The impact of Airbnb on residential property values and rents: Evidence from Portugal☆

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ABSTRACT

This article quantifies the impact of Airbnb's short-term rentals on housing affordability in Portugal. We find that on average a 1pp increase in a municipality Airbnb share results in a 3.7% increase in house prices. When zooming our analysis to the main cities of Lisbon and Porto, we find that a 1pp increase in a civil parish Airbnb share leads to a 3.2% price increase. Finally, exploring the spatial heterogeneity of the impact of Airbnb within the two cities we find strong effects localized in the historical centers and areas attractive to tourists. Compared to a low touristy parish, house prices in a high touristy parish increased by 24.3% in 2015 and 32.3% in the 1st quarter of 2016, relatively to pre-Airbnb expansion period (pre-2014Q2).

1. Introduction

While a beautiful image of a city is one of the backbones for tourism, peer-to-peer online marketplaces that ease matching between demanders and suppliers of short-term housing rentals such as Airbnb and Home-Away have facilitated the upraise trend in tourism growth in several cities around the world. By providing easy access to a wide range of services that are often more affordable than those provided by traditional businesses equivalents, community-based online platforms for listing and renting local homes have helped changing the tourism marketplace. In addition, home-sharing economy enthusiasts advocate that these online platforms provide opportunities for local residents to have new or complementary income streams while encouraging the rehabilitation of the housing stock and its associated economic benefits for the city as a whole (Kaplan and Nadler 2015).

Critics of the home-sharing economy, on the other hand, argue that these booking platforms exacerbate housing affordability issues for local residents by restricting the supply of long-term housing rentals and, provide unfair competition to traditional suppliers such as hotels (Lee 2016; Zervas et al., 2017; Sheppard and Udell 2018). In fact, hotel

associations claim that short-term rentals operate as hotels but have the unfair advantage of not paying taxes or complying with safety, labor and zoning regulations. Critics further allege that home-sharing platforms contribute to racialized gentrification as some hosts are prone to reject certain minority groups and, that tourists in residential buildings may disturb local residents with noise, crowded streets, congestion and competition for scarce parking (Edelman and Luca 2014; Lieber 2015; Cocola-Gant 2016; Edelman et al., 2017; Filippas and Horton 2018).[1] Moved by these concerns, attempts have been made to regulate or even to ban provision of these rental services in several cities around the world.[2]

The goal of this article is to provide empirical evidence to this debate by quantifying the effect of short-term home rentals on residential house prices and rents in Portugal using a comprehensive dataset of properties listed on Airbnb, the world's largest home-sharing platform.

In recent years, raising prices of long-term housing have gained substantial interest from policymakers and the public. The reasons for the affordability issues in key Portuguese cities can be related to income-inequality which is beyond the dynamics of housing markets, but also to inelastic housing supplies linked to land use regulations, geography and real estate speculation. In some cities like Lisbon and Porto but also like in many other European cities, land supply for new development is very limited, especially in central and historic areas, and floor-to-area ratios are kept in general low to preserve a city character and ambience and showcase the historical buildings and monuments which testify to the different periods in the city's history. In order to develop in the urban core, new housing is often times created through urban renewal and rehabilitation projects.[3] The boom of short-term housing rentals after 2014, especially in central locations, pushed further the ongoing concern of rising costs of housing for the Portuguese families.

Self-catered rented accommodation was not a new phenomenon in Portugal, but innovations in online technology opened up home sharing to an increasing number of Portuguese households. Listings data for Airbnb and HomeAway revealed how the use of these online platforms has risen rapidly after 2014, particularly in Lisbon and Porto.[4] Nationwide, in 2016 there were 44,808 advertised listings in Airbnb and 24,662 in HomeAway. According to data from Airdna in September 2016 there were 3960 listings in the city of Porto, while in June 2015 there were already 7011 Airbnb listings in the Lisbon market.[5] This number in Lisbon rose to 10,547 by the end of May 2016 indicating a 15% increase overall, supported by higher tourism demand in the historic center of the city.[6]

The large difference between the returns of short- and long-term rentals has also created an incentive for local and foreigner property owners to rent entire buildings/dwellings as short-term rentals. In 2016, at least 73% of the Airbnb properties on offer in Lisbon were entire apartments with an average daily rate of 84€/night. In contrast, the average long-term rental price in Lisbon in 2016 was 28€/night (830€/month). Hence, a dwelling on Airbnb for 10 days/month would yield pretty much the same income/month as a long-term rental. With an average gross salary of 900€/month, progressively more locals were pushed out to the suburbs and elsewhere as they could not afford housing in the city center. Moreover, in certain historic neighborhoods, platforms such as Airbnb represented also an attractive tool to the financialization of housing for buy-to-let investment, which in turn may have contributed to a buy-to-let gentrification in certain iconic historic neighborhoods (Cocola-Gant and Gago, 2019; Dominguez, 2019).

While some European cities like Berlin and Barcelona were already tightening regulations applied to short-term rentals via websites to keep housing affordable and protect residents from noisy visitors, in 2014 Portugal was also taking steps to facilitate the process of short-term rentals.[7] The 2014 regulatory reform, Decree-Law no. 128/2014, greatly simplified the process of entering into the short-term sublet business by just requiring a free pre-registration of the property with the Portuguese Registry Office of Short-Term Rentals (RNAL) before the host (whether a large establishment or rooms in a private home that are occasionally rented) lists the property on a hosting platform or accepts guests.[8]

The potential reduction of the supply of housing to city residents as properties shift from serving local residents to serving tourists is at the heart of the concerns over the impact of home-sharing on housing affordability. If property owners take dwellings that were available for long-term leases, in which residents are more likely to participate, and convert them to short-term listings in which non-residents are more likely to participate, this increases the supply of short-term rentals (hence driving down their price) but decreases the supply of long-term housing, increasing housing costs for locals. This "reallocation" effect on prices tends to happen in the short run when the total supply of housing is fixed or inelastic. But in order for such effect to have a meaningful impact on

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[1] Across Europe, historic cities have struggled with mass tourism, encouraged by governments after the 2008 crash to boost revenues and jobs but also fueled by the explosion of low-cost flights and online rentals. Overtourism in the historic parts of cities have prompted protests by residents and forced city halls to take action. According to the 2018 statistics by the Institute for Tourism Planning and Development, Lisbon and Porto had a higher ratio of tourists to residents than Barcelona and Prague (both with an average of 5 tourists/resident) or London (with an average of 4 tourists/resident). Lisbon averages 4.5 million tourists per year, meaning that for every resident there are 9 tourists. This is quite disconcerting as Lisbon is a rather small city with narrow streets and dense neighborhoods. Porto welcomes 1.6 million tourists annually, the equivalent of 8 visitors per local. The ratio is even higher in Albufeira in the Algarve region on Portugal's south coast, where tourists outnumber locals by 39 to 1.

[3] According to the Property Handbook 2018 by CBRE the number of new dwellings per year in the municipality of Lisbon decreased from 2900 in 2003 to 130 in 2015. The recovery of the construction sector started nevertheless in 2014, focusing mostly on housing rehabilitation projects in the city center. Just after 2017 (year outside our analysis period) land plots outside of the historic city center started to be acquired for the development of greenfield projects. A similar trend occurred in Porto. In 2015, only 20 new dwellings were concluded in the city, a substantial decrease when compared to the 1750 dwellings in 2002. The recovery of the construction sector in Porto reinitiated after Lisbon and also targeted the redevelopment and rehabilitation of buildings in central locations.

[4] Airbnb and HomeAway are two of the major online platforms worldwide that enable homeowners or tenants to informally rent out single rooms or entire properties for side income and at a lower cost than conventional hotels while providing guests with a different local cultural experience to that found in a hotel.

[5] Airdna is a company responsible for the production and management of information associated with local accommodation through Airbnb on a global scale.

[6] According to Lisbon's tourist board, the number of visitors to Lisbon increased by 18% from 2013 to 2015, and the 2016 report of Airbnb for the Lisbon market stated that 30% of the guests would not have visited Lisbon or stayed longer had they not had access to Airbnb.

[7] For example, in 2014 Barcelona's local government imposed a moratorium on the concession of permits for short-term rentals in an extended area in central Barcelona. Since then, the number of legal short-term rentals in Barcelona has been frozen at 9600 units (Segu 2018).

[8] According to RNAL, the number of short-term rentals in Portugal increased from 13,000 as of December 2014 to more than 55,000 units as of December 2017. The majority of these listings are concentrated in the cities of Lisbon (10,611 registrations), Porto (4881 registrations) and Albufeira (4815 registrations). In 2017, more rigorous legislation was also approved in Portugal to regulate short-term rental properties. This is outside our period of analysis. As of July 1st, 2017, properties posted on Airbnb, HomeAway and other platforms need to be enrolled on the national tourism register. To be allowed to advertise on such platforms, property owners will have to fill in a required field with the registration number of their accommodation. Platforms will be subject to sanctions if they market non-registered properties. This measure was set to guarantee the rules of legal competition.

residents' housing costs, the share of short-term housing in the market and its scale across a city must become relatively large. This implies that neither the majority of the short-term rentals are vacation homes nor that those supplying short-term rentals cohabit with guests. It is the sharing of non-vacation homes, as opposed to rooms, via online platforms that poses the greater risk to housing supply, as this has the greatest potential to divert residential units away from the rental market.

In addition, because housing demand is relatively inelastic, vacant developable land is relatively scarce and property owners may in general consider tourist lodging to be a more profitable and safe investment than long-term housing, small changes in housing supply can cause significant price increases in the long-term housing market even in the long run. The reasons are because property owners and leaseholders have an over-powering incentive to list dwellings in a building on Airbnb rather than rent them to local residents (an "hotelization" effect as mentioned in Lee (2016) and Barron et al. (2018)), and certain city areas may fail to build the homes they need due to scarce developable land. This affordable housing crisis may be particularly pronounced at locations that are attractive to tourists and other visitors and where sharing economy platforms are most popular. Property owners in more touristy areas or in gentrifying neighborhoods are more likely to switch into the short-term rental market in response to learning about Airbnb and other booking platforms than property owners in less touristy areas. On the other hand, the presence of negative externalities that short-term property rentals impose on neighbors like noise and safety concerns may lead to a reduction in housing costs.

Therefore, the effect of home-sharing on housing costs is a priory ambiguous and its quantification an empirical question. Using data we collected from the largest online short-term housing rental platform operating in Portugal-Airbnb, quarterly housing rents and prices from 106 municipalities in Portugal between 2012 and 2016, and several other auxiliary datasets to compile controls, we are able to quantify the extent to which Airbnb listings concentration (which we will denote as Airbnb share) has impacted house prices and rents in the country, and in particular in the municipalities of Lisbon and Porto, which have experienced both rapidly rising housing costs and growth in Airbnb listings since 2014. We define Airbnb share as total dwellings listed on Airbnb in a given spatial unit of analysis (e.g. a civil parish or a municipality) expressed as a decimal fraction of the total dwellings in that spatial unit of analysis.

We start our analyses with an instrumental variable regression. Our IV strategy is similar to Barron et al. (2018): our Airbnb share on a given municipality in a given quarter is instrumented by the interaction of Google time trends for the word "Airbnb" with the share of properties on Airbnb in the 1st quarter of 2014 (a proxy for the level of "*touristiness*" of the municipality). We apply this instrument to our sample of 106 municipalities and then just to the civil parishes of the municipalities of Lisbon and Porto.

The large heterogeneity in Airbnb share across the civil parishes of Lisbon and Porto also suggests that Airbnb share has not affected all areas of these cities equally. Therefore, we explore the spatial heterogeneity of these effects on local house prices in these municipalities. First, we map the Airbnb share impacts on house prices across the civil parishes of Lisbon and Porto in 2016. Then, we test whether high touristy parishes are more affected by Airbnb growth than low touristy parishes using a quasi-experimental design that uses a Difference-in-Differences approach. We estimate the changes in house prices and rents between the pre- and post-Airbnb expansion periods and between "high" and "low" touristy civil parishes. We define "high touristy areas" as civil parishes with the largest Airbnb share in the two municipalities, and the pre-and-post Airbnb expansion periods as the periods of high and low Airbnb growth.

It should be noted that the recovery of the residential market and expansion on Airbnb shares in high touristy areas coincide with the post-2014 reform period. Therefore, we visually explore if there is strong variation in the civil parishes Airbnb share stemming from the *Decree-*

Law no. 128/2014 reform that one could use for identification. The average number of new listings in the Airbnb platform increased by 39% in Lisbon and Porto after the policy was implemented. Then, as an alternative to our Google shift-share instrumental variable approach, we run a second IV where we predict Airbnb share in a given civil parish in a given quarter using pre-reform trends interacted with dummies for "high" and "low" touristy parishes. We then use the detrended series as an instrument for the Airbnb share. Our second IV strategy helps us clarify if the 2014 policy reform actually increased Airbnb shares. We further include trends for touristy and non-touristy parishes to be sure the reform captures something more than a simple trend increase (in the first stage) and to control for heterogenous trends in the outcome (in the second stage). The results suggest an acceleration of the Airbnb growth that accounts for an increase in the Airbnb share of 0.9pp by the 1st quarter of 2016.

While short-term rentals cannot be solely blamed for rises in housing costs in Portugal, our empirical approaches reveal that Airbnb share has increased housing prices, with strong effects localized to the historical centers and areas attractive to tourists. However, we do not find statistically significant impact of Airbnb share on long term rental prices, possibly due to the overlap of the phasing-out of the 2012 rental market liberalization, which limited the increase of "old" rents to market levels, and our study period.

The results from our IV exercise show that a one percentage point (1pp) increase in a municipality Airbnb share results in a 3.7% increase in the municipality housing prices on average. Our results are still statistically significant when we remove the two most important municipalities -Lisbon and Porto-from the analysis, resulting in a 2.5% increase in municipality house prices on average. When constraining our analysis to the parishes of Lisbon and Porto, our IV results reveal that a 1pp increase in a parish Airbnb share leads to 2.9% increase in a parish house prices on average. Finally, our DiD analysis shows that the effects on Lisbon and Porto house prices of Airbnb share are more pronounced in historical centers and areas attractive to tourists. Compared to a low touristy parish, house prices in a high touristy parish had an increase of 24.3% in 2015 and 32.3% in the 1st quarter of 2016, compared to our 2013 base period (pre-Airbnb expansion year). Given that the average Airbnb share in our treatment group (touristy parishes) was 0.112 for the 1st quarter of 2016, our DiD results compare with the IV estimated treatment effect of 32.48% in the case of Lisbon and 35.8% in the case of Porto.

The rest of the article is organized as follows: section 2 reviews the existing literature, while section 3 provides an overview of the housing market in Portugal. Section 4 discusses our data sources, provides descriptive statistics and presents our identification strategy. We report and discuss our main results in section 5, followed by robustness checks of our findings. Finally, Section 6 offers conclusions.

2. Related literature

While local amenities (e.g. cultural and historic amenities, noise) explain some of the variability in house prices within and across cities (Franco and Macdonald 2018a,b), quantity restrictions, natural geographic barriers and housing renewal programs have also been shown to impact property prices through a supply effect (Saiz 2010; Quigley and Raphael, 2005; Ihlanfeldt, 2007). Channels from both demand and supply sides can therefore contribute for observed trends in rents and house prices. However, Airbnb rentals can potentially exacerbate rising housing costs through both supply and demand mechanisms. Despite the public debate, apparent anecdotal evidence and regulatory bans, the empirical literature on how home-sharing impacts cities and the housing market is still thin, meaning that wider applicability to other cities and contexts is

unclear. Published academic studies on Airbnb are mostly tourism studies (Guttentag, 2015; Zervas et al., 2016), although some studies have addressed the regulation of the share economy overall (Morgan and Kuch, 2015) and short-term rentals, in particular (Gottlieb, 2013; Palombo, 2015).[9]

We are aware of only a limited number of academic articles that directly study the effect of Airbnb listings on housing rents and prices. With the exception of Segu (2018) who focuses in the city of Barcelona, the other studies focus on either a specific US Market (see for example Lee (2016) for Los Angeles, Horn and Merante (2017) for Boston, Sheppard and Udell (2018) and Wachsmuth et al. (2018) for New York city, Koster et al. (2019) for Los Angeles County) or on the entire US Market (Barron et al., 2018). In general, this emerging literature finds that Airbnb has a measurable effect on long-term housing supply and prices in the cities where it operates, raising housing costs for local residents.

Segu (2018) uses a Bartik-like instrument approach that combines distance to the beach with city-wide levels of tourism to study the effect of Airbnb density on housing rents in Barcelona. The study suggests that Airbnb is responsible for a 4% increase in rents between 2009 and 2016.

Horn and Merante (2017) use Airbnb listing data from Boston in 2015 and 2016 and, find that a one standard deviation increase in Airbnb listings relative to the total number of housing units in a census tract, is associated with a 0.4% increase in asking rents. For census tracts in the highest decile of Airbnb listings relative to total housing units, this increase in rents ranges from 1.3% to 3.1%.

On the other hand, Barron et al. (2018) study the effect of Airbnb on the long-term housing market using a dataset of all US properties listed in Airbnb between 2011 and 2016. The study uses an IV approach where Google trends of the search "Airbnb" is an instrument to identify the causal effect. Since this instrument is time variant but geographically invariant, the authors combined it with a measure of how "touristy" a ZIP code is in a base year.[10] The study finds that a one standard deviation increase in Airbnb listings at the ZIP code level raises rents by 0.54%. The authors explain that one reason for such a small impact is that most short-term rentals are owner-occupiers rather than commercial operators running mini-hotels or "hotelization" of entire buildings.

Wachsmuth et al. (2018) apply the regression results identified by Barron et al. (2018) to the increase in Airbnb rentals in New York City. They find a 1.4% increase in NYC rents from 2015 to 2017 due to Airbnb's expansion in that city. For the median NYC renter, this implies a $384 annual increase in rent from 2015 to 2017 due to Airbnb's expansion over that time.

Sheppard and Urdell (2018) also focus on the New York market while examining the impact of Airbnb listings on house prices. In contrast to the former studies, this study applies not only a hedonic approach but also a matched difference-in-differences approach similar to Zervas et al. (2014).[11] The first approach provides measures of the associational impact of Airbnb listings, while the second approach provides a causal effect by identifying treatment and control groups within the data. Since the authors have access to the number of individual sales both before and after Airbnb's entry into the New York City market, they apply quasi-experimental techniques to examine whether short-term rentals make New York City less affordable. Their results suggest that sold

properties subject to the treatment of having Airbnb properties nearby experienced an increase in price by 3.5% (if located far from the CBD, Wall Street, and with a treatment consisting of few Airbnb properties) to more than 65% for properties located near Wall Street and/or treated by having a larger number of Airbnb rentals nearby.

Very recently, Koster et al. (2019) apply a quasi-experimental approach to evaluate the causal impact of Airbnb listings on house prices in Los Angeles County. The study uses a spatial regression discontinuity design combined with a difference-in-differences set up to examine the changes in Airbnb listings and house prices close to the borders of the cities that have adopted Home-Sharing Ordinances. The authors find that the ordinances strongly reduced Airbnb listings by 50% and housing prices by 3%.

Our article contributes to this emerging literature on the effects of home-sharing on housing costs by presenting the first estimates on the effects of home-sharing on house prices that uses comprehensive data from across a European country. While most existing studies focus on the US case, there are underlying differences between the European and American contexts. For instance, European cities are much older, smaller and denser than American cities. Moreover, central areas of European cities lack developable land and are full of historic buildings and heritage, which conditions new construction and rehabilitation projects. As such, small changes in their housing supply may have significant impact on housing prices. By examining the case of Portugal and also Lisbon and Porto, we present evidence of the effects of Airbnb not only in the context of a European country but also in the context of European cities. In addition, our IV and Difference-and-Difference identification strategies yield similar results that cross-validate each other. Finally, by empirically showing the heterogeneity effects of Airbnb activity on house prices within a municipality, our results also highlight the need to designing spatially targeted regulations rather than blunt policies to regulate short-term rentals in a city. This is particular informative in a time when cities across the globe are struggling to regulate the short-term rental market, with some cities banning short-term rentals outright or enacting very strict legal restrictions on Airbnb rentals.

3. Overview of the housing market in Portugal

This section briefly overviews the housing market in mainland Portugal by focusing on the trends of house prices and rents and on the spatial distribution of short-term rentals between 2011 and 2016.[12]

3.1. Prices in the long-term housing market

House prices in the long-term residential market, as measured by transaction prices, have increased 14% in the municipality of Lisbon from the 1st quarter of 2011 (2011Q1) to the 1st quarter of 2016 (2016Q1), while decreasing 20% in the municipality of Porto and 12% in the rest of mainland Portugal. This discrepancy between Lisbon and the rest of the country can be better observed in Fig. 1, where house prices in Lisbon and Porto are compared to the rest of the country. The vertical line marks the 2nd quarter of 2014 (2014Q2), that is, the last quarter before the *Decree-Law no. 128/2014* took place.

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[9] Recently, Gurran and Phibbs (2017) examined the expansion of Airbnb listings in the Sydney metropolitan area, focusing on the implications for urban policy and planning.

[10] The rational for this approach is that if a certain area attracts a lot of tourists and receives a sudden surge in online search interest for Airbnb, then any subsequent increase in Airbnb listings is caused by the increased demand from visitors for short-term rentals.

[11] Zervas et al. (2017) use a difference-in-differences fixed effect strategy to identify the causal effect of Airbnb's entry into the market on hotel revenues. The authors found that a 10% increase in Airbnb units results in a 0.38% decrease in hotel revenue.

[12] Mainland Portugal, located at the western end of the Iberian Peninsula, has 95% of the country's total population and 96.6% of the country's land. We focus on mainland Portugal because we lack data on house prices and rents for the two Portuguese Autonomous regions of Azores and Madeira. Portugal has 308 municipalities (272 in mainland), 3092 civil parishes (2882 in mainland) and a total population of approximately 10 million inhabitants (census 2011). The municipality of Lisbon is the capital and largest city in the country, with a population of 505,526 inhabitants (census 2011). It occupies an area of 100 km^2 divided into 24 civil parishes (*freguesias*). The municipality of Porto is the second-largest city in the country, with a population of 237,559 inhabitants (Census, 2011). The city occupies an area of 41.42 km^2 divided into 7 civil parishes.
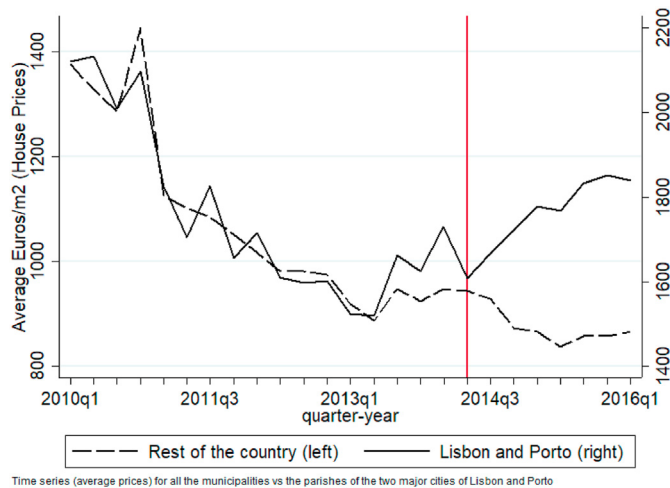
Fig. 1. Transaction Prices, in €/m², in Lisbon, Porto and the rest of Mainland Portugal.
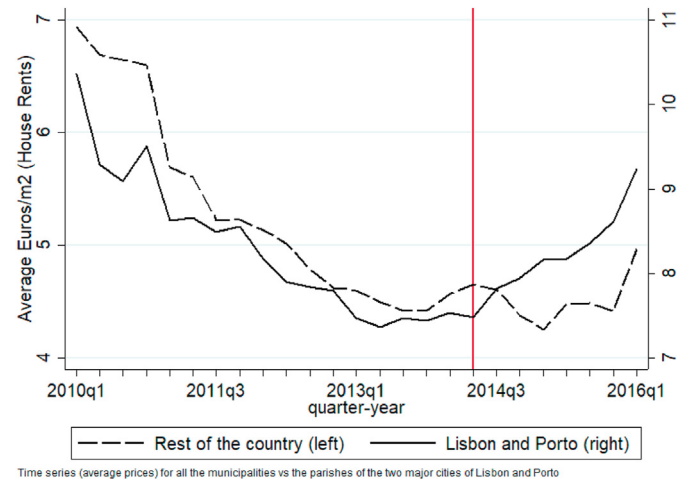

Fig. 2. Value of rents, in €/m², in Lisbon, Porto and the rest of Mainland Portugal.

Fig. 3. Transaction Prices, in €/m², in civil parishes within Lisbon and Porto.

In line with anecdotal evidence, Fig. 1 shows a change in the behavior of transaction prices after 2014Q2, particularly in Lisbon and Porto. However, it is important to note that until 2011 Portugal had very solid rent controls in place that left little incentive for landlords to maintain properties, and high housing sales tax rates which discouraged landlords also from wanting to sell. As a result, many buildings, particularly in historic areas, were left relatively dilapidated and run-down. Then, in 2011, Portugal entered into a severe economic crisis that made the country unable to repay or refinance its government debt, resulting in a €78 billion bailout program. In 2012, rent controls were rolled back considerably as a condition of the bailout program and foreign investment programs, such as the Golden visa, were established.[13] That may explain the recovery in 2013Q1. Throughout this period, the country also experienced an increase in tourism.[14]

Fig. 2 illustrates the behavior of long-term rental prices over time. A similar, though less pronounced pattern as that observed for transaction prices, also emerges in rental prices. Between 2014Q3 and 2016Q1, rental prices increased from 7.9€/m² in Lisbon and Porto, and 4.7€/m² in the rest of the country, to 9.1€/m² in Lisbon and Porto and 5€/m² in the rest of mainland Portugal.

The observed less pronounced impact on the long-term rental prices during our study period may be linked to the five-year transition period, set to last until 2017, that accompanied the 2012 housing rental market reform. The five-year transition period was designed to protect older (those aged over 65 years), disabled (those with a degree of disability in excess of 60%) and poorer tenants from the impact of a more liberalized rental market. Moreover, the 2012 reform maintained the 2006 phased out of the so-called "old rents", that is, of the rental contracts established before 1990 and which were open-ended leases with rent levels frozen

over decades.[15] Therefore, the liberalization of rent increases during the phase-out period 2012–2017 was gradual but with very limited rent increases. Finally, it should be mentioned that in 2012 the rental market in Portugal was very thin (with just 20% of the population being renters) and even nowadays landlords who want to get market value for their leases still have to wait until residents with "old contracts" 65 years old and older die or in the case of commercial properties, that these businesses just shutdown.

Fig. 3 shows transaction prices over time for civil parishes located in Lisbon and Porto with small versus large presence of short-term rentals. These cities have very diverse neighborhoods, and therefore looking solely at citywide trends may mask significant spatial variation. Note that before 2014Q3 transaction prices were already increasing in both types of civil parishes, most likely due to the market liberalization and the 2012Q4 Golden visa program. The preferable option under the Golden visa program was to purchase properties older than 30 years in the old city centers of Lisbon and Porto, rehabilitate them and then rent them out

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[13] The Golden visa program was launched in 2012 to attract foreign investment to Portugal. According to the program an investment of €500,000 in real estate will gain a residency permit for a family including dependent children. There is also the option of acquiring real estate with construction completed at least 30 years ago or located in an urban rehabilitation area, with the execution of rehabilitation works. The minimum investment for this option is reduced to €350,000. An investor under this program only has to spend about 7 days/year in Portugal to maintain the residency, while still reaping all the benefits of being an EU resident, including visa-free travel in the entire Schengen area.

[14] The annual number of tourists in Portugal went from 13.8 million in 2012 to almost 19 million in 2016 (INE statistics, www.ine.pt).

[15] According to the 2011 Census, 20% of the country population were renters, 17% of renters had more than 65 years old and 34.5% of all the rental contracts in the country can be classified as "old contracts" (with rents not exceeding 200€ in 50% of the cases). Moreover, in 2011 37.5% of the 40% of the Lisbon residents who rented a dwelling were more than 65 years old. Porto also exhibited similar statistics with 32% of its senior population being renters.

to short-stay visitors. After 2014Q3, civil parishes with large presence of short-term rentals exhibited stronger growth in transaction prices. Fig. A.3. in the Appendix also illustrates the log (Transaction prices) in both high and low touristy areas after detrending and suggests the same conclusions as Fig. 3. It is worth noting that after 2014Q2 some historic neighborhoods in these cities experienced an intensification of buy-to-let investment by both national and foreign investors (Cocola-Gant and Gago, 2019; Dominguez, 2019).[16] Airbnb and similar short-term rental platforms were seen by buy-to-let investors as an attractive and flexible tool to the financialization of housing and a way to further use housing markets as an asset to store surplus capital. As such, the arrival of local and global real estate capital in certain neighborhoods through the Airbnb channel may have also contributed to the strong price increase in these cities' iconic historic touristic neighborhoods after 2014Q2.

Maps 1 and 2 from Longo (2017) show the 2016Q1 spatial distribution of rental and transaction prices across 76 municipalities and 31 civil parishes located in Lisbon and Porto sourced from our dataset. It should be noted that most of the 76 municipalities are located along the coast, where 80% of the country's population resides and where most housing transactions occur.

Maps 1and 2 both exhibit similar patterns – the priciest properties (both in terms of rents and transaction prices) are found in Lisbon (located in the Central Coast), Porto (located in the Northern Coast) and in the district of Faro located in the Southern region of Algarve. Zooming into the municipality of Lisbon it can be seen that housing costs are highest in the southern part, namely in the historic downtown of *Baixa* and in *Parque das Nações,* a newly built area well-endowed with environmental amenities, but also in the inner-city parishes of *São Domingos de Benfica* and *Avenidas Novas*. In the case of the municipality of Porto, housing costs are also highest in the historic center, the oldest area of the city classified as World Heritage by UNESCO since 1996 and comprising the civil parishes of *Cedofeita, Santo Ildefonso, Sé, Miragaia, São Nicolau* e *Vitória*.

3.2. Supply of short-term rentals

The supply of short-term rentals within the country is officially registered with the Portuguese Registry Office of Short-Term Rentals - *Registo Nacional de Alojamento Local* (RNAL). Registers with RNAL grew rapidly between 2014 and 2016, from 1715 in 2013 to 3386 (2014) to 11,218 (2015) to 32,622 in 2016. In 2016, 96% of the registries in RNAL were located in Mainland Portugal.

Table 1 presents the split of RNAL short-term properties by district, municipality and civil parish in 2016 measured as a percentage of total listings in RNAL.[17] From Table 1, the largest percentage occurs in the districts of Faro, Lisbon and Porto, which account for 82% of all RNAL

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¹⁶ Cocola-Gant and Gago (2019) found that between 2015 and 2017 *Alfama* was under an intense process of buy-to-let investment and professionalization in the provision of short-term rentals (STRs) that drove an aggressive transformation of this neighborhood. *Alfama* is the oldest historic neighborhood of Lisbon covering parts of the civil parishes of *Santa Maria Maior* and *São Vicente* (see Figs. A.7-A.10 in the Appendix for location of these parishes in the city). In 2015, local landlords who ceased renting to tenants and listed their flats on Airbnb supplied 32% of the neighborhood STRs, and 62% of the STRs were supplied by buy-to-let national and foreigner investors (28% were corporate and 34% were individual investors). However, in 2016 local homeowners represented just 17% of the supply, while buy-to-let investors supplied 78% of the STRs: 44% were corporate investors, that is, companies that bought entire apartment buildings and converted them into accommodation for visitors and, 34% were individual investors composed of people who purchased one or two flats and then rented them as Airbnb.

¹⁷ Districts are the first-level administrative subdivisions of Mainland Portugal. Currently, Mainland Portugal is divided into 18 districts. The second-level administrative subdivisions are the municipalities (272 in Mainland Portugal) which are further subdivided into civil parishes (2882 in Mainland Portugal).

Table 1
RNAL short-term rentals by district, municipality and civil parish in 2016. (percentage of total). (Top-5).

	Districts	Municipalities	CIVIL Parishes
1	Faro – 49.3%	Lisbon (Lisbon) – 18.5%	Sta. Maria Maior (Lisbon) – 5.3%
2	Lisbon – 24.4%	Albufeira (Faro) – 9.6%	UF Cedofeita, …(Porto) – 5.0%
3	Porto – 8.4%	Portimão (Faro) – 7.5%	Misericórdia (Lisbon) – 4.1%
4	Leiria – 4.7%	Porto (Porto) – 6.7%	Sto. António (Lisbon) – 1.8%
5	Setúbal – 2.9%	Lagos (Faro) – 6.6%	Arroios (Lisbon) – 1.7%

Table 2
Airbnb listings by district, municipality and civil parish in 2016. (percentage of total). (Top-5).

	Districts	Municipalities	CIVIL Parishes
1	Lisbon – 32.0%	Lisbon (Lisbon) – 21.3%	UF Cedofeita, …(Porto) – 6.0%
2	Faro – 27.7%	Porto (Porto) – 9.4%	Sta. Maria Maior (Lisbon) – 5.5%
3	Porto – 12.9%	Albufeira (Faro) – 5.2%	Misericórdia (Lisbon) – 4.4%
4	Leiria – 5.5%	Loulé (Faro) – 4.1%	Albufeira (Faro) – 4.3%
5	Setúbal – 5.2%	Lagos (Faro) – 3.9%	Arroios (Lisbon) – 3.0%

registries. Similarly, the top five municipalities, all located in these three districts, account for almost half of the RNAL registries.

Table 2 presents the split of Airbnb listings by district, municipality and civil parish in 2016 measured as a percentage of total Airbnb listings in the country. As of 2016 there were 44,411 available listings in this home-stay site, being 75% listed as entire homes/apartments. When looking at the distribution of the hosts by districts, Lisbon, Faro and Porto account still for the majority of the Airbnb short-lets, representing 74% of the hosts' listings.

Fig. 4 shows the number of <u>new listings</u> in the Airbnb site and in the RNAL database in the municipalities of Lisbon and Porto relative to the rest of the country from 2010Q1 to 2016Q1.

Fig. 4 reveals that after 2014Q2 there was a substantial increase in the number of new listings in both platforms, particularly in the number of listings for the rest of mainland Portugal within the RNAL website. The simplification of the RNAL registration process introduced by the policy change seemed to have created an incentive for more hosts, in particular those located outside the most important municipalities, to start renting their properties as short-lets to tourists. Fig. 5 further illustrates the increase in new Airbnb listings for Lisbon and Porto pre- and post-policy reform. Note that the mean over the period pre-policy is 560 listings/ quarter while post-policy is 780 listings/quarter, a 39.2% increase.

4. Description of the data

Even though Airbnb is not the only short-term rental platform active in Portugal, its market share is the highest among its competitors. In addition, most short-term rentals are advertised through more than one platform. Therefore, we consider Airbnb listings a good proxy for the short-term rental market in Portugal. We collect information on Airbnb listings from web scrapes from the Airbnb website during the month of September 2016 for Mainland Portugal. For every listing, we have the location of the property (georeferenced coordinates), a range of characteristics of the listed property (e.g. number of rooms, number of bathrooms), the host id, the list of all reviews from guests who have stayed at the property and the year-month in which the user registered as a host on the platform. Our Airbnb dataset contains 44, 411 Airbnb listings spanning a period of 6 years, from 2010 to 2016.

The average quarter transacted and rental prices for residential real estate between 2010Q1 and 2016Q1 for 106 municipalities in Portugal and for all the 31 civil parishes located in Lisbon and Porto are obtained
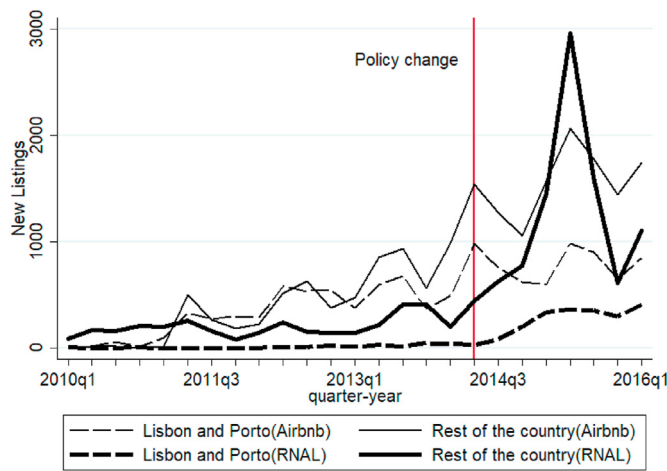
Fig. 4. Number of new listings in the Airbnb site and in the RNAL dataset for Lisbon and Porto and for the rest of the country.
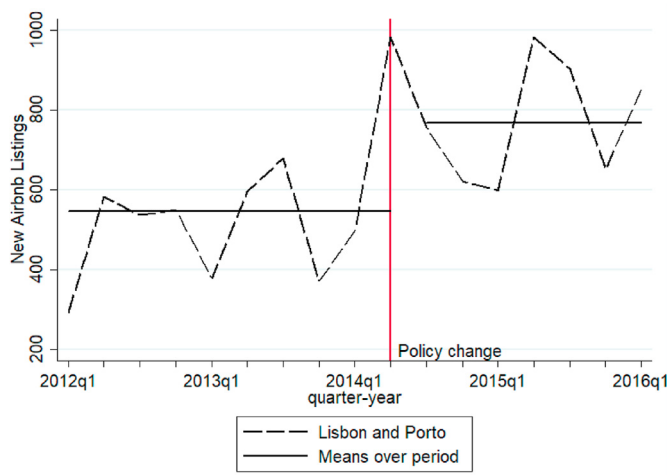

Fig. 5. New listings in Airbnb for Lisbon and Porto and means pre- and post-policy reform.

from *Confidencial Imobiliário*.[18] The 106 municipalities included in our dataset represent 35% of the existing municipalities in Portugal, encompassing 80% of the population living in the country. Our data is only available for a subset of all the country municipalities because for some of the smaller municipalities there are no regular housing transactions so that no sale residential price data can be collected. With the exception of the municipalities of Lisbon and Porto, rental and transaction prices were just available at the municipality level. For Lisbon and Porto both rental and transaction prices were also available at the civil parish level. Therefore, we build our measure of Airbnb activity, denoted as Airbnb share, for the period of the analysis as the decimal fraction of total dwellings in a given location (e.g. a parish or a municipality) listed in the Airbnb platform using GIS techniques. Note that our variable Airbnb share is thus measured between 0 and 1. As in Barron et al. (2018), we also calculate the number of Airbnb listings in each year using the reported entry date of the listing. Around 73% of all listings in our sample correspond to entire apartments/houses. This suggests that property-owners do not co-habit with guests.

Our sociodemographic area characteristics, total number of dwellings

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[18] This company is a data bank, being the only source in Portugal with statistical data on transaction prices and residential lease agreements.

and total population at both municipality and civil parish levels come from the 2011 Census. For each civil parish in the municipalities of Lisbon and Porto we also collected census data on buildings age, housing density, population density, percentage of derelict buildings and the average number of floors per building.

Finally, it should be noted that in 2013 there was a reorganization of the administrative boundaries of the civil parishes in Portugal (Law 11-A/2013). This administrative reform required the reduction, the amalgamation or extinction of various civil parishes as an attempt to control spending in light of the 2012 country sovereign debt crisis. The reform affected particularly the municipalities of Lisbon and Porto, which before the year 2013 had 53 and 15 civil parishes, but only 24 and 7 after, respectively. Since our Census data is from 2011, we had to convert the old civil parishes into the new parish divisions.

Tables A.1 and A.2 in the Appendix provides the summary statistics for our sample of municipalities and civil parishes used in our analyses. Our final dataset contains quarterly Airbnb shares and quarterly transaction and rental prices in 106 municipalities in Mainland Portugal and in 31 civil parishes in the municipalities of Lisbon and Porto between 2012Q1-2016Q1.

5. Empirical strategies

5.1. Baseline OLS specifications

Let $Y_{i,t}$ denote the natural log of average housing rents or transaction prices in municipality i in period t (a given quarter-year), $AbbShare_{it}$ is the share of listed Airbnb properties to the total dwellings in municipality/parish i in period t, $Covariates_i$ is a k-by-1 vector of time-invariant amenities in municipality i (see Table A.1 in the Appendix for the list) and τ_t are year-quarter fixed effects. Finally, let ε_{it} contain municipality/parish level shocks to transaction prices or rents. Our baseline specification is represented as

$$Y_{i,t} = \alpha_0 + \alpha_1 AbbShare_{it} + \boldsymbol{\alpha_2}' \boldsymbol{Covariates_i} + \tau_t + \varepsilon_{it}. \tag{1}$$

where α_1 is the parameter of interest and standard errors are clustered at the municipality/parish level to account for serial correlation within panel units and $\boldsymbol{\alpha_2'} = [\alpha_{2,1}, \ldots, \alpha_{2,k}]$ is a 1-by-k vector of coefficients for each of the k covariates. We also report the results from a specification where we include municipality/parish level fixed effects denoted by μ_i. Since all our covariates are time-invariant, in this specification their effects cannot be identified (multicollinearity). Hence in this case we obtain the following specification:

$$Y_{it} = \alpha_0 + \alpha_1 AbbShare_{it} + \tau_t + \mu_i + \varepsilon_{it}. \tag{2}$$

5.2. IV specification

Our baseline OLS results can nevertheless still be biased due to endogeneity issues and due to unobserved municipality/parish -specific, time-varying factors contained in our error term that are correlated with Airbnb share. To address this concern, we follow Barron et al. (2018) and instrument tourism pressure with Google trends for the word "Airbnb" ($Ggltrends_t$) interacted with a measure of how "touristy" an area is in the base quarter-year ($AbbShare_{i,Q1Y04}$). We define "touristy" to be a measure of an area's (i.e. municipality or civil parish) attractiveness for tourists and proxy it using Airbnb share in 2014Q1 (i.e. pre-Airbnb expansion period). The fact that we use a pre-2014 measure, it means that it is independent from any unexpected future shocks to local housing markets. Furthermore, the inclusion of municipality/parish level fixed effects controls for the ex-ante sources of heterogeneity (omitted variables). This instrument is expected to explain the variation of short-term rentals because areas (i.e. municipalities or civil parishes) that had a stronger presence of Airbnb before the policy, are more likely to experience a growth of Airbnb over time as Airbnb becomes more in demand and

property owners become more aware of the benefits of short-term rentals. Since the presence of Airbnb in the first quarter of 2014 may signal how touristy a given municipality is, we test the instrument significance in the first stage regression. Moreover, the exposure of "high" versus "low" touristy areas to Airbnb over time is expected to have no direct effect on the housing market and is thus uncorrelated with house prices. The intuition for this second assumption rests on the exogeneity of the aggregated trend in Airbnb Google searches to local shocks on house prices. The necessary exclusion restriction that guarantees identification is then that the evaluation of Airbnb Google searches in high versus low touristy areas only affect house prices through its effects on the demand from tourism.

The specification we use for the IV strategy is described next. In the first stage we predict Airbnb share in municipality (or civil parish) i and time t, $AbbShare_{it}$, as a function of Airbnb awareness (measured using Google trends) interacted with our "touristiness" measure that proxies how attractive a municipality (or a civil parish) is for tourists in the first quarter of the base year of 2014, that is, $AbbShare_{i,Q1Y04}$

$$AbbShare_{it} = \beta_0 + \beta_1 AbbShare_{i,Q1Y04} * Ggltrends_t + \tau_t + \mu_i + \varepsilon_{it}. \quad (3)$$

The second stage of our analysis computes the log of transaction prices or rents as a function of the predicted Airbnb share, $\widehat{AbbShare}_{it}$, and all the same controls used in the first stage as

$$Y_{it} = \alpha_0 + \alpha_1 \widehat{AbbShare}_{it} + \tau_t + \mu_i + \varepsilon_{it}. \quad (4)$$
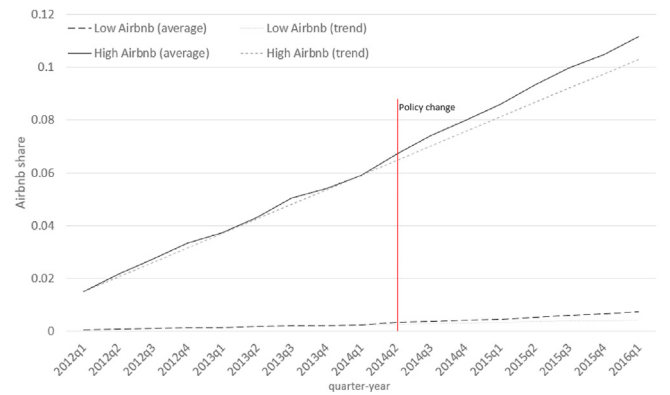
However, IV analysis relies on unverifiable conditions (Barron et al., 2018). For the instrument to be valid it must be the case that it is uncorrelated with municipality-specific (or civil parish-specific), time-varying shocks to the housing market, for instance sociodemographic changes or gentrification. This requires that either ex-ante "*touristiness*" in 2014 be independent of future municipality (civil parish) level shocks, or growth in Airbnb searches be independent of municipality-level (civil parish-level) shocks. Now suppose that there is a long-run trend towards gentrification, which leads to higher house prices and rents over time. In addition, this gentrification trend is higher in more touristy areas.[19] Since there is also a systematic long-run trend in the time-series variable (Google trends), the instrument may no longer be independent from the error term. In this case our IV estimates may reflect the effects of gentrification rather than home-sharing.[20] While exogeneity of ex-ante "*touristiness*" to future shocks to the housing market are a plausible assumption, it is the differential growth of Airbnb online searches that is a potential source of concern. Therefore, when zooming our analyses to the civil parishes of Lisbon and Porto, we compare our IV estimates with those from a Difference-in-Differences (DiD) approach. Our DiD approach compares the evolution of the average house prices and average rental prices in civil parishes with high versus low Airbnb share located in Lisbon and Porto. Next, we explain in more detail our DiD approach.

5.3. Difference-in-differences – civil parishes located in Lisbon and Porto

As seen in section 3, RNAL registries spiked in 2014Q3 but so did Airbnb listings especially in the municipalities of Lisbon and Porto (see

Notes:Plotted is the Airbnb share for the treated and non-treated parishes. We report both the average and a fitted pre-policy trend extrapolated for the period after the policy change in panel (a) and the difference between the average and the trend in panel (b).

Fig. 6. Airbnb Share –averages and trends in the civil parishes of Lisbon and Porto.

Fig. 5). This is further confirmed in Fig. 6 which reports the average Airbnb share in the low and high "touristy" civil parishes of Lisbon and Porto. Since Lisbon and Porto are the two municipalities with the largest presence of Airbnb listings in 2014Q1 (see Appendix Table A.3.), and both their high and low touristy civil parishes exhibit the same trends pre-2014 (see Fig. A.1. in the Appendix), we focus our DiD approach in the civil parishes of Lisbon and Porto.

Several notes are now in order. First, the goal of our DiD exercise is to test whether high touristy parishes experienced higher rents and price growth than low touristy parishes with the expansion of Airbnb (that is, post-2014). To accomplish this, we compare the changes in house prices and rents over time between properties that are located in high touristy parishes (the treatment group) and low touristy parishes (control).

Second, Figs. A.8 and A.10 in the Appendix map Airbnb shares across the civil parishes in Lisbon and Porto, respectively, for the first quarter of 2016. It is clear there is substantial variation in Airbnb shares within these cities, with the highest Airbnb shares located in the historic centers. Table 3 also presents the top six civil parishes located in Mainland Portugal with the highest Airbnb share in 2014Q1 and in 2016Q1. All six parishes are located in the municipalities of Lisbon and Porto and in the historic zones of those cities.

Therefore, in our DiD exercise our control group is composed by civil parishes that have little to no Airbnb listings in 2014Q1 (proxy for the "*touristiness*" of the civil parish), while our treatment group is composed by civil parishes with the highest Airbnb presence in 2014Q1.[21] As shown in Table A.2. in the Appendix, our treated and untreated civil parishes are similar in their housing costs, being their main differences in the Airbnb counts, house and population densities and average age of the housing stock. Since house density is an important feature on which treated and untreated parishes differ, we perform robustness checks of our results with regards to this characteristic in subsection 6.2.

Third, municipalities in the southernmost region of Mainland Portugal, Algarve, have also a strong presence of short-lets and will be used as a placebo group in our robustness checks. Algarve is the main beach and golf destination in Portugal and short-term rentals have been a strong presence in this region long before the existence of Airbnb and other similar peer-to-peer short-term rental platforms. In addition, Table A.3. in the Appendix reveals that most short-term vacation homes in Algarve are not listed in the Airbnb platform. For example, in

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[19] Specifically, in the municipalities of Lisbon and Porto Airbnb has grown the most in historic civil parishes and along the river, areas that have also been experiencing processes of urban renewal and foreign real estate investment in the last few years.

[20] One possible strategy to control for the potential effects of gentrification is to introduce in our specification a set of time-varying demographic controls at either the municipality or civil parish levels (depending on our unit of analysis). This would allow us to control for yearly changes in variables associated with gentrification. However, because our demographic controls come from the Census, we are not able to implement this approach.

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[21] The treatment group is composed of the following 6 civil parishes: Sta Maria Maior, Misericordia, Sto. Antonio, UF Cedofeita, S. Vicente, and Arroios. As a robustness check we expand this set of parishes to also include the second set of parishes by Airbnb presence: Bonfim (Porto), Avenidas Novas (Lisbon), Penha de França (Lisbon), Campolide (Lisbon), and Alvalade (Lisbon) as reported in Table A.3. in the Appendix.
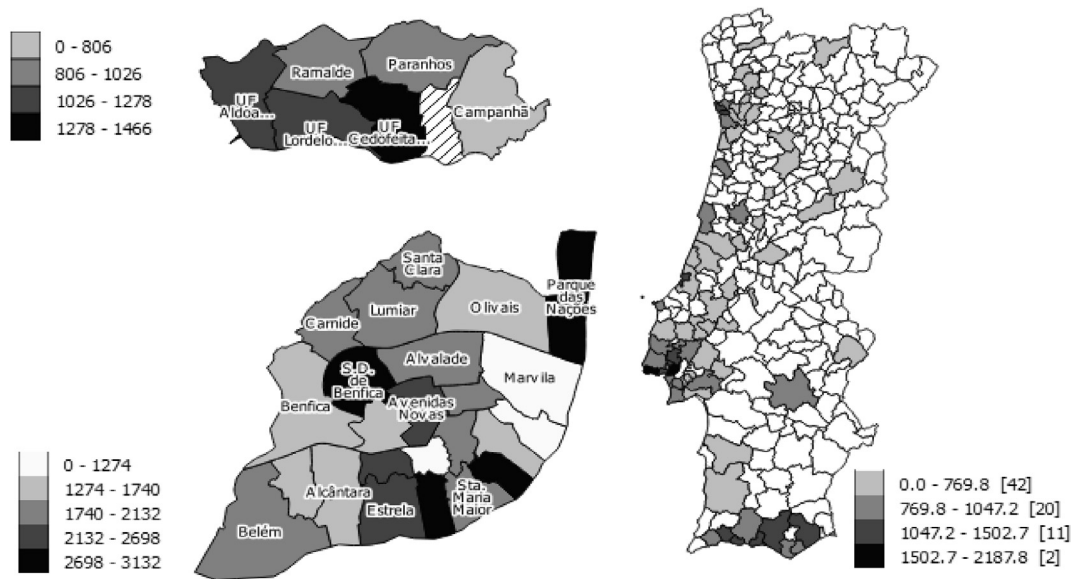
Map 1. Transaction price in €/m², in the 1st quarter of 2016, in Mainland Portugal (on the right), Porto (on the upper-left) and Lisbon (on the lower-left).
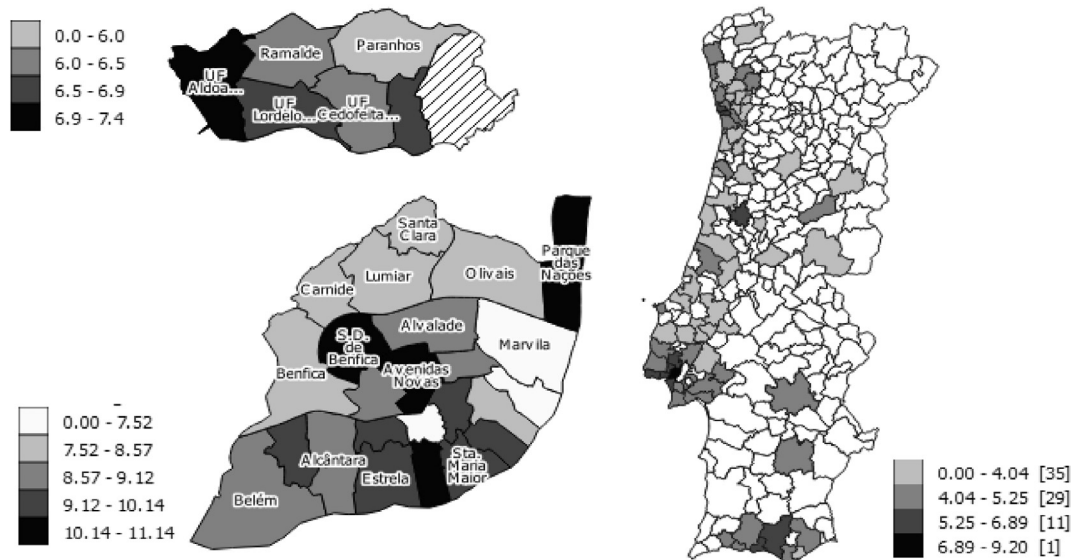
Map 2. Rental values € per m², in the 1st quarter of 2016, in Mainland Portugal (on the right), Porto (on the upper-left) and Lisbon (on the lower-left).

Table 3
Top six civil parishes in Mainland Portugal with the highest Airbnb share.

	1st quarter - 2014	1st quarter – 2016
1	Sta. Maria Maior (Lisbon) – 0.13	Sta. Maria Maior (Lisbon) – 0.226
2	Misericórdia (Lisbon) – 0.113	Misericórdia (Lisbon) – 0.175
3	Sto. António (Lisbon) – 0.054	Sto. António (Lisbon) – 0.103
4	UF Cedofeita, …(Porto) – 0.040	UF Cedofeita, …(Porto) – 0.088
5	S. Vicente (Lisbon) – 0.039	S. Vicente (Lisbon) – 0.079
6	Arroios (Lisbon) – 0.026	Arroios (Lisbon) – 0.053

Albufeira, the most popular touristy municipality in the region, the percentage of total housing units listed in Airbnb is 1.76% while in RNAL registries this share is 2.91%. Therefore, we use Algarve as a placebo test since no effect of the policy reform on housing costs in this part of the country should be expected as the great majority of real estate properties have always been used to accommodate tourist demand for accommodation.

Our DiD specification includes interaction variables consisting of a period dummy (=1 if a quarter-year is post-2014Q2) and treatment group dummies (=1 if the treatment is active in civil parish i; otherwise 0) as follows:

$$Y_{it} = \alpha_0 + \alpha_{1t} Period_t * Treatment_i + \tau_t + \mu_i + \varepsilon_{it}. \tag{5}$$

Therefore, $Period_t * Treatment_i$ captures the average impact since 2014Q2, by comparing house prices/rents during this period relative to house prices/rents during the quarters pre-Airbnb expansion, among the treatment group relative to the control group. Note that α_{1t} implies that the average treatment effect on housing costs may vary with time since exposure. The time-fixed effects trace out the common time trend, while the civil-parish fixed effects capture time-invariant characteristics of civil-parishes.

A valid DiD for causal inference rests on the stable unit treatment value assumption (SUTVA). SUTVA requires that the response of a particular unit should be unaffected by the particular assignment of treatments to the other units. Yet, this may prove difficult in urban

settings because high treatment areas may affect contiguous low treatment areas through equilibrium effects (Baum-Snow and Ferreira, 2015). One way to overcome this problem is to aggregate the data to the highest possible geographic unit. In our analyses our unit of observation is the civil parish. Civil parishes are geographic units higher than census sections and subsections. It should be noted that within the context of our analyses, violation of the SUTVA would actually decrease the treatment effect from short-term rentals, as a strong treatment would increase not only the house price in its civil parish but also in neighboring civil parishes, reducing the gap between the two. Thus, in the case of violation of SUTVA, the estimated treatment effect generated by the Airbnb share becomes a lower bound and our results are a conservative estimate of the true effect.

A second important assumption is the parallel trends in the dependent variable (home prices and rents) before 2014 for both treatment and control groups. This assumption requires that the untreated civil parishes provide the appropriate counterfactual of the trend that the treated civil parishes would have followed if they had not been treated – that is, that the two groups would have had parallel trends. In Fig. A.1. in the Appendix, we plot the values of house prices smoothed by a linear trend for the control and treatment group before and after 2014Q1 in order to visually examine the period before and after Airbnb expansion. This figure shows that while there is generally a similar pattern prior to 2014Q1 (statistically we do not reject parallel trends, see details below), the two lines diverge sharply after 2014Q3, which also happens to be when interest and expansion in Airbnb listings began to grow more, according to Fig. 6. Relative to the control group, the treatment group house prices start to increase from 2014Q1, although the larger increases occur after the third quarter of 2014. House prices of the control group on the other hand do not experience dramatic changes, but increase also in the third quarter of 2014, which could reflect the impact of national housing market improvements. We perform a formal statistical test for equality of trends using data from 2010Q1 to 2016Q1. We estimate a model with the same control variables as our main model, which we describe above, except that the key variable of interest is an interaction between the linear time trend and the treatment group dummy instead of the usual difference-in-differences variables. We conclude from our results included in Appendix Fig. A.1. that we fail to reject parallel linear trends in the pre-treatment data. (pval = 0.87).

For completeness, we also run a second IV where we predict Airbnb share in a given parish in a given quarter in the first stage with the instrument consisting of the Airbnb share detrended with separate pre-Reform trends for the high and low Airbnb parishes.[22] Our specification also includes separate time trends for the high and low touristy groups and parish fixed effects. This is a very demanding specification that eliminates most of the variation in our data. So, in the first stage, we run the following specification (results are presented in Table A.5. in the Appendix):

$$AbbShare_{it} = \beta_0 + \beta_1 Reform_t * HighTouristy_{it} + \beta_2 HighTouristy_{it} * Year_t$$
$$+ \beta_3 Year_t + \mu_i + \varepsilon_{it} \tag{6}$$

with $Reform_t$ a dummy equal to 1 if a quarter-year is post-reform, and in the second stage we run specification (4) using the estimated $AbbShare_{it}$ based on (6). Our second IV strategy helps us clarify if the 2014 policy reform actually increased Airbnb listings. We include trends for touristy and non-touristy parishes to be sure the policy reform captures something more than a simple trend increase (in the first stage) and to control for heterogenous trends in the outcome (in the second stage).

Even after controlling for trends, there can still be a concern that differences in growth may still reflect other sources. For example, tourism in the traditional hotel sector might have impacted house prices causing a faster increase in touristy parishes (even controlling for trends).

The hotel market might impact housing prices through the demand side (say resident earnings, due to higher spending) or the supply side (if hotels and business compete with housing for land). First, we note that the number of tourists in both municipalities has been steadily increasing since 2011. In addition, due to data limitations it is not possible to characterize the type of residents in these touristy parishes, that is, to understand whether they are related to the hotel industry. If it is the case where most workers in the hotel business in the touristy parishes live elsewhere, then we would expect house prices to increase outside of the touristy parishes because of income reasons. If anything, our estimates would then be biased downwards. Our results in section 6 do not seem to support this scenario. Second, we collected data from INE for the number of hotels and beds in these two municipalities between 2011 and 2016. This data is reported in Figs. A.2. and A.6. as well as in Table A.4. in the Appendix. Our collected data shows that the number of hotels has also been growing steadily over the whole period (about 10% per year since 2011) and not particularly more after the policy change. Nonetheless, we include separate time trends in our IV specification. Finally, we have also included in our DiD specification the number of beds and hotels as two separate covariates in each quarter-year.[23] Our results are presented in the Appendix-Table A.6. Overall, our main results are virtually unaffected, becoming even slightly stronger in magnitude and significance. We thus have no evidence in favor of housing prices being driven by demand for hotels.

6. Discussion of results

6.1. Is there empirical evidence that Airbnb share has pushed house prices and rents up?

Simple OLS and IV Evidence – Mainland Portugal (municipality level analysis)

Table 4-columns (1)–(4) report the OLS and IV results of the effects of Airbnb share in a municipality on the log of home sale prices and on the log rents in a given municipality.

The coefficient on Airbnb share in Table 4- column (1) shows that a one percentage point (1pp) increase in a municipality Airbnb share is associated with a 7.61% increase in the municipality housing prices, on average. We should note that in this specification we have time fixed-effects but the controls are time-invariant and do not account for other unobserved characteristics. While not reported, these other variables always have the expected signs and most are statistically significant. In Table 4-column (2) we introduce municipality fixed effects and the estimated coefficient is reduced from 7.61 to 3.09, implying that on average the impact of a 1pp. increase in the Airbnb Share results in a 3.09% increase on house prices. When evaluating at the sample mean house price this translates into an increase from €982/m² to €1012/m².

Table 4-column (3) reports the IV results with both municipality level and time fixed effects (and without the time invariant controls that are collinear with municipality fixed-effects). The diagnostics show a very significant first stage (p-value<0.001) meaning that our instrument is relevant and a non-rejection of the exogeneity of the FE model of column (2) (p-value = 0.325). Regarding our variable of interest, the IV results in column (3) show only a small reduction of our previous estimate with the simple OLS-FE model. A 1pp increase in Airbnb share in a municipality is now associated with a 3.74% increase in a municipality home sale prices, on average.

Table 4-column (4) repeats the previous IV analysis, but excludes the municipalities of Lisbon and Porto. Again, the diagnostics show a very significant first stage (p-value<0.001) meaning that our instrument is relevant and a non-rejection of the exogeneity of the FE model (p-value

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[22] We thank a referee for this suggestion.

[23] Since the hotel data is provided on a yearly basis, we use a linear interpolation between each end of year – e.g. if there are 100 hotels in 2013q4 and 104 in 2014q4 we estimate 101 in 2014q1, 102 in 2014q2, 103 in 2014q3.

Table 4
OLS and IV estimates of the effect of Airbnb Share in a municipality on home sale prices and rents.

Method:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	FE	IV	IV	OLS	FE	IV	IV
Dep. Variable:	Ln(Home Sale Price)				Ln(Rent)			
Airbnb Share	7.612***	3.088**	3.738***	2.502*	2.907*	0.139	0.385	−0.246
	(1.780)	(1.314)	(1.370)	(1.432)	(1.613)	(0.828)	(0.856)	(0.907)
Observations	791	791	791	757	884	884	884	850
R^2-adjusted	0.805	0.878	–	–	0.846	0.908	–	–
IV first stage (Fstat and pval)			687 0.000	655 0.000			761 0.000	729 0.000
Endogeneity (pval)			0.325	0.910			0.543	0.875
Quarter-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Covariates	Yes	No	No	No	Yes	No	No	No

Notes: *Significance levels*: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses clustered at the municipality level. Simple OLS results with municipality level covariates reported in (1) and (5). Columns (2) and (6) introduce fixed effects at the municipality level. The instrument in columns (3) and (7) is the interaction of google time trends for the word "Airbnb" times the share of properties on Airbnb in the first quarter of 2014 (before the policy). Finally, columns (4) and (8) exclude the municipalities of Lisbon and Porto.

= 0.91). Excluding Lisbon and Porto results in a slight reduction of our previous estimate, though our results are still statistically significant. A 1pp. increase in Airbnb share in a municipality is now associated with a 2.5% increase in a municipality house prices, on average. This is not surprising given that Lisbon and Porto are not only the two largest municipalities in Portugal but also the municipalities with the largest Airbnb shares in our study period.

Table 4-columns (5)–(8) repeat the same specifications when the dependent variable is the logarithm of rental prices. As with the house price regressions, we find that controlling for municipality amenities and characteristics is important, as the estimated effect of Airbnb share decreases when controls are included. Moreover, as in the case of house prices, the IV estimate (column (7)) and the FE estimate with municipality fixed effects (Column (5)) have very different magnitudes. Finally, for rents we do not reject the validity of the OLS-FE model. In general, we do not find statistically significant impact of Airbnb share on long term rental prices. As explained previously this is most likely due to the overlap of the phasing-out period of the 2012 rental market liberalization and our study period, as discussed in subsection 3.1.

7. Evidence – Lisbon and Porto (civil parish level analysis)

Next, we zoom our analyses to the effects of Airbnb share on housing costs in Lisbon and Porto. Table 5-columns (2) and (5) repeat the IV analysis conducted in Table 4-columns (3) and (7) using a different geographic unit of analysis – the civil parishes of Lisbon and Porto (column 1 reports the baseline OLS results). The diagnostics show a statistically significant first stage (p-value<0.001) and an F-stat above 10. We also find a non-rejection of the exogeneity of the simple FE model. Regarding our variable of interest, we do not find a statistically significant impact on long term rental prices. Our results on house prices on Table 5-column (2) show a small reduction of the OLS with fixed effects estimate reported in column (1) and also a slight reduction with the IV model in the sample of municipalities.

On average, a 1pp increase in a civil parish Airbnb share is associated with a 2.92% (3.11% for the OLS with fixed effects) increase in house prices (compared to a 3.73% effect across municipalities in Table 4 – column (3)).[24] Because the large degree of heterogeneity in Airbnb share across civil parishes implies that Airbnb has not affected all civil parishes equally, we illustrate the impacts in Figs A.7 and A.9 in the Appendix. We plot the product of our coefficient in Table 5-column (2) with the Airbnb share of each civil parish in 2016. While the suggested effects are close to zero for the less central civil parishes, our estimates imply some very large local impacts in iconic historic areas. On average, the effect of Airbnb share on house prices on the six civil parishes with highest Airbnb shares in Lisbon and Porto in 2016 was 32.48%. These six civil parishes house iconic touristy neighborhoods such as *Alfama, Mouraria, Bairro Alto* and *Cais do Sodré*, all located in the historic core of the city of Lisbon (within the civil parishes of Santa Maria Maior and Misericórdia) and with some of the highest rates of derelict buildings in 2012. Case studies of central areas of Lisbon show that in 2016 a large percentage of the supply of short-term rentals in these iconic neighborhoods was supplied by individual and corporate buy-to-let investors (Cocola-Gant and Gago, 2019; Dominguez, 2019).

Table 5-column (3) present IV results using an alternative instrument composed by a period dummy interacted with a dummy for the treated parishes (those with the largest Airbnb share) while also controlling for two separate time trends for the treatment and control groups. Again, the diagnostics show a statistically significant, yet marginally, first stage (p-value = 0.028).[25] For this reason these results should be taken with caution (F-test is 4.86 below the usual threshold of 10). We also confirm the non-rejection of the exogeneity of the simple FE model (p-value = 0.361). Regarding our variable of interest, the results show an increase of our previous estimate. On average, a 1pp. increase in a civil parish Airbnb share is associated with a 3.59% increase in the parish house prices. This last specification is nevertheless very demanding in terms of data variation. As a robustness check we detrend house prices and rents and the Airbnb Share using separate pre-2014Q2 trends for the high and low touristy parishes. We then use an OLS fixed effects specification. The results reported in Appendix Table A.6 show that the coefficient is estimated at 3.03 and the results are robust to the separate time trends specification.

[24] Note that Barron et al. (2018) use a ln(Airbnb Listings) specification at the municipality level. We, on the other hand, use an Airbnb share specification and we run our IV specifications at the municipality (Table 4) and parish levels (Table 5). When we use our IV result from Table 4 (so excluding Lisbon and Porto), we have that a one standard deviation increase in the Airbnb share (0.5%) is equivalent to an estimated increase of 1.25% (our estimated coefficient times the standard deviation is 2.5*0.005 = 0.0125) which compares to their estimate of a 0.93% increase in house prices (0.54% in Rental Rates). If instead we use our IV estimate from Table 5, we have that a one standard deviation increase in the Airbnb share is equivalent to an estimated increase of 1.45%. So, our estimates are in the same ballpark.

[25] The first stage coefficient is 0.0075 (p-value = 0.0026) which suggests that the policy generated an extra increase in the share of homes on Airbnb for the touristy areas of 0.75 percentage points. Full first stage results are reported in Table A.5. in the Appendix.

Table 5
IV estimates of the effect of Airbnb share in the parishes of Lisbon and Porto on home sale prices and rents.

	(1)	(2)	(3)	(4)	(5)	(6)
Method:	OLS	IV		OLS	IV	
Dep. Variable:	ln(Home Sales Prices)			Ln(Rents)		
Airbnb density	3.108***	2.923***	3.586***	−0.198	−0.384	0.145
	(0.508)	(0.505)	(0.589)	(0.290)	(0.290)	(0.376)
Observations	456	456	456	506	506	506
IV first stage	–	3932	4.86	–	4374	7.43
(Fstat and pval)	–	0.000	0.028	–	0.000	0.007
Endogeneity (pval)	–	0.258	0.361	–	0.441	0.412
Quarter-year FE	Yes	Yes	No	Yes	Yes	No
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes
Separate time-trends	No	No	Yes	No	No	Yes

Significance levels: ***p < 0.01, **p < 0.05, *p < 0.1. Notes: Standard errors in parentheses clustered at the parish level. The instrument in columns (2) and (5) is the interaction of google time trends for the word "Airbnb" times the share of properties on Airbnb in the first quarter of 2014 (before the policy). Columns (3) and (6) use as instruments the interaction of the dummies for the the years after the reform period interacted with the dummies for high Airbnb presence ("*touristiness*") as defined in Section 4 and includes separate time trends for the "treated" and control groups.

Table 6
DiD estimates of the effect of Airbnb share in a Civil Parish of Lisbon and Porto on home sale prices and rents.

Dep. Variable	(1)	(2)	(3)	(4)	(5)
	log(sales)	log(rents)	Airbnb Share	(1)/(3)	(2)/(3)
Treatment x 2012	0.0578	−0.0170	−0.0262***	−2.206	0.649
	(0.0618)	(0.0278)	(0.00680)		
Treatment x (2013 & 2014Q1 2014Q2): base	–	–	–	–	–
	–	–	–	–	–
Treatment x (2014Q3 & 2014Q4)	0.139	−0.0518**	0.0234***	5.940	−2.214
	(0.0861)	(0.0222)	(0.00536)		
Treatment x 2015	0.243***	−0.00146	0.0407***	5.971	−0.036
	(0.0586)	(0.0258)	(0.00886)		
Treatment x 2016	0.323***	0.0419	0.0547***	5.905	0.766
	(0.0805)	(0.0536)	(0.0113)		
Observations	456	506	527		
R^2-adjusted	0.803	0.832	0.949		
Quarter-year FE	Yes	Yes	Yes		
Parish FE	Yes	Yes	Yes		

Significance levels: ***p < 0.01, **p < 0.05, *p < 0.1. Notes: Standard errors clustered at the parish level. The treatment group are the parishes of UF Cedofeita, Sto António, Sta Maria Maior, Misericórdia, Arroios, and S Vicente. The control group are all the remaining parishes in Lisbon and Porto.

7.1. Difference-in-differences effects: Lisbon and Porto civil parishes

Table 6 presents our DiD results. We remind the reader that we have estimated the changes in house prices and rents between the pre- and post-Airbnb expansion periods and between "high" and "low" touristy civil parishes. Compared to a low touristy parish, Airbnb share in a high touristy parish had an increase of 4.07pp in 2015 and 5.47pp in 2016Q1. It is also shown that compared to a low touristy parish, house prices in a high touristy parish had an increase of 24.3% in 2015 (2–5 quarters after 2014Q2) and 32.3% in 2016Q1 (6 quarters after 2014Q2). Since the average Airbnb share in our treatment group (touristy parishes) is 11.2pp for 2016Q1, our DiD results compare with our preferred IV estimated treatment effect of 32.48% (=2.9*11.2pp).[26] Finally, from column (4) we further observe that after 2014Q2 on average, a 1pp increase in Airbnb

share translated to increases of 6% in house prices in high touristy parishes (our treatment group).

7.2. Robustness checks

Table 7 presents the results of our robustness checks. We first extend the set of treated parishes to the second set of parishes ranked highest by Airbnb share (see Appendix-Table A.3) to ensure our results are not driven by our definition of high and low touristy parishes. Then, we restrict our analysis to parishes with a house density above 4700 units/km^2 to ensure our results do not result from differences in house densities. Lastly, we perform a placebo test at the municipality level. The treatment placebo group are municipalities with similar Airbnb share but where the effect of Airbnb on house prices should not be present (the municipalities in the southern region of the Algarve).

7.3. Extended set of treated parishes

As reported in Table 7- column (2), the average effect on home sale prices is reduced to 24.1% in 2016Q1. This is not surprising since the average Airbnb share is now 7.2pp, almost 64% of the previous 11.2pp, and therefore the estimated coefficient is roughly reduced by slightly more than 30%. This is consistent with a linear effect of the Airbnb share on house prices as reported in Table 5. On the other hand, reported in Table 7- columns (6)–(8), the effect of Airbnb share on rental prices remains insignificant.

7.4. High house density areas

From Appendix Table A.2. we know that the main difference between our original treated and untreated parishes is their level of housing density. In particular, our original six treated civil parishes have higher housing densities than our original control parishes. It should be mentioned however that our original treated parishes are all located in the historical Central Business District. Since both Porto and Lisbon are monocentric cities it is not surprising that these treated parishes are characterized by both high housing density and high level of historic amenities. Therefore, to exclude house density differences as a possible driver of our findings, we use a comparable set with respect to house density for the treatment and control groups. In particular, we restrict our analysis to the subset of parishes with house density above 7400 units/km.[2] This results in a control group that now only includes the parishes of Alvalade (Lisbon), Beato (Lisbon), Belém (Lisbon), Bonfim (Porto), Campo de Ourique (Lisbon) and Estrela (Lisbon). All these control parishes are located in an adjacent ring surrounding our treated group, and therefore they are in very close proximity to the historic core. The results

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[26] We remind the reader that in Table 5 the explanatory variable was the contemporaneous Airbnb share in civil parish i and period t, while in our DiD the explanatory variable is the "*touristiness*" dummy interacted with the period dummy (=1 if a quarter-year is post-2014Q2).

Table 7
DiD estimates of the effect of Airbnb on home sale prices and rents.

Dep. Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln(Home Sale Prices)				Ln(Rents)			
Treatment x 2012	0.0578	0.0225	−0.0220	0.00428	−0.0170	−0.00341	−0.0294	0.00947
	(0.0618)	(0.0574)	(0.0625)	(0.0299)	(0.0278)	(0.0217)	(0.0323)	(0.0288)
Treatment x 2013	–	–	–	–	–	–	–	–
(base)	–	–	–	–	–	–	–	–
Treatment x 2014	0.139	0.0449	0.179*	−0.0339	−0.0518**	−0.0311	−0.0248	−0.0523**
	(0.0861)	(0.0610)	(0.0953)	(0.0339)	(0.0222)	(0.0228)	(0.0346)	(0.0239)
Treatment x 2015	0.243***	0.142**	0.175**	0.0321	−0.00146	0.00776	0.00496	0.000997
	(0.0586)	(0.0627)	(0.0738)	(0.0351)	(0.0258)	(0.0199)	(0.0309)	(0.0262)
Treatment x 2016	0.323***	0.241***	0.214**	0.0729*	0.0419	0.00721	0.0151	−0.0295
	(0.0805)	(0.0704)	(0.0902)	(0.0434)	(0.0536)	(0.0387)	(0.0688)	(0.0484)
Observations	456	456	186	757	506	506	201	850
R^2-adjusted	0.803	0.788	0.807	0.857	0.832	0.831	0.820	0.884
Quarter-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Columns (2) and (6) extend treatment group to include the parishes of Bonfim (Porto), Avenidas Novas (Lisboa), Penha de França (Lisboa), Campolide (Lisboa), and Alvalade (Lisboa). Columns (3) and (7) restrict the control group to parishes with house density above 4700 units/km.[21] Columns (4) and (8) present results at the municipality level for our placebo exercise with the municipalities of Lisbon and Porto excluded from the control group (that includes all remaining municipalities in the country). Standard errors clustered at the parish (municipality for columns (4) and (8)) level.

in Table 7- columns (3) and (7) reveal that the effect of parish Airbnb share on the parish house prices is slightly reduced to 22.3%. This suggests that our findings are also not driven by the spatial structure of the city. Even within very dense city areas there is a distinct evolution of house prices between high and low Airbnb parishes. The effect on rental prices remains insignificant.

7.5. Placebo tests

The *placebo* tests involve constructing a *placebo* group. In the *placebo* group the Airbnb effect should not be present and finding it would suggest a mis-specified design. For this robustness check we conduct the analysis at the municipality level and select a set of municipalities similar to the treated group but where the impact of Airbnb share should not be present. The Algarve region has a large presence of Airbnbs (see Appendix Table A.3) and will be used to construct our *placebo*. This region is well-known for being the primary beach destination of the country with many holiday homes available for rent all year round. Since 2014, this region has seen its hospitality market shift as second homes increasingly become second sources of income. We make nevertheless a distinction between the traditional markets for *holiday homes*, such as beach communities, and the recent trend in *short-term rentals* potentiated by Airbnb. Short-term rentals are mostly a new urban phenomenon, unlike beach holiday homes. Therefore, we do not expect the rental housing market in Algarve's beach communities to be strongly affected by the widespread use of online short-term rental platforms such as Airbnb. We also exclude the municipalities of Lisbon and Porto from our control group. The results in Table 7- columns (4) and (8) show that we find a very small effect of Airbnb share in the *placebo* groups. We thus have no evidence of design misspecification for our baseline results.

We have also investigated whether our results may be driven by market liberalization by checking for the possibility of the results occurring pre-2014 using two additional placebo tests (see Figs. A.4. and A.5. in the Appendix). Both market liberalization and the golden visa program were implemented during 2012Q3 (market liberalization by "Law 31/2012 of 14th August 2012" and Golden Visa by "Law 29/2012 of 9th August 2012"). We thus use the period post 2012q2 as an alternative placebo date. And, since some of these laws took time to be implemented, we use as a second placebo two quarters later (post 2012Q4).

While prices are recovering between 2013 and 2014, this recovery is occurring in both high and low touristy areas (as one would expect as the result of market liberalization and the golden visa program which affected both areas). The results of these additional placebo DiD are reported in Table 8 and confirm that the effect on house prices is not

Table 8
DiD estimates of the effect for a placebo date post 2012q2 and post 2013q4.

Placebo date	Post 2012Q2	Post 2012Q4
Dep. Variable	log(sales)	
Treatment (dummy)	−0.04	−0.026
	0.077	(0.043)
Treatment x 2012	0.029	–
	(0.086)	–
Treatment x 2013	−0.05	−0.065
	(0.096)	(0.066)
Treatment x 2014	0.047	0.032
	(0.103)	(0.067)
Observations	310	310
R^2-adjusted	0.999	0.999
Quarter-year FE	Yes	Yes
Municipality FE	Yes	Yes

Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

statistically different in high vs low touristy areas. Therefore, we do not seem to have any evidence that market liberalization or the golden visa program could explain our findings.

8. Conclusions

Since it was founded in 2008, the short-term rental platform Airbnb has been the subject of critics that have blamed it for raising housing prices, changing employment dynamics and the quality of life of residential neighborhoods, and triggering gentrification and displacement of residents from central and urban historic zones. However, causal evidence on how Airbnb and other home-sharing platforms affect housing markets is mostly lacking, despite several cities worldwide have already reacted to the rise of Airbnb with different policy interventions, varying from *laissez faire* to prohibition to allowing it with certain restrictions.

This article quantified the effect of an increase in Airbnb share in a given location (i.e. a municipality or a civil parish) on housing affordability. Using a difference-in-differences strategy we show that there was an increase in housing transaction prices between 2014Q2 and 2016Q1 for areas with strongest presence of Airbnb share. The effects are mostly localized to the historical centers of the two largest cities in Portugal, Lisbon and Porto. These effects are also not trivial, implying that even within historical centers large discrepancies have arisen solely due to the higher presence of short-term rentals. This should not be ignored, as these effects are far from neutral from a distributional point of view (see

for example Koster et al., 2019). Despite the distributional concerns and the potential displacement of existing residents, the increase in house prices has also created incentives for dwellings in historical centers to be renovated and redeveloped. This process in turn has helped rebirth some of the old city areas by attracting buy-to-let investors and some younger population to invest and move in, and through a gentrification process that has attracted people with higher incomes and more upscale urban amenities and services. The study of these consequences should be the subject of future research. In addition, future work should explore how short-term rental platforms have helped housing financialization in historic centers and may have contributed to a new form of gentrification in certain neighborhoods currently known as buy-to-let gentrification.

Moreover, short-term rentals, especially when they become the primary form of occupation of specific neighborhoods, can weaken community networks and the social fabric of a city, which in turn undermines the promotion of long-term rental as an essential tenure system for local residents. Yet, in our study we don't find robust evidence for such long-term rent increases. A possible explanation for our finding may be the phase-out of the rent controls that lasted from 2012 to 2017, thus covering our study period. During the phase-out period the so-called "old" rents, which represented a large portion of the total existing rental contracts, had very limited price increases and were further constrained by the tenant characteristics (age, disability level, income). Thus, during our study period only the new rental agreements were under the new regime (and set to market levels), but these are not enough to generate a relevant price increase in the data. Our results then suggest that in Portugal the phase out of the 2012 rental market liberalization may have attenuated the effect of an increase in Airbnb share on long-term rental prices during our study period. Future research should explore how the phase-out of rent controls interplayed with the price effects of Airbnb growth.

Finally, it should be noted that Lisbon and Porto have already introduced tourist taxes in 2016 and 2018, respectively, to help cope with the issues of urban cleaning and transportation in areas where tourism exerts greater pressure and expansion. The Algarve region also voted to follow suit in March 2018. Moreover, these cities are currently weighting the benefits of expanding tourism accommodation at the expense of domestic housing, upmarket condominiums rather than affordable homes.[27] As of July 1st, 2017, accommodation rental websites such as Airbnb risk fines up to €32,500 if they run ads for properties in Portugal without displaying RNAL registration numbers. The RNAL registration number is the vacation home's identification number and signs that the offering is fully compliant with vacation rental laws and thus can be opened for business. The new 2017 decree law covers both the website and the property owner or promoter and a scale of fines has been published.[28] The idea of this new rule is to reinforce the message that the registration of short-term rentals or *Alojamento Local* is mandatory by pushing illegal rentals off accommodation websites.

Declaration of competing interest

The authors reveal no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.regsciurbeco.2021.103667.

Appendix

Table A.1
Summary statistics. Observations at the municipality-year-quarter level. Total Municipalities in the dataset is 106. Total number of quarters is 17.

Variable	Observations	Mean	S.d.	Min	Max
Transaction Price (€/m^2)	986	982	324	374	2245
Rental Price (€/m^2)	986	4.98	1.22	2.91	10.39
Total Dwellings	986	72,277	58,203	8365	323,981
Airbnb Properties	986	812	1699	6	9273
RNAL Registered Properties	986	577	1171	1	5804
Airbnb Share (between 0 and 1)	986	0.002	0.005	0	0.051
Derelict Buildings (%)	986	4	1	0	10
House density (N/km2)	986	790	1047	22	3814
Population density (N/km2)	986	1505	1953	36	7363
Population age (years)	986	41	2	36	46

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[2] Some cities have laws that restrict the ability to host paying guests for short periods (e.g. Amsterdam, New York, Paris, San Francisco). In other cities, the host must register (e.g. Lisbon), get a permit (e.g. Barcelona, Berlin, Paris and San Francisco), or obtain a license (e.g. Cape Elizabeth) before the host lists the property or accepts guests. In other cases, the measures include paying a rental tax (e.g. Amsterdam and San Francisco).

[27] A March 2017 article published in the Property section of the Financial Times reports that Graça, a hilltop neighborhood in the historic heart of Lisbon, is currently undergoing a process of urban construction, demolition and restoration. Old buildings are being made into luxury apartment blocks and dilapidated mansions converted into smart hotels.

[28] The fines for property owners are between €125 and €3250 for individuals and between €1250 and €32,500 if the owner is a company. Fines for the hosting websites are the same with sites owned by companies attracting fines of between €1250 and €32,500 and sites owned by individuals receiving fines of between €125 and €3250.

Table A.1 (*continued*)

Variable	Observations	Mean	S.d.	Min	Max
Dwelling age (years)	986	37	8	24	62
Ageing index	986	115	32	59	229
Dependency index (elderly)	986	26	6	16	46
Dependency index (youth)	986	23	2	18	28
Dependency index (total)	986	49	5	41	67
Population renovation index	986	95	11	73	143
Longevity index	986	46	3	40	54
Number of floors per building	986	2.2	0.5	1.4	3.7

Table A.2

Summary statistics (averages) for treated and control civil parishes. Observations at the parish-year-quarter level.

Variable	Observations	Treated	Control
Number of Parishes		6	25
Transaction Price (€/m^2)	520	1846	1664
Rental Price (€/m^2)	520	8.8	8.0
Total Dwellings	520	15,418	16,171
Airbnb Properties	520	1736	150
RNAL Registered Properties	520	993	81
Airbnb Share (between 0 and 1)	520	0.062	0.003
Derelict Buildings (%)	520	11.2	5.4
House density (N/km2)	520	8337	4000
Population density (N/km2)	520	11,000	6823
Housing cost (€/month)	520	461	471
Population Age (years)	520	45.8	44.7
Dwelling Age (years)	520	79.5	55.9
Ageing index	520	253.7	195.0
Dependency index (elterly)	520	39.6	38.5
Dependency index (youth)	520	16.0	20.2
Dependency index (total)	520	55.7	58.7
Sustainability index	520	2.6	2.8
Population renovation index	520	107.0	91.7
Longevity index	520	56.1	52.0
Number of floors per building	520	3.6	3.8

Table A.3

Ranking of the top 20 municipalities (M) and civil parishes (P) by Airbnb share and definition of the members of the treatment, treatment extended and placebo groups.

Municipality	Airbnb Share Q1Y04	Density of RNAL Q1Y04	Treatment	Treatment Extended	Placebo
Sta Maria Maior (P)	0.1299	0.0000	x		
Misericórdia (P)	0.1134	0.0090	x		
Sto António (P)	0.0542	0.0000	x		
UF Cedofeita, …(P)	0.0396	0.0000	x		
S Vicente (P)	0.0386	0.0000	x		
Arroios (P)	0.0263	0.0026	x		
Lagos (M)	0.0256	0.0119			x
Albufeira (M)	0.0176	0.0291			x
Bonfim (P)	0.0164	0.0018		X	
Peniche (M)	0.0154	0.0025			
Tavira (M)	0.0134	0.0173			x
Avenidas Novas (P)	0.0131	0.0011		X	
Mafra (M)	0.0112	0.0014			
Loulé (M)	0.0090	0.0024			x
Cascais (M)	0.0074	0.0003			
Penha de França (P)	0.0071	0.0006		x	
Grândola (M)	0.0068	0.0015			
Portimão (M)	0.0067	0.0184			x
Campolide (P)	0.0063	0.0000		x	
Olhão (M)	0.0062	0.0101			x

Table A.3 (*continued*)

Municipality	Airbnb Share Q1Y04	Density of RNAL Q1Y04	Treatment	Treatment Extended	Placebo
Silves (M)	0.0058	0.0054			x
Alvalade (P)	0.0056	0.0001		x	
Faro (M)	0.0052	0.0012			x

Table A.4
Total Number and Growth Rate for Hotels in the Municipalities of Lisbon and Porto from 2011 to 2016.

Year	Hotels			
	Lisbon		Porto	
	Number	Growth rate	Number	Growth rate
2011	107	–	49	–
2012	117	9.3%	58	18.4%
2013	130	11.1%	61	5.2%
2014	143	10.0%	64	4.9%
2015	155	8.4%	71	10.9%
2016	167	7.7%	75	5.6%

Table A.5
First Stage (Equation [6]) regression results.

Dep. Variable	Airbnb Share		
	Coef.	Std. Err.	t
Reform x High touristy	0.0075	0.0026	2.82
High Touristy x Year	0.0020	0.0001	17.86
Year (trend)	0.0002	0.0000	5.83
Parish FE	Yes		

Notes: Standard errors in parentheses clustered at the parish level.

Table A.6
DiD estimates controlling for number of hotels and number of beds.

Dep. Variable	(1)
	log(sales)
Treatment x 2012	0.0832
	(0.062)
Treatment x 2013 (base)	–
	–
Treatment x 2014	0.145*
	(0.0831)
Treatment x 2015	0.259***
	(0.0357)
Treatment x 2016	0.344***
	(0.059)
Observations	456
Quarter-year FE	Yes
Municipality FE	Yes

Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table A.7
First Stage (Equation [6]) regression results

Method:	(1)	(2)
	OLS	
Dep. Variable:	log(sales)	log(rents)
Airbnb density	3.033***	−0.445
	(0.964)	(0.584)
Observations	456	506
Quarter-year FE	Yes	Yes
Parish FE	Yes	Yes

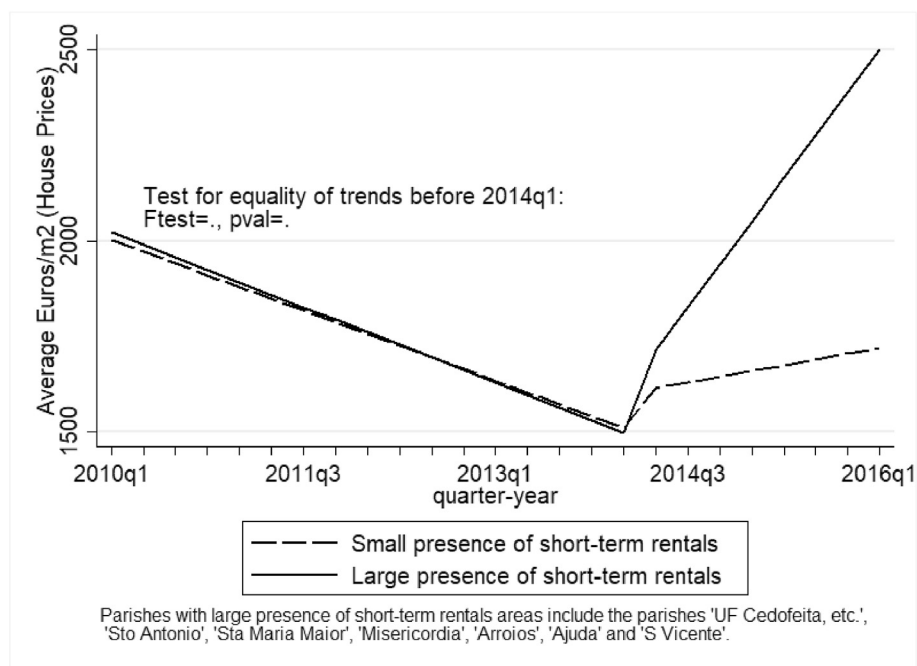*Significance levels*: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

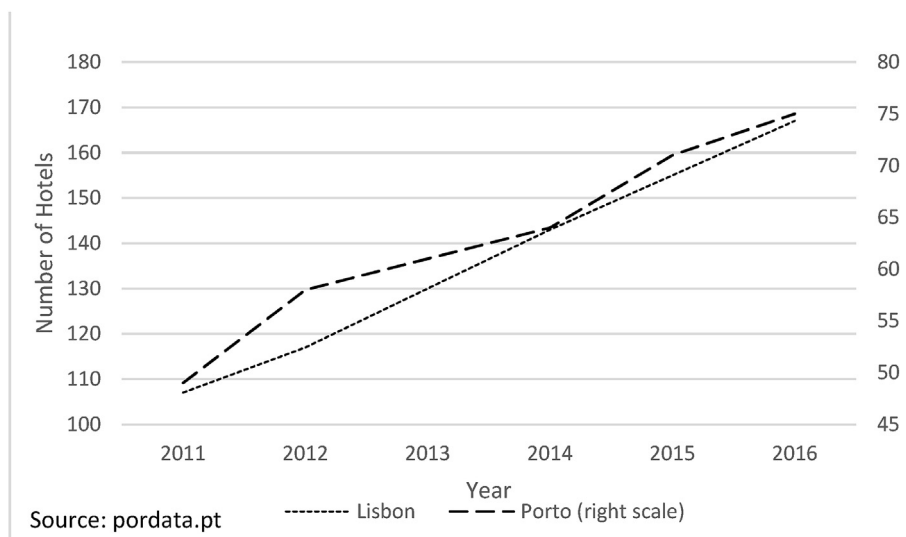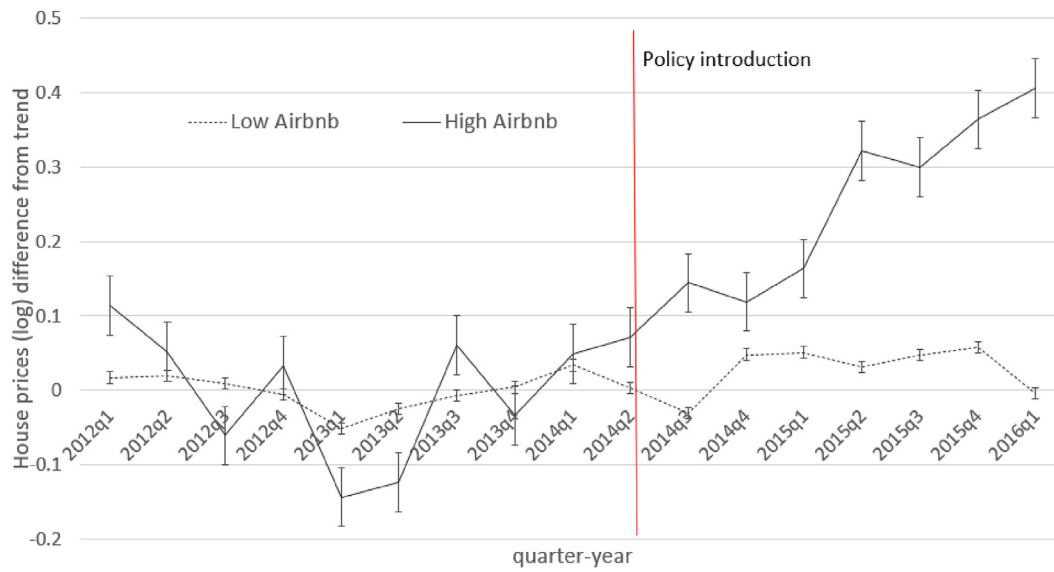**Fig. A.1.** Estimated linear trend for treatment and control group.

Fig. A.2. Number of Hotels in the Municipalities of Lisbon and Porto.

Notes: House prices (log) is detrended with separate pre-reform trends and quarter effects for the treated and the non-treated parishes. 95% confidence intervals are also reported.
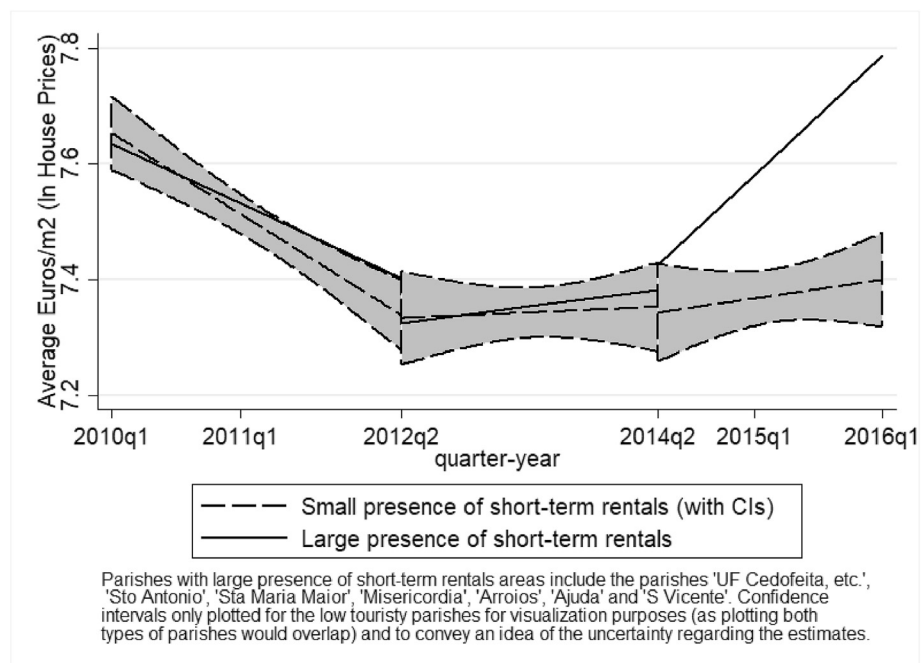
Fig. A.3. House prices (log), detrended.

Parishes with large presence of short-term rentals areas include the parishes 'UF Cedofeita, etc.', 'Sto Antonio', 'Sta Maria Maior', 'Misericordia', 'Arroios', 'Ajuda' and 'S Vicente'. Confidence intervals only plotted for the low touristy parishes for visualization purposes (as plotting both types of parishes would overlap) and to convey an idea of the uncertainty regarding the estimates.

Fig. A.4. House price trends for parishes with large and small of Airbnb share, by subperiod (2010q1/2012q2/2014q2/2016q1).
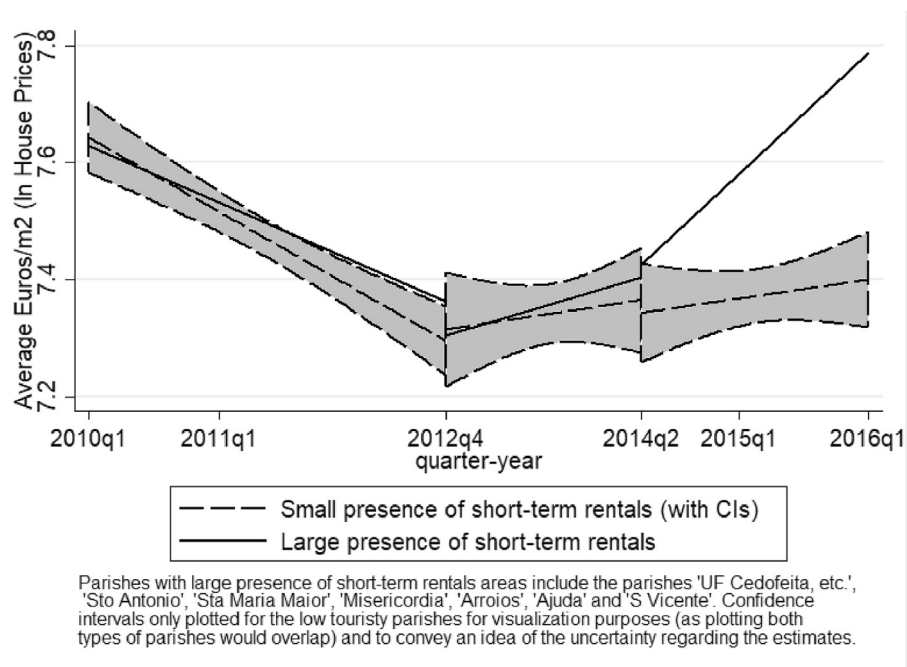
Fig. A.5. House price trends for parishes with large and small of Airbnb share, by subperiod (2010q1/2012q4/2014q2/2016q1).
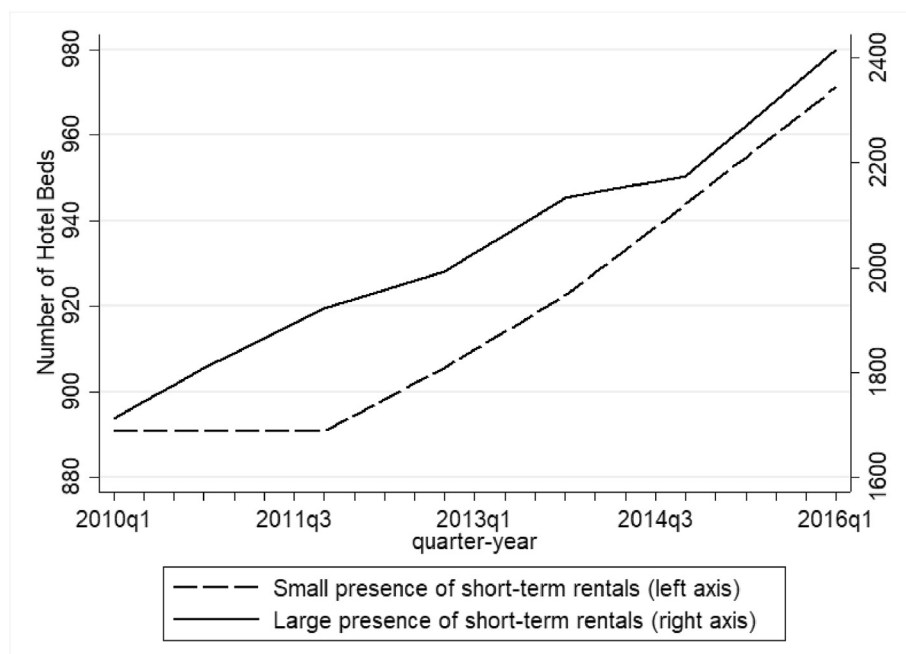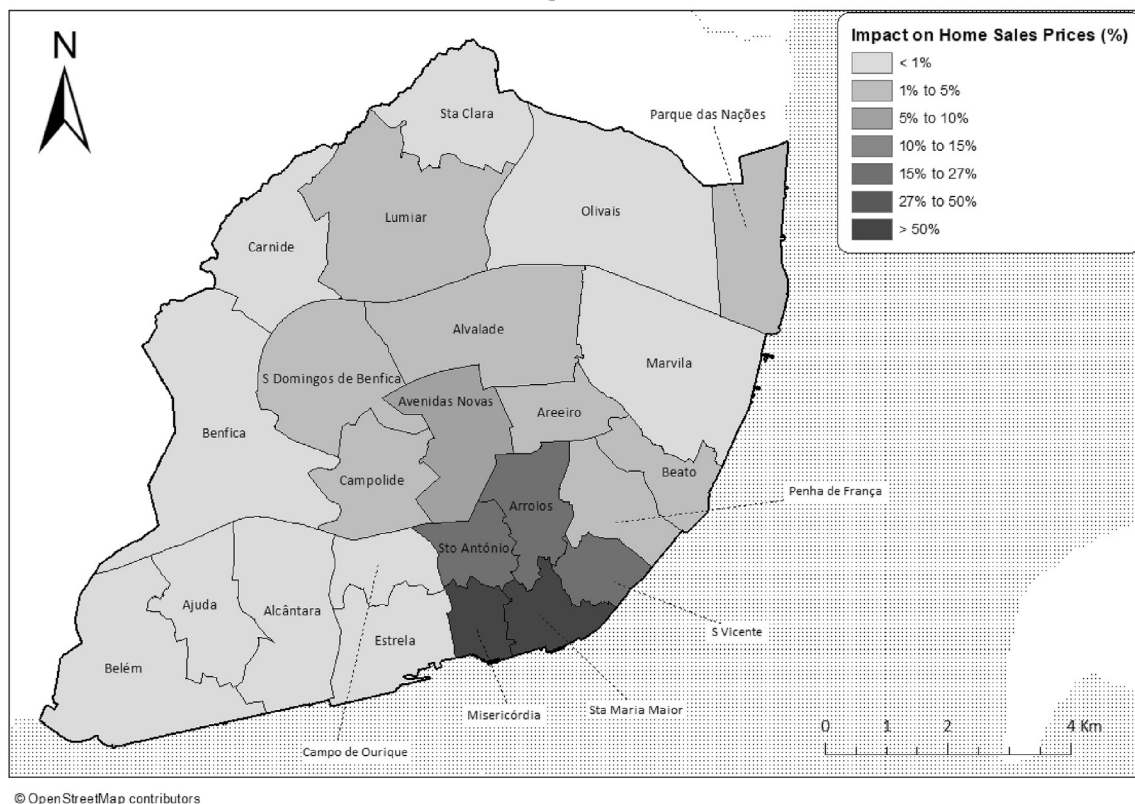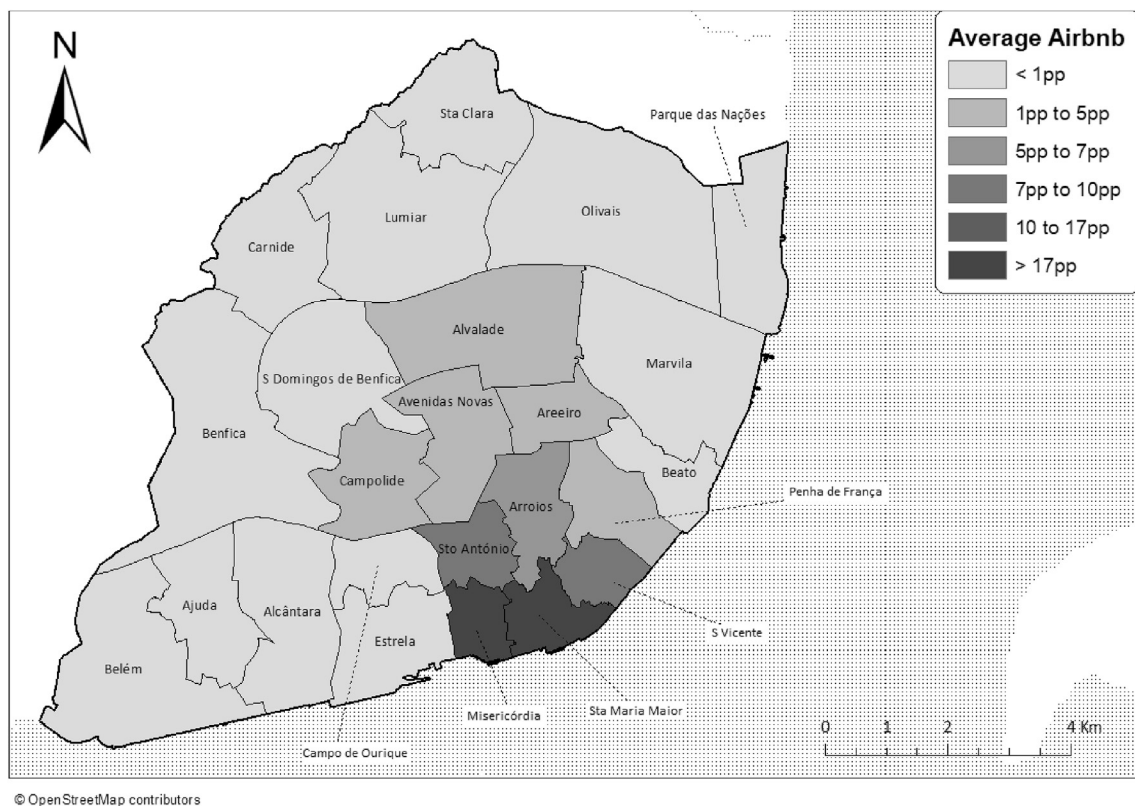

Fig. A.6. Number of beds in high vs low touristy parishes.

Fig. A.7. Heterogeneous Impact of Airbnb Share on Home Sales Prices in Lisbon in the 1st Quarter of 2016.

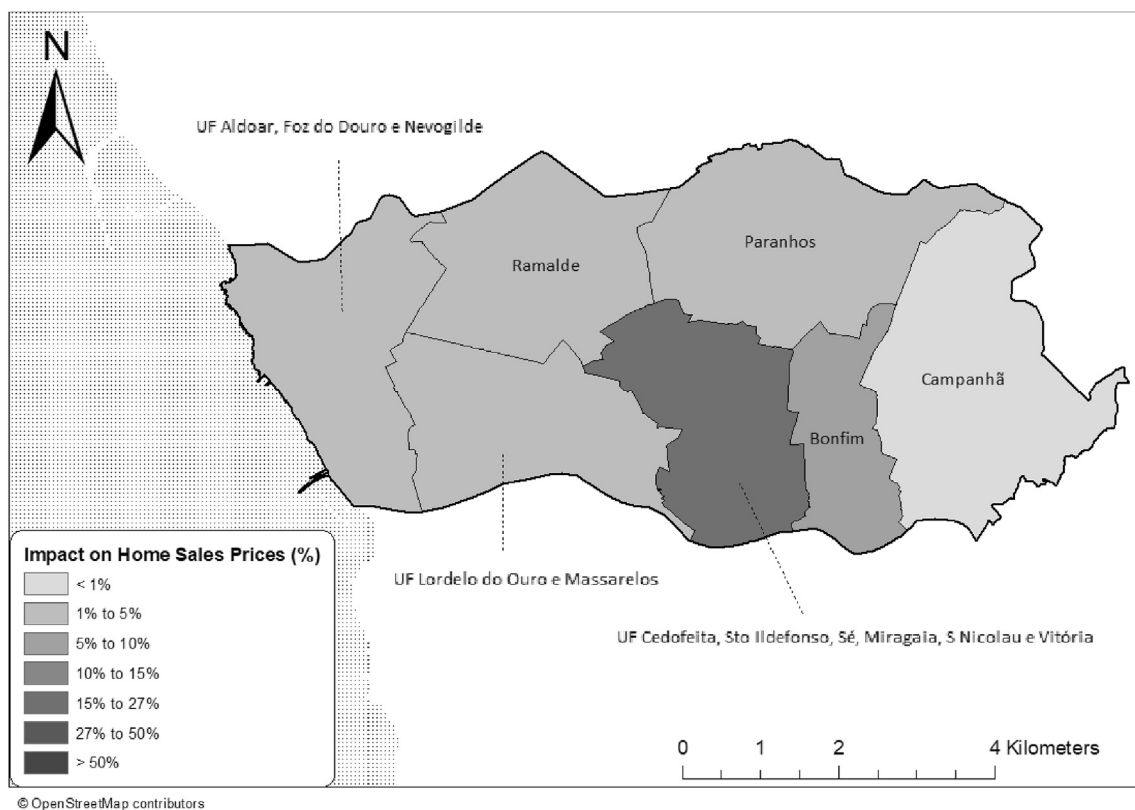**Fig. A.8.** Airbnb Share across Lisbon in the 1st Quarter of 2016.

Fig. A.9. Heterogeneous Impact of AirBnB Activity on Home Sales Prices in Porto in the 1st Quarter of 2016.
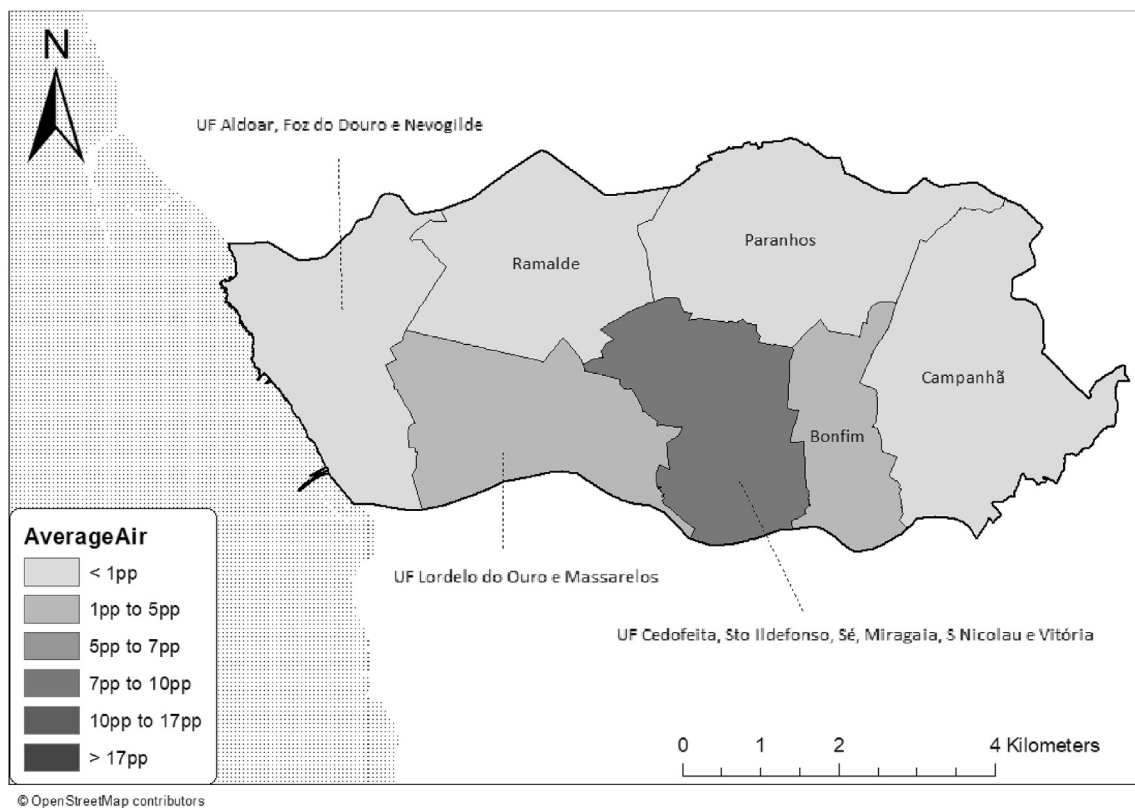

Fig. A.10. Airbnb Share across Porto in the 1st Quarter of 2016.

Author statement

The authors state that this research is original and has not been published elsewhere.

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