Can more housing supply improve affordability? A sub-national perspective from Portugal

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Abstract

We investigate the impact of housing supply on affordability in rapidly appreciating sub-national markets in Portugal. Our spatial econometric model confirms a negative relation between housing stock and prices, yet predicts that, on average, maintaining the construction pace of the 2000s would lower prices by only 3%, while doubling it would bring a 6% reduction. We also find significant price impacts from short-term rentals and international demand. Simulations indicate that a policy mix combining moderate supply growth with sensible limitations in those domains could more effectively alleviate affordability pressures in high-demand regions, bringing spatial nuance to the "supply skepticism" debate.

Keywords: R21, R23, R31, R38

JEL classifications: housing affordability, supply skepticism, short-term rentals, tourism, spatial spillovers

1. Introduction

Housing prices have been rising steadily across developed countries since the Great Recession (OECD, 2023). In many places, these increases have largely outpaced income growth, exacerbating what is now widely recognized as an affordability crisis. Yet, while policy and scholarly interest in housing issues have increased substantially, there is still no consensus on the drivers of the crisis or on how to address it (e.g., Rodríguez-Pose & Storper, 2020; The Economist, 2024). In particular, the debate on how to deal with the housing affordability crisis has been spatially blind and polarized between supply advocates and supply sceptics (see, e.g., Been et al., 2019; 2025; Burn-Murdock, 2023), leading to diverse types of policy prescriptions, ranging from market-led supply expansion to more restrictive measures aimed at controlling demand.

In fact, gaps remain in understanding the impact of housing supply on prices. The existing economic literature often lacks an integrative approach that considers the interplay of various market factors. In particular, it tends to neglect the broader regional economic context in which housing markets operate (Rodríguez-Pose & Storper, 2020; 2022). This is problematic as, in many urban and regional economies, for instance, factors like intensifying tourism, international mobility and foreign investment flows are challenging – if not breaking – the link between housing supply, price and affordability (e.g., Mikulić et al, 2021; Cocola-Gant & Gago, 2021; Zhang, 2023). However, these claims neglect other important price determinants too and are not always systematically assessed. Overall, the jury is still out on the extent to which expanding housing supply can improve affordability, particularly in regions facing significant tourism demand and attractiveness to foreign investment flows.

In this study, to contribute to this debate, we model and provide robust empirical evidence on the link between housing supply and prices in Portugal. As of 2023, nominal house prices have surged by 108% since 2015, one of the largest and fastest increases among developed economies, leading to a persistent deterioration of housing affordability indicators (Rodrigues et al., 2023; Appendix A). Different studies have highlighted distinct drivers behind this phenomenon: both demand increases, for example, linked to income, tourism, and international demand (e.g., Peralta et al., 2020; Franco & Santos, 2021; Santos & Strohmaier, 2024), and supply constraints – notably, a slowdown in new housing development (Rodrigues et al., 2023; Appendix A). This combination of competing explanations, as well as the marked concentration of economic activity, tourism and international investment flows in a small number of coastal and metropolitan areas (e.g., Sgambati & Carvalho, 2024), makes Portugal and its different urban and regional contexts a relevant setting for better understanding contemporary motors of housing prices and to discuss the likely effectiveness of supply side policies in similar types of geographies. As such, connecting regional studies and real estate research (Derudder & Bailey, 2021) we seek to geographically broaden the supply advocacy versus supply skepticism debate, which has so far been substantially confined to the North American and Anglo-Saxon contexts and tends to overlook the sub-national environments in which housing markets unfold (Rodríguez-Pose & Storper, 2020; Been et al., 2025). This aligns with a renewed interest in regional studies on the effects of short-term rentals (Zou et al, 2025), international mobility (Sciuva, 2025) and demand shocks on metropolitan and regional housing markets (Yanotti et al., 2025).

To do so, we integrate different explanatory dimensions in a spatial econometric model accounting for spillovers between nearby areas, estimated at fine-grained municipal level, thus allowing for spatially nuanced analyses across sub-national scales. Overall, in line with supply advocates, we find that prices are negatively associated with housing supply increases in Portugal. However, the effect was modest. Country-level simulations, which we also decompose at the regional and municipal level, reveal that had housing construction kept the pace of the 2000s, prices would only be 3% lower; had it doubled the pace, just 6% lower. Simultaneously, the price impact of the boom in short-term tourism rental accommodation and international demand is substantial and regionally salient. The estimates suggest that constraining short-term tourism rental properties to levels before the 'Airbnb' boom would result in housing prices being on average 14% lower, with substantially stronger effects in major cities and touristic regions, resonating with the intuition of supply sceptics.

The remainder of this paper is organized as follows. Section 2 briefly reviews the arguments presented by the sceptics of market-led housing expansion and empirical evidence that addresses these concerns. Sections 3 and 4 detail the modelling framework and data used in the analysis, respectively. Section 5 presents the results and runs simulations under different scenarios for cities and regions facing the highest price and affordability pressures. Section 6 concludes and presents policy implications.

2. Literature review

2.1 Housing supply and affordability

The debate over increasing housing supply to improve affordability has gained significant attention recently (e.g., Nall et al., 2022; Been et al., 2019; 2024). One argument often posed by supply sceptics is that new housing projects, typically of higher quality, may not cater to lower-income individuals. While standard economic analyses have long suggested that newly built properties depreciate over time, becoming more affordable and filtering down to lower segments (Sweeney, 1974), critics contend that housing market segments are not well connected (Aguirre et al., 2016), especially in countries where the supply sector largely focuses on high-end stock for wealthier buyers and investment funds (e.g., Cordeiro Santos, 2024; Dewilde, 2018). This implies that filtering may take considerable time, and many high-end homes may never filter down (e.g., Rodríguez-Pose & Storper, 2022).

Recent evidence using detailed data on chains of housing moves does provide some support for filtering. In the United States of America, Mast (2023) estimates that a new market-rate development for 100 households in a city centre would free up 45 to 70 homes in low-income areas within three years. In Finland, Bratu et al. (2023) found similar effects within one to two years. In Germany, Mense (2023) found that increasing new supply by 1% can decrease average rents by 0.2% through a disproportionate increase in second-hand units offered for rent. While these studies show that filtering can operate, they highlight that it may be insufficient to alleviate affordability concerns, especially in places with wealthier demand pressure (Rosenthal, 2014).

Another concern is that new housing developments might increase nearby home prices by improving the area's attractiveness, counteracting the negative price pressure from increased supply (Been et al., 2019). New developments often come with improved amenities, making the area more desirable and driving up prices, as highlighted in the urban and tourism gentrification literature (Zukin, 2009; Cocola-Gant, 2018). Recent studies found that new housing units cause higher local business turnover, indicating an amenity effect (Pennington, 2021; Li, 2022). However, these studies also conclude that the supply effect dominates, resulting in a net decrease in residential property prices (Asquith et al., 2023). This suggests that while localized price increases can occur, the overall city and region-wide impact on housing affordability is likely to remain positive (Glesson, 2023)

Supply skeptics also argue that increasing housing supply in desirable areas could induce additional local demand, limiting price impacts. This idea, grounded in the New Economic Geography framework (Krugman, 1991), suggests that more housing in attractive "core" metropolitan regions draws more people and jobs, potentially negating affordability benefits. Yet, empirical analyses of this effect are fraught with challenges and come with mixed results: some studies show significant induced demand, while others find it minor compared to the supply effect (Fingleton, 2008; Szumillo et al., 2017; Fingleton et al., 2019; Been et al., 2024).

2.2 Empirical strategies

Quantifying the effects of supply on prices is challenging due to endogeneity issues. A prevalent strategy in the literature to address this problem uses the strictness of land-use policy as an instrumental variable. The underlying premise is that restrictive regulations can stifle construction activity, leading to fewer homes being built than intended, and therefore elucidate the effects of reduced supply on housing prices. This approach has been useful to refute the supply skeptics' claims, but has also been strongly criticized, notably by economic geographers (Rodríguez-Pose & Storper, 2020; 2022).

Gyourko and Molloy (2015) surveyed this literature and found evidence, primarily from the United States, that areas with stricter regulations experience higher house prices. However, the authors raise doubts over the causality of the observed correlations on some of the studies they collect. Most of these employ a cross-sectional approach across metropolitan regions, under the assumption that regulations are exogenous, randomly distributed across space. They thus ignore the possibility of regulations being correlated with confounding variables which could themselves be driving up prices, such as market dynamics (Wallace, 1998), local political factors (Ortalo-Magné & Prat, 2014), physical constraints and amenities (Saiz, 2010; Moretti, 2013), and the regional distribution of jobs, skills, and wages (Rodríguez-Pose & Storper, 2020). When controlling for local characteristics, as Glaeser and Ward (2009) do through panel data estimations with fixed effects, no significant correlation is found between regulation and prices.

Accetturo et al. (2021) take a different approach, using physical constraints as an instrument to predict the price elasticities of housing supply in Italian regions. They found that cities with low elasticities experience higher price increases when faced with positive demand shocks, evidencing a connection between supply and prices. Their methodology does not lead to a precise quantification of this effect, however, and is arguably still not free of confounding variables – the main physical constraint of many cities is their proximity to the sea, which may drive up prices through a demand channel as a valuable amenity, rather than just acting as a constraint on supply.

The limitations of instrumental variable strategies (see also Davidoff, 2016) has led other studies to use more direct modelling approaches, under the assumption that the housing stock is exogenous to current prices. This is so as the construction of new units can take years, with the decision to build often taken only with an expectation of prices at completion; what is endogenous to price, then, is not the stock, but the portion of it which is then placed on the market for sale. While some housing units are sold before their completion, this would be less of a concern in housing markets with faltering supply – as is the case of developed economies, including Portugal – where the number of new units produced each year is relatively small compared to the existing stock. Following this line of reasoning, Anenberg and Kung (2020) used a discrete location choice model in the United States to study the impact of increases in housing stock on rental values, finding a negative but small effect – a 1% increase in housing stock leading to a 0.1% decrease in rent. Freemark (2025), estimated similar elasticities for both prices and rents across counties in the

United States. In contrast to others, these studies suggest that increasing housing supply may not significantly improve affordability.

Moreover, while many studies overlook spatial spillovers (e.g. Gleeson, 2023), ignoring such dynamic linkages between nearby places can distort results, as inhabitants can choose to move residences and commute across spatial units, notably in metropolitan regions. Both in a cross-sectional setting (Wang et al., 2017) or using time-series (Kuethe & Pede, 2011; Cohen et al., 2016), there is evidence that spatial spillovers are a determinant factor, highlighting the importance of accounting for these spatial relationships in regional focused real estate research (e,g., Tsai, 2015; Funderburg, 2019; Zhang, 2019) – namely, the smaller and the closer to one another the units of analysis are (Osland, 2010). Given the relatively small size of Portugal and its unbalanced geographical concentration of economic activity in just two metropolitan regions, incorporating spatial spillovers is deemed essential for accurate modelling and quantification of the link between housing supply and prices across geographical units.

3. Model

The modelling framework used here is based on hedonic price models (Rosen, 1974) and is applied to describe location choice, inspired by Fingleton (2008), Osland (2010), and Baltagi et al. (2014). It has two key features for analysing supply impact on prices. First, housing supply is modelled as exogenous to market conditions, allowing estimation of price elasticity to the number of dwellings and simulation of exogenous changes. Second, it considers spatial correlation and price spillovers, with local housing prices influenced by nearby municipalities' prices, meaning higher surrounding prices can lead a municipality to absorb demand from neighbours.

N locations are indexed by $i = 1, 2, \dots, N$. At time t, demand and supply shape a market for the housing good $Q_{i,t}$, and a price $P_{i,t}$. Prices are per square meter, with quantity measured in total square meters of housing units. All other individual dwelling characteristics are subsumed into this measure and are not explicitly modelled. $P_{i,t}$ is, therefore, not so much a price that market participants could observe directly but a reflection of the market value of the average housing unit in each location.

3.1 Demand

Housing demand in location i at time t is given by:

$$Q_{i,t}^{D} = P_{i,t}^{\delta_1} \, (\mathrm{W}_i \mathrm{P}_t)^{\delta_2} \, Y_{i,t}^{\delta_3} \, F_{i,t}^{\delta_4} \, D_{i,t}^{\delta_5} \, T_{i,t}^{\delta_6} \, e^{\delta_7 L_i + \delta_8 K_i} \, e^{\delta_0 + \tau_t^D + \varepsilon_{i,t}^D}. \tag{3.1}$$

Demand should be negatively correlated with the local price $P_{i,t}$ (elasticity δ_1 is negative) through two main effects. On the one hand, if prices rise, households tend to seek smaller homes and with fewer amenities. On the other hand, through spillover mechanisms, when facing higher prices in a given location, households may give up searching for housing there and start looking in nearby places where prices are lower.

Thus, housing demand also depends on the prices at other locations. It is assumed that the strength of the connection between two locations is larger when they are closer to one another, as it is easier for agents to possess or collect relevant information. We consider an $N \times N$ matrix $\mathbf{W}^*$ whose cell (i,j) reflects the importance of the price in location j on housing demand in location i:

$$W_{ij}^* = \begin{cases} \frac{1}{d_{ij}^2}, & 0 < d_{ij} < 50 \\ 0, & otherwise \end{cases}, \tag{3.2}$$

where d_{ij} is the distance between locations i and j, measured in kilometres. That is, the strength of the spatial correlation decreases in inverse proportion to the square of the distance between the locations. Connections between locations above 50 km were disregarded[i]. To ensure comparability between locations, $\mathbf{W}^*$ is row standardized into $\mathbf{W}$, whose cell (i,j) is given by

$$W_{ij} = \frac{W_{ij}^*}{\sum_j W_{ij}^*} . \tag{3.3}$$

This matrix provides an adequate set of weights to attribute to each linkage between the locations. Taking row i of $\mathbf{W}$ and multiplying it by the (column) vector of all prices at time t results in a spatially weighted average of prices around location i, $\mathrm{W}_i\mathrm{P}_t$, which is included in the demand specification.

Household income, $Y_{i,t}$, is also modelled as a driver of housing demand in each location, either due to larger populations or wealthier residents seeking better housing. Next, $F_{i,t}$ expresses the number of registered foreign citizens living in each area, included because their buying propensity may not be reflected in income data. Portugal's tax regime for foreign pensioners, benefiting over 70,000 individuals as of 2022 (Tribunal de Contas, 2023), exemplifies this. This is deemed relevant enough to include because the portion of homes acquired by foreign citizens and institutions in Portugal is significant, especially in some regions[ii].

Demand is also modelled as a function of location amenities in each location, the first two of which are employment density ($D_{i,t}$), associated with urbanisation, and tourist overnight stays ($T_{i,t}$). Higher employment density leads to a greater variety of goods and services, attracting households (Ciccone & Hall, 1996). Tourist overnight stays, on the one hand, seeks capture hard-to-quantify location-specific amenities; on the other hand, tourism activity may also have direct effects on housing demand (Biagi et al., 2015; Schäfer and Hirsch, 2017) – which can be positive, in that the provision of certain services catered to tourists becomes amenities to residents, and negative, through congestion externalities and residential-commercial displacement (e.g., Cocola-Gant, 2018). Two other location amenities are included, through dummy variables for seaside municipalities (L_i) and regional capital cities[iii] (K_i), to reflect other potential impacts of the regional environment on housing markets.

The final term of the model captures unobserved factors. Some of these are assumed to be constant and are estimated by the coefficient δ_0. Time-fixed effects, τ_t^D, are included to capture the time-variant factors common to all locations, such as interest rates and economic sentiment. All other location-specific unobserved factors, such as amenities derived from public services, the level of local taxes, the social composition of the area, and criminality, are captured by a mean zero error term $\varepsilon_{i,t}^D$. To address the spatial correlation problems associated with spillover and clustering effects in unobserved variables, $\varepsilon_{i,t}^D$ is modelled by the specification proposed by Kapoor et al. (2007):

$$\varepsilon_{i,t}^D = \eta_i^D + \mu_{i,t}^D + \lambda \, \mathrm{W}_i \, \varepsilon_t^D. \tag{3.4}$$

This assumes that a portion of the unobserved factors is time-invariant, captured by $\eta_i^D \sim N(0, \sigma_{\eta^D}^2)$, another portion is purely idiosyncratic and varying in both time and space, captured by $\mu_{i,t}^D \sim N(0, \sigma_{\mu^D}^2)$, and yet another portion is due to the influence of nearby locations $\lambda \, \mathrm{W}_i \, \varepsilon_t^D$. This final term follows a pattern of spatial autocorrelation, similar to prices, mediated by the same linkage matrix $\mathbf{W}$ and a specific parameter λ.

3.2 Supply

Housing supply is modelled from the perspective of property owners and their decision to place housing units in the market. Thus, the quantity supplied is given by multiplying the size of the existing stock, $H_{i,t}$, by the average probability that one of its units is placed in the market. In the interest of simplicity and tractability, this probability is described by the product of a set of explanatory variables. The supply function then becomes

$$Q_{i,t}^S = H_{i,t} \times Prob.\ of\ market\ placement_{i,t}$$

$$\Leftrightarrow Q_{i,t}^S = H_{i,t} \times \left[P_{i,t}^{\gamma_1} \, (\mathrm{W}_i \mathrm{P}_t)^{\gamma_2} \left(\frac{B_{i,t}}{H_{i,t}} \right)^{\gamma_3} e^{\gamma_0 + \tau_t^S + \varepsilon_{i,t}^S} \right]$$

$$\Leftrightarrow Q_{i,t}^S = P_{i,t}^{\gamma_1} \, (\mathrm{W}_i \mathrm{P}_t)^{\gamma_2} \, H_{i,t}^{1-\gamma_3} \, B_{i,t}^{\gamma_3} \, e^{\gamma_0 + \tau_t^S + \varepsilon_{i,t}^S}. \tag{3.5}$$

The supply probability is expected to be positively correlated with price; the greater the prices property owners observe, the more willing they will be to place their units now rather than later. By including the spatial average of prices, the possibility that owners respond to the level of nearby prices is also accounted for.

Based on previous insights into the impact of rental tourism accommodation on the housing market, its prevalence in each location is also expected to influence the probability of supply. Over 100 000 establishments of this nature are currently registered in Portugal, mainly in regions with high tourism demand (Turismo de Portugal, 2024). The offer of tourism homestay rentals has been shown to come primarily from units that were not owner-occupied in the first place (Barron et al., 2021), meaning that it can have immediate and disproportionate effects on local supply, as it depletes the most 'liquid' segment of the market. Therefore, the average probability of supply is assumed to be negatively impacted by the level of tourist homestay units $B_{i,t}$, in proportion to the local housing stock $H_{i,t}$.

Finally, as with the demand specification, unobserved factors are captured by a constant term γ_0, time-fixed effects τ_t^S, and an error term that admits spatial autocorrelation $\varepsilon_{i,t}^S = \eta_i^S + \mu_{i,t}^S + \lambda \, \mathrm{W}_i \, \varepsilon_t^S$, where $\eta_i^S \sim N(0, \sigma_{\eta^S}^2)$ and $\mu_{i,t}^S \sim N(0, \sigma_{\mu^S}^2)$.

3.3 Equilibrium

In equilibrium, demand equals supply, $Q_{i,t}^D = Q_{i,t}^S$, and so:

$$P_{i,t}^{\delta_1} (\mathrm{W}_i \mathrm{P}_t)^{\delta_2} Y_{i,t}^{\delta_3} F_{i,t}^{\delta_4} D_{i,t}^{\delta_5} T_{i,t}^{\delta_6} \, e^{\delta_7 L_i + \delta_8 K_i} \, e^{\delta_0 + \tau_t^D + \varepsilon_{i,t}^D} = P_{i,t}^{\gamma_1} (\mathrm{W}_i \mathrm{P}_t)^{\gamma_2} H_{i,t}^{1-\gamma_3} B_{i,t}^{\gamma_3} e^{\gamma_0 + \tau_t^S + \varepsilon_{i,t}^S} . \quad (3.6)$$

Rearranging with respect to price:

$$P_{i,t}^{\gamma_1 - \delta_1} = (\mathrm{W}_i \mathrm{P}_t)^{\delta_2 - \gamma_2} Y_{i,t}^{\delta_3} H_{i,t}^{\gamma_3 - 1} F_{i,t}^{\delta_4} D_{i,t}^{\delta_5} T_{i,t}^{\delta_6} B_{i,t}^{-\gamma_3} e^{(\delta_7 L_i + \delta_8 K_i) + (\delta_0 - \gamma_0) + (\tau_t^D - \tau_t^S) + (\varepsilon_{i,t}^D - \varepsilon_{i,t}^S)}, \quad (3.7)$$

applying logarithms:

$$\begin{aligned}(\gamma_1 - \delta_1) \, ln \, P_{i,t} = {} & (\delta_0 - \gamma_0) + (\delta_2 - \gamma_2) \, ln \, \mathrm{W}_i \mathrm{P}_t + \delta_3 \, ln \, Y_{i,t} \\ & + (\gamma_3 - 1) \, ln \, H_{i,t} + \delta_4 \, ln \, F_{i,t} + \delta_5 \, ln \, D_{i,t} + \delta_6 \, ln \, T_{i,t} \\ & - \gamma_3 \, ln \, B_{i,t} + \delta_7 \, L_i + \delta_8 \, K_i + (\tau_t^D - \tau_t^S) + \left(\varepsilon_{i,t}^D - \varepsilon_{i,t}^S\right), \end{aligned} \quad (3.8)$$

and simplifying the coefficients and error terms, yields the following econometric model:

$$\begin{aligned} ln \, \mathrm{P}_{i,t} = {} & \beta_0 + \rho \, ln \, \mathrm{W}_i \mathrm{P}_t + \beta_1 \, ln \, Y_{i,t} + \beta_2 \, ln \, H_{i,t} + \beta_3 \, ln \, F_{i,t} + \beta_4 \, ln \, D_{i,t} \\ & + \beta_5 \, ln \, T_{i,t} + \beta_6 \, ln \, B_{i,t} + \beta_7 \, L_i + \beta_8 \, K_i + \tau_t + \varepsilon_{i,t} , \end{aligned} \quad (3.9)$$

where $\varepsilon_{i,t} = \eta_i + \mu_{i,t} + \lambda \, \mathrm{W}_i \, \varepsilon_t$, with $\eta_i \sim N(0, \sigma_{\eta^D}^2 - \sigma_{\eta^S}^2)$ and $\mu_{i,t} \sim N(0, \sigma_{\mu^D}^2 - \sigma_{\mu^S}^2)$.

The model arrived at here merits further discussion. First, it uses a random effects structure, which is preferred for cross-sectional analysis owing to the nature of the data (many locations, few time periods). Second, the autoregressive term $\rho \ ln \ \mathrm{W}_i \mathrm{P}_t$, which accounts for spatial spillovers, makes it part of the family of spatial autoregressive (SAR) models[iv]. In this sense, while spatial weights assume that nearby objects should be more correlated than distant ones, LeSage and Pace (2014) contend that SAR model results are rarely sensitive to the specific weights adopted – see Appendix B for robustness checks with alternative $\mathbf{W}$ specifications. Hence, the form of the spatial weights chosen for this model is based on its relative simplicity and common use in the literature. Third, as household income in each municipality, $Y_{i,t}$, is likely endogenous to housing prices – households choose their residence considering, among others, housing prices in each location – an instrumental variable, $Y_{i,t}^L$, was introduced, assuming that household income is associated with labor and employment positions available in and around each municipality, and their wages.

$$Y_{i,t}^L = \mathbf{C} \, \mathrm{E}_t \, \mathrm{w}_t \, . \tag{3.10}$$

Here, $\mathbf{C}$ is an $N \times N$ column-standardized matrix of observed commuting flows between the N municipalities, E_t the vector of the number of employees working in each of the N municipalities at time t and w_t the average wage paid to them[v]. This strategy is inspired by shift-share analysis, also known as a Bartik instrument (Bartik, 1991), by fixing the structure of links between each municipality – the 'share' – and exploiting the effects of annual changes to employment and wages in each one and its neighbours – the 'shift' –, which is assumed to have no other correlation to housing demand than through this channel.

Naturally, by simplifying some aspects of housing market dynamics, our model has inherent limitations. Residential location decisions result from a complex interplay of factors, many of which lie outside the housing market (e.g., O'Sullivan, 2007) and thus beyond the scope of the model. Our aim was to build on existing modelling approaches by incorporating spatial variation while retaining enough tractability to simulate plausible counterfactual scenarios and interpret their outcomes both at regional and municipal levels. In particular, the model does not fully capture the stratified effects of supply expansions and demand restrictions on housing prices across income groups: housing markets are segmented, and local distributions of prices and wages may result in differentiated affordability outcomes, which we do not capture here. Similarly, the model abstracts from some of the microeconomic mechanisms—such as those relating to tourism pressure on demand—that would be needed for a more granular analysis. These refinements are promising directions for future improvement but do not detract from the core aims of our analysis.

4. Estimation and data

Models were estimated by the Maximum Likelihood method, widely considered apt for spatial panel data model estimation, using Stata software. Estimations were performed using panel data on the municipalities of mainland Portugal between 2019 and 2022, which represent the finest spatial scale with consistent public data on housing prices, stock, and relevant explanatory variables (e.g., tourism, international demand, income) are publicly available. This granularity captures spatial heterogeneity and local spillover effects – which are central to the spatial econometric framework employed – while enabling policy relevant simulations and further interpretation at both municipal and regional levels (see section 5.2). Most data are accessible from Portugal's National Statistical Office (INE). The descriptive statistics are presented in Table 1.

For housing prices, the annual median transaction price per square meter in each municipality was used. This was obtained from the registry of all housing acquisitions maintained by the national tax authority. 23 out of the 278 municipalities were excluded due to missing values, but the sum of these municipalities' housing stock represents less than 2% of the national total. We demonstrate (see Appendix B) that even removing an additional 23 small municipalities from the sample would have a negligible effect on the coefficient estimates.

Household income data refer to the total net income for the inhabitants of each municipality, as declared by the tax authority. As discussed, this is instrumented with data on local employment and wages obtained from the national social security registry and with the matrix of commuting flows between municipalities observed in the 2011 census. Housing stock was measured by annual estimates of the number of dwellings for each municipality. These are produced by INE by combining decennial census data with the number of new finished units registered by local authorities in each year. The number of housing units was then multiplied by the average surface area in each municipality, as recorded by the census.

For foreign residents, we used the number of foreign nationals living in each municipality with a legal permit of residence, and tourism was measured by the number of overnight stays in hospitality establishments, including stays in hotels, hostels, and large homestay properties[vi]. Data on homestay establishments were collected from the national tourism office, which keeps a registry of all properties, their opening date, their capacity, and other details. However, it does not provide information on the area of each property. To estimate this, the lodging capacity of each establishment was multiplied by the average housing area per inhabitant in each municipality as recorded in the 2021 census.

Finally, the distance between municipalities was measured based not on their geographic centers but on their population-weighted centroids, as is common in geographical analyses (Boyle &

Flowerdew, 1997). These were computed based on fine-level census tract population data from the latest national census of 2021 with the aid of geographical information software.

Table 1: Descriptive statistics

Insert Table 1 about here

5. Results

5.1 Model estimates

Table 2 presents the coefficient estimates for the various specifications. The first two columns exclude spatial effects. In column 1, income is assumed exogenous, while in column 2 and all subsequent columns, it is instrumented as described in Equation 3.10. Moran's *I* test for Models 1 and 2 confirms the need for explicit consideration of spatial effects in the model specification. In Column 3, the spatial autoregressive term is introduced, but the error terms remain independent and identically distributed. The significant coefficient for the endogenous spatial lag indicates that prices in nearby municipalities influence the prices in each location. However, the $\bar{I}$ test statistic shows the spatial correlation of the unobserved factors. Column 4 presents the full spatial model with autoregressive errors; the negative estimate for parameter λ is unexpected and likely due to identification issues. Thus, model 3 is preferred for further analysis because of its simplicity and because ignoring error correlation does not result in any bias of model coefficients, only a small loss of efficiency and consistency (LeSage & Pace, 2009).

As discussed, in line with Anenberg & Kung (2020) and Freemark (2025), the assumption that the level of housing stock is exogenous to current prices is key to our modelling framework. Yet, in Appendix C, we also demonstrate that our results are very robust to a relaxation of this assumption. We do so by considering two alternative model specifications, one of which implements an instrumental variable related to spatial regulatory constraints on new housing supply, as typically used in the economic literature (Gyourko & Molloy, 2015). The results remain similar in both specifications (see appendix C).

Table 2: Estimates of house price models

Insert Table 2 about here

Across all the specifications (Table 2), the regression coefficients are generally significant and conform to expectations. The price decreases with the level of housing stock and increases for all other variables. However, the inclusion of the autoregressive term means that the regression coefficients of the spatial models are not directly interpretable as the marginal effect of each independent variable on prices due to spillover effects and subsequent feedback percolating all spatial units. To make such an interpretation possible, and based on these estimates, we followed LeSage and Pace (2009) and calculated the direct, indirect, and total impacts of each variable on price (see Appendix D for additional details). Table lists these impact measures and their respective standard errors as computed from the coefficient estimates of Model 3. Owing to the log-log specification of the model, these impacts can be interpreted as elasticities. Hence, considering spatial spillovers, a 1% increase in housing stock in one municipality is estimated to result, on average, in a direct 0.358% decrease in housing prices in that municipality and a decrease of 0.236% in housing prices in its surroundings. The average total impact (0.593%) is the sum of both. In other words, a 1% increase in housing stock in all municipalities would lead to a 0.593% decrease in housing prices nationwide.

Table 3: Impact estimates with spillover effects

Insert Table 3 about here

The value obtained for $ln\ Y_{i,t}$ (Table 3) points to an income elasticity of housing demand of 0.521, in line with the estimates in the literature that put it below the unit (Albouy et al., 2016). However, as $Y_{i,t}$ refers to aggregate income (number of households times average income), it cannot be discerned from this estimated elasticity if the marginal effect of an increase in the number of households is different from the effect of an increase in their wealth, the latter being the most common definition of the income elasticity of demand.

The explicit inclusion of the number of foreign residents, $F_{i,t}$, appears vindicated by the results in Table. Because foreign residents account for less than 10% of all households in the country, if their elasticity of demand is like that of native residents, the price impact obtained for $ln\ F_{i,t}$ should be approximately 10 times smaller than that of $ln\ Y_{i,t}$. The fact that it is only about four times smaller suggests that their declared income does not disclose their demand propensity as well as it does for national residents[vii].

The estimates also indicate the significant effects of tourism on the housing market. These come more because of the housing stock that, instead of being placed in the residential market, is dedicated to rental tourism accommodation, $B_{i,t}$, rather than the actual size of tourism demand, $T_{i,t}$. This was in part to be expected, considering that the period of analysis coincided with the COVID-19 pandemic, where tourist numbers were notably inferior. Yet, in any case, it is estimated that a 1% increase in homestay capacity can increase housing prices by 0.103% (Table 3). Related with that, it is worth noticing the substantial price premium of coastal municipalities, which our model estimates at 26%. By contrast, the price effect associated with regional capital cities is positive but not statistically significant – consistent with fact that not all of them are dynamic regional employment centres, but also small- to medium-sized cities embedded in predominantly rural hinterlands.

5.2 Simulations

A clearer picture of the importance of different explanatory variables emerges when using our spatial model to simulate house prices under alternative (policy) scenarios. To capture how these variables play out across different geographical contexts, we complement our analyses with simulations at nested municipal and regional levels, focusing on the regions where housing price hikes have been most pronounced: Porto, Lisbon, and the Algarve. To do so, as detailed below, we use the variables that most closely proxy for alternative policy prescriptions discussed in the "supply optimism" versus "supply skepticism" debate—namely, supply increases (housing stock) versus demand restrictions, particularly limits on short-term rental dwellings, and controls on international housing demand (e.g. Been et al., 2019; 2025; Rodriguez-Pose & Storper, 2020: 2022).

As mentioned in Section 1 (see also Appendix A), between 2012-2022, roughly 80% fewer dwellings were built in Portugal than during the 2000s, with such a construction slowdown suggested as the culprit of the current affordability crisis (e.g., Rodrigues et al., 2023). To test this idea, that is, to predict how much prices could be lower would the country have a greater housing supply, the following equation was used:

$$ln\ \mathrm{P}^{\mathrm{S}} = (\mathbf{I} - \hat{\rho}\mathbf{W})^{-1}(\mathbf{X}^{S}\hat{\beta} + \hat{\varepsilon})\ . \tag{5.1}$$

Here, $\mathbf{X}^{S}$ is the matrix of explanatory variables, where the level of housing stock is replaced by hypothetical values, and all other variables remain constant. $\hat{\rho}$ and $\hat{\beta}$ are the estimated model coefficients in Column 3 of Table 2, and $\hat{\varepsilon}$ is the vector of residuals produced by these coefficients. The base year for this analysis was 2022, with counterfactual comparisons performed between the actual prices in this year and those obtained by the simulations.

We initially simulated two scenarios: one if housing construction would keep pace with the previous decade, i.e., the 2000s (Scenario 1), and a more ambitious one, assuming housing construction would double that of the 2000s, hypothetically reflecting a more efficient supply sector capable of delivering even more homes in the face of rising demand (Scenario 2)[viii], mirroring a common policy recommendation from housing supply advocates (e.g., Burn-Murdock, 2023). For the Portuguese case, this would mean adding approximately 300 thousand (scenario 1) and 700 thousand (Scenario 2) new dwellings to the 2022 housing stock, which we allocated to municipalities in proportion to the actual construction numbers between 2012-2022[ix]. The predicted average housing prices decreased by 3% in Scenario 1 and by 6% in Scenario 2. These decreases would be more substantial in the industrial northwestern region around Porto and less so in the metropolitan area of Lisbon, with a maximum 4% decrease under the most ambitious scenario (Figure 1).

Figure 1: Scenarios 1 and 2: predicted difference (%) in regional house prices (NUTS3)

Figure 1a – Scenario 1: Maintain pace of construction – Average price: 1 584 €/m2 (–2.9%)
Figure 1b – Scenario 2: Double pace of construction – Average price: 1 531 €/m2 (–6.2%)

(Please see pdf. file, for the combined appearance into a single figure)

Insert Figure 1 about here

Figure 2 shows the most ambitious scenario for the three most expensive Portuguese regions (Porto, Lisbon, and the Algarve), and an affordability indicator – the share of median net income needed to purchase a 100 m^2 home over 40 years. While affordability would improve in Porto's region, it remains problematic in Algarve and Lisbon, with Lisbon's effort rate reaching 61%[x]. Even an extraordinary housing supply expansion would not provide substantial relief in these regions. In addition, while we assumed additional housing units to be geographically distributed proportionally to last decade's construction, it is only natural that greater effects would be in outlying areas of metropolitan regions, as core cities face heightened land use competition and scarcity. If so, generic policy actions aimed at boosting the housing supply nationwide would likely be unfruitful in the most dynamic cities and attractive regions, as constraints in these locations are fundamentally different from those in the rest of the country.

Figure 2: Scenario 2: predicted difference (%) in prices and predicted effort rates

Porto Metro Area

Figure 2a – Average price: 1 510 €/m^2 (–7.3%)
Figure 2b – Average effort rate: 28.0% (–2.2pp)

Lisbon Metro Area

Figure 2c – Average price: 2 362 €/m2 (–4.9%)
Figure 2d – Average effort rate: 40.5% (–2.1pp)

Algarve

Figure 2e – Average price: 2 193 €/m^2 (–5.9%)
Figure 2f – Average effort rate: 46.7% (–2.9pp)

Note: Maps not to scale.

(Please see pdf. file, for the combined appearance into a single figure)

Insert Figure 2 about here

Next, we simulated a counterfactual return to the year 2015, when listed homestay properties and the attractiveness to foreign residents had started to rise in the country (e.g., Carvalho et al., 2019; Rodrigues et al., 2023), but not yet to the extent they later did (see Appendix F) – to predict what house prices would be in 2022 had the number of foreign residents (Scenario 3) and homestay properties (Scenario 4) remained at those levels[xi]. Other explanatory factors are assumed to be constant, including tourism stays, which in 2022 remained below pre-pandemic levels and can therefore be reasonably treated as stable, even with reduced accommodation capacity. Simulations indicate that, with the number of foreign residents of 2015, house prices in 2022 would be lower by 8%; with the number of homestay properties of 2015, prices would be 14% lower. Simulating both counterfactuals simultaneously (Scenario 5), the prediction is that prices would be 22% lower. While these are just counterfactual simulations – in reality, assuming that everything else in the country's housing market would remain constant despite these shifts would not be completely realistic – the results nonetheless illustrate the relevance of these two factors alone vis-à-vis simulated housing supply expansions.

Finally, taking the previous into consideration, we simulated a final "policy mix" scenario (Scenario 6) by combining reasonable actions on both sides of the market, associating policy prescription elements of both supply skeptics and supply advocates (e.g. Been et al., 2024). We assume that i) new housing supply was able to offer the same number of new units as in the 2000s (i.e., Scenario 1); ii) policies aiming to attract foreign investment and residents are curtailed, leading to 10% fewer foreign residents in the country,[xii] and iii) there is a limit to local tourist homestay accommodation in each municipality, hypothetically not exceeding 10% of the number of dwellings (which, in practice, would imply enacting restrictions in 13 municipalities). Under these conditions, the model predicts that house prices would be lower by 6%, similar to the impact of Scenario 2 (i.e., record-high housing construction). Table 4 compares all scenarios in terms of the predicted average prices nationwide and the corresponding affordability effort rate.

Table 4: Comparison of simulated scenarios

Insert Table 4 about here

Although the aggregate impact of such a policy mix would not be much larger than an ambitious housing supply expansion, its regional imprint would be rather different, with the advantage of bringing greater relief where prices are currently higher (Figure 3). For example, in the city of Lisbon, prices are predicted to be 11% lower in comparison to 2022 prices, whereas under Scenario 2, the difference was 4% only; in Algarve, a policy mix would bring regional average house prices down by 9%, in comparison with 6% under Scenario 2. In any case, as suggested by the simulated effort rates (Figure 3), housing affordability problems would persist with severity in these regions. Although less acute in the most attractive cities – because of restricting local homestays – effort rates would remain high for many households, with the predicted effects of scenarios 1, 2, and 6 still far from proving a substantial relief. In fact, such an improvement appears only achievable through demand-restrictive measures of such severity to make them highly contentious, subject to multiple trade-offs, and challenging to achieve.

Figure 3: Scenario 6: predicted difference (%) in prices and predicted effort rates

Porto Metro Area

Figure 3a – Average price: 1 529 €/m^2 (–6.2%)
Figure 3b – Average effort rate: 28.4% (–1.9pp)

Lisbon Metro Area

Figure 3c – Average price: 2 326 €/m^2 (–6.4%)
Figure 3d – Average effort rate: 42.7% (–2.7pp)

Algarve

Figure 3e – Average price: 2 112 €/m^2 (–9.4%)
Figure 3f – Average effort rate: 45.0% (–4.7pp)

Note: Maps not to scale.

(Please see pdf. file, for the combined appearance into a single figure)

Insert Figure 3 about here

6. Conclusions

While housing price hikes and affordability crises have affected many places over the last decade, the severity of the Portuguese case – and of some regions in particular – makes it a particularly insightful geography to better understand and quantify their determinants and to furnish new evidence to the arguments and claims recently made by both supply advocates and sceptics (e.g. Been 2019; 2023; Rodríguez-Pose and Storper, 2022). Our modelling and empirical strategy allowed analysing with high spatial resolution if and to what extent housing affordability problems could be mitigated by a greater market supply of new housing – and in which local and regional environments those effects would be more (and less) relevant.

In line with supply advocates, we found the number of housing units to be a highly significant explanatory factor of prices: all else being constant, on average, a municipality with a 1% higher housing stock experiences 0.59% lower house prices. While the impact of supply on prices is larger than that found in recent studies focusing on the United States (e.g. Anenberg and Kung, 2020; Freemark, 2025), it is insufficient to support the claim that more supply could lower prices by a substantial amount. Simulations predict that had supply kept the pace of the previous decade, prices would only be 3% lower; had it doubled, prices would be 6% lower. At the same time, the much discussed – but rarely quantified (e.g., Mikulić et al., 2021 Peralta et al., 2020) – impact of the boom in homestay properties and affluent international demand in particular regions was found to be very relevant. Counterfactuals considering these variables' levels in 2015 would point to prices being between 14% and 22% lower, which resonates with supply skepticism concerns. Under these conditions, especially for core municipalities in metropolitan Lisbon and the Algarve region, a simulated policy mix combining homestay restrictions, reasonable international demand controls, and achievable supply expansion would be a more effective method to relieve the most price-affected places.

This study has two major policy implications. First, in line with supply advocates (e.g., Been et al., 2019; 2025), it indicates that increasing market supply should still be an essential component of the policy response to the problems of housing affordability. It is beyond the scope of this study to discuss the most suitable instruments to achieve such a goal. However, as shown, the impacts of such a policy would likely be higher in the outlying places of metropolitan areas, notably as the densest urban areas tend to be constrained by land scarcity and competition for alternative uses. Hence, our analysis supports previous considerations that spatially blind policy action aimed at boosting housing supply nationwide could be unfruitful, particularly for the most attractive urban regions (e.g., Rodríguez-Pose and Storper, 2020), calling for housing supply interventions and regulatory frameworks that consider sub-national environments differently.

Second, supply expansion should not be the sole component of policy response. As shown, wrestling housing stock from tourist purposes back to housing supply is a necessity to significantly ease prices in the most pressured locations, as suggested e.g. by Cocola-Gant & Gago (2021); this is more so as there is mounting evidence that the price and affordability impacts of many contemporary regulatory measures on short-term rentals (e.g. caps, zoning restrictions) are limited and volatile (e.g., Columb & Moreira de Souza, 2024; Zou et al, 2025). However, it raises questions about the side effects that this would have in other spheres of national and regional economies. It is unclear whether national governments' strategies – in Portugal and elsewhere – of abandoning restrictions on tourism lodgings and relinquishing this power at the municipal level is wise. In any case, expectations should be tempered on what is presently accomplishable with the policy levers at hand, as only drastic measures could produce a price decrease that many would hope. Further work at the intersection of real estate research and regional studies (Derudder & Bailey, 2021) – with the latter typically more focused on the structure of regional economies and different types of inequality – is particularly necessary to develop a more holistic understanding and capacious perspective on those intersections and trade-offs, and to integrate them more effectively into policy debates.

In conclusion, we would argue that the price model developed here introduces relevant regional and geographical dimensions to the identification of housing market determinants that are often overlooked in the literature (e.g. Gleeson, 2023; Rodríguez-Pose and Storper, 2020) – even if it would benefit from more years of data to improve its estimates and predictions. To be sure, we see this approach and our model as especially useful and generalizable for studying housing markets in countries in which demand and supply side drivers are notably heterogeneous across the country, in particular where the influence of tourism flows and international demand is sizeable and regionally salient – of course, assuming that there are no other confounding factors limiting its generalization in other geographies. Nevertheless, the modelling framework in this study captures this phenomenon somewhat simplistically. More research is needed to understand the interplay between these drivers in greater detail and develop more refined and place-sensitive policy recommendations.

Conflict of interest statement: The authors have declared that no competing interests exist.

Note: Diogo Ribeiro is currently affiliated at CIPES – Centre for Research in Higher Education Policies, Portugal.

Data availability statement: The data that support the findings of this study are available from the corresponding author, upon reasonable request. Restrictions apply to the availability of some data, which were used under licence for this study; such data is available with the permission of the Portuguese National Statistical Office (INE).

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Table 1: Descriptive statistics

		Mean	SD	Min	Max
Main regression variables:					
P	Median house price p/m^2	853.7	522.8	156	3 872
Y	Household income (k€)	344 010.1	666 642.1	15 120	7 874 641
H	Housing stock (m^2)	2 498 638.9	3 181 007.0	267 873	31 004 595
F	Foreign residents	2 613.5	8 310.6	12	118 104
D	Employment density	0.8	3.0	0.01	36
T	Tourist stays	168 912.1	800 199.3	0	13 985 262
B	Homestay properties (m^2)	72 085.0	275 790.0	169	3 861 786
Auxiliary variables:					
w	Average annual wage	12 809.4	2 137.2	9 532	24 900
E	Employment	8 749.6	23 195.8	237	355 063

Note: SD – standard deviation.

Table 2: Estimates of house price models

	1	2	3	4
Constant	7.077 **	7.091 **	3.952 **	2.570 **
	(0.411)	(0.422)	(0.430)	(0.442)
$\ln W_i P_t$			0.413 **	0.592 **
			(0.036)	(0.044)
$\ln Y_{i,t}$	0.472 **	0.479 **	0.306 **	0.259 **
	(0.065)	(0.090)	(0.068)	(0.058)
$\ln H_{i,t}$	-0.546 **	-0.554 **	-0.348 **	-0.277 **
	(0.069)	(0.091)	(0.070)	(0.060)
$\ln F_{i,t}$	0.120 **	0.120 **	0.072 **	0.047 **
	(0.017)	(0.018)	(0.016)	(0.014)
$\ln D_{i,t}$	0.046 **	0.045 *	0.031 *	0.015
	(0.016)	(0.019)	(0.015)	(0.013)
$\ln T_{i,t}$	0.012	0.012	0.017 *	0.020 **
	(0.008)	(0.008)	(0.008)	(0.007)
$\ln B_{i,t}$	0.081 **	0.082 **	0.060 **	0.045 **
	(0.016)	(0.016)	(0.014)	(0.013)
$L_i = 1$	0.263 **	0.263 **	0.152 **	0.124 **
	(0.049)	(0.049)	(0.041)	(0.036)
$K_i = 1$	-0.139 *	-0.140 *	0.065	0.132 *
	(0.060)	(0.061)	(0.052)	(0.053)
τ_t				
2020	0.056 **	0.056 **	0.034 **	0.027 **
	(0.011)	(0.011)	(0.011)	(0.008)
2021	0.061 **	0.060 **	0.029 *	0.018 *
	(0.012)	(0.012)	(0.012)	(0.009)
2022	0.098 **	0.097 **	0.043 **	0.021
	(0.015)	(0.017)	(0.015)	(0.012)
$W_i \varepsilon_t$				-0.446 **
				(0.101)
Observations	1020	1020	1020	1020
R^2	0.825	0.825	0.851	0.854
Log likelihood			551.71	560.40
$\bar{I}$	20.16	20.18	3.20	-3.00

Notes:

** statistical significance at 1%; * at 5%. R^2 for models 3 and 4 is the squared correlation of actual and fitted values. $\bar{I}$ is the standardised Moran's I statistic for spatial autocorrelation of residuals of panel data models, calculated with the matrix W.

Table 1: Impact estimates with spillover effects

	Direct	Indirect	Total
ln $Y_{i,t}$	0.314 **	0.207 **	0.521 **
	(0.070)	(0.050)	(0.115)
ln $H_{i,t}$	-0.358 **	-0.236 **	-0.593 **
	(0.072)	(0.052)	(0.117)
ln $F_{i,t}$	0.074 **	0.049 **	0.123 **
	(0.016)	(0.011)	(0.026)
ln $D_{i,t}$	0.032 *	0.021 *	0.053 **
	(0.015)	(0.010)	(0.025)
ln $T_{i,t}$	0.018 *	0.012 *	0.030 *
	(0.008)	(0.006)	(0.013)
ln $B_{i,t}$	0.062 **	0.041 **	0.103 **
	(0.014)	(0.010)	(0.023)
L_i	0.156 **	0.103 **	0.259 **
	(0.042)	(0.029)	(0.068)
K_i	0.067	0.044	0.111
	(0.054)	(0.038)	(0.091)

Note: ** statistical significance at 1%; * at 5%.

Figure 1: Scenarios 1 and 2: predicted difference (%) in regional house prices (NUTS3)

Scenario 1: Maintain pace of construction
Average price: 1 584 €/m² (–2.9%)

Scenario 2: Double pace of construction
Average price: 1 531 €/m² (–6.2%)

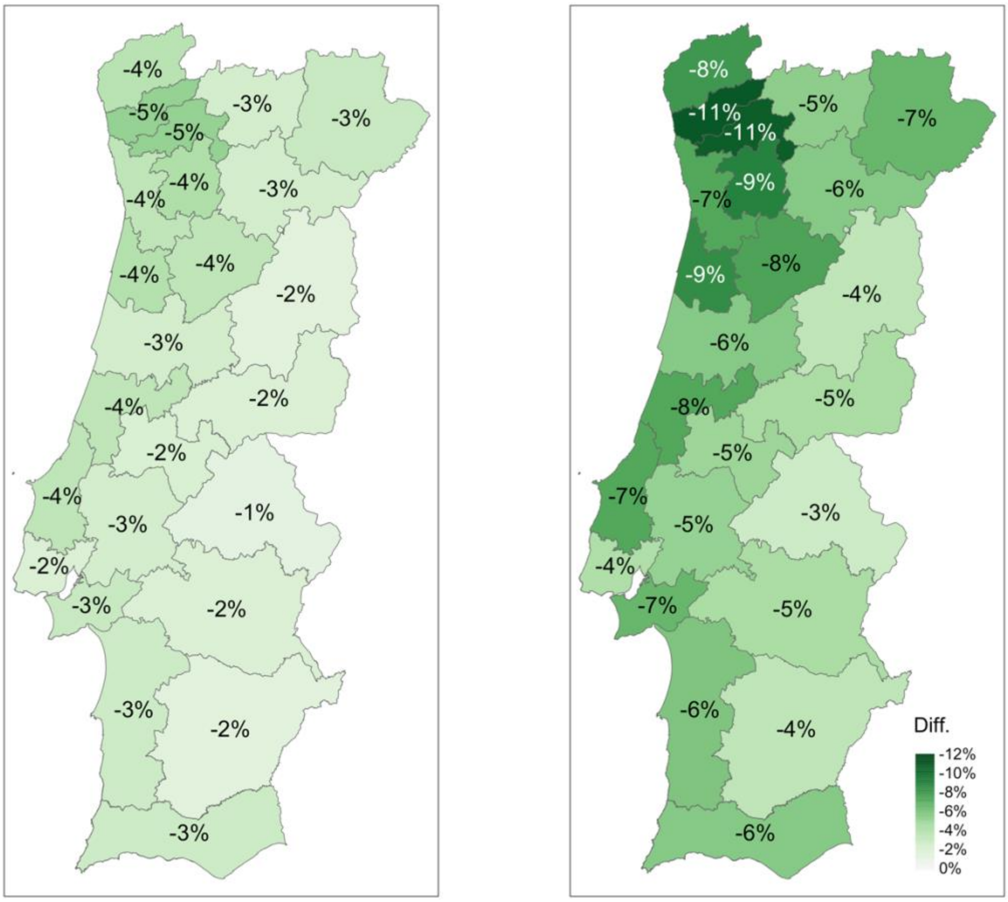
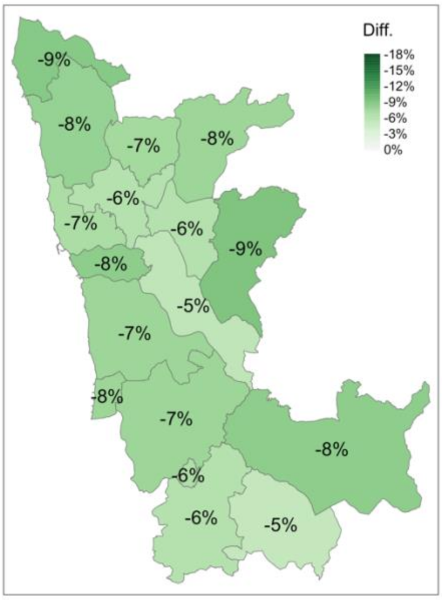


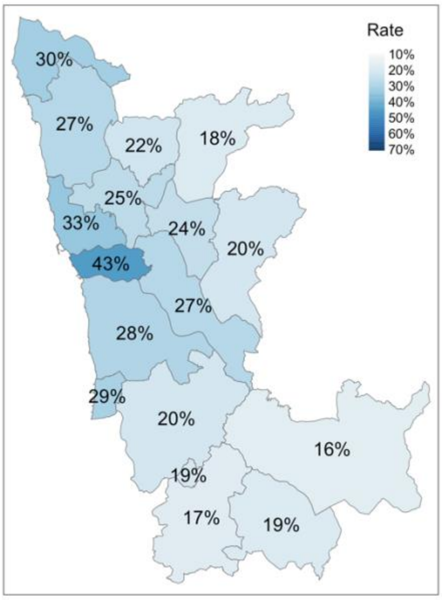
Figure 2: Scenario 2: predicted difference (%) in prices and predicted effort rates

Porto Metro Area

Average price: 1 510 €/m² (–7.3%)

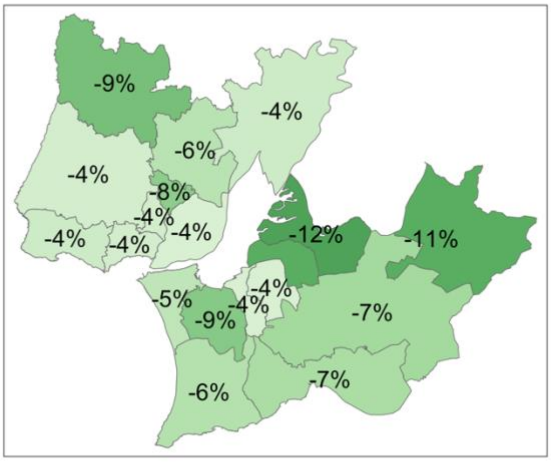


Average effort rate: 28.0% (–2.2pp)

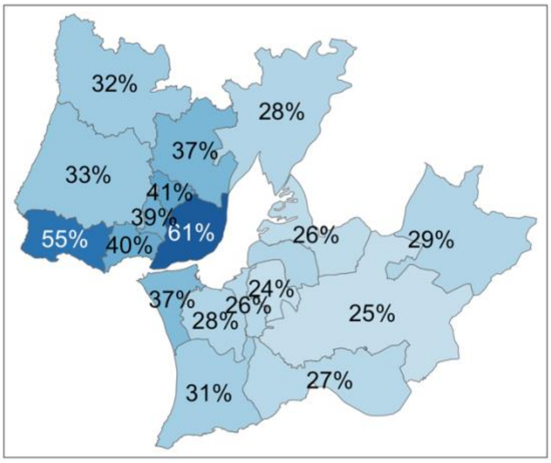


Lisbon Metro Area

Average price: 2 362 €/m² (–4.9%)

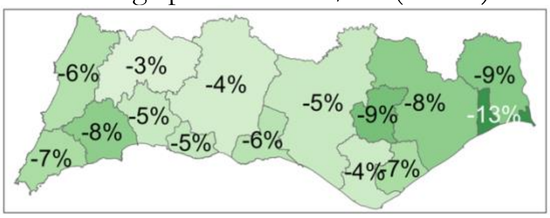


Average effort rate: 40.5% (–2.1pp)

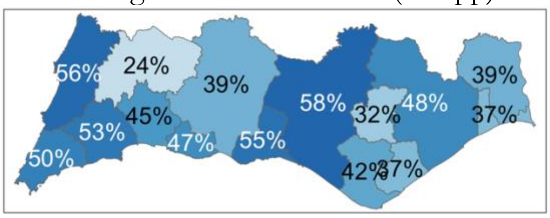


Algarve

Average price: 2 193 €/m² (–5.9%)



Average effort rate: 46.7% (–2.9pp)



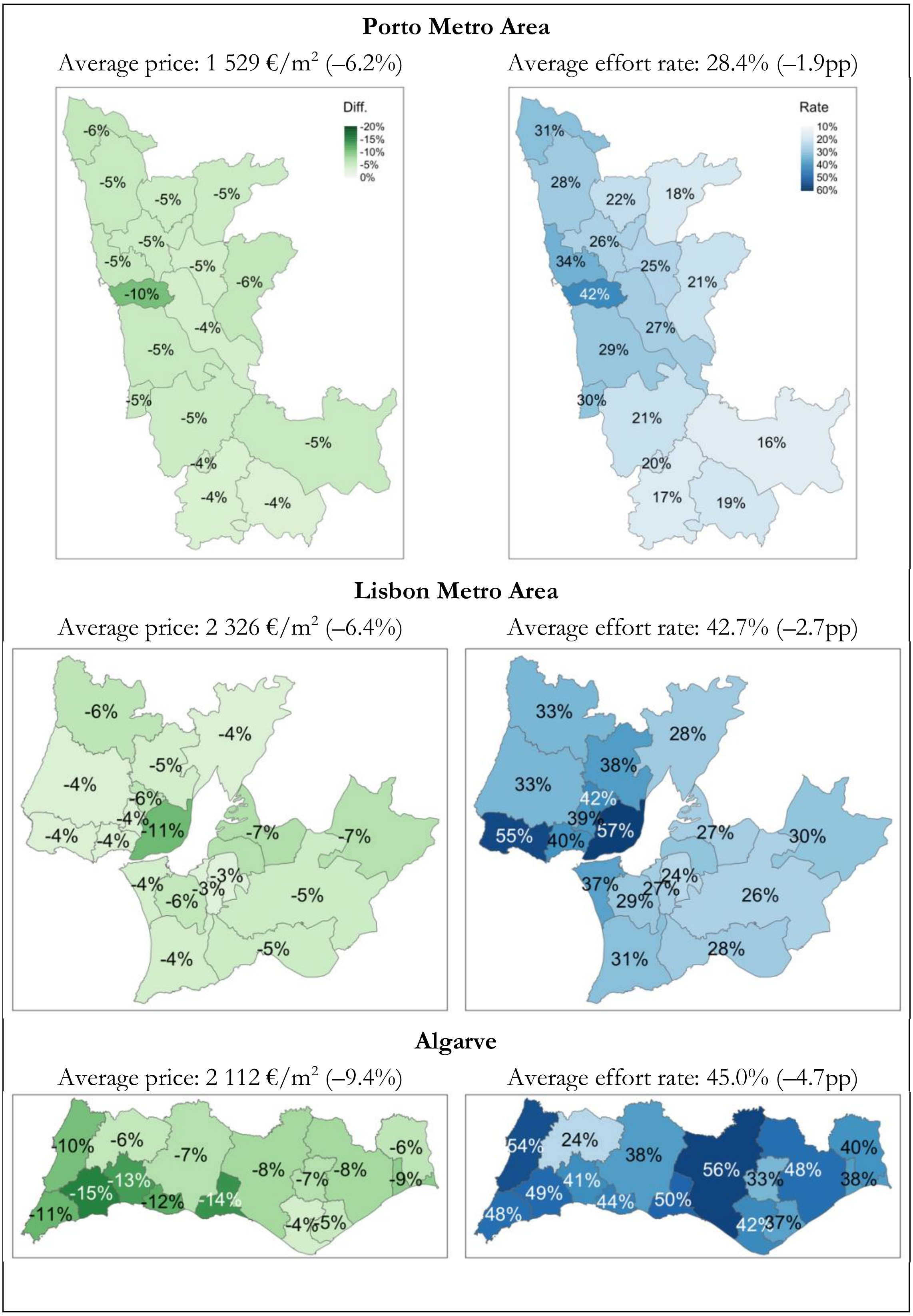
Note: Maps not to scale.

Table 4: Comparison of simulated scenarios

Scenario	Price (€/m^2)		Index	Effort rate	
Base: 2022	1 632		195.9	29.9%	
1: Maintain the pace of construction	1 584	–2.9%	190.1	29.1%	–0.9pp
2: Double the pace of construction	1 531	–6.2%	183.8	28.1%	–1.9pp
3: Foreign residents at 2015 levels	1 495	–8.4%	179.4	27.4%	–2.5pp
4: Homestays at 2015 levels	1 399	–14.3%	168.0	25.7%	–4.3pp
5: Foreign residents & homestays at 2015 levels	1 281	–21.5%	153.8	23.5%	–6.4pp
6: Policy mix	1 532	–6.2%	183.9	28.1%	–1.8pp

Notes: Price index base 2015 = 100; for reference, household income grew 40% in nominal terms in the 2015–2022 period (in all the scenarios, house prices would grow faster).

Figure 3: Scenario 6: predicted difference (%) in prices and predicted effort rates



Note: Maps not to scale.

[i] This is done to turn the matrix less dense and reduce computational complexity, as the calculated weights at those distances become miniscule.

[ii] In 2023, these accounted for 27% of all house purchases in Algarve (INE, 2024).

[iii] Regional capital cities are the administrative capitals (municipalities) of Portuguese "Distritos", the main regional administrative subdivision of Portugal for two centuries until their abolition in 2011; their capitals remain important centers for public service provision.

[iv] For advantages and limitations of spatial autoregressive models, please see LeSage & Pace (2009).

[v] Empirically, the matrix $\mathbf{C}$ draws on the flows observed in the 2011 census, predating the period of analysis to assume exogeneity, and is fixed for all t.

[vi] Other more informal forms of tourism accommodation, such as camping parks and small homestays, are not included.

[vii] Again, as the marginal effect of $Y_{i,t}$ potentially comprises both size and wealth effects, while for $F_{i,t}$, only size, this is left as not more than a mere suggestion.

[viii] This hypothetical scenario would imply that additional construction would have begun while Portugal was still experiencing an economic downturn in the aftermath of the financial crisis of 2008. Hence, to test for robustness, in Appendix E, we explore alternative scenarios in which construction starts only after 2015, using simulations for the 2015–2022 period based on figures from the 2001–2008 period preceding the financial crisis. The simulated results are very similar to the ones found for the 2012-2022 period (see appendix E).

[ix] Scenario 2 would be at the very top end of what is conceivable: only in a brief period in the 1990s was the country ever able to produce more than 80.000 new homes each year, at a time of a large housing investment boom.

[x] These rates exclude financing and all running costs associated with housing maintenance; adding those would likely increase predicted effort rates way above 40% in many municipalities, the threshold above which a household is deemed to be overburdened with housing costs (Eurostat, 2023).

[xi] As the relevant data for 2015 has less geographical detail, the total figures are allocated to municipalities in the same proportions as 2022.

[xii] We used this figure based on the fact that, in 2022, around 760 000 foreigners resided in Portugal, 70 000 of which benefitting from the expatriate retiree tax scheme and 12 000 others from a residence-by-investment 'golden visa' permit (SEF, 2022).