.004)	-0.01486***	(0.004)	-0.01479***	(0.005)	-0.01353*	(0.007)
log(Dist. to Nearest Public Parking)	-0.03439***	(0.003)	-0.03429***	(0.003)	-0.03440***	(0.003)	-0.03573***	(0.005)
log(Dist. to Nearest Train Station)	0.01697***	(0.003)	0.01484***	(0.004)	0.01726***	(0.004)	0.01543**	(0.006)
Count of Metro Stations 100 m	0.01617*	(0.009)	0.0141	(0.009)	0.01531	(0.009)	0.01095	(0.010)
log(Dist. to 25th April Bridge)	-0.14485***	(0.011)	-0.14463***	(0.012)	-0.14701***	(0.013)	-0.14921***	(0.019)
log(Dist. to Nearest Fitness Amenity)	0.02004***	(0.007)	0.02159***	(0.007)	0.01907**	(0.007)	0.01827*	(0.010)

log(Dist. to Nearest School)	0.00864*	(0.004)	0.00999**	(0.004)	0.00865*	(0.004)	0.00806	(0.006)
log(Dist. to Nearest University)	-0.00208	(0.005)	0.00299	(0.005)	-0.00236	(0.005)	0.00115	(0.008)
log(Dist. to Nearest Health Amenity)	0.02948***	(0.004)	0.02979***	(0.004)	0.02967***	(0.004)	0.02791***	(0.006)
log(Dist. to Nearest Hospital)	0.00696**	(0.003)	0.00630*	(0.003)	0.00644*	(0.003)	0.0047	(0.005)
log(Dist. to Nearest Shopping Center)	-0.00884*	(0.004)	-0.00726	(0.004)	-0.00977*	(0.005)	-0.01139	(0.007)
log(Dist. to Nearest Security Amenity)	-0.00544	(0.005)	-0.00467	(0.005)	-0.0044	(0.006)	-0.00002	(0.008)
log(Dist. to Nearest Fire station)	-0.00014	(0.006)	0.00086	(0.006)	-0.00014	(0.006)	-0.00169	(0.009)
log(Dist. to Nearest Cemetery)	0.05799***	(0.004)	0.05888***	(0.004)	0.05801***	(0.005)	0.05829***	(0.007)
log(Dist. to Freeway)	0.17527*	(0.097)	0.17888*	(0.100)	0.16025	(0.107)	0.15077	(0.151)
log(Dist. to Stadium)	0.26739***	(0.048)	0.28308***	(0.049)	0.26147***	(0.053)	0.27973***	(0.078)
log(Dist. to Stadium)*log(Dist. to Freeway)	-0.04426***	(0.007)	-0.04662***	(0.007)	-0.04328***	(0.007)	-0.04547***	(0.011)
Environmental Amenities								
log(Dist. to Nearest Open Space)	-0.22159***	(0.061)	-0.24350***	(0.063)	-0.22154***	(0.067)	-0.28329***	(0.092)
Count of Open Spaces 50 m	0.03497***	(0.012)	0.02057	(0.014)	0.03163**	(0.013)	0.0141	(0.015)
Count of Open Spaces 200 m	-0.02323***	(0.004)	-0.02282***	(0.005)	-0.02212***	(0.004)	-0.01719***	(0.005)
Count of Open Spaces 500 m	0.00663***	(0.001)	0.00784***	(0.001)	0.00639***	(0.001)	0.00535***	(0.001)
Count of Open Spaces 1000 m	0.00180***	(0.000)	0.00182***	(0.000)	0.00181***	(0.004)	0.00177***	(0.004)
log(PM10 Particulates)	-0.60572***	(0.171)	-0.66647***	(0.173)	-0.62153***	(0.187)	-0.77595***	(0.248)
log(PM10 Particulates)*log(Dist. to Nearest Open Space)	0.05959***	(0.016)	0.06491***	(0.017)	0.05951***	(0.018)	0.07520***	(0.025)
log(PM10 Particulates)*log(Dist. to Freeway)	0.05160***	(0.019)	0.05610***	(0.020)	0.05382**	(0.021)	0.06139**	(0.029)
Architectural Ambiance								
log(% Buildings built pre 1919)	0.00384***	(0.00056	0.00389***	(0.0005)	0.00384***	(0.0006)	0.00352***	(0.0007)
log(% Buildings built 1919 to 1945)	-0.00193***	(0.00056	-0.00194***	(0.0005)	-0.00202***	(0.0006)	-0.00233***	(0.0008)
log(% Buildings built 1946 to 1960)	0.00213***	(0.00053	0.00207***	(0.0005)	0.00215***	(0.0005)	0.00233***	(0.0007)
log(% Buildings built 1961 to 1970)	0.00156***	(0.00051	0.00141***	(0.0005)	0.00139**	(0.0005)	0.00042	(0.0007)
log(% Buildings built 1981 to 1990)	0.00145***	(0.00055	0.00153***	(0.0005)	0.00155***	(0.0006)	0.00173**	(0.0007)
log(% Buildings built 1991 to 1995)	-0.00014	(0.00061	-0.00006	(0.0006)	-0.00006	(0.0006)	0.00018	(0.0008)
log(% Buildings built 1996 to 2000)	0.00073	(0.00068	0.00058	(0.0006)	0.00068	(0.0007)	0.00066	(0.0009)
log(% Non-Residential Buildings)	0.00228***	(0.00055	0.00211***	(0.0005)	0.00235***	(0.0006)	0.00241***	(0.0007)
log(% Vacant Buildings)	-0.00092	(0.00067	-0.00098	(0.0006)	-0.00097	(0.0007)	-0.00127	(0.0009)
Count of Dilapidated Buildings 1000 m	-0.00076***	(0.00009	-0.00080***	(0.0000)	-0.00076***	(0.0001)	-0.00082***	(0.0001)
log(Average Freguesia Income)	0.17222***	(0.0134)	0.16949***	(0.0140)	0.16883***	(0.0145)	0.14302***	(0.0193)
log(Population Density)	-0.01099***	(0.00332	-0.01177***	(0.0033)	-0.00968***	(0.0036)	-0.00633	(0.0046)
log(% Population w. Superior Education)	0.00191*	(0.00112	0.00220*	(0.0011)	0.0018	(0.0012)	0.00163	(0.0015)
log(% Population under 19)	0.00374**	(0.00146	0.00367**	(0.0014)	0.00340**	(0.0015)	0.00232	(0.0019)
log(% Population over 65)	-0.0038	(0.00246	-0.00413*	(0.0024)	-0.00365	(0.0026)	-0.00245	(0.0033)
Natural Hazard Risk								
High Flood Risk Dummy	-0.05111***	(0.00961	-0.04948***	(0.0098)	-0.05044***	(0.0105)	-0.04298***	(0.0140)
High Seismic Risk Dummy	-0.00837	(0.00728	-0.00803	(0.0073)	-0.00898	(0.0080)	-0.01141	(0.0110)
Views								
log(Dist. to Viewpoint)	0.05990***	(0.02201	0.06036***	(0.0224)	0.06203**	(0.0243)	0.07534**	(0.0342)
log(Elevation)	0.07327**	(0.03315	0.07103**	(0.0339)	0.07645**	(0.0365)	0.09261*	(0.0512)
log(Dist. to Viewpoint)*log(Elevation)	-0.01153**	(0.0055)	-0.01120**	(0.0056)	-0.01210**	(0.0060)	-0.01518*	(0.0085)
Historic amenities								
Protected Zone Dummy	-0.01637*	0.0089)	-0.03114	(0.0231)	-0.01501	(0.0098)	-0.04873	(0.0336)
Protected Zone Dummy*No. of Dilapidated Buildings 1000 m			0.00026*	(0.0001)			0.00035*	(0.0001)

Protected Zone Dummy*No. of Open Spaces 50 m			0.08838**	(0.0361)			0.05343	(0.0413)
Historic Amenity Concentration								
Structural								
log(Area)	0.78416***	(0.008)			0.78202***	(0.0081)		
New Dummy	0.15385***	(0.005)			0.15366***	(0.0056)		
View of Tagus Dummy	0.06065***	(0.008)			0.06055***	(0.0085)		
Pool Dummy	0.12248***	(0.023)			0.12209***	(0.0235)		
Parking Dummy	0.07008***	(0.007)			0.06983***	(0.0073)		
Fireplace Dummy	0.02755**	(0.013)			0.02768**	(0.0129)		
Double Windows Dummy	0.01590***	(0.005)			0.01601***	(0.0055)		
Air Conditioning Dummy	0.14240***	(0.006)			0.13986***	(0.0066)		
Elevator Dummy	0.01577***	(0.005)			0.01535***	(0.0055)		
Accessibility								
log(Dist. to Baixa)	-0.12297***	(0.013)			-0.12243***	(0.0144)		
log(Dist. to Expo)	-0.12135***	(0.014)			-0.12009***	(0.0154)		
log(Dist. to Airport)	0.07273***	(0.014)			0.06885***	(0.0154)		
log(Dist. to Nearest Cultural Amenity)	0.02426***	(0.004)			0.02432***	(0.0050)		
log(Dist. to Nearest Arts Amenity)	-0.01323***	(0.004)			-0.01225**	(0.0050)		
log(Dist. to Nearest Public Parking)	-0.03329***	(0.003)			-0.03329***	(0.0037)		
log(Dist. to Nearest Train Station)	0.01973***	(0.003)			0.01967***	(0.0043)		
Count of Metro Stations 100 m	0.01207	(0.010)			0.01153	(0.0106)		
log(Dist. to 25th April Bridge)	-0.12697***	(0.012)			-0.12899***	(0.0135)		
log(Dist. to Nearest Fitness Amenity)	0.02412***	(0.007)			0.02247***	(0.0079)		
log(Dist. to Nearest School)	0.00596	(0.004)			0.00619	(0.0051)		
log(Dist. to Nearest University)	-0.00046	(0.005)			-0.00104	(0.0057)		
log(Dist. to Nearest Health Amenity)	0.02913***	(0.004)			0.02933***	(0.0046)		
log(Dist. to Nearest Hospital)	0.00919**	(0.003)			0.00812**	(0.0039)		
log(Dist. to Nearest Shopping Center)	-0.01384***	(0.004)			-0.01442***	(0.0053)		
log(Dist. to Nearest Security Amenity)	-0.01442**	(0.005)			-0.01307**	(0.0064)		
log(Dist. to Nearest Fire station)	0.00072	(0.006)			0.00105	(0.0068)		
log(Dist. to Nearest Cemetery)	0.05979***	(0.005)			0.05950***	(0.0054)		
log(Dist. to Freeway)	0.21717**	(0.101)			0.20729*	(0.1102)		
log(Dist. to Stadium)	0.28619***	(0.051)			0.28356***	(0.0563)		
log(Dist. to Stadium)*log(Dist. to Freeway)	-0.04724***	(0.007)			-0.04675***	(0.0084)		
Environmental Amenities								
log(Dist. to Nearest Open Space)	-0.15821**	(0.063)			-0.16812**	(0.0673)		
Count of Open Spaces 50 m	0.03043**	(0.014)			0.02826*	(0.0148)		
Count of Open Spaces 200 m	-0.02316***	(0.004)			-0.02179***	(0.0048)		
Count of Open Spaces 500 m	0.00831***	(0.001)			0.00812***	(0.0018)		
Count of Open Spaces 1000 m	0.00169***	(0.0004)			0.00171***	(0.0004)		
log(PM10 Particulates)	-0.45952***	(0.169)			-0.48822***	(0.1833)		
log(PM10 Particulates)*log(Dist. to Nearest Open Space)	0.04062**	(0.017)			0.04337**	(0.0187)		
log(PM10 Particulates)*log(Dist. to Freeway)	0.04527**	(0.019)			0.04719**	(0.0212)		
Architectural Ambiance								
log(% Buildings built pre 1919)	0.00330***	(0.001)			0.00333***	(0.0006)		
log(% Buildings built 1919 to 1945)	-0.00159***	(0.001)			-0.00166***	(0.0006)		

log(% Buildings built 1946 to 1960)	0.00167***	(0.001)	0.00168***	(0.0005)
log(% Buildings built 1961 to 1970)	0.00101*	(0.001)	0.00095*	(0.0005)
log(% Buildings built 1981 to 1990)	0.00160***	(0.001)	0.00167***	(0.0006)
log(% Buildings built 1991 to 1995)	0.00005	(0.001)	0.00012	(0.0006)
log(% Buildings built 1996 to 2000)	0.00014	(0.001)	0.00016	(0.0007)
log(% Non-Residential Buildings)	0.00229***	(0.001)	0.00237***	(0.0006)
log(% Vacant Buildings)	-0.00061	(0.001)	-0.00067	(0.0007)
Count of Dilapidated Buildings 1000 m	-0.00070***	(0.000)	-0.00070***	(0.0001)
log(Average Freguesia Income)	0.18739***	(0.014)	0.18210***	(0.0150)
log(Population Density)	-0.01138***	(0.003)	-0.01002***	(0.0036)
log(% Population w. Superior Education)	0.00086	(0.001)	0.00085	(0.0011)
log(% Population under 19)	0.00499***	(0.001)	0.00441***	(0.0016)
log(% Population over 65)	-0.00497**	(0.002)	-0.00477*	(0.0026)
Natural Hazard Risk				
High Flood Risk Dummy	-0.05434***	(0.009)	-0.05327***	(0.0107)
High Seismic Risk Dummy	0.00764	(0.007)	0.0053	(0.0080)
Views				
log(Dist. to Viewpoint)	0.03256	(0.022)	0.03594	(0.0244)
log(Elevation)	0.027	(0.033)	0.03307	(0.0367)
log(Dist. to Viewpoint)*log(Elevation)	-0.00433	(0.005)	-0.00533	(0.0061)
Historic amenities				
Count of Landmark Church 100m	0.04393	(0.035)	0.04561	(0.0351)
Count of Landmark Church 1000m	-0.03441***	(0.007)	-0.03448***	(0.0074)
Count of Non-Landmark Church 50m	-0.00006	(0.061)	0.0057	(0.0625)
Count of Non-Landmark Church 100m	0.03999**	(0.017)	0.04244**	(0.0180)
Count of Non-Landmark Church 1000m	-0.00110***	(0.0003)	-0.00092**	(0.0003)
Count of Landmark Palace 50m	0.021	(0.041)	0.01606	(0.0408)
Count of Landmark Palace 1000m	-0.00204	(0.005)	-0.00048	(0.0057)
Count of Non-Landmark Palace 50m	0.09237	(0.072)	0.0902	(0.0720)
Count of Non-Landmark Palace 100m	-0.04642	(0.049)	-0.04183	(0.0492)
Count of Non-Landmark Palace 1000m	-0.00162	(0.001)	-0.00178	(0.0011)
Count of Landmark Lithic 50m	-0.08701	(0.063)	-0.08058	(0.0636)
Count of Landmark Lithic 1000m	0.03205***	(0.009)	0.02963***	(0.0096)
Count of Non-Landmark Lithic 50m	0.04198	(0.032)	0.04953	(0.0331)
Count of Non-Landmark Lithic 1000m	0.00623	(0.004)	0.00707*	(0.0041)
Count of Non-Landmark Other 50m	0.05710**	(0.026)	0.05886**	(0.0276)
Count of Non-Landmark Other 100m	-0.04451***	(0.017)	-0.04395**	(0.0176)
Count of Non-Landmark Other 1000m	-0.00087*	(0.0004)	-0.00093*	(0.0004)
Historic Amenity Proximity				
Structural				
log(Area)	0.78391***	(0.008)	0.78173***	(0.0081)
New Dummy	0.15628***	(0.005)	0.15561***	(0.0056)
View of Tagus Dummy	0.06197***	(0.008)	0.06163***	(0.0085)
Pool Dummy	0.12109***	(0.023)	0.12088***	(0.0235)
Parking Dummy	0.07055***	(0.007)	0.07025***	(0.0073)
Fireplace Dummy	0.03045**	(0.013)	0.03001**	(0.0129)
Double Windows Dummy	0.01425**	(0.005)	0.01470***	(0.0055)

Air Conditioning Dummy	0.14336***	(0.006)	0.14100***	(0.0066)
Elevator Dummy	0.01662***	(0.005)	0.01606***	(0.0055)
Accessibility				
log(Dist. to Baixa)	-0.08972***	(0.013)	-0.09032***	(0.0152)
log(Dist. to Expo)	-0.13886***	(0.015)	-0.13774***	(0.0172)
log(Dist. to Airport)	0.06428***	(0.014)	0.06178***	(0.0164)
log(Dist. to Nearest Cultural Amenity)	0.01957***	(0.004)	0.01992***	(0.0051)
log(Dist. to Nearest Arts Amenity)	-0.01231***	(0.004)	-0.01173**	(0.0051)
log(Dist. to Nearest Public Parking)	-0.03449***	(0.003)	-0.03437***	(0.0037)
log(Dist. to Nearest Train Station)	0.01678***	(0.003)	0.01689***	(0.0042)
Count of Metro Stations 100 m	0.01537	(0.009)	0.01449	(0.0097)
log(Dist. to 25th April Bridge)	-0.12350***	(0.012)	-0.12578***	(0.0139)
log(Dist. to Nearest Fitness Amenity)	0.01280*	(0.007)	0.01215	(0.0078)
log(Dist. to Nearest School)	0.00703	(0.004)	0.00711	(0.0051)
log(Dist. to Nearest University)	-0.0014	(0.005)	-0.00175	(0.0056)
log(Dist. to Nearest Health Amenity)	0.03120***	(0.004)	0.03128***	(0.0046)
log(Dist. to Nearest Hospital)	0.00670*	(0.003)	0.00632	(0.0038)
log(Dist. to Nearest Shopping Center)	-0.00449	(0.005)	-0.00557	(0.0054)
log(Dist. to Nearest Security Amenity)	-0.00568	(0.005)	-0.00434	(0.0062)
log(Dist. to Nearest Fire station)	-0.00227	(0.006)	-0.00225	(0.0068)
log(Dist. to Nearest Cemetery)	0.05472***	(0.004)	0.05457***	(0.0052)
log(Dist. to Freeway)	0.07342	(0.100)	0.06409	(0.1089)
log(Dist. to Stadium)	0.19501***	(0.049)	0.19203***	(0.0539)
log(Dist. to Stadium)*log(Dist. to Freeway)	-0.03321***	(0.007)	-0.03271***	(0.0080)
Environmental Amenities				
log(Dist. to Nearest Open Space)	-0.21159***	(0.064)	-0.21200***	(0.0695)
Count of Open Spaces 50 m	0.03147**	(0.012)	0.02911**	(0.0131)
Count of Open Spaces 200 m	-0.02544***	(0.004)	-0.02407***	(0.0046)
Count of Open Spaces 500 m	0.00623***	(0.001)	0.00608***	(0.0017)
Count of Open Spaces 1000 m	0.00183***	(0.000)	0.00184***	(0.0004)
log(PM10 Particulates)	-0.59421***	(0.173)	-0.60905***	(0.1875)
log(PM10 Particulates)*log(Dist. to Nearest Open Space)	0.05780***	(0.017)	0.05784***	(0.0193)
log(PM10 Particulates)*log(Dist. to Freeway)	0.05386***	(0.019)	0.05558***	(0.0212)
Architectural Ambiance and Neighborhood				
log(% Buildings built pre 1919)	0.00358***	(0.001)	0.00360***	(0.0006)
log(% Buildings built 1919 to 1945)	-0.00140**	(0.001)	-0.00150**	(0.0006)
log(% Buildings built 1946 to 1960)	0.00186***	(0.001)	0.00190***	(0.0005)
log(% Buildings built 1961 to 1970)	0.00107**	(0.001)	0.00096*	(0.0005)
log(% Buildings built 1981 to 1990)	0.00056	(0.001)	0.00071	(0.0006)
log(% Buildings built 1991 to 1995)	-0.00023	(0.001)	-0.00013	(0.0006)
log(% Buildings built 1996 to 2000)	0.00157**	(0.001)	0.00147**	(0.0007)
log(% Non-Residential Buildings)	0.00218***	(0.001)	0.00224***	(0.0006)
log(% Vacant Buildings)	-0.00093	(0.001)	-0.001	(0.0007)
Count of Dilapidated Buildings 1000 m	-0.00078***	(0.001)	-0.00078***	(0.0001)
log(Average Freguesia Income)	0.15816***	(0.013)	0.15614***	(0.014)
log(Population Density)	-0.01207***	(0.003)	-0.01080***	(0.003)
log(% Population w. Superior	0.0012	(0.001)	0.00116	(0.001)

Education)				
log(% Population under 19)	0.00394***	(0.001)	0.00361**	(0.001)
log(% Population over 65)	-0.00402	(0.002)	-0.00382	(0.002)
Natural Hazard Risk				
High Flood Risk Dummy	-0.05703***	(0.009)	-0.05619***	(0.010)
High Seismic Risk Dummy	-0.00852	(0.007)	-0.00918	(0.007)
Views				
log(Dist. to Viewpoint)	0.02762	(0.022)	0.03147	(0.024)
log(Elevation)	0.02701	(0.033)	0.03271	(0.036)
log(Dist. to Viewpoint)*log(Elevation)	-0.00396	(0.005)	-0.00493	(0.006)
Historic amenities				
log(Dist. to Nearest Church)	-0.00035	(0.004)	-0.00058	(0.004)
log(Dist. to Nearest Palace)	0.0007	(0.004)	0.00063	(0.005)
log(Dist. to Nearest Lithic)	-0.01026*	(0.006)	-0.01012	(0.006)
log(Dist. to Nearest Other)	-0.03462***	(0.004)	-0.03355***	(0.005)

Notes: ****Significance at 1 p.c. level; **Significance at 5 p.c. level; *Significance at 10 p.c. level.*