Determinants of Housing Prices in Portugal: A Municipal-Level Analysis

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Abstract. This study analyzes the determinants of housing transaction values at the municipal level in Portugal, providing empirical evidence to support decision-making by households, investors, and policymakers. Using cross-sectional data for all 308 Portuguese municipalities in 2017, obtained from the PORDATA database, the analysis estimates a multiple linear regression model with the logarithm of the average value of housing transactions as the dependent variable. Explanatory variables capture geographic location, demographic characteristics, economic capacity, labor market conditions, environmental quality, and housing market structure.

The results indicate that regional location, purchasing power per capita, average family size, homeownership rates, and housing availability are the most significant determinants of municipal housing prices. In contrast, population density and environmental quality do not exhibit statistically significant effects once economic and structural factors are controlled for. Robustness checks using Generalized Least Squares confirm the stability of the main findings.

By focusing on the municipal scale and jointly considering demand-side and supply-side factors, this study contributes to the literature on housing price formation in Portugal and complements existing national and regional analyses. The findings highlight the importance of accounting for regional heterogeneity and housing supply conditions when designing policies aimed at improving housing affordability and market efficiency.

Keywords: Housing Price · Portugal · Multiple Linear regression · Decision making · Housing policy · Data analysis

1 Introduction

Housing markets play a central role in economic stability, household welfare, and social cohesion. The global financial crisis of 2007–2009 highlighted the strong

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2027
O. Gervasi et al. (Eds.): ICCSA 2026 Workshops, LNCS 16760, pp. 87–98, 2027.
https://doi.org/10.1007/978-3-032-30521-3_6

interconnections between housing prices, credit conditions, and macroeconomic performance, reinforcing the relevance of housing markets for both economic policy and financial stability ([7,22]). Since then, housing affordability and price volatility have become persistent concerns in many countries, particularly in urban and coastal regions where demand pressures coexist with constrained supply.

A substantial body of literature has examined the determinants of housing prices, identifying income, credit conditions, demographic factors, and location-specific attributes as key drivers of housing market dynamics. Cross-country evidence shows that housing prices are closely linked to macroeconomic and financial variables, such as income growth, interest rates, and credit availability, while institutional and structural differences explain observed heterogeneity across countries [22]. At the regional and urban level, hedonic pricing models consistently highlight the importance of location, accessibility, and structural dwelling characteristics in explaining spatial price variation ([1], [2]) and [16].

Recent studies further emphasize that supply-side constraints and institutional arrangements play a decisive role in shaping long-term housing price trajectories. Analyses of highly constrained markets, such as Hong Kong, show that persistent limitations on land supply and housing availability can sustain high price levels despite repeated policy interventions [6]. Similar concerns have emerged across European housing markets, where limited supply responsiveness has amplified price pressures and affordability challenges in recent years [10]. These findings suggest that housing price formation reflects a complex interaction between demand-side forces and structural characteristics of housing markets.

In the Portuguese context, existing research has primarily focused on national or regional dynamics over longer time horizons, highlighting the influence of macroeconomic conditions, credit cycles, and demographic trends on housing prices [17,23]. Other studies employing hedonic approaches at a regional or metropolitan scale confirm the relevance of location and local public dynamics in shaping housing values ([13,19]). However, empirical evidence at the municipal level for the entire Portuguese territory remains relatively scarce, particularly studies that jointly consider demographic, economic, social, and housing supply factors within a unified econometric framework.

This paper seeks to address this gap by analyzing the determinants of housing transaction values across all 308 Portuguese municipalities using cross-sectional data for 2017. By combining location indicators, demographic characteristics, economic capacity measures, and housing market structure variables, the study provides a comprehensive assessment of the factors driving municipal-level housing price variation. The empirical analysis employs multiple linear regression techniques and robustness checks to identify the variables most strongly associated with housing transaction values. The results aim to contribute to the literature by offering new evidence on housing price determinants at a fine spatial scale and by informing policymakers and market participants about the structural forces shaping housing market outcomes in Portugal.

Therefore this study examines how municipal-level characteristics influence housing values in Portugal, addressing a gap in the empirical literature on local housing markets. By quantifying the impact of demographic, economic, and housing-related factors on transaction values, the analysis provides evidence relevant for households, investors, and policymakers, supporting more informed decision-making and housing policy design.

The remainder of this paper is organized as follows. Section 2 reviews the main theoretical and empirical contributions in the literature on housing price determinants, with particular emphasis on location, demographic, economic, and housing supply factors. Section 3 presents the econometric framework, describing the Ordinary Least Squares and Generalized Least Squares methodologies adopted in the analysis. Section 4 introduces the data, outlines the model specification, and discusses the empirical results at the municipal level. Finally, Sect. 5 concludes the paper, summarizing the main findings and outlining policy implications and directions for future research.

2 Factors Influencing the Value of Housing

The value of housing is shaped by a complex interaction of geographic, demographic, economic, and social factors. A substantial body of literature has investigated these determinants, commonly employing hedonic pricing models and regression-based approaches to explain spatial and temporal variations in housing prices. However, empirical evidence at the municipal level remains relatively limited, particularly in the Portuguese context, which motivates the present study.

Location is consistently identified as one of the most influential determinants of housing values. Accessibility, proximity to employment centers, public services, and environmental amenities contribute significantly to spatial price differentials [1]. Studies have shown that quality-of-life attributes, including access to green spaces, coastal areas, and urban infrastructure, are capitalized into housing prices, reflecting households' willingness to pay for favorable living conditions [5]. Empirical analyses conducted in metropolitan regions such as Istanbul, Ankara, and several Spanish provinces further confirm the dominant role of location in explaining housing price variation [2,18]. These findings justify the inclusion of territorial classifications, such as NUTS levels, as key explanatory variables.

Demographic pressure, commonly proxied by population density, has also been associated with housing market dynamics. Zhou et al. [24] documented a positive relationship between population density and housing prices across Chinese cities, suggesting that denser urban environments tend to exhibit higher demand and increased productivity. Similarly, Rappaport [20] found that higher density areas in the United States experience rising land and housing prices, reflecting the capitalization of urban amenities into property values. These results support the hypothesis that population concentration influences housing demand and price formation.

Economic conditions represent another central dimension in housing valuation. Income and purchasing power are repeatedly shown to be strong predictors

of housing prices, as they directly affect households' ability to acquire property. McGreal and Taltavull de La Paz [18] emphasized the relevance of income and accessibility factors in determining housing prices across European regions. In addition, Fuller et al. [11] highlighted the long-term implications of housing price dynamics for wealth accumulation and intergenerational equity. Accordingly, per capita purchasing power is included in the model as a fundamental economic determinant.

Household composition and labor market conditions further contribute to housing market behavior. Family size influences the demand for housing types and dwelling sizes, with larger households typically requiring more spacious accommodations. Empirical evidence from urban housing markets, such as the Chicago metropolitan area, confirms the importance of family size in explaining housing prices [3]. Unemployment rates, on the other hand, reflect local economic vulnerability and income uncertainty. Johnes and Hyclak [14] demonstrated that labor market conditions, including unemployment, are closely linked to housing prices through their impact on purchasing capacity and residential stability.

Social and demographic characteristics, including population aging and educational attainment, also play a role in shaping housing demand. Aging populations may alter housing preferences and slow market dynamics, while higher education levels are often associated with higher incomes, greater residential mobility, and increased housing demand [4,8]. These relationships motivate the inclusion of aging and education indicators as explanatory variables.

Finally, housing market structure itself influences price behavior. Homeownership rates may signal market maturity or saturation, while housing availability affects supply-side pressures. Studies on housing supply constraints indicate that limited availability can significantly increase prices, particularly in regulated or densely populated regions [15]. Consequently, indicators capturing owner-occupied housing and dwelling availability are incorporated to account for structural market effects.

Overall, the literature supports a multifactorial approach to housing price modeling, where location, demographic pressure, economic capacity, household structure, and housing supply jointly influence transaction values. Building on these insights, the present study empirically examines whether these determinants exhibit similar effects at the municipal level in Portugal.

3 Model Theoretical Framework

This section presents the econometric framework adopted to analyze the determinants of housing prices in Portuguese municipalities. The methodological approach is based on linear regression techniques, starting with Ordinary Least Squares (OLS) estimation and extending to Generalized Least Squares (GLS) to address potential violations of classical assumptions.

3.1 Ordinary Least Squares Estimation

Ordinary Least Squares (OLS) is a standard estimation technique for multiple linear regression models and serves as a natural starting point for empirical housing market analysis. The method estimates the parameters of a linear relationship between a dependent variable and a set of explanatory variables by minimizing the sum of squared residuals.

Model Specification. The general multiple linear regression model is defined as

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon},$$

where $\mathbf{Y}$ is an $n \times 1$ vector of observations of the dependent variable, $\mathbf{X}$ is an $n \times k$ matrix of explanatory variables, $\boldsymbol{\beta}$ is a $k \times 1$ vector of unknown parameters, and $\boldsymbol{\varepsilon}$ is an $n \times 1$ vector of error terms.

In this study, the dependent variable corresponds to the logarithm of the average value of housing transactions (VMPT), while the explanatory variables represent location, demographic, economic, and housing market characteristics at the municipal level.

Estimation and Properties. The OLS estimator of the parameter vector $\boldsymbol{\beta}$ is given by

$$\hat{\boldsymbol{\beta}} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Y}.$$

Under the Gauss–Markov assumptions, this estimator is the Best Linear Unbiased Estimator (BLUE). These assumptions include linearity of the model, absence of perfect multicollinearity among regressors, zero conditional mean of the error term, homoscedasticity, and absence of serial correlation.

Model adequacy is commonly assessed using the coefficient of determination R^2 and its adjusted version, which accounts for the number of explanatory variables. In addition, the overall statistical significance of the model is evaluated using the F-test.

Assumptions Verification. The validity of OLS inference relies on the verification of its underlying assumptions. Residual diagnostics are therefore conducted to assess normality, homoscedasticity, and serial independence. Multicollinearity among regressors is examined using correlation analysis and variance inflation factors, allowing the identification and exclusion of redundant explanatory variables when necessary.

Interpretation of Coefficients. The estimated regression coefficients represent the expected average change in the dependent variable associated with a one-unit change in the corresponding explanatory variable, holding all other variables constant. Given the logarithmic transformation of the dependent variable, the coefficients can be interpreted as semi-elasticities, facilitating economic interpretation in terms of percentage changes in housing values.

3.2 Generalized Least Squares Estimation

Although OLS provides consistent and unbiased estimates under ideal conditions, empirical housing data often exhibit heteroscedasticity and autocorrelation, particularly in cross-sectional datasets with spatial or regional structure. When such violations are detected, OLS estimators remain unbiased but lose efficiency, and standard errors may be inconsistent.

To address these issues, the analysis is extended to a Generalized Least Squares (GLS) framework. GLS relaxes the assumption of spherical error terms by allowing for a non-diagonal variance–covariance matrix of the disturbances. The GLS estimator is defined as

$$\hat{\boldsymbol{\beta}}_{\mathrm{GLS}} = (\mathbf{X}'\boldsymbol{\Omega}^{-1}\mathbf{X})^{-1}\mathbf{X}'\boldsymbol{\Omega}^{-1}\mathbf{Y},$$

where $\boldsymbol{\Omega}$ denotes the variance–covariance matrix of the error term.

By explicitly modeling the structure of the error variance, GLS yields more efficient parameter estimates and reliable inference when heteroscedasticity or autocorrelation is present. In this study, GLS is employed as a robustness check to confirm the consistency of the estimated effects obtained under OLS.

4 Data and Results

4.1 Data Description

This study is based on cross-sectional data for the year 2017, covering all 308 Portuguese municipalities, including mainland Portugal and the Autonomous Regions of the Azores and Madeira. Demographic indicators reported by the National Statistics Institute (INE) highlight a declining population trend since 2010 and a progressive aging process, reflected in an increase in the median age from 42.7 to 44.2 years between 2012 and 2017.

The empirical analysis uses data obtained from the PORDATA database, which provides harmonized municipal-level information on demographic, economic, and housing-related variables. The spatial distribution of municipalities across NUTS I and NUTS II regions is presented in Table 1. Location variables were coded as ordinal indicators to capture regional heterogeneity within the regression framework.

Housing value is measured by the Average Value of Property Transactions (VMPT). Explanatory variables include population density, purchasing power per capita, average family size, unemployment rate, environmental quality, aging index, education level, marital status, homeownership rate, and housing availability. With the exception of the location variables, all regressors are continuous. A detailed description of the variables and their measurement units is provided in Table 2.

Table 1. Distribution of Municipalities by NUTS I and NUTS II

NUTS Level	Classification	Frequency	Percentage	NUTS Level	Classification	Frequency	Percentage
I	Continente	278	90.3	II	Alentejo	58	18.8
				II	Algarve	16	5.2
				II	Lisboa	18	5.8
				II	Centro	100	32.5
				II	Norte	86	27.9
I	Madeira	11	3.6	II	Madeira	11	3.6
I	Açores	19	6.2	II	Açores	19	6.2

Table 2. Determinants of Housing Market and Their Measurements

Determinant	Description	Unit of Measurement
Housing Value/Price	Average Value of Transacted Buildings	VMPT (€)
Location	NUTS I, II, and III	NA
Population Density	Population Density	DP (People/Km^2)
Purchasing Power	Per Capita Purchasing Power	PCPC (€/person)
Family Size	Average Size of Families	DMF (People)
Unemployment	Percentage of Unemployed Registered at IEFP	DIEFP (%)
Environmental Quality	Environmental Quality Index	IQA (€/inhabitant)
Aging	Aging Index	IE (elderly per 100 young people)
Education Level	Percentage of People with Higher Education	PES (%)
Marital Status	Percentage of Married Individuals	PCAS (%)
Home Ownership	Percentage of Owner-Occupied Dwellings	PFHP (%)
Existing Dwellings	Proportion of Dwellings per Inhabitant	PFH (dwellings/inhabitant)

4.2 Model Specification and Estimation

To analyze the determinants of housing prices, a multiple linear regression model was estimated with the natural logarithm of VMPT as the dependent variable. The logarithmic transformation allows the estimated coefficients to be interpreted as semi-elasticities, facilitating economic interpretation in percentage terms.

$$\begin{aligned}\ln(\mathrm{VMPT}_i) = {} & \beta_0 + \beta_1 \mathrm{NUTSII}_i + \beta_2 \mathrm{DP}_i + \beta_3 \mathrm{PCPC}_i \\ & + \beta_4 \mathrm{DMF}_i + \beta_5 \mathrm{DIEFP}_i + \beta_6 \mathrm{IQA}_i \\ & + \beta_7 \mathrm{IE}_i + \beta_8 \mathrm{PCAS}_i + \beta_9 \mathrm{PFHP}_i \\ & + \beta_{10} \mathrm{PFH}_i + \varepsilon_i.\end{aligned} \tag{1}$$

Multicollinearity diagnostics revealed strong correlations between certain explanatory variables. In particular, education level (PES) exhibited a high correlation with purchasing power per capita (PCPC) and was therefore excluded from the final specification.

The refined model was estimated using Ordinary Least Squares (OLS). The adjusted R^2 of 0.7121 indicates that approximately 71.2% of the variation in municipal housing transaction values is explained by the included regressors. The overall model was statistically significant at conventional levels.

Diagnostic tests were conducted to assess the validity of the OLS assumptions. The Breusch–Pagan test provided no evidence of heteroscedasticity, while the Shapiro–Wilk test indicated deviations from normality. Given the large sample size, inference based on asymptotic normality remains appropriate. Evidence of autocorrelation motivated the estimation of a Generalized Least Squares (GLS) model as a robustness check.

4.3 Regression Results and Interpretation

The estimated GLS coefficients are reported in Table 3. The results indicate that location, economic capacity, household composition, and housing market structure play a significant role in explaining municipal housing prices in Portugal.

Table 3. GLS Estimation Model Coefficients

Coefficient	Estimate	Std. Error	t value	Pr(> |t|)
(Intercept)	10.74110	0.894	15.149	$< 0.0001^{***}$
NUTSII	-0.12690	0.220	-9.670	$< 0.0001^{***}$
DP	0.00003	0.045	0.572	0.5674
PCPC	0.00454	0.242	4.070	$< 0.0001^{***}$
DMF	0.33442	0.217	4.616	$< 0.0001^{***}$
DIEFP	-0.01575	0.113	-1.655	$0.0989^{\cdot}$
IQA	0.35309	0.658	-1.111	0.2686
IE	-0.00021	0.503	-1.803	$0.0724^{\cdot}$
PCAS	0.41720	1.150	-4.746	$< 0.0001^{***}$
PFHP	-1.56822	0.562	-5.825	$< 0.0001^{***}$
PFH	62.04535	40.900	2.167	0.031^{*}

Notes: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.
Residual standard error: 0.3442.
Degrees of freedom: 308 total; 297 residual.

The strong and statistically significant effect of the NUTS II location variable confirms the central role of regional heterogeneity in housing price formation. This result is consistent with earlier hedonic and regional housing studies, which emphasize the persistence of spatial price differentials driven by accessibility, economic concentration, and coastal proximity [1,18]. In the Portuguese context, similar evidence has been reported by Lourenço and Rodrigues [17], who document pronounced regional disparities in housing prices following the financial crisis, particularly between coastal/metropolitan areas and inland municipalities.

Average family size (DMF) also exhibits a positive and statistically significant effect on housing transaction values. This result supports the hypothesis that household composition influences housing demand, particularly with respect to

dwelling size and quality. Similar conclusions were reached by Archer et al. [3], who identified family size as a dominant determinant of housing prices in urban markets, reflecting increased demand for larger or more suitable housing units.

The positive and significant coefficient associated with purchasing power per capita (PCPC) aligns with a broad strand of literature identifying income and economic capacity as key drivers of housing demand. Empirical studies across European regions consistently show that higher income levels translate into higher willingness and ability to pay for housing, thereby exerting upward pressure on prices [12,18]. This finding corroborates evidence from the Portuguese housing market, where income growth and improved credit conditions have been closely associated with housing price appreciation in recent years [17].

Several variables traditionally highlighted in the literature, such as population density, unemployment rate, environmental quality, and demographic aging, were not statistically significant in the final specification. This does not necessarily imply that these factors are irrelevant, but rather suggests that, at the municipal level, their effects may be indirect or captured by stronger covariates such as purchasing power and regional location. Similar attenuation effects have been documented in regional housing models where income and supply-related variables dominate once included jointly [14,17].

Finally, the significant effects associated with homeownership rates (PFHP) and housing availability (PFH) highlight the importance of housing market structure. A higher prevalence of owner-occupied dwellings may signal market maturity or reduced transaction activity, while greater housing availability appears to alleviate supply constraints. These findings are consistent with studies emphasizing the role of supply-side factors and regulatory constraints in shaping housing price dynamics [9,15].

5 Conclusions

This paper examined municipal-level determinants of housing transaction values in Portugal using cross-sectional data for 2017. The principal empirical findings indicate that regional location (NUTS II), purchasing power per capita (PCPC), average family size (DMF), and structural housing variables (homeownership rate—PFHP—and dwellings per inhabitant—PFH) are the covariates most consistently associated with municipal VMPT. These relationships remain robust when estimated under GLS as a robustness check for heteroscedasticity and autocorrelation.

When compared with recent national and European analyses, our results align with several documented patterns. First, the dominant role of regional location and a clear coastal/metro premium in housing values is consistent with recent Portuguese analyses that emphasise strong spatial heterogeneity and supply constraints in high-demand areas [17,21]. Second, the positive and significant effect of purchasing power per capita is in line with cross-country evidence showing that income and debt capacity are primary drivers of housing demand and affordability pressures [10,12]. Third, the evidence that structural supply factors

matter (PFH and PFHP) coheres with Eurostat and Commission findings which highlight that limited supply responsiveness in many EU regions has amplified price pressures in recent years [9,10].

Some variables included in the specification—notably population density (DP) and the environmental quality index (IQA)—were not statistically significant in the final model. This suggests that, at the municipal aggregation used here, macroeconomic and structural variables (income, location, housing stock) tend to dominate price formation, while certain local attributes may operate through indirect channels or be collinear with stronger proxies. This pattern is also observed in other empirical exercises that find the relative importance of local amenities declines when stronger income and supply variables are controlled for [17].

This study contributes to the literature by providing a comprehensive municipal-level analysis for the entire Portuguese territory, combining demographic, economic, social, and housing supply variables within a unified econometric framework.

Policy implications stemming from these findings are threefold: (i) Demand-side measures only (for example, tax incentives to buy) are likely to exacerbate price pressures where supply is inelastic; targeted supply-side interventions (increasing permitted supply, accelerating permitting, subsidising affordable construction) are therefore essential [10,21]. (ii) Policies that raise local purchasing power without accompanying supply measures can have unintended distributional effects on affordability; coordinated measures balancing supply, demand and access to credit are preferable [9,12]. (iii) Regional heterogeneity matters: national policy should be combined with regionally-tailored instruments to account for the marked differences between metropolitan/coastal and inland municipalities [17].

This study is based on cross-sectional data for 2017, its main limitation; panel and spatial models would allow direct estimation of temporal dynamics, spatial spillovers and price momentum, which recent work suggests are important in Portugal's coastal and metropolitan markets [21]. Further research should also explore microdata (parish or transaction-level) and causal identification strategies (instrumental variables, difference-in-differences, or synthetic control designs) to strengthen causal claims about supply interventions and policy measures.

The concluding remark of the work is that the municipal evidence for Portugal shows that geography (NUTS II), purchasing power, and housing market structure are the main vectors of variation in transaction values. These results are broadly consistent with contemporaneous national and European analyses and underline the need for supply-focused and regionally-differentiated policy responses to restore housing affordability.

Acknowledgments. This work has been supported by national funds through FCT - Fundação para a Ciência e Tecnologia through project UIDB/04728/2020.

Disclosure of Interests. The authors declare that they have no competing interests that are relevant to the content of this article.

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