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Can More Housing Supply Improve Affordability? Insight from Europe's Fastest Appreciating Housing Market

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Acknowledgements

At times, it did feel like a lonely endeavour.

But more often than not, others were there to help. To them, I owe my gratitude.

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To my parents, for their limitless love and support.

Abstract

120 000 new homes were built in Portugal between 2011 and 2021, four hundred thousand fewer than in the previous decade. This dissertation examines to what extent this faltering supply is to blame for the exceptionally high housing prices the country currently faces. Surprisingly, many seem convinced of the opposite, contending that traditional market mechanisms may not apply to the housing market and putting into question whether an expansion of supply is the appropriate policy response to the current crisis. To assess this, a spatial econometric model is developed that is capable of discerning the determinants of house prices in Portugal. The results do show a negative correlation between housing stock and prices, but lead to an underwhelming prediction: had housing construction kept the pace of the previous decade, prices would only be 3% lower; had it doubled the pace, providing a million new homes, just 7% lower. Meanwhile, the model uncovers a large price impact of the recent boom in 'Airbnb' properties and foreign demand in the country. A policy mix of sensible restrictions to these segments, combined with some supply growth, is shown to bring greater relief to price-afflicted areas than a large nationwide policy of supply expansion. The apparent necessity of restrictions to the tourism sector, to which Portugal owes so much of its recent economic growth, leaves a difficult dilemma for policy makers to solve.

JEL codes: R21, R23, R31, R38

Keywords: Housing affordability, Housing policy, Housing supply

Resumo

120 000 casas foram construídas em Portugal entre 2011 e 2021, menos quatrocentas mil que na década anterior. Esta dissertação examina até que ponto este défice de oferta é responsável pelos preços da habitação excepcionalmente elevados que o país hoje enfrenta. De modo surpreendente, muitos parecem convencidos do oposto, defendendo que os mecanismos tradicionais de mercado podem não se aplicar ao mercado da habitação e pondo em questão se uma expansão de oferta é a resposta política adequada à actual crise. Para avaliar isto, é desenvolvido um modelo econométrico espacial capaz de discernir os determinantes dos preços da habitação em Portugal. Os resultados do modelo mostram uma correlação negativa entre *stock* de habitação e preços, mas levam a uma previsão decepcionante: se a construção de habitação tivesse mantido o ritmo da década anterior, os preços seriam somente 3% inferiores; se tivesse duplicado o ritmo, fornecendo um milhão de novos fogos, apenas 7% inferiores. Ao mesmo tempo, o modelo desvenda um grande impacto nos preços associado ao recente crescimento do alojamento local e da procura externa no país. É demonstrado que uma combinação de políticas que envolva restrições razoáveis a estes segmentos e algum crescimento de oferta pode trazer um alívio maior e localizado nas zonas mais críticas do que uma grande política nacional de expansão de oferta. A aparente necessidade de restrições ao sector do turismo, ao qual Portugal deve tanto do seu recente crescimento económico, deixa um dilema difícil para os decisores de política resolverem.

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1. Introduction

Housing prices have been rising steadily across developed countries since the Great Recession. Portugal is a notable case of this trend, having witnessed some of the largest and quickest increases. As of 2023, nominal prices have increased by 108% since 2015[1], with the effects having been especially felt in the two main metropolitan areas in the country, Lisbon and Porto, as well as the popular tourist region of Algarve.

A striking consequence of this price surge is the degree to which it has worsened housing affordability, as household incomes have not been able to keep up. Since 2015, the country has seen housing prices increase nearly 50% more than income has, which is the largest gap in all OECD countries[2]. Housing now accounts for 39% of Portuguese households' expenditure, whereas in 2011 it accounted for 29% and in 2000 for just 20%[3]. The situation has developed so severely so as to now being unanimously described as a housing crisis.

Political and academic interest over the drivers of this surge in prices has been growing in Portugal but is yet to yield any robust, comprehensive answers. The usual demand-side factors such as disposable income, interest rates and population growth offer part of an explanation (Huget et al., 2022). A rise in tourist demand and in the attraction of foreign real estate investment have also been found to contribute to the escalation of prices (Peralta et al., 2020; Pereira dos Santos & Strohmaier, 2024). In addition, some studies uncover signs of speculative behaviour shaping the market, even if firm evidence of this has been difficult to produce (Cunha & Loureiro, 2024; Rodrigues et al., 2023).

But the main culprit appears to be the country's supply sector – between 2001 and 2011, it built over half a million new homes, while in the following decade, only 120 000. Portugal's newly elected government, aiming to address the crisis, has concurred with this diagnosis and laid as one of its main courses of action a boost in the market supply of homes (Governo, 2024). This follows the trend of many other countries where an increase of housing supply has been the solution most often put forward to tackle the issue of high house prices, even if debate persists on how this can be best be achieved (Burn-Murdoch, 2023).

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[1] INE (2023), *Índice de Preços da Habitação*.
[2] OECD (2024), *Housing prices (indicator)*.
[3] INE (2024), *Orçamentos Familiares 2022/2023*.

The idea of facilitating greater supply so as to relieve price increases seems to be in line with sound economic principles. Curiously, however, it appears a substantial number of common people are sceptic of this notion, as Nall et al. (2022) have discovered in a recent public survey conducted in the United States. When respondents were asked about the effect of a supply shock on prices for consumer goods, labour, or commodities, the vast majority of them gave correct answers. But when asked on the effect of an increase in housing supply on prices, the outcome was entirely different: 40% of respondents expected prices to rise as a result of that increase, and only a third said they would fall.

These findings echo a growing trend of political activism that is rejecting the premise that housing affordability can be improved through an expansion of supply and increasingly campaigning for restrictions in new market-led urban development. This so-called 'supply scepticism' has been gaining traction mainly in the United States, but some are beginning to voice similar ideas in Portugal. Its advocates propose a number of theories as to why the market for housing may behave differently from other markets, and not all are straightforwardly dismissible (Been et al., 2019).

The present dissertation examines some of the key arguments that underlie this scepticism by confronting them with recent evidence in economic research. Although it is mostly successful in disproving each idea individually, it is argued that the literature lacks a holistic approach capable of providing large-scale, credible evidence of a causal link between supply and prices. It is possible that the question of whether more supply can decrease prices is so readily evident for economists, given the fundamental principles of the discipline, that concerted efforts to provide meaningful evidence of this have been somewhat lacking.

This main aim of this study is thus to provide firm evidence that, even in a strained market such as Portugal's, with multiple confounding market factors such as tourism and foreign demand, it is possible to identify and quantify the effect of housing supply on prices. Furthermore, it seeks to use this evidence to generate concrete predictions of how and where prices could be lower had the country been able to build more homes, and with this contribute to the current housing policy debate in the country.

An econometric model of the housing market is developed and applied to the municipalities of mainland Portugal. The framework adopted is essentially cross-sectional: the aim is to describe the local determinants of housing prices in each municipality and discern the effect of each area possessing a different number of housing units on the local transaction prices of properties. Doing so requires a spatial econometric approach which, rather than assuming each municipality is an isolated unit, recognises that spatial spillovers between nearby areas are very likely to exist.

The model estimates obtained show that the stock of available homes is indeed a significant factor in housing prices in the country. All else constant, a municipality with a 1% higher number of homes will observe housing prices that are, on average, lower by 0.54%. But translating this estimate into more tangible insight by using the house price model to simulate alternative scenarios leads to underwhelming results. If the country had built as much housing as it did in the previous decade, the model's prediction is that the average house price would only be 3% lower; had it built double that, it would be 7% lower.

Meanwhile, the significant impact of tourism and foreign demand that the house price model identifies prompts the consideration of scenarios where restrictions are imposed on these variables. It is shown, for example, that constraining tourist accommodation rental properties to levels before the recent 'Airbnb' boom would result in house prices being 17% lower. Not necessarily advocating for such drastic restrictions, a main conclusion of this study is that a supply expansion cannot be expected to bear the full burden of solving the current problems of housing affordability. Rather, policy should be open to the idea of a broader set of measures that may require difficult political compromises to be made.

This dissertation is structured as follows. Section 2 places the theme of the dissertation in context by examining the topic of housing affordability and by performing a brief diagnosis of the situation in Portugal. Section 3 examines existing theory and empirical evidence of the connection between housing supply and prices. The main exercise then follows, with sections 4, 5 and 6 respectively dealing with the modelling framework, the data used in the analysis, and its results. Section 7 concludes.

2. Context

2.1. Why care about housing affordability?

It is questionable that the concept of affordability is well suited for economic inquiry. To state that agents are paying too much for a good relative to their capacity would be a normative judgement in contradiction with the conventional wisdom that in free markets under perfect competition prices reflect an efficient matching of consumer preferences with production possibilities.

However, the housing market is far from a freely competitive market, much owing to the special characteristics of the housing good. Homes are immobile and moving from one to another entails significant costs, limiting the possibility of markets to clear efficiently. They are at once consumption and investment goods, which means they are influenced not just by internal market conditions but also by those of alternative investments. Furthermore, supply is notably inelastic in the short-term, due to the time and effort required to erect new homes. Given these and other market imperfections, the housing market is prone to lead to less than ideal outcomes (Brueckner, 2011; Kholodilin, 2022).

Since shelter of some form is practically an indispensable condition for social integration and labour force participation, market deficiencies that lead to higher prices can be especially harmful for households. Evidence aggregated by Gabriel and Painter (2020) from multiple studies shows a consistent negative association between affordability and indicators of household quality of life, which is symptomatic of how cost-burdened households tend to depress expenditure on other vital goods in order to be able to afford housing.

But affordability may also have broader impacts on the wider economy. A decrease of affordability in a popular urban centre leads people to seek housing further away from that centre and commute across longer distances to reach it, as evidenced by studies by Tse and Chan (2003) and Ben-Shahar et al. (2020). This geographic expansion entails increases in transport costs, as it forces economic activity to be spread further out in space, and may also lead to problems of congestion in the routes of access to the centre.

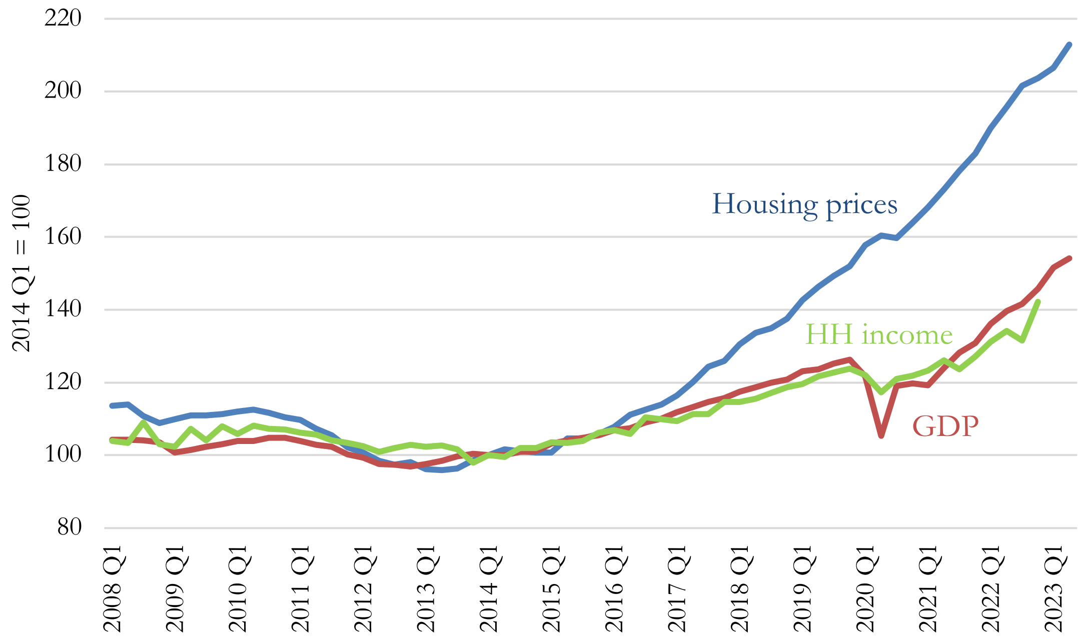
Moreover, a lack of affordable housing in an area with relatively high economic output can weaken its true potential by restricting the number of workers who could move there. This is a thread of research which has been taken up by Glaeser and Gyourko (2018) and Hsieh and Moretti (2019). They estimate significant losses of economic output in the United States due to housing market constraints which limit the movement of workers to the country's most productive metropolitan areas.

In summary, these contributions underscore the importance of researchers and policymakers maintaining a watchful eye over the housing market and its ability to deliver affordable accommodation to all to the greatest possible extent. As it will be examined in the following subsection, the Portuguese housing market appears to be failing this standard.

2.2. The situation in Portugal

Figure 1 plots the evolution of housing prices in Portugal since 2008 in comparison with household income and GDP. The recovery from the economic and financial crisis has led to modest income growth that has been unable to keep up with housing prices rising at a much faster pace. Even during the COVID-19 pandemic, prices showed little sign of being affected by the economic slowdown. It is this divergence between income and house prices has led to a serious deterioration of housing affordability for Portuguese households.

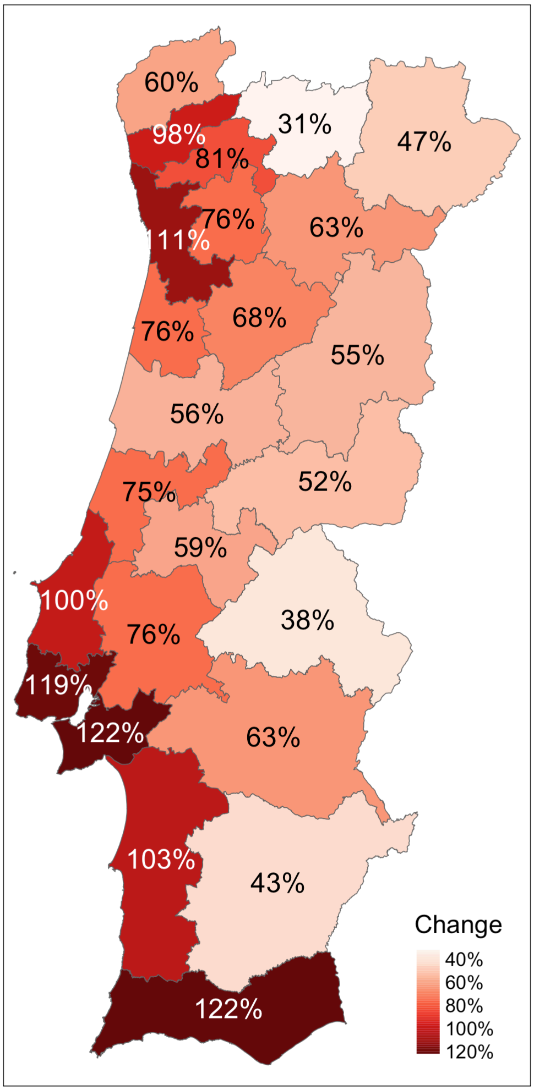
Figure 1: Housing prices, household income and GDP, 2008–2023 (nominal)



Source: INE and author's calculations

This problem is especially acute in a few areas of the country. Figure 2 charts the percentage increase in median house prices as measured by bank appraisals, which closely follow actual transaction prices (Huget et al., 2022), between 2014 and 2023 for each NUTS III region of mainland Portugal.

Figure 2: Change (%) in regional house prices (bank appraisals), 2014–2023



Source: INE and author's calculations

Prices have notably risen much more in the two largest metropolitan areas, Lisbon and Porto, and the southern region of Algarve than in the rest of the country. This heterogeneity matches the structural changes in the Portuguese economy in recent years. Tourism has been one of the largest drivers of economic growth, attracting millions of annual visitors and sizeable foreign direct investment to the three aforementioned regions. The growing hospitality sector competes for land use with housing, and thus can contribute to an increase in land price in these areas. Moreover, as these urban centres offer an increasing share of employment, they have become the main poles of attraction to migration flows, both from within the country (from the poorest, innermost regions) and outside it (INE, 2023).

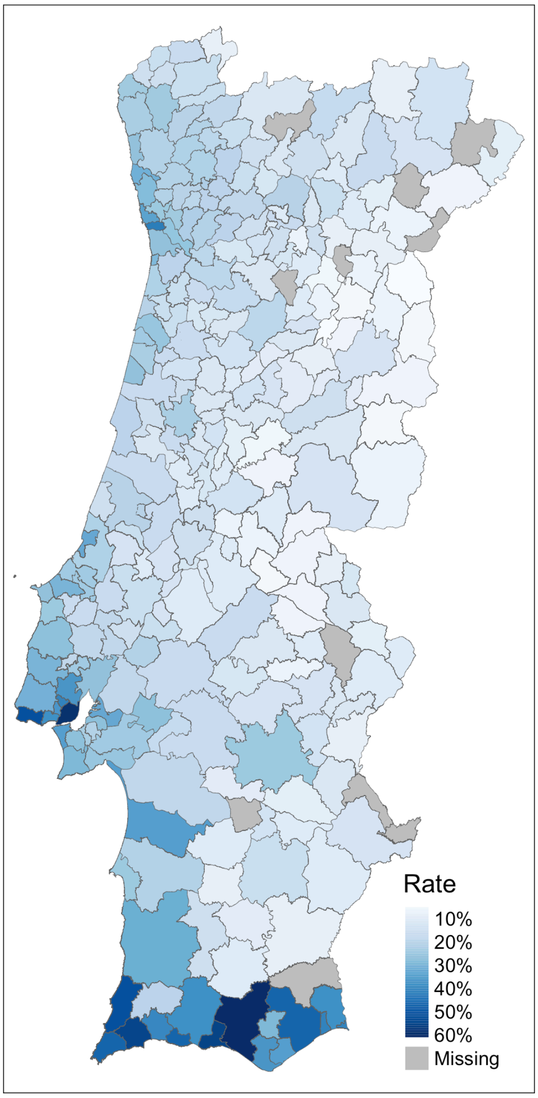
Furthermore, the country has tried to play off its strengths as a seaside country with good weather and affordable quality of life by seeking to attract migration of wealthy foreign residents. It has done so, most notably, by implementing policies that concede tax breaks or expedite routes to citizenship to those who choose to reside or invest in the country. As they have sought to do so mainly in Lisbon, Porto and Algarve, they only add to housing demand in these regions.

But high housing prices in the wealthiest, most productive areas of the country would not necessarily lead to worse housing affordability if firms were able to offer wages high enough to compensate the greater cost of living there. To assess the current level of housing affordability in Portugal, Figure 3 below plots the portion of its net income that a median household in each municipality would need to dedicate each year to purchase a 100 m^2 home, assuming they pay the house off regularly during a work life of 40 years. The map uses the most recent available data on income, which is from 2021; in any case, there is little indication of the situation having improved since then.

The map elucidates just how worse affordability has gotten in the main metropolitan areas compared to the rest of the country. Whereas in most municipalities this effort rate measures below 20%, in practically all municipalities in Algarve it is 40% or higher, in Porto 43%, and in Lisbon, almost 60%. The capital city is only trumped by Loulé, a municipality in Algarve, where this indicator reaches 60.1%. As this analysis excludes financing costs and the vast majority of households require a mortgage to purchase their home, the actual effort required of households is even greater than quantified here.

It should be stressed that these price increases do not impact all equally. Current owner-occupiers face these higher prices but possess an asset that has also appreciated. It is those that are outside the market and seeking to rent a home or acquire one for the first time that are increasingly being priced out of the largest, most attractive urban areas. Rodrigues et al. (2023) find that a household composed of two working individuals can now only afford a median dwelling in the cheapest areas of Lisbon and Porto if it is at or above the 60th income percentile, whereas in 2017 being in the 40th percentile in Lisbon and the 20th in Porto would suffice. The price increases also imply larger first deposits when acquiring homes, making it more difficult for young first-time buyers to have enough capital to enter the market. And as the country has a relatively small and feeble rental market, there is often little alternative to acquisition, leading households to incur on a mortgage much sooner than they perhaps would like.

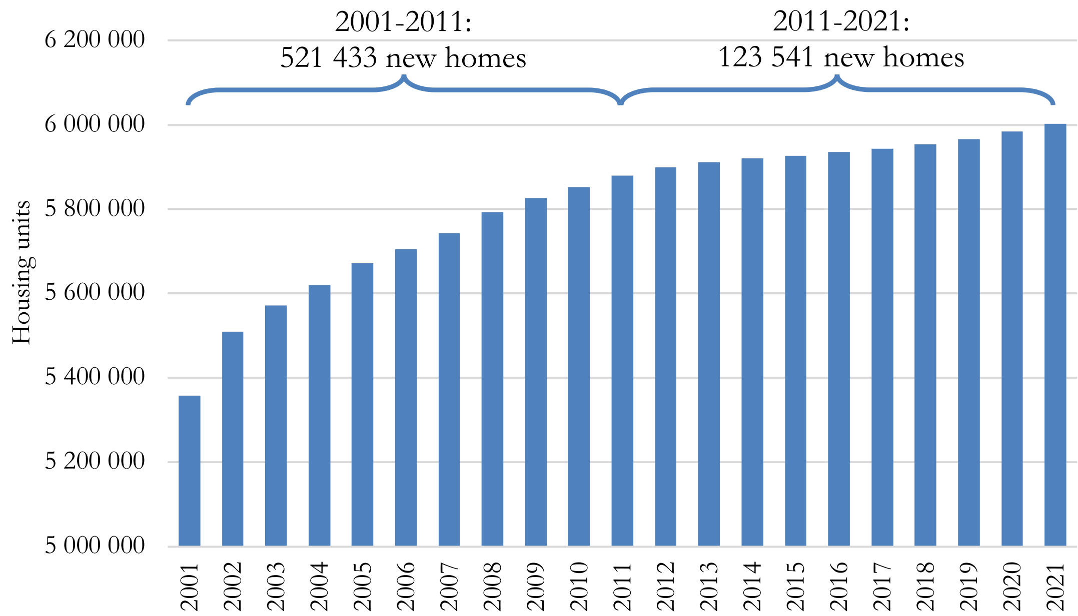
Figure 3: Housing affordability effort rates in municipalities, 2021



Source: INE and author's calculations

Meanwhile, it seems that supply has failed to respond to increased demand and produce more homes where people are seeking them. Figure 4 shows the evolution of the number of dwellings in the country in the past two decades and demonstrates how the pace of new housing construction has notoriously slowed down after 2011 and has yet to recover.

Figure 4: Housing units, 2001–2021



Source: INE and author's calculations

The causes for this slowdown in production of new homes are manifold. The construction sector was one of hardest hit by the economic crisis, of which it is still recovering. A change in urban policy by many cities has had them encourage rehabilitation of abandoned stock in city centres rather than new construction, which can often be more time consuming and technically complex work. Finally, the supply industry in the country has complained of a high tax burden and an ever-changing regulatory framework around licensing, construction, and the rental market, all of which are said to deter more investment in housing construction (Rodrigues et al., 2023).

But despite this slowdown, Portugal still has the third highest number of dwellings per capita of all OECD countries[4], which puts into question whether a lack of supply has really been a key factor in the escalation of prices. A recent INE (2024a) report, however, suggests that this headline number hides a misallocation of housing stock across the country. Homes are relatively more abundant in the innermost regions of the country than its main urban areas, in spite of growing trends of relocation and even international emigration away from its innermost regions. This is in no small part due to the age of the country's stock, with over half of its housing buildings dating from before 1980 and more than 80% from before 2000.

[4] OECD (2024), *OECD Affordable Housing Database, indicator HM1.1. Housing stock and construction.*

The troubles of the Portuguese housing market appear, then, to stem in some part from this rigidity of supply to adapt to substantial changes to the composition and volume of housing demand. In this light, the most natural solution to address the affordability problem in Portugal would be to seek to unlock a greater supply of homes, particularly in the locations where demand has risen substantially.

But this is if, of course, these shifts in demand are taken as a given. Some instead prefer to place the blame not on supply but on demand. In particular, those on the political left have focused above all else on the role that tourism and foreign demand have played in the escalation of housing prices in the country. They argue that placing restrictions on this demand would be a better solution to bring down prices than boosting market supply, and that it would have the added benefit of tempering the weight of tourism in the Portuguese economy, which they find to be excessive (Ferreira, 2023; G. Rodrigues & Murta, 2023).

In their defence, research evidence has been somewhat supportive of their claims of the impact of foreign demand being larger than first thought. For example, Peralta et al. (2020) look at the effects of the supply of short-term rental accommodation, such as Airbnb, on real estate prices. They estimate that a ban on the registration of new units that was enacted in some areas of Lisbon caused local house prices to fall by 8%, evidencing that the possibility of subletting homes in these platforms is a significant demand driver in the city. On another front, Pereira dos Santos and Strohmaier (2024) study the impacts of a controversial 'golden visa' programme, through which Portugal granted an expedite route to citizenship to foreign residents who invest at least $500,000 in real estate in the country. They find that the scheme boosted high-end real estate prices by, on average, 15%.

Nonetheless, anyone proposing demand-side restrictions invariably has to wrestle with the question of what effect that would have on an economy that has leaned so strongly on tourism and opening itself to the world to trail a path of growth after a heavy economic crisis. Whether the benefits of this choice outweigh the hardship that many face to afford a home, or whether a different path could be possible, are difficult political questions. For the moment, political consensus appears to have coalesced around rejecting any serious demand restrictions, instead seeking to promote more supply and not question the importance that these segments have assumed in shaping the country's economy and housing market. Even so, as will be seen in the next section, some continue to contend that more supply might still not solve the issue.

3. Supply and prices

3.1. The sceptics’ arguments

As alluded to before, solving the affordability problem through an expansion of housing supply would be an economist’s intuitive answer. However, scepticism over the ability of the housing market to provide for this has been growing, both in the general public (Nall et al., 2022) and in political actors (Been et al., 2019), especially as many of them have observed house prices increase despite a substantial amount of new construction in some countries. This subsection exposes the main arguments that these sceptics propose in their defence and the research efforts undertaken to rebut them.

A first argument put forward against market-led construction of new housing posits that since new housing projects are tendentially of a higher quality, they might do little to improve affordability for people with low incomes, who seek housing of lesser quality. Doubts are raised of the extent to which the different market segments are linked to one another (Aguirre et al., 2016). This is considered by some to be especially true in Portugal. Louçã (2023) argues that the supply sector has been led by the increase in tourism and foreign demand to focus on producing high-end stock catering to wealthier foreigners and ‘global investment funds’, so much so that he considers housing prices in Portugal to have fundamentally disconnected from local supply and demand.

Economic analysis of the housing market has, of course, paid attention to the fact that it is a market offering goods of very heterogeneous quality. It is true that new housing stock tends to be offered much more at the middle and higher segments than the lower ones, but as homes age, they depreciate and should ‘filter’ down to lower segments and become more affordable. Thus, in theory, it is not necessary for new housing stock to be offered directly in the lowest segments for there to be affordable homes (Sweeney, 1974).

The supply sceptics, however, would argue that this filtering process takes a considerable amount of time to offer new affordable homes for lower income people. As homes are very durable goods, its depreciation can take many years. Furthermore, they note that there are high-quality homes that possess such luxury features that might make it practically impossible for them to ever be considered as anything but luxury homes. Given these shortcomings, they often propose restrictions to new market-led urban development so that in its place affordable public housing can be built.

Assessing whether the filtering mechanism is operating as theory predicts it has required researchers to obtain detailed data on 'chains' of housing moves, that is, the moves that are initiated when a household inhabits a brand-new home and frees up their old house for another household to move into, who in turn frees up their old home, and so on. The results obtained so far have been somewhat positive.

In the United States, Mast (2023) collects evidence allowing him to estimate that a new market-rate development in a city centre for 100 households would induce a chain of moves that would free up between 45 and 70 homes in low-income areas, most of them within three years. For Finland, Bratu et al. (2023) estimate similar sized effects in an even shorter time span, within one to two years. For Germany, Mense (2023) goes further by using this type of data to discern the impacts on the distribution of rents, finding that increasing new supply by 1% can decrease average rents by 0.2% through a disproportionate increase in the number of second-hand units offered for rent.

Although these studies prove that the filtering mechanism does operate, they show that the connection between segments can be imperfect and that indeed not all homes are able to filter down to lower segments. Thus, if housing production is found to be excessively geared to the highest segments, there are valid concerns that such supply will not help much to lower average prices. This matches the conclusion of Rosenthal (2014) that, through a different method of analysis, finds that filtering process tends to be weaker in places with wealthier demand. For these areas, more direct policy intervention could be adequate to temper problems in housing affordability, such as the granting of subsidies to the production of affordable homes or zoning regulations that dedicate space for this segment of housing.

The second point raised by the sceptics argues that new housing development may tend to increase the prices of other homes in its vicinity. Be it because a new building could improve the physical landscape of the area or because its new residents may draw new services and amenities to locate in the neighbourhood, the local area may become more attractive to those who are seeking housing and push up the values of local properties and rents. These concerns are even greater if the new development is catered to high-income residents, as it could be a sign of gentrification. All in all, the argument is that even if an increase in the number of dwellings exerts negative price pressure (the supply effect), the local impact to its surroundings (an amenity effect) could work against it.

Recent research has found that the supply effect very much dominates the amenity effect. Of note are studies by Pennington (2021) and Li (2022), which look at the impacts of new development in the cities of San Francisco and New York, respectively. Both find causal impacts of new housing units on local business turnover in its vicinity, which is indicative of a possible amenity effect. But they conclude, with different strategies to control for endogeneity, that even in relative proximity of new housing units the supply effect wins out, estimating a net decrease of residential property prices as a result. Nonetheless, even if this were not the case and the amenity effect prevailed, one could hardly argue that this would be net negative in terms of welfare, as residents naturally draw utility both from the amenities available to them and their disposable income.

Finally, the third argument to be examined here contends that increasing supply may induce additional local demand for housing and therefore have little effect on prices. For example, suppose there is an increase of housing supply in a highly sought out area to live in. As the new homes are taken up, prices should decrease. Crucially, though, local population in this area would increase and, as a result, so would household demand for goods and services in the area. Producers of these goods would respond to this increased demand by expanding their supply, which would require more labour. These new job listings would attract more people to settle to the area and fuel more housing demand. Thus, an initial supply increase could, in time, induce additional demand, limiting the extent to which prices could decrease, and thus do little to improve affordability.

This hypothesis has been put forward in studies by Fingleton (2008) and Fingleton et al. (2019). Their reasoning is to some extent a corollary of the New Economic Geography trend inaugurated by Krugman (1991), which conceives the spatial structure of economic activity as composed of 'core' and 'periphery' regions. The core regions – cities – are the places where, as a result of agglomeration economies, economic activity is further and further concentrated at the expense of the ever-emptier periphery. As Helpman (1998) notes, housing will inevitably be more expensive in the core, since its supply requires land, of which there is a limited amount in these regions. The relative expensiveness of housing thus acts as somewhat of a counterbalance to the centripetal force of agglomeration, as the higher cost of living deters migration. As such, an exogenous policy which increases housing supply may attenuate this counterbalancing force, allow more people to afford living in the core, and ultimately do nothing but to feed the source of the problem it originally sought to remedy.

The 'core-periphery' framework seems very applicable to the recent development of the Portuguese economy, which has seen a notable increase of concentration of population and economic activity in the coastal regions, and in particular in its two largest metropolitan areas, Lisbon and Porto, at the expense of the innermost parts of the country. That supplying more homes in those areas would only aggravate this phenomenon and therefore be to some extent a further cause of housing affordability problems seems, *prima facie*, an interesting hypothesis to explore.

However, an empirical analysis capable of detecting such an induced demand effect would be very difficult to implement. It would require a model that could simultaneously describe the housing market, the labour market, and how these two determine the relocation of households from one area to another. Attempts at developing such a model, such as by Fingleton (2009), are invariably conducted at such a level of abstraction that there is little hope of discerning this hypothesis with any statistical significance. Any possible reinforcing effects of increased housing supply on the concentration of population in large urban areas would be relatively small, and invariably tied up with all other mechanisms through which cities continue to attract growing numbers of people.

Nonetheless, this contribution is valuable in so far as it brings to light the fact that housing markets are inextricably linked to the spatial dynamics of economic activity, which no doubt exhibit a trend to concentrate growing numbers of people in urban areas. To continue to accommodate them, it seems they have little choice but to expand in size. But at some point, regional policy may come to question whether this is sustainable or desirable. In Portugal, for example, the two main metropolitan areas, which take up only 5% of the country's land, now harbour almost half of the national population. Any study, especially if it is geared towards policy purposes, ought to be mindful of this reality.

To sum up, examining the sceptics' arguments one by one has enabled us to refute them in essence but, especially in what concerns the first and the third one, not with full certainty. To solidify these conclusions, more direct empirical evidence of a link between supply and prices is sought in the next subsection.

3.2. Empirical strategies

Shedding light on the effects of supply on prices in any market naturally faces a problem of endogeneity. The foremost strategy in the literature to deal with this issue has been to take the strictness of land use policy in a given area as an instrument. The underlying idea is that more restrictive regulation can stifle construction activity and lead to fewer homes being built than intended, which can then serve to elucidate the effects that lesser supply has on housing prices. These studies have been the main port of call to refute the sceptics' claims (Been et al., 2019).

Gyourko and Molloy (2015) survey this literature and find a body of evidence, mostly from the United States, that suggests that areas with stricter regulations do in fact experience higher house prices. However, as they duly note, the methodology on many of the studies they collect can raise doubts over whether this correlation is causal. Most of them, such as Katz and Rosen (1987) or Malpezzi (1996), employ a cross-sectional approach across metropolitan areas. For the results to hold, this requires assuming that land use regulations are not correlated with any omitted variables which could at the same time be correlated with price. In reality, valuable amenities deriving from location could well be examples of such variables (Hilber & Robert-Nicoud, 2013) and so could spatial constraints (Saiz, 2010).

To exemplify, are housing prices high in New York purely because of heavy planning restrictions, or are those heavy restrictions just a consequence of the density at which the city is inhabited because of its attractivity, and it is that attractivity that is driving prices to be high? Likewise, in the coastal and hilly city of San Francisco, are planning restrictions a cause of high prices or just a consequence of its geographical constraints which compel a more cautious land use policy, and it is those physical constraints which are limiting the supply of land and housing? The method employed by this sort of studies is inherently unable to deal with this issue.

In light of this limitation, Glaeser and Ward (2009) study the link between regulation and prices by using panel data and implementing local fixed effects. Their results show no significant correlation between regulation and price when controlling for local characteristics. In their view, this is due to local areas being very close substitutes to one another. Though no conclusive evidence of this is offered, supply constraints in one jurisdiction appear to just shift development to surrounding areas that have fewer restrictions, with virtually no effect on housing prices.

A different approach to tackle endogeneity is then taken by Accetturo et al. (2021), who use physical constraints as an instrument to predict the price elasticities of housing supply of metropolitan areas in Italy. They then test whether cities with low elasticities, when faced with a positive demand shock, experience higher housing price increases than those with high elasticities. They conclude that this is in fact the case, which is interesting evidence of the connection between supply and prices, but the methodology they use does not lend itself to a determinate quantification of this effect.

A clearer definition of 'housing supply' can perhaps be of use to unburden us of the problem of endogeneity. So far, this term has been used to refer interchangeably to both the concept of market supply – the number of housing units available for purchase in the market at some given moment in time – and the concept of housing stock – the total number of inhabitable housing units. Distinguishing between these two allows us to see that, while the former is certainly endogenous to price, the latter may not be so. Housing construction can take a considerable amount of time to provide new units, such that the number of new homes finished each year is a reflection of decisions taken years before, decisions often based on market prices observed then or mere expectations of what prices would be in the future. As such, housing stock and prices can be exogenous enough to model the two directly and quantify the impact one can have on the other.

Very few studies have developed models under this assumption. Anenberg and Kung (2020) implement a discrete location choice model in the United States and study the impact of an exogenous increase of housing stock on rental values. They show that the effect of a 1% increase in housing stock on rents is negative but fairly low, being less than 0.1% for a number of U.S. metropolitan areas. Freemark (2024), on the other hand, take U.S. counties as the unit of analysis but estimate similar size elasticities, only marginally different from zero, for both prices and rents. The two studies therefore appear to offer the interesting conclusion that increases in housing supply are not the most effective route to improving housing affordability, at least in the United States.

However, these results still suffer from a problem affecting many studies that compare housing markets across locations – they fail to account for the possibility of spatial spillovers, that is, how conditions in one area may affect those of others nearby. For example, if in a given area housing supply is faltering and prices rise, its inhabitants have the option of moving elsewhere and just commute to and from their old place of residence if that remains their place of work. Ignoring this possibility may distort the results obtained.

A growing number of studies have paid attention to the importance of spatial relationships in modelling the housing market. Osland (2010) is of note in its discussion of alternatives for the spatial modelling of house prices, elucidating how spatial econometrics is able to provide useful explanatory models, statistical tests and theoretical intuition for this purpose. Empirical research efforts have since ensued, both in a static, cross-sectional setting, like Wang et al. (2017), and in time-series analysis like those conducted by Kuethe and Pede (2011) or Cohen et al. (2016), all of which uncover significant evidence of these spatial spillovers being a determinant factor in local housing markets.

The problem of spatial correlation is larger the smaller and the closer to one another the spatial units of analysis are. Given the relatively small size of Portugal and the aim of drawing conclusions at the level of local municipalities, it seems apt that the model of this dissertation fully incorporates the possibility of spatial spillovers.

4. Model

The modelling framework adopted here is in the tradition of the hedonic price model developed by Rosen (1974), which describes how consumers value differentiated goods based on the attributes or characteristics of each available variety. This approach has been widely used to explain individual house prices and remains predominant in housing and urban economics (Brueckner, 2011). Here, it is applied to describe location choice rather than individual property choice, and is mainly inspired by models developed by Fingleton (2008), Osland (2010) and Baltagi et al. (2014).

In light of the goal of deciphering the impact supply can have on prices, the model presented here possesses two noteworthy features. Firstly, housing supply is modelled under the assumption that the stock of housing units is exogenous to market conditions at each moment in time. This will allow the model to provide an estimate of the elasticity of price to the number of dwellings and be used to simulate scenarios where exogenous changes are affected to explanatory variables.

Secondly, the cross-sectional frame of analysis requires the consideration of spatial correlation between locations. Informed by the evidence discussed in the previous section, the price of housing in each location is assumed to be determined not just by local factors but also by the level of prices of municipalities nearby. The higher the level of surrounding prices, the more likely it is a municipality will absorb some of the demand arising from its neighbours, with individuals then having to commute across locations to access the workplaces and amenities they desire.

There are N locations indexed by $i = 1, 2, \dots, N$. At time t, demand and supply shape a market for the housing good $Q_{i,t}$, which participants transact at a price $P_{i,t}$. Prices are per square metre, so the quantity of this good is measured in total square metres of housing units. All other individual amenities of homes are subsumed into this measure and not explicitly modelled. The price $P_{i,t}$ is therefore not so much a price that market participants could observe directly, as more a reflection of the value of the average housing unit in each location.

4.1. Demand

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

$$Q_{i,t}^{D} = P_{i,t}^{\delta_1} \, (\mathrm{W}_i \mathrm{P}_t)^{\delta_2} \, Y_{i,t}^{\delta_3} \, F_{i,t}^{\delta_4} \, D_{i,t}^{\delta_5} \, T_{i,t}^{\delta_6} \, e^{\delta_0 + \tau_t^D + \varepsilon_{i,t}^D} \, . \tag{4.1}$$

Demand should be negatively correlated with the local price $P_{i,t}$ (the elasticity δ_1 be negative) through two main effects. The first is obvious: if prices rise, households will tend to seek smaller homes and with fewer amenities. The second is the spillover mechanism described previously: facing higher prices in a given location, households may give up searching for housing there and start looking in other places close by where prices are lower.

To capture the other side of this phenomenon, housing demand must then also depend on the prices of other locations. Naturally, not all locations will be equally relevant. Intuition would suggest that the strength of the connection between two locations should be larger the closer they are to another, as it is then easier for agents to possess or collect relevant information. To put this idea in practice, consider a N by N matrix $\mathbf{W}^*$ whose cell (i, j) denotes the importance that the price in location j has on housing demand in location i:

$$W_{ij}^* = \begin{cases} \dfrac{1}{d_{ij}^2}, & 0 < d_{ij} < 50 \\ 0, & otherwise \end{cases}, \tag{4.2}$$

with d_{ij} being the distance between locations i and j, measured in kilometres. That is, the strength of spatial correlation decreases in inverse proportion to the square of the distance between locations. Connections between locations at a distance above 50 km are disregarded. This is done as the calculated weights at those distances become miniscule and in order to turn the matrix less dense and reduce computational complexity. To ensure comparability between locations, $\mathbf{W}^*$ is row standardised into $\mathbf{W}$, whose cell (i, j) is hence given by:

$$W_{ij} = \frac{W_{ij}^*}{\sum_j W_{ij}^*} \,. \tag{4.3}$$

This matrix provides us then with an adequate set of weights to attribute to each linkage between locations. Taking row i of $\mathbf{W}$ and multiplying it with 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 what is included in the demand specification.

The third variable included is household income, $Y_{i,t}$. This should be the main driver of housing demand in each location – the higher the aggregate income, the higher the housing demand – either because high aggregate income is due to high population, which would then mean a high number of housing units is sought, or due to a substantial number of wealthy residents, which would then mean larger, better housing units are sought.

Next, $F_{i,t}$ denotes the number of registered foreign citizens living in each area. This is included in the suspicion that their propensity to buy is not fully reflected in declared income data. For example, Portugal possesses an attractive tax regime that has attracted a good number of foreign pensioners, whose wealth is much more a result of their past income than their current one. This regime benefitted more than 70 000 people as of 2022[5]. This is deemed relevant enough to include since the portion of homes acquired by foreign citizens and institutions in Portugal is significant, especially so in some regions – in 2023, these accounted for 27% of all house purchases in Algarve[6].

Demand is also a function of the amenities of each location. The specification considers two amenities. Firstly, it includes $D_{i,t}$, the density of employment at each location. This is in keeping with urban economic theory suggesting that locations with a greater concentration of employment lead, through increasing returns to agglomeration, to a larger variety of goods being offered there (Ciccone & Hall, 1996). Households expectably prefer to live in locations where they can access a greater range of consumption goods and services.

The second amenity is $T_{i,t}$, the number of tourist overnight stays. This is included, first and foremost, as there are a number of location-specific amenities which could be common drivers to tourism and housing demand, such as proximity to the coast, beaches, and other natural and cultural points of interest. The level of tourism in each location can thus be used as somewhat of an instrument to capture these underlying amenities, which are often difficult to quantify.

Secondly, tourism may also have direct effects on housing demand, as evidenced by Biagi et al. (2015) in Italy or Schäfer and Hirsch (2017) in Berlin. These include both positive effects, in that the provision of certain services catered to tourists may also benefit local residents, such as certain commercial or cultural establishments; and negative ones, through the negative externalities of tourism such as congestion and gentrification.

The final term deals with all other relevant but unobserved factors. A part of these is assumed constant and estimated by the coefficient δ_0. Time fixed effects, τ_t^D, are included to capture time-variant factors common to all locations, such as interest rates and economic sentiment. All other location-specific unobserved factors, such as amenities deriving from public

[5] Tribunal de Contas (2023), *Parecer sobre a Conta Geral do Estado 2022*, p. 191.
[6] INE (2024), *Transações de alojamentos familiares por localização geográfica*.

services, the level of local taxes, the social composition of the area or criminality are captured by a mean zero error term $\varepsilon_{i,t}^{D}$. The standard assumption would be to take these errors as originating independently from a normal distribution. But it is highly likely that many of these unobserved variables are not randomly distributed but rather spatially correlated. This may be due to spillover effects – for instance, a public amenity such as a hospital catering to local residents and those of nearby municipalities – or because some variables are likely to appear in clusters rather than randomly – criminality, for example. In this case, assuming i.i.d. errors would be inadequate and lead to slightly incorrect inference estimates. To address this, $\varepsilon_{i,t}^{D}$ is modelled by the specification proposed by Kapoor et al. (2007):

$$\varepsilon_{i,t}^{D} = \eta_{i}^{D} + \mu_{i,t}^{D} + \lambda\, \mathrm{W}_{i}\, \varepsilon_{t}^{D}. \tag{4.4}$$

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 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 due to the influence of locations nearby, $\lambda\, \mathrm{W}_{i}\, \varepsilon_{t}^{D}$. 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.

4.2. Supply

Housing supply is modelled from the perspective of property owners and their decision to place their housing units in the market. The quantity supplied is thus 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, that probability is described by the product of a set of explanatory variables. The supply function then comes as:

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

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

$$\Leftrightarrow Q_{i,t}^{S} = P_{i,t}^{\gamma_1}\, (\mathrm{W}_i \mathrm{P}_t)^{\gamma_2}\, H_{i,t}^{1-\gamma_3}\, B_{i,t}^{\gamma_3}\, e^{\gamma_0 + \tau_t^S + \varepsilon_{i,t}^S}. \tag{4.5}$$

First and foremost, the probability of supply is expected to be positively correlated with price – the greater the prices property owners observe, the more willing they will be to want to sell their units now rather than later. By including the spatial average of prices, the possibility of owners responding to the level of prices nearby is also accounted for.

Based on the previous discussion of the impacts of rental tourism accommodation on the housing market, its prevalence in each location is also assumed to be a determinant factor for the probability of supply. Over 100 000 establishments of this nature are currently registered in Portugal[7], mainly situated in regions with high tourism demand. The offer of tourism house rentals has been shown to come primarily from units that were not owner-occupied in the first place (Barron et al., 2021), meaning its offering 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 of 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 which admits spatial autocorrelation $\varepsilon_{i,t}^S = \eta_i^S + \mu_{i,t}^S + \lambda \, W_i \, \varepsilon_t^S$, where $\eta_i^S \sim N(0, \sigma_{\eta^S}^2)$ and $\mu_{i,t}^S \sim N(0, \sigma_{\mu^S}^2)$.

4.3. Equilibrium and estimation

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

$$P_{i,t}^{\delta_1} (W_i P_t)^{\delta_2} Y_{i,t}^{\delta_3} F_{i,t}^{\delta_4} D_{i,t}^{\delta_5} T_{i,t}^{\delta_6} e^{\delta_0 + \tau_t^D + \varepsilon_{i,t}^D} = P_{i,t}^{\gamma_1} (W_i P_t)^{\gamma_2} H_{i,t}^{1-\gamma_3} B_{i,t}^{\gamma_3} e^{\gamma_0 + \tau_t^S + \varepsilon_{i,t}^S}. \quad (4.6)$$

Rearranging with respect to price:

$$P_{i,t}^{\gamma_1 - \delta_1} = (W_i P_t)^{\delta_2 - \gamma_2} Y_{i,t}^{\delta_3} H_{i,t}^{\gamma_3 - 1} F_{i,t}^{\delta_4} D_{i,t}^{\delta_5} T_{i,t}^{\delta_6} B_{i,t}^{-\gamma_3} e^{(\delta_0 - \gamma_0) + (\tau_t^D - \tau_t^S) + (\varepsilon_{i,t}^D - \varepsilon_{i,t}^S)}, \quad (4.7)$$

applying logarithms:

$$\begin{aligned}(\gamma_1 - \delta_1) \, ln \, P_{i,t} = {} & (\delta_0 - \gamma_0) + (\delta_2 - \gamma_2) \, ln \, W_i P_t + \delta_3 \, ln \, Y_{i,t} \\ & + (\gamma_3 - 1) \, ln \, H_{i,t} + \delta_4 \, ln \, F_{i,t} + \delta_5 \, ln \, D_{i,t} + \delta_6 \, ln \, T_{i,t} \\ & - \gamma_3 \, ln \, B_{i,t} + (\tau_t^D - \tau_t^S) + \left(\varepsilon_{i,t}^D - \varepsilon_{i,t}^S\right), \end{aligned} \quad (4.8)$$

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

$$\begin{aligned} ln \, P_{i,t} = {} & \beta_0 + \rho \, ln \, W_i P_t + \beta_1 \, ln \, Y_{i,t} + \beta_2 \, ln \, H_{i,t} + \beta_3 \, ln \, F_{i,t} + \beta_4 \, ln \, D_{i,t} \\ & + \beta_5 \, ln \, T_{i,t} + \beta_6 \, ln \, B_{i,t} + \tau_t + \varepsilon_{i,t}, \end{aligned} \quad (4.9)$$

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

[7] Turismo de Portugal (2024), *Estabelecimentos de Alojamento Local—Dados Abertos*.

The model arrived at here merits some discussion. Firstly, note that this structure of error terms amounts to a random effects model. This is preferred to a fixed effects structure as the frame of analysis here is eminently cross-sectional – how one location differs from one another – rather than temporal – how year-on-year changes in each variable affect prices. As the panel data used for estimation consist of many more locations (254) than time periods (3), a cross-sectional model is practically a necessity to obtain insightful results.

Secondly, note the presence of the term $\rho \; ln \; \mathrm{W}_i\mathrm{P}_t$, which is what enables us to account for spatial spillovers (ρ is used to distinguish this regression coefficient from others). This type of econometric model is referred to in the literature as 'spatial autoregressive' (SAR), due to the dependent variable being regressed with its own values in other locations.

Though a prominent feature of modern spatial econometrics, this approach has been criticised by some in the literature. Without doubt, if spatial correlation in the dependent variable exists but is omitted, model estimates would be biased and inconsistent (LeSage & Pace, 2009). But some, like McMillen (2010) or Pinkse and Slade (2010), argue that the inclusion of an autoregressive term is a crude technique of capturing the effect of spatial correlation, as it relies on an arbitrary specification of the structure of spillovers, which inherently lacks any empirical basis. Gibbons and Overman (2012) say this is a reflection of a mechanistic and descriptivist approach that is common in applied spatial economics, often more interested in achieving a good data fit than identifying the causal economic processes originating those data.

Granted, it is difficult to argue that a spatially weighted average is an accurate reflection of how economic agents perceive or are influenced by distance. Spatial weights are ultimately defined on the basis of a cursory notion of how near things should, in principle, be more correlated than further ones. But crucially, as LeSage and Pace (2014) contend, the significance of results obtained by SAR models rarely depends on the specific form of spatial weights adopted. This is confirmed for the present model in the Appendix, where it is shown the results of the model generally hold under various alternative specifications of $\mathbf{W}$. The form of spatial weights chosen for this model is based on its relative simplicity and since it is the most common one in spatial econometrics (Arbia et al., 2021).

Thirdly, it should be evident that household income in each municipality, $Y_{i,t}$, is endogenous to housing prices, as households decide where to reside taking into account, among other things, the house prices in each location. To address this, an instrumental variable is introduced. It is assumed that household income is heavily driven by the potential labour income close by, that is, the employment positions available in and around each municipality and their respective remuneration. This prediction of the level of household income deriving from labour, denoted $Y_{i,t}^{L}$, is assumed exogenous to house prices and therefore suited to instrument total household income.

$$Y_{i,t}^{L} = \mathbf{C}\,\mathrm{E}_t\,\mathrm{w}_t\,. \tag{4.10}$$

Here, $\mathbf{C}$ is an N by N column-standardised 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 wages paid to them. The matrix $\mathbf{C}$ refers to the flows observed in the 2011 census, predating the period of analysis to assume exogeneity, and is fixed for all t. This strategy is inspired by shift-share analysis, also known as a Bartik instrument after his econometric implementation (Bartik, 1991). The underlying idea is to fix the structure of links between each municipality – the 'share' – and exploit 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.

The autoregressive nature of the model poses challenges to estimation. The method of ordinary least squares is incapable of estimating the autoregressive parameters simultaneously with the remaining coefficients. SAR models such as this one therefore require iterative estimation either by maximum likelihood (ML) or general method of moments (GMM). The models in this dissertation are estimated with Stata, which implements ML estimators apt for spatial panel data models (StataCorp, 2023)

5. Data

Estimations of the house price model are performed using panel data on the municipalities of mainland Portugal between 2019 and 2021. Practically all data are made available by Portugal's national statistical office, INE, most of which originates from confidential administrative datasets. This section presents the data in more detail and its descriptive statistics in Table 1 below.

For housing prices, the annual median transaction price per square metre in each municipality is used. This is obtained from the registry of all housing acquisitions maintained by the national tax authority. 24 of the 278 municipalities are excluded due to missing values in one or more of the three years for which the analysis is conducted. Given the assumption of spatial correlation between observations, the exclusion of missing values means coefficient estimates will be biased and inconsistent. However, given the fact that these are predominantly small municipalities, the sum of their housing stock representing less than 2% of the national total, these effects are arguably small enough to not disturb the general results of the dissertation. This is attested in the Appendix, where it is shown that removing an additional 24 small municipalities from the sample has a negligible effect on the coefficient estimates.

Data on household income refers to total net income for the inhabitants of each municipality as declared to the tax authority. As discussed, this is instrumented with data on local employment and wages, which are obtained from the national social security registry, and with the matrix of commuting flows between municipalities observed in the 2011 census.

The housing stock is 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 each year. The number of housing units is then multiplied by their average surface area in each municipality, as recorded by the census.

For foreign residents, the national border and migration agency registers the number of foreign nationals living in each municipality with a legal permit of residence.

Tourism is measured by the number of overnight stays in hospitality establishments. These include stays in hotels, hostels and large homestay properties for each municipality as obtained from a regular mandatory survey. Other more informal forms of tourism accommodation, such as camping parks and small homestays, are not included.

Data on homestay establishments are collected from the national tourism office, which keeps a registry of all properties, their opening date, their capacity and other details. It does not keep information on the area of each property. To estimate this, the lodging capacity of each establishment is 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 centres but their population-weighted centroids, as is common in geographical analysis (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

		Mean	SD	Min	Max
Main regression variables:					
P	Median house price p/m^2	811.2	482.5	156	3 531
Y	Household income (k€)	334 584.5	649 280.2	15 120	7 337 921
H	Housing stock (m^2)	2 507 632.0	3 187 404.0	270 459	30 206 241
F	Foreign residents	2 497.1	8 019.8	12	108 653
D	Employment density	0.8	2.9	0.01	32
T	Tourist stays	149 316.7	709 982.5	0	13 985 262
B	Homestay properties (m^2)	68 690.3	267 662.9	169	3 716 971
Auxiliary variables:					
w	Average annual wage	14 628.9	2 409.6	11 121	28 543
E	Employment	8 609.3	22 467.9	237	318 799

Note: SD – standard deviation.

6. Results

6.1. Model estimates

Table 2 presents the coefficient estimates of the house price model under various specifications. The first two columns exclude any spatial effects. In column 1 income is assumed exogenous, while in column 2 and all subsequent ones, it is instrumented as described in Equation 4.10.

To examine the validity of the inclusion of spatial effects, Moran's I test is performed, which tests for the presence of spatial correlation in the regression residuals. As $\bar{I} \sim N(0, 1)$, the test statistics for models 1 and 2 overwhelmingly reject the null hypothesis of no spatial correlation of residuals, confirming the need for an explicit consideration of spatial effects in the model specification. The relatively high R^2 statistic of model 2 suggests, in any case, that the variables included in the model are a good basis for further analysis.

In column 3 the spatial autoregressive term is introduced, but the error terms remain i.i.d. The coefficient obtained for the endogenous spatial lag is very significant, indicating that prices of nearby municipalities are indeed a determinant factor for prices in each location. However, the $\bar{I}$ test statistic for this model indicates that some correlation of residuals remains. This is in part to be expected, as the spatial lag of the dependent variable introduces a displacement effect of conditions in one location to surrounding ones. But it could also be indicating the presence of spatial correlation of unobserved factors, which would mean that the assumption of i.i.d. errors is inadequate.

Column 4 exhibits the results of the full spatial model with autoregressive errors. The estimate obtained for parameter λ is significantly negative, which is at odds with what would be expected. Rather than indication of negative spatial correlation of error terms, this is likely the result of a concern raised by LeSage and Pace (2009), who note that the estimation of models with simultaneous autocorrelation in the dependent variable and errors can struggle with proper identification of parameters.

This leads to model 3 being elected as the preferred specification for subsequent analysis. Since the disregard of the possibility of error correlation does not result in any bias of model coefficients, only a small loss of efficiency and consistency (LeSage & Pace, 2009), this simpler model is deemed satisfactory enough to proceed.

Table 2: Estimates of house price models

	1	2	3	4	5
Constant	7.098 **	7.201 **	3.896 **	3.074 **	3.953 **
	(0.417)	(0.435)	(0.461)	(0.517)	(0.459)
$ln\ \mathrm{W}_i \mathrm{P}_t$			0.400 **	0.499 **	0.398 **
			(0.037)	(0.049)	(0.037)
$ln\ Y_{i,t}$	0.340 **	0.397 **	0.269 **	0.252 **	0.277 **
	(0.066)	(0.092)	(0.070)	(0.064)	(0.070)
$ln\ H_{i,t}$	-0.464 **	-0.519 **	-0.326 **	-0.290 **	-0.337 **
	(0.072)	(0.096)	(0.074)	(0.068)	(0.074)
$ln\ F_{i,t}$	0.147 **	0.141 **	0.088 **	0.074 **	0.088 **
	(0.018)	(0.019)	(0.016)	(0.015)	(0.016)
$ln\ D_{i,t}$	0.079 **	0.071 **	0.042 **	0.029 *	0.042 **
	(0.016)	(0.019)	(0.015)	(0.014)	(0.015)
$ln\ T_{i,t}$	0.011	0.011	0.020 *	0.023 **	0.020 *
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
$ln\ B_{i,t}$	0.114 **	0.117 **	0.081 **	0.071 **	0.082 **
	(0.015)	(0.016)	(0.014)	(0.014)	(0.014)
τ_t					
2020	0.053 **	0.052 **	0.034 **	0.031 **	0.034 **
	(0.011)	(0.011)	(0.011)	(0.009)	(0.011)
2021	0.059 **	0.055 **	0.027 *	0.021 *	0.027 *
	(0.012)	(0.012)	(0.012)	(0.010)	(0.011)
$\mathrm{W}_i\ \varepsilon_t$				-0.280 *	
				(0.112)	
Observations	762	762	762	762	762
R^2	0.809	0.809	0.843	0.845	0.844
Log likelihood			360.82	363.93	361.64
$\bar{I}$	19.46	19.52	2.89	-0.83	2.85

Notes: ** denotes statistical significance at the 1% level, * at 5%.
R^2 for models 3, 4 and 5 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 (Beenstock & Felsenstein, 2019), calculated with the matrix $\mathbf{W}$.

In column 5, the assumption that the level of housing stock is exogenous to current prices is relaxed by replacing the number of housing units in each municipality by a Bartik-type instrument. Here, the 'shift' is the annual number of units in each NUTS III region, and the 'share' is each municipality's portion of the regional stock in 2011. Results remains very similar in this specification. This is not surprising considering the few homes built in the country in the last decade, which only amount to around 2% of the total housing stock as of

2021. As such, controlling or not for endogeneity in this very small shift of stock is practically irrelevant, strengthening the validity of the results obtained under column 3.

Across all specifications in Table 2, the regression coefficients are generally significant and conform to expectations. The price is, reassuringly, decreasing in the level of housing stock and increasing for all other variables.

Note, however, that the inclusion of the autoregressive term means the regression coefficients of the spatial models are not directly interpretable as the marginal effect of each independent variable on prices. To see this, consider a reduced form of the spatial model in equation 4.9, where $\mathbf{X_t}$ is the matrix of the right-hand side variables at time t, except the spatial lag, β their respective coefficients, and ε_t the mean zero error terms:

$$ln\ \mathrm{P}_t = \rho \mathbf{W}\ ln\ \mathrm{P}_t + \mathbf{X_t}\beta + \varepsilon_t = (\mathbf{I} - \rho\mathbf{W})^{-1}(\mathbf{X_t}\beta + \varepsilon_t)\,, \qquad (6.1)$$

whence the expected values of the dependent variable come as:

$$E(ln\ \mathrm{P}_t) = (\mathbf{I} - \rho\mathbf{W})^{-1}\mathbf{X_t}\beta\,. \qquad (6.2)$$

The marginal effect of the independent variable k is then calculated by taking the partial derivative of $E(ln\ \mathrm{P})$, which yields an N by N matrix $\mathbf{S_k}$:

$$\mathbf{S_k} = \frac{\partial E(ln\ \mathrm{P}_t)}{\partial \mathrm{X}_k} = (\mathbf{I} - \rho\mathbf{W})^{-1}\beta\,, \qquad (6.3)$$

which, expanded into an infinite series, can be written as:

$$\mathbf{S_k} = (\mathbf{I} - \rho\mathbf{W})^{-1}\beta = \sum_{n=0}^{\infty}(\rho\mathbf{W})^n\ \beta = (\mathbf{I} + \rho\mathbf{W} + \rho^2\mathbf{W}^2 + \cdots)\beta\,. \qquad (6.4)$$

This elucidates the underlying dynamics of marginal effects in spatial models. A change in one location has immediate local effects to price, $\mathbf{I}\beta$, but also affects prices on surrounding locations, $\rho\mathbf{W}\beta$. By the same logic, these changes then cause further spillovers nearby, $\rho^2\mathbf{W}^2\beta$, and infinitely many subsequent spillovers, as the feedback effects percolate all spatial units. With $|\rho| < 1$, the spillovers become smaller and smaller and so the elements of matrix $\mathbf{S_k}$ converge to finite values. Each entry of the matrix, $s_{ij} = \frac{\partial E(ln\ P_{i,t})}{\partial X_{kj}}$, is the impact of a unit change in the variable X_k in location j on price in location i. Thus, not only are marginal effects tough to deduce from regression coefficients, they also differ across the N locations.

To facilitate a general interpretation of the marginal impact of each variable, three summary measures can be derived from each $\mathbf{S_k}$ matrix: average direct impact, average indirect impact and average total impact (LeSage & Pace, 2009). Table 3 exhibits these impact measures and their respective standard errors as computed from the coefficient estimates of model 3. Due to the log-log specification of the model, these impacts can be interpreted as elasticities.

Table 3: Impact estimates

	Direct	**Indirect**	**Total**
$ln\ Y_{i,t}$	0.276 ** (0.072)	0.172 ** (0.047)	0.448 ** (0.115)
$ln\ H_{i,t}$	-0.334 ** (0.076)	-0.209 ** (0.050)	-0.543 ** (0.120)
$ln\ F_{i,t}$	0.090 ** (0.017)	0.056 ** (0.011)	0.146 ** (0.026)
$ln\ D_{i,t}$	0.044 ** (0.015)	0.027 * (0.010)	0.071 ** (0.024)
$ln\ T_{i,t}$	0.020 * (0.008)	0.013 * (0.006)	0.033 * (0.014)
$ln\ B_{i,t}$	0.083 ** (0.014)	0.052 ** (0.010)	0.135 ** (0.022)

Note: ** denotes statistical significance at the 1% level, * at 5%.

The diagonal terms of the matrix $\boldsymbol{S_k}$ express the marginal effect of a unit change in X_k in each location on the respective local price. The mean of these effects, given by $N^{-1}\ tr(\mathbf{S_k})$, is defined as the average direct impact. Meanwhile, the off-diagonal elements of $\boldsymbol{S_k}$ express the spillover effects of a unit change in X_k in one municipality to surrounding ones. The mean of these effects is defined as the average indirect impact. The results of Table 2 suggest therefore that a 1% increase in housing stock in one municipality results, on average, in a direct 0.334% decrease in housing prices in that municipality, and a decrease of 0.209% in housing prices in its surroundings. The average total impact, 0.543%, is the sum of both of these.

Since the total impact is essentially the mean of all elements in matrix $\mathbf{S_k}$, $N^{-2}\sum_{i,j} s_{ij}$, this measure can also be interpreted as the mean of the row sums of the matrix, that is, the mean of the marginal effects resulting from a unit change in X_k across all locations. As such, Table 3 also allows us to predict that a 1% increase in housing stock in all municipalities would result in a 0.54% decrease in housing prices nationwide.

The price impacts of other variables are also insightful. The value obtained for $ln\ Y_{i,t}$ points to an income elasticity of housing demand of 0.448, a figure that is broadly in line with estimates in the literature which put it at below 1 (Albouy et al., 2016). But as $Y_{i,t}$ in this model denotes aggregate income – number of households times average income – it cannot be discerned from this estimated elasticity if the marginal effect of an increase in number of households is different from the effect of an increase of their wealth, the latter being the most common definition of income elasticity of demand.

The explicit inclusion of the number of foreign residents, $F_{i,t}$, appears vindicated by the results of Table 3. As foreign residents account for less than 10% of all households in the country, if their elasticity of demand was similar to that of native residents the price impact obtained for $ln\ F_{i,t}$ should be around 10 times smaller than that of $ln\ Y_{i,t}$. The fact that it is only about 3 times smaller suggests that their declared income indeed does not disclose their demand propensity as well it does for native residents. But, 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 no more than a mere suggestion.

The model results also point to the significant effects of tourism in the housing market. These come more as a result of housing stock that, instead of being placed in market, is dedicated to rental tourism accommodation, $B_{i,t}$, rather than the actual size of tourism demand, $T_{i,t}$. This is in part to be expected, considering the period of analysis partly coincides with the COVID-19 pandemic, where tourist numbers were notably inferior. In any case, Table 3 allows us to infer that a 1% increase in homestay capacity can increase housing prices by 0.14%.

6.2. Simulations

The impact estimates extracted from the model give a summary account of the influence of each explanatory factor in house prices. But a more concrete picture of their importance can be produced by using the spatial model to simulate house prices under alternative scenarios where hypothetical changes are affected to those explanatory variables. Given the aim of this study, it would be of particular interest to predict just how much prices could be lower if the country had a greater housing supply.

The simulated house prices, P^S, are obtained using the following equation:

$$ln\ \mathrm{P^S} = (\mathbf{I} - \hat{\rho}\mathbf{W})^{-1}(\mathbf{X}^{\boldsymbol{S}}\hat{\beta} + \hat{\varepsilon})\ . \tag{6.5}$$

Here, $\mathbf{X}^{\boldsymbol{S}}$ 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 of this analysis is 2021 – counterfactual comparisons will be performed between the actual prices in this year to those obtained by the simulations.

In section 2.2, it was seen just how significant the decline in new housing construction has been in Portugal, amounting more or less to a 75% drop in new supply, and how this slowdown seems an obvious culprit of the current crisis. This notion can now finally be put to the test. The first simulated scenario predicts house prices under the assumption that housing construction between 2011 and 2021 would have kept the same pace of the previous decade. This would mean an additional 397 892 new homes in the 2021 housing stock, which are allocated to the municipalities in proportion to the actual construction numbers from 2011 to 2021. The results from this simulation are that the average house price would be 1 334 €/m^2 instead of 1 379, a decrease of only 3%.

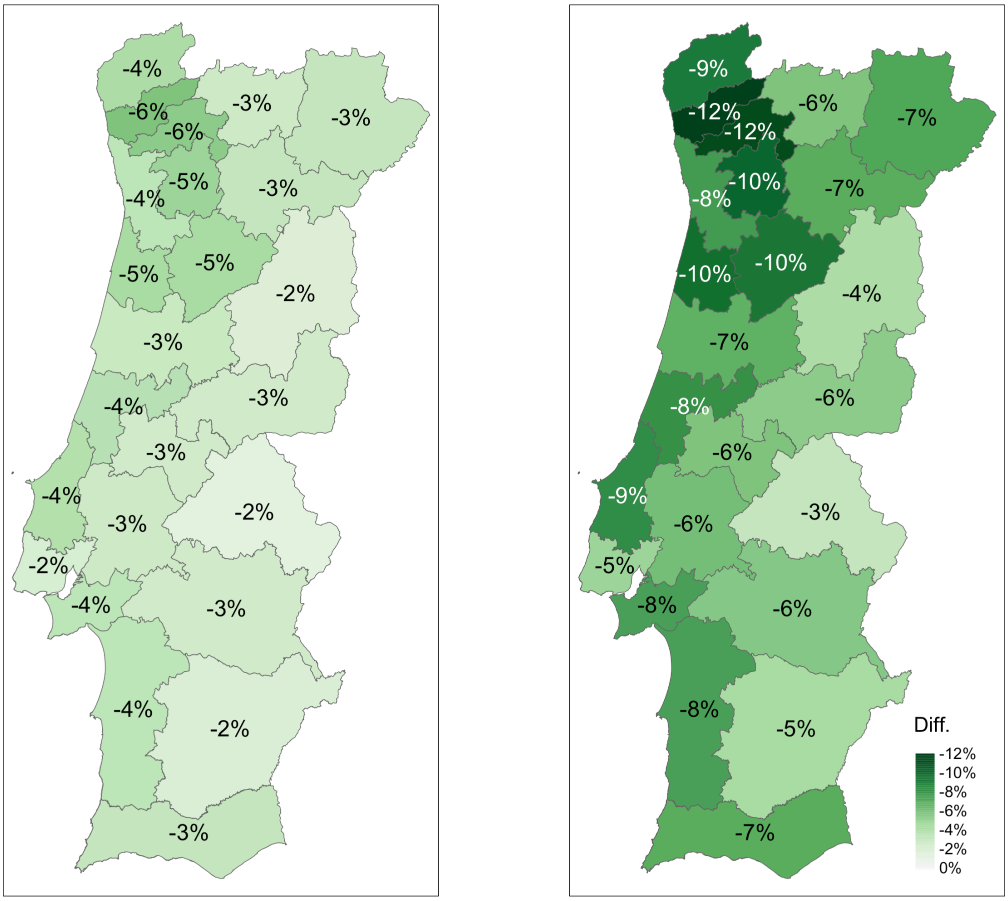
But let us be more ambitious – in face of a larger demand this decade than the previous one, an efficient supply sector could have produced even more homes than before. For the second scenario, suppose then that housing construction this decade would double that of the previous decade. This would mean an additional 919 325 new dwellings, for a total number of homes built between 2011 and 2021 that would surpass one million. This is at the very top end of what could be reasonably imaginable – in only a brief period in the late 1990s coinciding with a large investment boom was the country ever able to produce 100 000 new homes each year. The predicted average house price in this case would be 1 282 €/m^2, just 7% lower than actual 2021 prices.

Figure 5 shows the results of these two simulations in terms of the predicted difference in average regional house prices, compared with 2021. Decreases appear more significant in the north-western region surrounding Porto and less so in Lisbon, where even in the ambitious scenario, average prices would be lower by no more than 5%.

Figure 5: Scenarios 1 and 2: predicted difference (%) in regional house prices

Scenario 1: Maintain pace of construction — Average price: 1 334 €/m² (–3.3%)

Scenario 2: Double pace of construction — Average price: 1 282 €/m² (–7.0%)



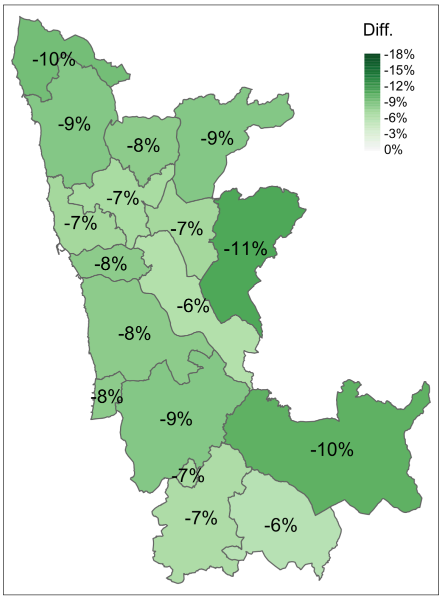
These price decreases are probably underwhelming when compared to expectations. The fact that even a construction sector producing new homes at record levels would lead to prices being lower by no more than 7% nationwide is concerning. Figure 6 elucidates what this decrease would look like in the three most troublesome regions: Porto, Lisbon and Algarve. Results in terms of affordability are also presented, using the effort rate indicator which was previously defined – the portion of the median net income necessary to purchase a 100 m² home over a period of 40 years.

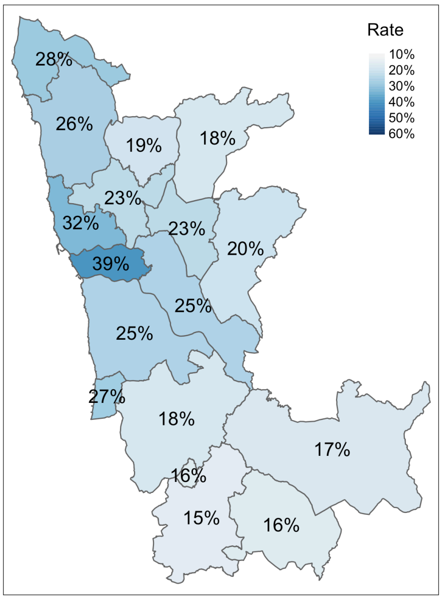
While in Porto affordability is a little more in control, the situation remains problematic in Lisbon and Algarve. The effort rates in the mid-30s in the municipalities adjacent to Lisbon seem not so bad when compared to the 57% rate in the city proper, whose expensiveness appears incurable.

Figure 6: Scenario 2: predicted difference (%) in prices; predicted effort rates

Porto Metro Area

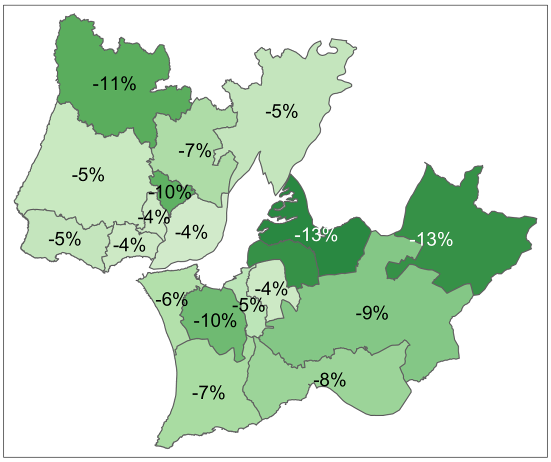
Average price: 1 335 €/m^2 (–7.9%) | Average effort rate: 26.1% (–2.3pp)

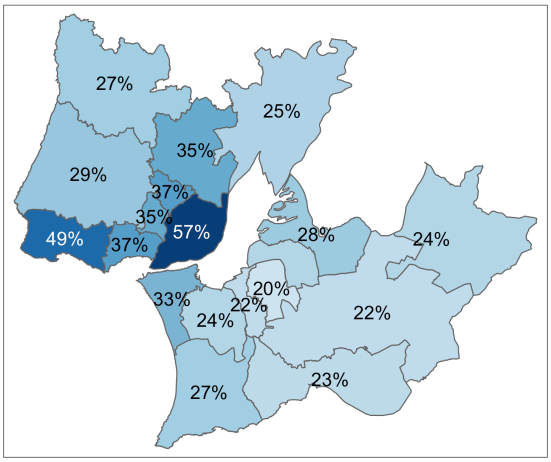




Lisbon Metro Area

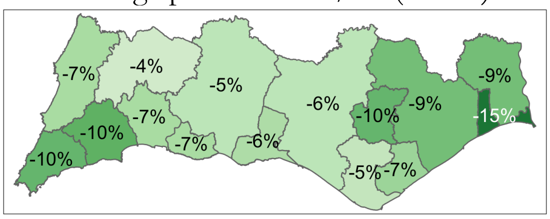
Average price: 2 090 €/m^2 (–5.6%) | Average effort rate: 36.9% (–2.2pp)

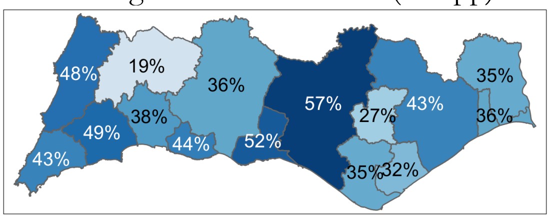




Algarve

Average price: 1 894 €/m^2 (–7.2%) | Average effort rate: 43.0% (–3.4pp)





Note: Maps not to scale.

But it is worth reminding that these effort rates exclude financing costs and other running costs of housing maintenance, such as electricity, water, home repairs, among others – when adding these, effort rates in the mid-30s would likely rise to 40% or more. As 40% is usually the threshold above which a household is deemed to be overburdened with housing costs (Eurostat, 2023), a median effort rate of this magnitude would mean that half of all households in these municipalities remain unable to adequately afford their accommodation. Figure 6 therefore paints a grim picture where an extraordinary expansion of supply would still be insufficient to significantly improve the living conditions of many of the inhabitants of Lisbon and the municipalities in a 15km radius, as well as practically all of Algarve.

As the additional housing units are assumed to be distributed across the country in the same proportion as actual construction in the last decade, it is only natural that further construction has a greater effect in the outlying areas to where metropolitan areas have expanded more and more in recent years. This is so despite the city centres being the predominant drivers of growth, which suggests that construction in these centres might be constrained by factors such as land scarcity or high competition for land use with tourism activities. If so, generic policy action aiming to boost housing supply might turn out to be unfruitful in city centres, as constraints in these locations are fundamentally different from what might be holding back supply in the rest of the country.

In particular, the meaningful impact of tourism and foreign demand evidenced by the house price model motivates us to consider scenarios of what the housing market in Portugal would look like today had the country not experienced the growth that it did in these sectors. We can think of a return to the year of 2015, when tourism and immigration had risen somewhat but not yet to the dramatic extent they later did, and simulate what house prices would be in 2021 had the number of foreign residents and of touristic local accommodation establishments remained at those levels. For reference, Table 4 shows how in 2015 these were, respectively, about a half and a quarter of what they were in 2021.

Table 4: Comparison of 2015 and 2021 levels of foreigners and homestays

		2015	**2021**
F	Foreign residents	374 741	683 669
B	Homestay properties (m^2)	4 789 065	19 011 365

Note: Figures refer to all municipalities of mainland Portugal

As the relevant data for 2015 have less geographical detail, the total figures are allocated to municipalities in the same proportions as 2021. Other explanatory factors are assumed constant, including tourism stays, which in 2021 were much lower due to the pandemic and so reasonable to consider even with less accommodation capacity. The simulations indicate that with the number of foreign residents of 2015, house prices in 2021 would be lower by 8%. With the number of homestay properties of 2015, they would be 17% lower. Simulating both of these hypotheses simultaneously, the prediction is that prices would be 24% lower.

The results of these three scenarios should, of course, be taken as a theoretical illustration rather than a policy prescription. Even so, assuming that all else in the country's housing market and economy would remain constant despite dramatically lower tourism lodging capacity and foreign demand is not very realistic. But the results nonetheless provide some notion of just how significant these two factors are to the housing market in Portugal today. Demand-restrictive policies suddenly become much more appealing, especially after seeing that a very large expansion of supply could only bring about a 7% decrease in prices.

For a final scenario, we can then think of a policy mix that combines reasonable action in both sides of the market. In light of the results of previous simulations, in this scenario three variables suffer changes. Firstly, as in scenario 1, suppose supply had been able to maintain its pace and offer the same number of new units as it did in the previous decade.

Secondly, suppose that policies aiming to attract foreign investment and residents were substantially curtailed or not implemented. The number of foreign residents in 2021 was almost 700 000 and it is known that over 70 000 people benefit from the expatriate retiree tax scheme and 12 000 others from a 'golden visa'[8]. As such, assume that by cutting back on these programmes the number of foreign residents would be 10% lower than today.

Thirdly, suppose that local tourist accommodations were restricted by imposing a limit on the number of establishments in each municipality. Many such limits have been proposed and discussed – here, the restriction is that the number of establishments must not exceed 10% of the number of buildings in the municipality. This would imply enacting restrictions in twelve municipalities: Lisbon, Porto, nine in Algarve, and Nazaré.

The model predicts that this broad set of measures would result in house prices being lower by 7%, roughly equal to the impact predicted in scenario 2. Table 5 below compares all

[8] SEF (2024), *Mapas Estatísticos – Autorização de Residência para Investimento*.

simulated scenarios in terms of the predicted average prices nationwide and the corresponding affordability effort rate. Prices are also expressed in index terms with base in 2015. For reference, household income grew 20% in nominal terms in the 2015–2021 period – in all scenarios, house prices display larger growth than that.

Table 5: Comparison of simulated scenarios

Scenario	Price (€/m^2)		Index	Effort rate	
Base: 2021	1 379		176.0	26.8%	
1: Maintain pace of construction	1 334	–3.3%	170.2	25.9%	–0.9pp
2: Double pace of construction	1 282	–7.0%	163.6	24.9%	–1.9pp
3: Foreign residents at 2015 levels	1 263	–8.4%	161.1	24.5%	–2.3pp
4: Homestays at 2015 levels	1 145	–17.0%	146.0	22.2%	–4.6pp
5: Foreigners & homestays at ‘15	1 048	–24.0%	133.7	20.4%	–6.4pp
6: Policy mix	1 279	–7.2%	163.2	24.9%	–1.9pp

Note: Price index base 2015 = 100.

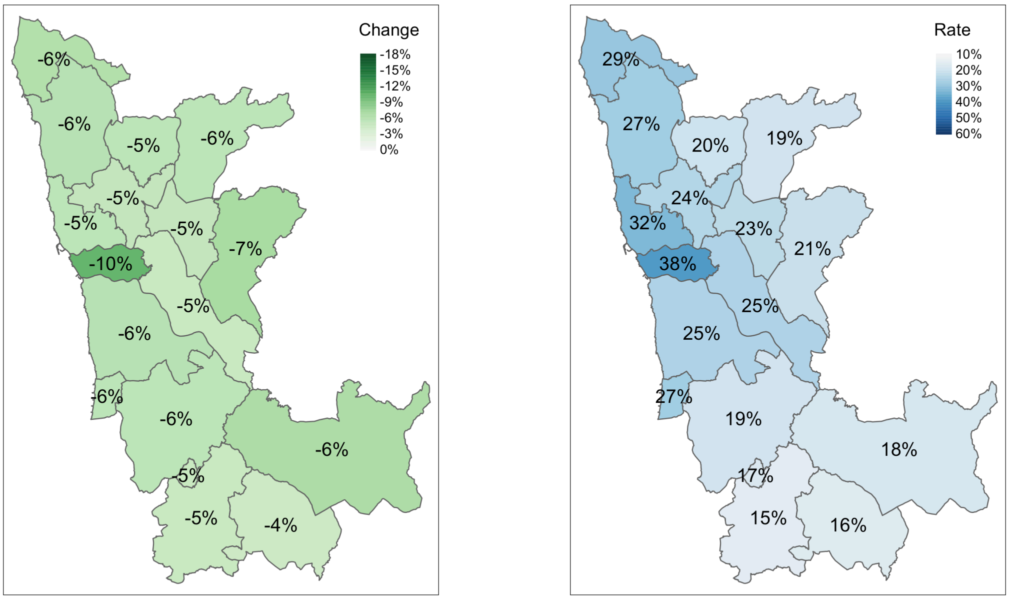
Although this policy mix results in price decreases that are not much larger in aggregate terms than the scenario of an ambitious expansion of supply, Figure 7 below shows that it has the advantage of bringing greater relief to where prices are currently higher. This can be seen in the city of Lisbon, where prices are predicted to be 13% lower in comparison to actual 2021 prices, whereas under scenario 2 this difference was only 4%. The same can be generally said of Algarve, where the predicted regional average price is 11% lower in scenario 6, while under scenario 2 it was 7% lower.

In any case, as can be seen from the simulated effort rates, housing affordability problems would persist with severity in these regions. Though less acute in the most touristic centres, due to the effects of restricting local accommodations, effort rates would remain achingly high for a large number of households. Without doubt, when prices are so high, any improvement is welcome, but the predicted effects of scenarios 1, 2 and 6 (the sensible ones, as it were) are probably far from the substantial improvement that many hope. In truth, such an improvement appears only achievable through demand-restrictive measures of such severity as to make them practically impossible to implement.

Figure 7: Scenario 6: predicted difference (%) in prices; predicted effort rates

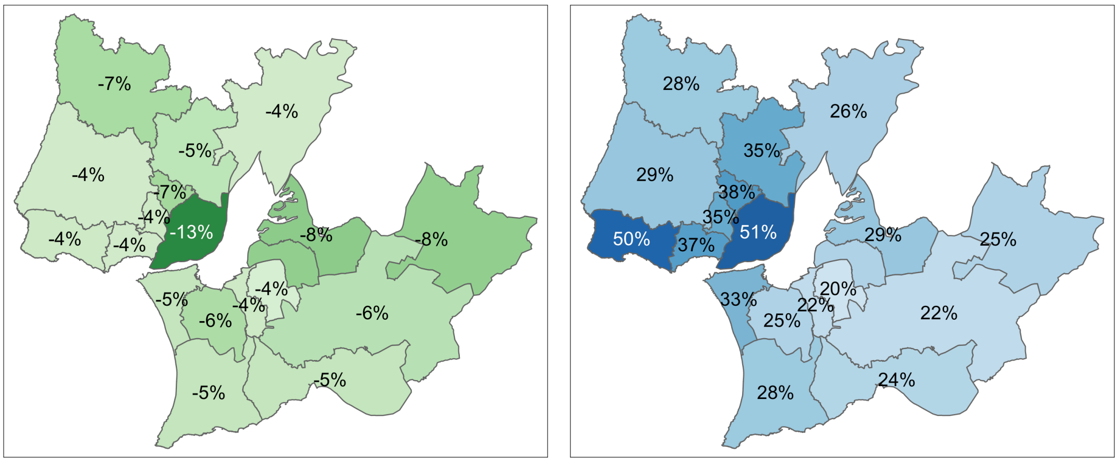
Porto Metro Area

Average price: 1 352 €/m² (–6.7%) Average effort rate: 26.5% (–1.9pp)



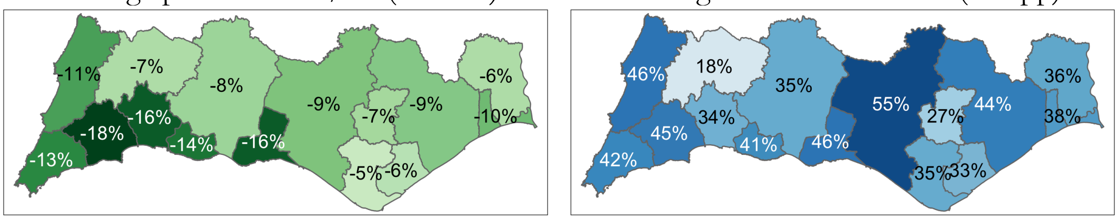
Lisbon Metro Area

Average price: 2 041 €/m² (–7.8%) Average effort rate: 36.1% (–3.0pp)



Algarve

Average price: 1 816 €/m² (–11.1%) Average effort rate: 41.2% (–5.2pp)



Note: Maps not to scale.

7. Conclusion

The main aim of this dissertation has been to ascertain whether the major housing affordability problems Portugal currently faces could be mitigated by unlocking a greater market supply of homes. To this end, evidence of a tangible, causal link between housing supply and prices was sought. It may seem nonsensical to think that this wouldn't be the case in any minimally operative market, but a review of relevant literature raised valid questions that demanded a closer look at the subject. Moreover, we saw how attempts to furnish empirical evidence of this link are rare, narrow but intriguing. Focusing on the United States, these studies predict almost insignificant elasticities between supply and prices, suggesting that more construction could be of little use to mitigate the current escalation of house prices.

In light of this, a spatial econometric model of the housing market was developed and applied to explain local house prices in Portugal. The model is rich enough to capture some of the peculiar drivers of housing demand and supply in the country, such as the growing importance of tourism and foreign demand. The number of housing units is found to be a highly significant explanatory factor of housing prices: all else constant, a municipality with a 1% higher housing stock experiences 0.54% lower house prices. Though the size of the impact of supply on prices is notably larger than the few previous results known of in the literature, it is insufficient to support the claim that more supply could lower prices by a substantial amount. The model framework allowed us to perform simulations that attest this: had supply kept its pace of the previous decade, prices would only be 3% lower; had it doubled, producing a million new homes, they would be 7% lower.

Meanwhile, model predictions seem to support those who call for restrictions to the tourism sector as a means to address the current crisis. Simulating 2021 prices under the assumption that the number of local tourism accommodations would return to levels before the recent Airbnb boom results in prices being lower by as much as 17%. Such drastic restrictions are untenable, but it is as a sign that the role that tourism plays in the Portuguese housing market cannot be disregarded. In light of this, a policy mix involving local Airbnb restrictions, reasonable foreign demand controls and an achievable supply expansion was proposed. House prices would be 7% lower and bring particular relief to price-afflicted Lisbon and Algarve. This strategy involves only a fraction of possible housing policy instruments – subsidies, taxation and other fiscal measures were not examined here, especially as fiscal policy in Portugal has been subject to multiple constraints in recent times.

The results of the dissertation allow the drawing of two conclusions that are relevant to the current debate surrounding housing policy in Portugal. The first is that an increase in market supply should be a prominent component of the policy response to the problems of housing affordability in the country. As an analysis of specific measures that could best achieve this are outside of the scope of this dissertation, a detailed discussion of the current government's plans is not carried out here. But its stated plans of boosting market supply seem, in light of these results, an appropriate course of action.

The second conclusion is that such a supply expansion should by no means be the sole component of the policy response. Only a very large boost in supply, matching the very highest numbers of new homes that the country has ever been able to produce, could achieve noticeable effects on its own; if this is deemed unattainable, tackling high house prices will require a broader set of measures. From the analysis conducted here, wrestling housing stock from tourist purposes back to proper housing supply is a necessity to ease prices in the most pressed locations, but raises questions on what side effects this would have on a country who has relied so heavily on tourism to recover from its economic troubles. It is unclear whether the current government's strategy of abandoning national restrictions on tourism lodgings and relinquishing this power over to the municipal level is wise. In any case, expectations should be tempered on what is presently accomplishable with the policy levers on hand, as only very drastic measures could produce the price decreases that many would hope.

This dissertation hopefully leaves open avenues for further research. The price model developed here introduces a spatial dimension to the identification of housing market determinants that is often overlooked in the literature and clearly capable of producing valuable insight, even if it would clearly benefit from more years of data to improve its estimates and predictions. It is particularly useful for studying the Portuguese market, where demand and supply drivers are notably heterogeneous across the country. The most salient of these drivers was found to be the competing market of tourist accommodation, which seems to be drawing a disproportionate amount of housing stock away from the common housing market in major city centres. In any case, the modelling framework in this study captures this phenomenon somewhat simplistically. More research is needed to understand the interplaying dynamics between these two sectors in greater detail and with that develop more refined economic models and more informed policy recommendations.

Appendix: robustness tests

Table 6 compares the coefficient estimates of the preferred house price model with those obtained by five alternative specifications of the spatial weight matrix $\mathbf{W}$. These include different functional forms of weights and distance thresholds. All matrices are row standardised. The model results are generally consistent in the face of these alternatives, except for column 5, where the 25km threshold appears to remove much of the relevance of the spatial lag. Even so, the estimated total impact of housing supply remains very similar across all columns, consistently around –0.5.

Table 7 examines the effects of removing another 24 small municipalities from the sample, to help show that the validity of the base model results should not be affected by the 24 small municipalities which are excluded from the analysis due to missing values. The 24 locations removed here are those with the lowest level of housing stock in the sample. Again, coefficients are broadly similar, and so is the total impact of housing supply.

Table 6: Estimates of house price model under alternative weight matrices

	Base	**2**	**3**	**4**	**5**	**6**
W_{ij}^*	$\frac{1}{d_{ij}^2}$	$\frac{1}{\mathrm{d}_{ij}}$	$e^{-0.05\, d_{ij}}$	$e^{-0.1\, d_{ij}}$	$\frac{1}{d_{ij}^2}$	$\frac{1}{d_{ij}^2}$
Threshold	50 km	50 km	50 km	50 km	25 km	100 km
Constant	3.896 **	3.499 **	3.551 **	3.937 **	6.571 **	3.333 **
	(0.461)	(0.474)	(0.470)	(0.458)	(0.452)	(0.481)
$ln\ \mathrm{W}_i\mathrm{P}_t$	0.400 **	0.443 **	0.434 **	0.390 **	0.038 **	0.473 **
	(0.037)	(0.039)	(0.039)	(0.037)	(0.013)	(0.041)
$ln\ Y_{i,t}$	0.269 **	0.257 **	0.254 **	0.265 **	0.343 **	0.252 **
	(0.070)	(0.070)	(0.070)	(0.070)	(0.083)	(0.070)
$ln\ H_{i,t}$	-0.326 **	-0.305 **	-0.303 **	-0.322 **	-0.445 **	-0.300 **
	(0.074)	(0.074)	(0.074)	(0.074)	(0.088)	(0.074)
$ln\ F_{i,t}$	0.088 **	0.083 **	0.084 **	0.089 **	0.140 **	0.081 **
	(0.016)	(0.016)	(0.016)	(0.016)	(0.018)	(0.016)
$ln\ D_{i,t}$	0.042 **	0.042 **	0.043 **	0.043 **	0.062 **	0.044 **
	(0.015)	(0.015)	(0.015)	(0.015)	(0.018)	(0.015)
$ln\ T_{i,t}$	0.020 *	0.023 **	0.023 **	0.020 *	0.011	0.020 *
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)
$ln\ B_{i,t}$	0.081 **	0.077 **	0.077 **	0.081 **	0.113 **	0.078 **
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)
τ_t						
2020	0.034 **	0.034 **	0.035 **	0.036 **	0.050 **	0.030 **
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
2021	0.027 *	0.026 *	0.027 *	0.030 *	0.054 **	0.020
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Total impact of $ln\ H_{i,t}$	-0.543 **	-0.548 **	-0.535 **	-0.528 **	-0.462 **	-0.570 **
	(0.120)	(0.128)	(0.126)	(0.117)	(0.090)	(0.136)
Observations	762	762	762	762	762	762
R^2	0.843	0.846	0.847	0.844	0.811	0.847
Log likelihood	360.82	365.50	365.33	360.44	319.09	366.83

Notes: ** denotes statistical significance at the 1% level, * at 5%.
R^2 is the squared correlation of actual and fitted values.

Table 7: Estimates of house price model with further missing values

	Base	**2**
Constant	3.896 **	3.611 **
	(0.461)	(0.510)
$ln\ \mathrm{W}_i\mathrm{P}_t$	0.400 **	0.416 **
	(0.037)	(0.039)
$ln\ Y_{i,t}$	0.269 **	0.253 **
	(0.070)	(0.073)
$ln\ H_{i,t}$	-0.326 **	-0.295 **
	(0.074)	(0.077)
$ln\ F_{i,t}$	0.088 **	0.080 **
	(0.016)	(0.017)
$ln\ D_{i,t}$	0.042 **	0.047 **
	(0.015)	(0.015)
$ln\ T_{i,t}$	0.020 *	0.016 *
	(0.008)	(0.008)
$ln\ B_{i,t}$	0.081 **	0.084 **
	(0.014)	(0.014)
τ_t		
2020	0.034 **	0.030 **
	(0.011)	(0.010)
2021	0.027 *	0.024 *
	(0.012)	(0.011)
Total impact of $ln\ H_{i,t}$	-0.543 **	-0.505 **
	(0.120)	(0.127)
Observations	762	690
R^2	0.843	0.839
Log likelihood	360.82	373.19

Notes: ** denotes statistical significance at the 1% level, * at 5%.
R^2 is the squared correlation of actual and fitted values.

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