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The Impact of Home Sharing on Housing Affordability

Evidence from Airbnb in Urban Cities in Europe

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Abstract

Housing affordability has been impacted by rising house prices in Europe and it is argued that home-sharing is making housing less affordable. The purpose of this thesis is to provide empirical evidence whether home sharing has a relationship on housing affordability by utilizing an extensive set of Airbnb listings data acquired from multiple European urban cities between the years of 2011and 2020. We conduct a panel data analysis using a fixed effects model to regress the relationship between the accumulated Airbnb supply and price-to-income ratio. The results display statistically insignificant results between the price-to-income ratio and the accumulated supply of Airbnb, implying that there is not enough statistical evidence to determine the relationship between short-term rental and European housing affordability. We unfold this relationship through analyzing transmission mechanisms such as supply reallocation, changes in demand and positive and negative externalities, and reassure the validity of our results through the use of comprehensive robustness tests. Additionally, we explore the agglomeration of the Airbnb listings by separating cities to further distinguish that the varying relationship depends on the size of the Airbnb market. We find that cities with high Airbnb supply have a positive relationship with the price-to-income ratio.

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1. Introduction

Housing affordability[1] has been impacted by rapidly increasing housing prices exceeding the income of residents since the late twentieth century (Le Goix et al., 2021). Housing has an important role in the economy as it is a large part of household wealth and household consumption, and it is the main asset in the balance sheet of banks (Martins et al., 2021). Additionally, the rapid growth of peer-to-peer markets, also known as the sharing economy, has increased the attention of the interaction between the housing market and home-sharing platforms (Chang, 2020). Sharing economy encourages and enables individuals to maximize the utility of their assets by sharing and lending the underutilized capacity and therefore, contributing to a more sustainable economic system by increasing the use of all available resources. The use of the latest technology, easy access, readiness, and supply flexibility are meeting the demands of both the consumers and suppliers. Hence, companies such as Airbnb, Lyft and Uber are rapidly increasing their growth as more consumers adapt to the market (Zervas et al., 2017).

The topic of whether home-sharing platforms create positive or negative welfare is still an open question as emphasized by Barron et al. (2021). Critics argue that short-term rentals set off a process of gentrification, which is denoted as the reallocation of properties to short-term tourist rentals that can potentially have a disruptive impact on housing affordability and -availability in the traditional long-term market (Nieuwland, & van Melik, 2020). On the other hand, home-sharing creates a new source of income (Holm, 2016) and offers tourists more authentic experiences of staying with locals (Gutiérrez et al. 2017). Airbnb and other short-term rental businesses argue that the peer-to-peer platform is not responsible for the changes in the housing market and is not responsible for making housing less affordable (Barron et al., 2021). This paper provides evidence supporting the latter argument, and it does so using a comprehensive dataset of home-sharing in Europe.

In this study, we examine the relationship of home-sharing on housing affordability by using evidence from Airbnb within 28 different European cities[2] from 2011 to 2020. Since Airbnb is the largest home-sharing platform within the home-sharing market (Barron et al., 2021), we

[1] Housing affordability is determined by the individuals' ability to afford or purchase a home (Dumicic et al., 2015).
[2] The chosen urban cities are Amsterdam, Athens, Barcelona, Berlin, Bristol, Brussels, Copenhagen, Dublin, Geneva, Lisbon, London, Lyon, Madrid, Milan, Munich, Naples, Oslo, Paris, Porto, Prague, Riga, Roma, Seville, Stockholm, Thessaloniki, Valencia, Vienna and Zurich.

believe that it presents an extensive picture of the short-term rental market in Europe. Thus, Airbnb supply represents home-sharing, and it is measured by the amount of Airbnb listings in this study. We will measure housing affordability with the price-to-income ratio (PIR), which is a common measure of housing affordability, and it has been widely used to explain the changes in the housing market (Rizi, 2021). PIR is measured as the ratio of median apartment prices to median familial disposable income (Numbeo, 2022). An increase in PIR indicates that the housing is less affordable (OECD, 2020). To gather a robust combination of the data, all European cities with available Airbnb data were chosen.

Home sharing and its impact have been previously studied in relation to taxation (Dalir et al., 2021), the hospitality industry (Zervas et al., 2017), rental market in the United States (Barron et al., 2021; Horn & Merante, 2017) and house prices in New York (Sheppard & Udell, 2016), London (Benítez-Aurioles & Tussyadiah, 2021) and Barcelona (Garcia-López et al., 2020). However, only two studies (Barron et al., 2021; Liang et al., 2022) have focused on the impact of home-sharing on housing affordability by using the price-to-rent ratio as their dependent variable. While most studies have focused on single cities and have used housing transaction records, such as house prices and other housing affordability measures, we extend previous studies by including multiple cities and by introducing PIR as our dependent variable. Additionally, since the chosen cities vary in tourism level and Airbnb listings, we will distinguish some of the largest and smallest tourism cities with the most and the least Airbnb listings within Europe by creating dummy variables for our regression model. With this, we estimate if the relationship between Airbnb and housing affordability varies depending on the Airbnb market size, which provides important information for the cities as the market expands further.

In order to measure whether there is relationship between Airbnb supply and PIR, we estimate a two-way fixed effects model (FEM) with control variables to account for unobserved heterogeneity. The overall accumulated results are insignificant and therefore we cannot determine the relationship between Airbnb supply and PIR. Further, a dummy variable for the most listings display a positive relationship with PIR, hence, indicating a larger decrease in housing affordability in London, Paris and Rome than in the rest of the cities. Moreover, the results imply that on a wider level within Europe, there is not enough proof to determine the association between Airbnb supply and housing affordability, instead, when taking a closer

look at the cities with a high concentration of Airbnb listings, the short-term rental market is large enough to associate with housing affordability.

We believe this research area is highly important in order to understand the economic and welfare consequences as the sharing economy platforms continue expanding further as emphasized by Barron et al., (2021). Furthermore, as the purpose of this study is to provide empirical evidence whether home sharing has an impact on housing affordability, the results of this study can also provide crucial information for policymakers, when implementing appropriate regulations for the short-term market in the future. Most of the previous studies have found a positive relationship between Airbnb supply and housing market as the housing supply is reallocated to the short-term market (Barron et al, 2021; Horn & Merante, 2017; Garcia-López et al., 2020). On the other hand, changes in the short-term market, such as Airbnb listings, might not have any significant impact on the long-term market if the short-term rental market is relatively small compared to the long-term market (Barron et al., 2021).

This thesis paper is divided into six different sections. We start by introducing the background of Airbnb and the home-sharing concept in section 2. This section also presents the trends of house prices in Europe, as well as tourism within Europe and Airbnb regulations. Additionally, section 3 presents the previous literature on this topic to build up an understanding of how short-term rentals can affect housing affordability through different theoretical mechanisms such as, the change in supply, demand, and the existence of externalities. In the empirical framework in section 4, we motivate and explain the chosen econometric model for this study by dividing the section between the data, variables and the methodology used. The data section describes how the data was gathered and includes a detailed description of the descriptive statistics and correlation. Lastly, we will present and analyze the results of our empirical model in section 5, and section 6 provides conclusions with limitations and suggestions to further research.

2. Background

2.1 Home-Sharing and Airbnb

In recent years there has been a rapid rise in home-sharing platforms, such as Airbnb Vacation Rental by Owner (VRBO), Home Away, and Flip Key, which offer visitors an alternative to traditional hotel accommodation by allowing them to connect with hosts who are willing to share their homes short-term for a fee (Barron et al., 2021; Deale & Crawford, 2018). Airbnb is a leading short-term accommodation provider in the sharing economy that allows a more authentic experience to the visitors with the cost of fewer amenities and services provided by traditional hotels (Nieuwland & van Melik, 2020). Airbnb has exceedingly increased its market size in the industry since its launch in 2007 and grown to a four million host base in more than 220 countries around the world. The demand for staying at an Airbnb has exponentially increased during the recent years resulting in over one billion increases in listings after a study made by Adamiak et al. (2019) and there are now more than six billion listings worldwide (Airbnb, 2022)[3]. However, the Airbnb market size differs between countries and cities as seen in figure 1, which illustrates how large difference in accumulated Airbnb listings is between the chosen urban cities in 2020. Additionally, Appendix 1 shows that London, Paris and Rome have most listings and Riga, Zurich and Bristol have lowest number of listings according to the year 2020. The exponential increasing trend of Airbnb listings in London, Paris and Rome can be seen in Figure 2.

[3] The empirical company data information is limited and gathered from Airbnb itself, but we can see an increase in numbers from previous studies that used the same source (Sheppard & Udell, 2016; Adamiak et al., 2019)

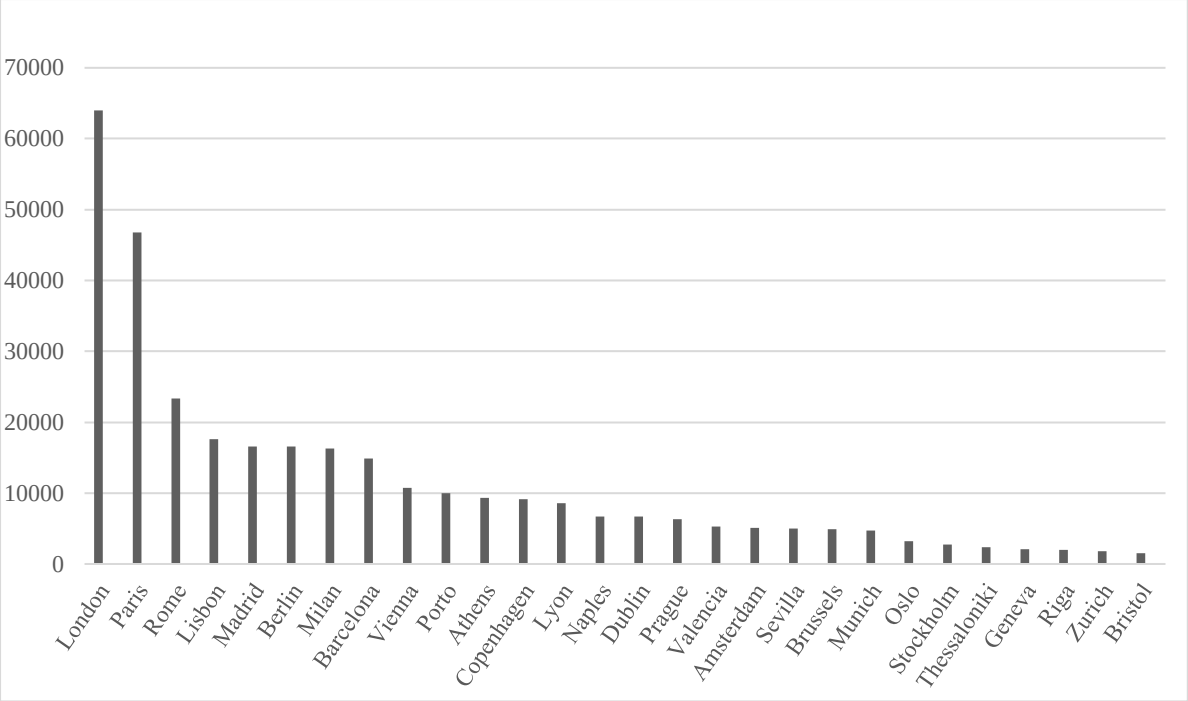

Figure 1 *Distribution of the accumulated number of Airbnb listings in European cities in 2020*

Note. The Data are from *Get the Data*, by InsideAirbnb, n.d., (http://insideairbnb.com/get-the-data). Copyright by InsideAirbnb Data.

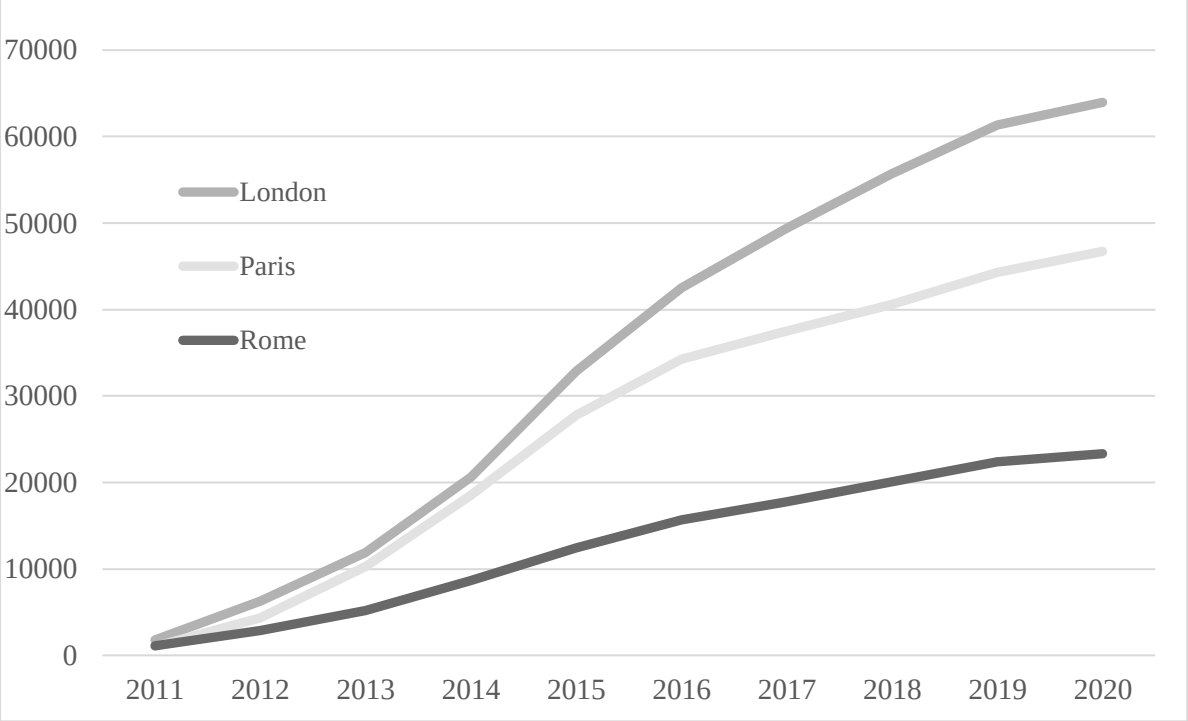

Figure 2 *Accumulated Airbnb Listings in London, Paris & Rome, 2011-2020*

Note. The Data are from *Get the Data*, by InsideAirbnb, n.d., (http://insideairbnb.com/get-the-data). Copyright by InsideAirbnb Data.

2.2 Housing Affordability in Europe

House prices have a significant impact on macroeconomic development as house prices correlate closely with the business cycles[4]. Additionally, the development of house prices has an impact on housing affordability measured by the PIR (Martins et al., 2021). Since the 1990s there has been unequal housing affordability across and within European cities but on average, PIR increased steadily in most European countries from 2012 to the first quarter of 2020 before the COVID-19 pandemic (OECD, 2021; Le Goix et al., 2021).

In Europe the downward trend of PIR took place after the 2008 financial crisis especially in the countries most impacted by the crisis, such as in Ireland, Spain and in Latvia. In the meanwhile, in Austria, Belgium, Germany and Luxembourg house prices continued to increase. According to Martins et al. (2021), PIR started to recover in most of the euro countries in 2013 due to increasing household incomes as seen in figure 3, illustrating the trend of PIR in Bristol, London, Lisbon, Porto, Paris, and Lyon. The same phenomenon for rest of the chosen European cities can be seen in Appendix 2. Furthermore, even though COVID-19 had a negative impact on household income and employment rate, on average, the pandemic has not dramatically affected the PIR as seen in figure 3 and Appendix 2 (OECD, 2021). Instead, PIR kept increasing in most of the European countries in 2020, which can be due to an increase in household savings, government income support programs and expansionary fiscal- and macro policies spurred by COVID-19, which together supported the demand for housing (Martins et al., 2021).

Different development of the house prices over time between European countries explains why there are differences in housing markets across European countries, which includes both the rental market and the property market (Martins et al., 2021). For instance, there are cross-country differences in home-ownership rates where a higher rate indicates a higher average house price cycle length and higher credit volume. Between 1995 and 2013 home-ownership rate was 85% in Spain and 76% in Italy, but only 52% in Austria and Germany, which may explain why housing cycles are less coincident in Europe (Rünstler and Vlekke, 2018). Furthermore, there are differences in mortgage contract terms. For instance, the average loan-to-value ratio is 50% in Italy and up to 90% in the Netherlands. However, the changes over

[4] Business cycles refer to the upswings and downswings of economic activity (Martin et al., 2021).

time are relatively minor and therefore, the significant structural differences across the euro area tend to remain (Martins et al., 2021).

Differences do not only exist between countries but also across cities. In recent years there has been an increase in PIR in some large cities. Moreover, across European countries, urban residents are less satisfied with the availability of quality affordable housing relative to rural residents. Urbanization driven by higher-paid jobs and an increase in cultural amenities within cities are one of the reasons that have led to gentrification and PIR growth in some large cities (OECD, 2021). For instance, if comparing inter-city differences in the United Kingdom, London has a house price inflation double the amount compared to the rest of the country, which has led to lower housing affordability in London as seen in figure 3. Additionally, a similar phenomenon is found in Paris where the house price inflation is 50% higher than in other parts of France as seen in figure 3 (OECD, 2021). The same trend can be seen between the cities in Portugal. From 2011 to 2016 house prices have increased 14% in Lisbon while decreased by 20% in Porto, which has influenced differences in housing affordability between these two cities as seen in figure 3. Overall, the reasons for the affordability issues in the rest of the chosen European cities as seen in Appendix 2, can be due to the inelastic housing supply due to land use regulations and limited land supply, especially in central and historic areas in Europe (Franco & Santos, 2021).

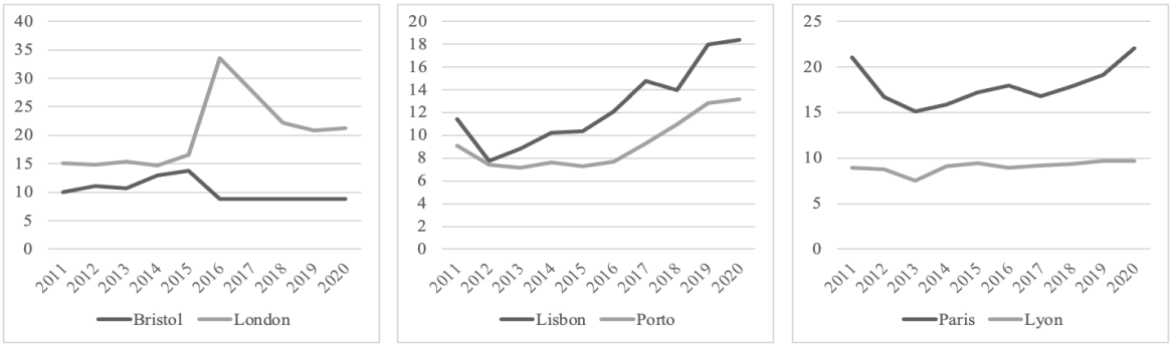

Figure 3 *The 10-year Trend of PIR in London, Bristol, Lisbon, Porto, Paris & Lyon, 2011-2020*

Note. The Data are from *Property Price Index by Country*, by Numbeo, n.d., (https://www.numbeo.com/property-investment/rankings_by_country.jsp). Copyright 2009-2022 by Numbeo.

2.3 Tourism in Europe

According to the World's Tourism Organization (UNWTO) the general trend for tourism globally has been expanding despite some occasional shocks, such as COVID-19. Nevertheless, Europe has been consistently the most visited destination and accounts for half of the world's international arrivals. In 2019, Europe hosted 744 million tourists, compared to the Americas' 219 million tourists, Asia, and Pacific's 362 million tourists and Africa's 70 million tourists. Within Europe, France, Spain, and Italy are the countries which host the highest number of tourists yearly, setting the Southern and Western European countries as the leading areas of tourism arrivals in Europe. Additionally, the Northern European countries combined show a robust growth from 2010 to 2019 but stay as the least visited area by international arrivals within Europe (UNWTO, 2020).

The pressure of increased tourism is emphasized in cities by the availability of accommodation offered through the new peer-to-peer platforms, Airbnb being the most successful platform (Gutiérrez et al., 2017). For instance, Garcia-López et al. (2020) gathered information on the rise of tourism in Barcelona by looking at the global destination cities index and researching the increase of tourism from 1990 until 2017. They stated a rise from 400 million up to 1300 million worldwide tourists and noted that Airbnb successfully acted as a platform for accommodating the increased demand for tourism in Barcelona. According to Gutiérrez et al. (2017), Barcelona was the fifth city in relation to the number of international tourists in 2014 in Europe, being only surpassed by London, Paris, Berlin, and Rome. Airbnb has been able to answer quickly to the increased tourism demand even in cities and neighborhoods that do not typically receive many tourists as it is easier for Airbnb to expand supply wherever houses and apartments exist. On the contrary, hotels need the whole building to be available and local permits from the authorities (Gutiérrez et al., 2017). As of the end of 2019 and the beginning of 2020, tourism and the short-term rental industry were impacted by COVID-19 around Europe. Boros et al. (2020) have researched this impact in the Airbnb market in 15 different cities and discovered a high drop in the bookings, but the characteristics of the changes were non-uniform between the cities, one reason being, the local tourism market characteristics. Figure 4 illustrates the leading European tourist cities according to number of bed nights millions during 2019 and 2020. Additionally, it shows how COVID-19 impacted tourism by showing the difference between 2020 and 2019.

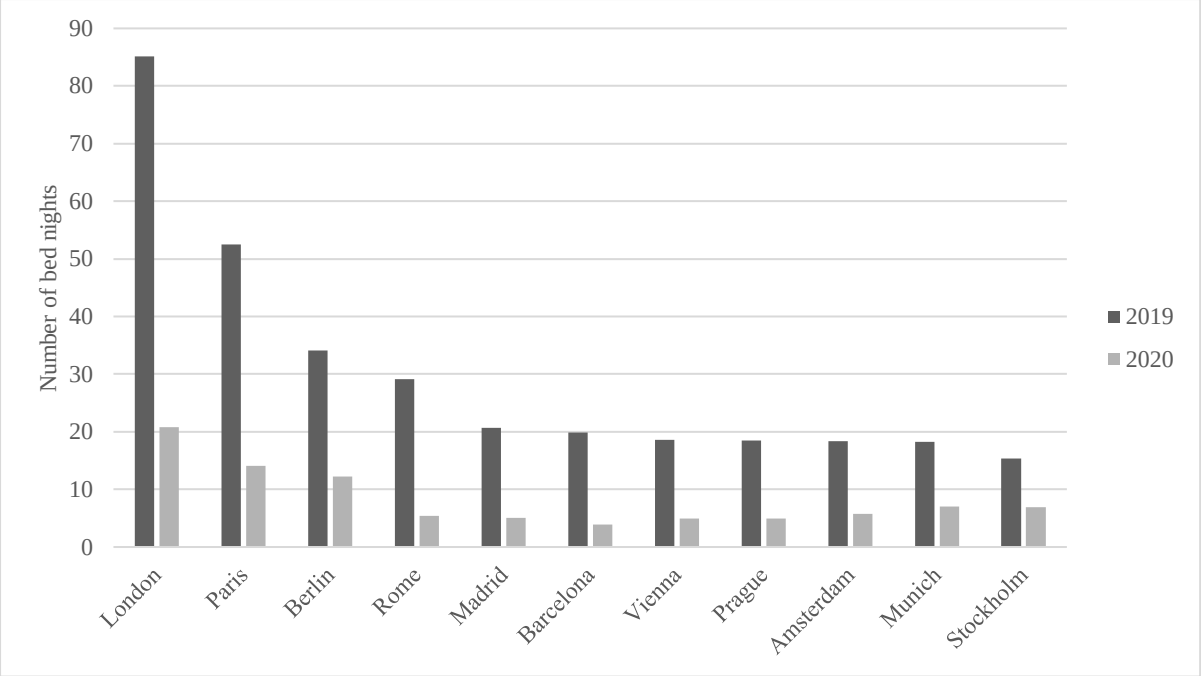

Figure 4 *Leading European Tourist Cities According to Number of Bed Nights in 2019 and 2020*

Note. The numbers are in millions. The *D*ata are from *Leading European city tourism destinations in 2019 and 2020, by number of bed nights,* by Statista Research Department, 2021, *(*https://www.statista.com/statistics/314340/leading-european-city-tourism-destinations-by-number-of-bednights/*).* Copyright 2022 by Statista.

2.4 Regulations Against Sharing Economy in Europe

Even though Airbnb is not the first nor the only home-sharing platform, it is the rapid rise of its popularity that concerns policymakers (Sheppard & Udell, 2016). Short-term rentals and tourism together are suggested to encourage the gentrification process (Nieuwland & van Melik, 2020; Füller & Michel, 2014). This process is increasing as investors are buying residential properties for commercial use and reallocating them to the short-term rental market as Airbnb accommodations (Gurran & Phibbs, 2017). As the supply of houses decreases by renting them out to tourists, the availability and affordability of housing for locals becomes troubling (Lines, 2015).

To prevent the disruption of short-term rentals in traditional housing markets, local governments have implemented regulative manners for sharing economy on a variety of levels, from total probation to limitations to the number of days of short-term renting (Ključnikov et al., 2018). The impacts on the city caused by Airbnb depend on a variety of different factors, such as, city size, tourism industry, listing location and concentration (Oskam & Boswijk,

2016). The lack of understanding the new and innovative sharing economy industry is hindering the regulations to succeed as governments are visioning Airbnb as reflecting a traditional market (Espinosa, 2016). Airbnb regulations have been implemented with a basis on business-to-business and business-to-consumer models (Espinosa, 2016), but as home-sharing through Airbnb is a peer-to-peer platform, the traditional regulation models are surpassed (Guttentag, 2015). Gurran and Phibbs (2017) also argue that the regulations do not focus on the negative externalities, such as, regulating the spatial clustering of Airbnb, which causes congestion and increases noise and traffic, but rather regulate the number of allowed renting nights. As the impact of Airbnb depends on different factors, previous research suggests that not all cities should impose the same regulative strategies (Guttentag, 2015).

As an example, Sweden has no specific regulations for short-term renting through Airbnb as the traditional tenancy legislation is complex and relatively strict, which limits any type of renting without the permission of a landlord or board owners (Einefors, 2018). Hence, since there is no economic incentive for landlords to short rent their apartments, such as, during vacation, this has led to a situation where apartments are rarely rented through Airbnb (Einefors, 2018). On the contrary, stricter regulations have been introduced in other European cities, such as in Amsterdam, Paris and London. These cities regulate maximum renting nights within a year with respect to 60 days in Amsterdam, four months in Paris and 90 days in London. On the other hand, in Berlin it is not allowed to rent out the entire apartment so that at least 50% of the apartment is in the use of the property owner. Additionally, regulations have some intercity differences also. In the old town of Paris, property owners are allowed to supply only one listing per owner and the number of renters is restricted to the number of people the property is built for (Nieuwland, & van Melik, 2020). As the COVID-19 pandemic raises concern about the future of Airbnb, Boros et al. (2020) debate that when the tourism sector starts to recover, the local governments might support the traditional hospitality market over the short-term rentals by increasing regulations for peer-to-peer markets.

3. Literature Review and Theoretical Framework

There are several studies concerning the impact of home-sharing on housing markets. A study made by Horn and Merante (2017) discovered that one deviation rise in the listings of Airbnb would increase the Boston rents by 0.4%. Garcia-López et. al. (2020) also found evidence that rents in Barcelona would increase by 1.9%. Additionally, research made by Sheppard & Udell,

(2016) of New York, detected that doubling Airbnb listings have increased property values by 6–11%. Moreover, studies focusing on housing affordability (Barron et al., 2021; Liang et al., 2022) found a relationship between Airbnb and housing affordability but some studies achieved insignificant results (Franco & Santos, 2021; Chang, 2020). Regarding previous studies, we concentrate on the studies that focus on Airbnb's relationship to the long-term housing market and housing affordability, as well as introduce an alternative theoretical point of view in case of no relationship.

The key instrument of home-sharing, which has an effect on housing affordability, is supply reallocation (Sheppard & Udell, 2016; Zervas et al., 2017). As the owner of the property can decide if they supply the property through short-term Airbnb rental or more traditional long-term market, the more profitable channel will be chosen. The profitability depends on the demand side, which includes individuals' preferences and willingness to pay. If a property is rented through a short-term rental market, the decrease of supply in the traditional market has an increasing impact on the house prices which makes housing less affordable (Barron et al., 2021; Horn & Merante, 2017). For instance, a previous study concentrating on supply reallocation by Benítez-Aurioles & Tussyadiah (2021) found out that Airbnb listings increase house prices in London as more homeowners were listing their homes in a short-rental market. Furthermore, Barron et al. (2021) found that a 1% increase in Airbnb listings leads to a 0,026% increase in house prices in the United States since Airbnb induces homeowners to move properties from the long-term housing market to the short-term market. In addition, he found empirical evidence that zip-codes with lower owner-occupancy rates would have a larger reallocation effect as non-owner occupiers are more likely to relocate their properties to the short-term market. Ultimately, as the supply of housing is generally inelastic or fixed in the short run, and if the property owners view short-term rentals more profitable, even a small reallocation of supply can have an increasing effect on prices in the long run (Barron et al., 2021; Franco & Santos, 2021). To generate this effect on housing prices and house affordability, the relative share of the short-term market and its scale within the city would have to be significantly large (Franco & Santos, 2021).

In addition, an increase in demand results in inflated prices. As Airbnb hosts lend their property in the short-term rental market, they create an income source. This results in the hosts gaining additional income during the ownership of the property and in potential capital gains due to appreciation. Both benefits can encourage investors to buy property for the sole purpose of

lending it forward in the short-term rental market. As a consequence, this increases the demand for buying property and therefore, drives up prices. The new income stream of Airbnb reduces also the cost of ownership which attracts homeowners to keep properties for a longer time as they see it is more profitable to rent their spare room or apartment in the short-term market than sell in the long-term market. Hence, the supply of properties decreases within the long-term market, and therefore, there is a simultaneous impact of increasing demand and decreasing supply (Sheppard & Udell, 2016).

According to Sheppard & Udell, (2016), Airbnb generates positive externalities for cities, such as, increasing tourism and economic benefits. They state that the rise of the tourism population has an increasing effect on the demand for local services and, therefore, the higher demand for commercial space and provision of amenities for visitors increases the value of properties. In contrast to positive externalities caused by home-sharing, Sheppard and Udell (2016) argue that Airbnb gathers a concentration of unsafe accommodations by violating health and safety laws as short-term rentals often lack traditional hospitality industry's safety regulations. In addition, short-term renters create increased density, more noise and traffic to calm neighborhoods, which might act as a decreasing factor for house prices (Sheppard and Udell, 2016). A city-specific example of a negative externality is Barcelonans experiencing a decreasing local culture and cohesiveness within their neighborhoods (Gant, 2016). Furthermore, a study made by Roth (2021) investigated whether there is a connection between crime and home-sharing, and he distinguished a positive relationship between Airbnb private rooms and alcohol offenses, which could decrease the attractiveness of the area. Moreover, sharing economy has received criticism by negative externalities exceeding the benefits. Researchers imply that increase in societal inequality (Schor, 2017) is due to the rise of the sharing economy. As the property value increases, residents that do not have the financial needs are forced out from the particular neighborhood while the homeowners benefit from the rise of tourism (Nieuwland, & van Melik, 2020).

Barron et al. (2021) additionally suggest that home-sharing driving up house prices is an empirical question and states several reasons why a relationship might not exist. Firstly, the short-term rental market can be relatively small compared to the long-term market, which implies that changes in the short-term market could potentially not have any significant impact on the long-term market. A small short-term market could be a result of property owners' preferences, in which they prefer stable long-term income and reliable tenants. This is

supported by Coyle and Yeung (2016) suggesting that the extent of the effect of Airbnb depends on the property owners' risk averseness. Short-term rental might be riskier, especially rented by tourists, as the guaranteed tenancy is lower. Hence, risk-averse property owners do not create reallocation. Secondly, Barron et al. (2021) argue that the supply reallocation could be relatively small. If the owners only temporarily rent their property or only rent a part of their property instead of renting it out completely, this implies that the property is still primarily seen as occupied in the long-term market. In these cases, home-sharing supports the owners by generating income from the underutilized capacity of their assets without causing supply reallocation and therefore, having no impact on housing affordability. Lastly, Franco & Santos (2021) and Chang (2020) suggest that their insignificant results could be explained by the low concentration of Airbnb listings or different housing market characteristics such as, differences in homeownership rates. In figure 5, we illustrate the potential impact of Airbnb on housing affordability through the theoretical transmission mechanisms.

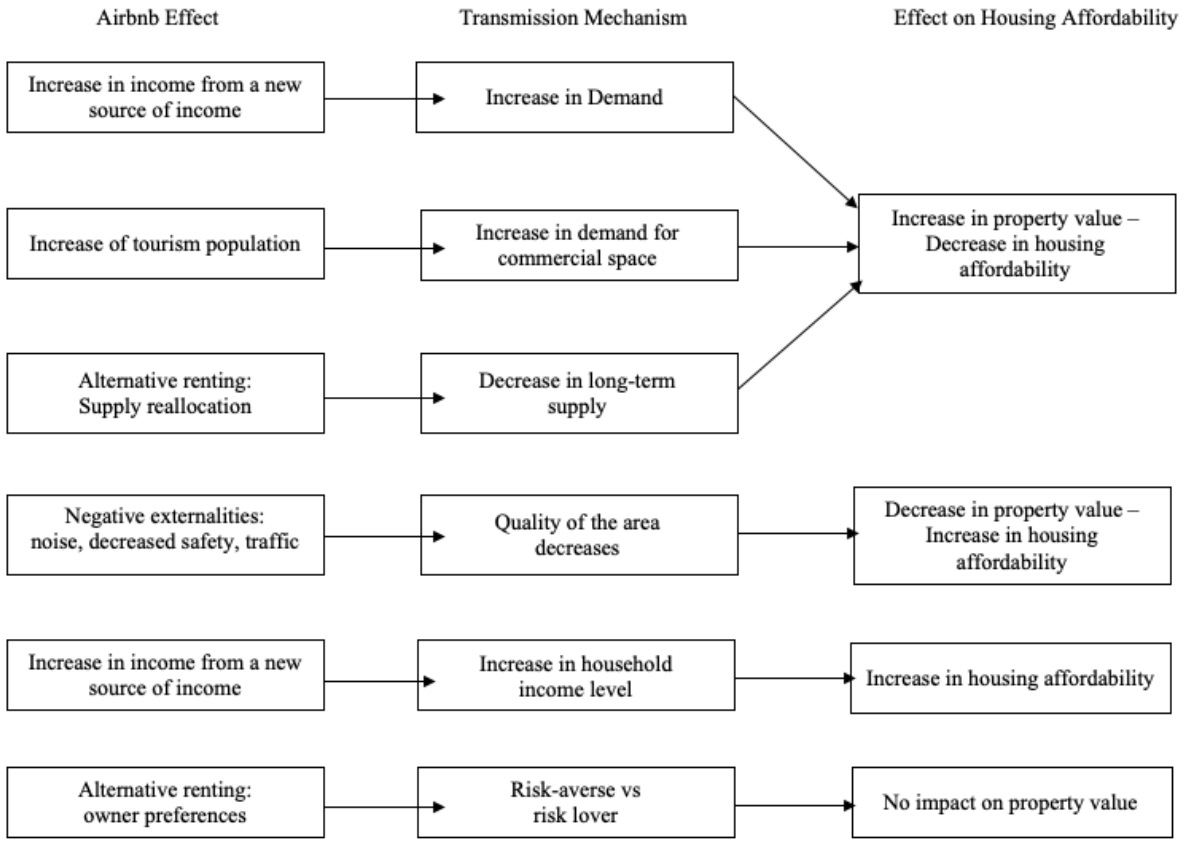

Figure 5 *Transmission Mechanisms for the Effect of Airbnb on Housing Affordability*

Note. Based on Sheppard & Udell (2016).

3.1 Hypothesis

Based on the above theoretical mechanisms, the industry background of Airbnb, market structure and previous studies, we concentrate on the following hypothesis to be empirically tested; there is a relationship between Airbnb supply and PIR.

4. Empirical Framework

4.1 Data

We gather a dataset that combines data on PIR, Airbnb supply and other determinants that influence PIR and Airbnb Supply. The main data sources are; InsideAirbnb, which is the public database that collects information on reviews and listings posted by users of Airbnb, OECD statistics, which is a statistical database including data on a wide range of topics for OECD countries and selected non-member countries, Eurostat, which is the database of the European Union including high-quality Europe-wide statistics and Numbeo, which is a global database gathering information of property price indices, cost of living measures and quality of life information. Details of the variables and datasets used are listed below.

The data of all variables are collected for 28 urban cities in Europe for the period from 2011 to 2020 at annual intervals. Since InsideAirbnb only gathers information about Airbnb listings at the neighborhood and city levels and PIR was only able to find at a city or a country level, the data is gathered at the city level for the independent variable, dependent variable and for the majority of the control variables. The urban cities in our study are defined as areas that are densely populated areas with at least 50,000 people and 1,500 inhabitants per square kilometer (OECD, 2020). With city-level data we can capture data on city characteristics that are associated with PIR. On the other hand, we cannot capture the heterogeneity effects of different neighborhoods within cities that might have an impact on house prices, which might cause bias in our estimates. Additionally, Airbnb supply is unequally distributed in the cities as usually there are more listings in the city centers as tourists want to be closer to the popular sights (Franco & Santos, 2021). However, the city level data is appropriate as the house prices are connected due to spillover effects such as amenities in the cities (Gong & Boelhouwer, 2020). The chosen sample period is appropriate for this study as Airbnb was gaining more popularity in Europe starting from 2010 and has rapidly increased since then (Coyle & Yeung, 2016). By including the year 2020, we will also see how COVID-19 is affecting our results as there was

a decrease in tourism and new Airbnb suppliers during 2020 as seen in figure 4. Lastly, we have chosen to use yearly intervals as the total supply of housing is inelastic in the short run and therefore housing affordability will not change considerably in the short run.

4.2 Variables

Price-to-Income Ratio

In this study, the dependent variable is PIR, which measures the population's ability to afford to purchase a home. According to the OECD (2020), housing affordability can be measured with the price-to-rent ratio and PIR, where PIR is the most common indicator of housing affordability (Dumicic et al., 2015). Additionally, PIR is used widely in media and policy institutions to indicate the property market's condition and it can be used for cross-sectional comparison across different periods (Leung & Tang, 2021). In this study, the data for PIR is collected from Numbeo, a database where we were able to find data for all the 28 chosen cities from 2011 to 2020 apart from some missing observations for some years which will compute by extrapolating[5]. According to Numbeo (2022), PIR is measured as a ratio of median house price and median family disposable income based on yearly income. Additionally, the formula has several assumptions such as the median apartment size is 90 square meters and the price per square meter is the average price of square meter in and outside of the city center (Numbeo, 2022). Thus, we acknowledge that PIR will not account for the whole long-term housing market due to the assumptions.

Even though housing affordability ratios have been used in previous studies to examine the relationship between Airbnb and rents or house prices (Barron et al., 2021), they have their limitations. Using PIR, we cannot distinguish the relationship between Airbnb and house prices and the relationship between Airbnb and household income. Despite its limitations, and with the support of the theoretical framework, PIR offers tangible results concerning its relationship to housing affordability. In addition, some previous studies have used the PIR ratio from the Numbeo database. For instance, housing affordability was predicted in three selected post-transition economies where the data of PIR was used as a house affordability indicator and the Numbeo database was used as a data source (Dumicic et al., 2015).

[5] Extrapolating is a statistical method for forecasting missing variables, which assumes past trend to be a good predictor of the future behavior (Glantz & Mun, 2011).

Airbnb Supply

As mentioned, since Airbnb is the biggest home-sharing platform in the home-sharing market (Barron, et al. 2021), we believe that it presents a comprehensive picture of home-sharing in Europe. In this study, Airbnb supply is the focus variable and it is defined by the total accumulated Airbnb listings. In other words, total amount of properties Airbnb's hosts have listed to rent. Since Airbnb does not provide any database of its listings, the data come from InsideAirbnb, which collects data from listings and reviews as posted by users (Alsudais, 2021). The data further provide information about the listings such as hostname, listings ID and availability. Since the InsideAirbnb database has been used in many earlier studies it is an appropriate database to be used in this study. For instance, Barron et al. (2021) used data from InsideAirbnb to show that Airbnb listings have a positive impact on house prices and rents. Additionally, Sheppard & Udell (2016) showed that localized Airbnb availability is associated with an increase in property values in New York based on InsideAirbnb data. However, the InsideAirbnb dataset provides problems to measure accurate Airbnb supply as some of the Airbnb listings appear to be part of the available supply due to the hosts forgetting to update the availability status (Zervas et al. 2017).

To measure Airbnb supply of the listings we need to determine the entry and exit dates for the listings. Barron et al. (2021) and Zervas et al. (2017) state that there are several ways to determine market entry for Airbnb listings, such as, by first review date or host's registration date. In this study entry and exit date for the listing is going to be determined by the date the owners became Airbnb members and the listing is assumed to never exist. This means that the previous year's listings are added to the next year's listings which will create an accumulated supply of Airbnb listings. The advantage of using this method is that for the majority of listings, the host join date is the most precise measure of when the listing was first posted. On the other hand, the accumulated measure of Airbnb supply can slightly exaggerate the listings that are available on Airbnb since listings are expected to be available at any point in time (Barron et al, 2021). Hence, our estimate of Airbnb supply will be consistent if the unobserved fraction of active Airbnb listings is not endogenously correlated with accumulated listing supply and PIR (Zervas et al. 2017).

However, the Airbnb supply does not show the real size of the Airbnb compared to the city's size. Some cities have high listings, but they also have a large population and therefore, the

impact of Airbnb could slightly be exaggerated within the city. In contrast, some cities might have a low amount of listings but also a low population and therefore, the impact of Airbnb in that city might be lower than expected. Additionally, according to Barron et al. (2021), population growth leads to growth of Airbnb listings. Therefore, we create a new independent variable where the Airbnb listings are normalized by the city population. This variable is then estimated separately from the variable measuring the total Airbnb listing. Total population data is collected at annual intervals from 2011 to 2021 on a city level from OECD statistics which includes data for OECD member countries and non-member economies. Nevertheless, due to data limitations for Paris and Lyon in the OECD database, the data for Paris and Lyon is derived from Population Stat, which is a public database gathering information about population statistics both at the city and country levels. For transparency, population is also illustrated in the descriptive statistics and correlation matrix.

4.2.1 Control Variables

The traditional long-term market is not only impacted by short-term renting, but also by other variables play an important role in defining the magnitude of change in PIR and Airbnb supply. Additionally, the impact of Airbnb might differ between cities and therefore two dummy variables are included. Since PIR is ratio, we cannot define the expected impact of our control variables on PIR as we cannot distinguish the impact of the control variables on household income and house prices separately. However, the possible impact of control variables on household income and house prices are discussed. The data of control variables is collected at the city level except for GDP per capita and interest rate, which are collected at the country level. Details of the control variables and datasets are listed below.

Gross Domestic Product (GDP) per Capita

Gross domestic product (GDP) per capita at a constant price is the final result of the economic activity of production of goods and services in a region or country during a specific time period divided by the total population (OECD, 2022). Growth in GDP per capita increases household income, which makes housing more affordable. On the other hand, an increase in household income will fuel the demand for housing and therefore housing becomes less affordable (Allen et al., 2016). Furthermore, as GDP per capita increases, the living costs tend to increase, which increases hosts' motivation to rent their properties or room on Airbnb and earn additional income. Hence, Airbnb listings will increase (Dogru, et al. 2020). GDP per capita is collected at annual intervals from 2011 to 2021 at a country level and it is measured in US dollars at

constant prices and the data comes from OECD statistics which includes data for OECD member countries and non-member economies. The country data can bring bias to our results as it could slightly exaggerate or understate cities' GDP per capita compared to the real GDP per capita of the city. On the other hand, since almost all the cities are capital cities, they might dominate the countries' GDP per capita and therefore, it could be an acceptable proxy for this study. However, to motivate our choice we will use city-level GDP per capita data in our second robustness check to assure that our results are not resulted from the country-level data. City-level GDP per capita measured by US dollars at constant prices is collected at annual intervals from 2011 to 2018 and the data source is OECD statistics.

Employment Rate

Reichert (1990) showed in his study that the employment rate has a significant relationship with house prices suggesting that housing policy and further research should consider regional trends, such as employment. Additionally, according to Dogru et al. (2020), when the employment rate increases, more people have jobs and consequently, more people have the financial ability to afford to buy a house or a spare house to rent on Airbnb. Employment rates are going to be derived annually between 2011 and 2020 at a city level from Eurostat and OECD statistics. Employment rates are defined as the ratio of the numbers of employed persons aged 15 to 64 to the working-age population (Eurostat, 2021). However, there are some missing observations for some years which we will compute by extrapolating.

Interest Rate

Many researchers have found that interest rates have an impact on housing affordability (Englund & Ioannides, 1997; Orsal, 2014; Agnello & Schuknecht, 2011). However, the relationship between PIR and short-term interest rate is not straightforward as the interest rate affects both household income and house prices. For instance, the increase in short-term interest rate affects negatively household income through increasing interest expenditures. In addition, an increase in short-term interest rates decreases the probability of a housing boom and therefore house prices stay at low level (Agnello & Schuknecht, 2011). Hence, we are going to add short-term interest rate as a control variable, is derived on a country level annually from 2011 to 2021 from the OECD statistics.

Most Listings

We will include a dummy variable for London, Paris, and Rome, as these cities had the most listings in 2020 as illustrated in figure 1, and these cities were also among the European leading tourism cities in 2019 and 2020 as seen in the figure 4. $DMostlistings_i$ =1 for London, Paris, and Rome and $DMostlistings_i$ =0 for the other cities. This dummy variable is useful to present if the accumulated supply of Airbnb has a relationship with more touristic cities and in cities with larger short-term rental supply.

Least Listings

We will include a dummy variable for Bristol, Zurich, and Riga, which had the least listings in 2020 as illustrated in figure 1, where $DLeastlistings_i$ =1 for Bristol, Zurich, and Riga, and $DLeastlistings_i$ =0 for the other cities. This dummy variable is useful to show if the accumulated supply of Airbnb has a relationship with cities with less short-term rental supply.

4.3 Descriptive Statistics

Table 1 illustrates the descriptive statistics of PIR, Airbnb Supply, Airbnb/POP, interest rate, employment rate, GDP per capita and population with a total of 28 cities for 10 years. We can see that the standard deviation is highest for population, GDP per capita and Airbnb listings. This is due to the differences between city characteristics, which we will account for by using a FEM. Additionally, Airbnb supply has a great difference between minimum and maximum, which can be due to that Airbnb listings were low in the beginning of the launch in Europe, but the listings have increased rapidly during recent years (Coyle & Yeung, 2016). Lastly, since most of the chosen cities are capital cities, we can see that the average GDP per capita and the population are high. However, since GDP per capita is measured at country level due to data limitations, it does not show the accurate average level of chosen cities, which could cause bias in our estimations.

Table 1 *Descriptive Statistics*

Variable	Mean	Std. Deviation	Minimum	Maximum	Observations
PIR	11.9	4.5	4.3	33.5	280
Airbnb	6228.0	9703.5	13.0	63960.0	280
Airbnb/POP	0.0017	0.00147	0.00001	0.00774	280
Interest rate	0.1	0.6	-0.8	2.9	280
Employment	66.0	10.0	36.9	81.1	280
GDP	43926.9	12805.0	19257.0	93450.0	280
Population	3245844.0	2705274.0	544772.0	12500000.0	280

In Appendix 3 we can see the descriptive statistics for London, Paris, and Rome, which have the most Airbnb listings according to the year 2020. The descriptive statistics for Zurich, Riga and Bristol which have the least Airbnb listings according to the year 2020 and can be found in Appendix 4. In the Most listings, almost all the variables have higher means compared to the Least listings. Additionally, the large difference in the means of Airbnb supply between Most listings and Least listings supports our chosen classification. Additionally, as seen in Appendix 3, almost all the variables have high standard deviations indicating that the variables differ even between cities with the same classification.

In table 2, we show the correlation[6] matrix between the chosen variables. A high correlation between variables suggests that there might be a collinearity[7] problem. The relationship between our dependent and variable of interest is 0.5338, which indicates that there is a positive relationship between Airbnb supply and PIR. In other words, more Airbnb listings are associated with decreasing housing affordability. Additionally, all the chosen control variables have weak to moderate correlation and therefore, provide evidence of a non-existing collinearity problem. However, there is a strong correlation between population and Airbnb supply and therefore, we will not use population as our control variable, but we will take it into account in our regression analysis by adding Airbnb/POP in a separate estimation. The relationship between Airbnb supply and PIR becomes smaller when normalizing Airbnb supply by dividing the listing by the population as seen in table 2. Furthermore, the correlation between

[6] Correlation measures the linear relationship between two variables on a scale between -1 and 1 (Alin, 2010).
[7] Collinearity problem refers to issues that arise when two variables are highly correlated and therefore there is a risk of interpreting coefficient results wrong (Alin, 2010).

Airbnb and PIR is significant at a 5% significance level, which indicates that there is evidence of a positive relationship between these variables. Furthermore, GDP per capita and population are significant, implying that these variables have a relationship with PIR. The signs of the coefficient are expected as if GDP per capita increases, household income increases and therefore, housing becomes more affordable. In addition, cities with growing population usually have rising house prices, which leads to lower housing affordability (Barron et al, 2021).

Table 2 *Correlation matrix*

Variable	PIR	Airbnb	Airbnb/ POP	Interest Rate	Employment	GDP	Population
PIR	1.0000						
Airbnb	0.5338*	1.0000					
Airbnb/POP	0.2399*	0.6110*	1.0000				
Interest rate	0.0482	-0.1918*	-0.4940	1.0000			
Employment	-0.0215	0.1405*	0.1452*	0.0996	1.0000*		
GDP	-0.1837*	0.0401	0.1682*	-0.1861*	0.4969*	1.0000	
Population	0.5372*	0.7413*	0.1705*	0.0352	0.0364	-0,1169	1.0000

* = Significant at 5%

Additionally, figure 6 below shows the positive relationship between PIR and Airbnb supply as the regression line is upward sloping. However, we can see that the line is not a perfect fit for the dots as there is considerable dispersion around the line. Hence, there might be some other factors that have an impact on both PIR and Airbnb listings and therefore, control variables are added to our regression.

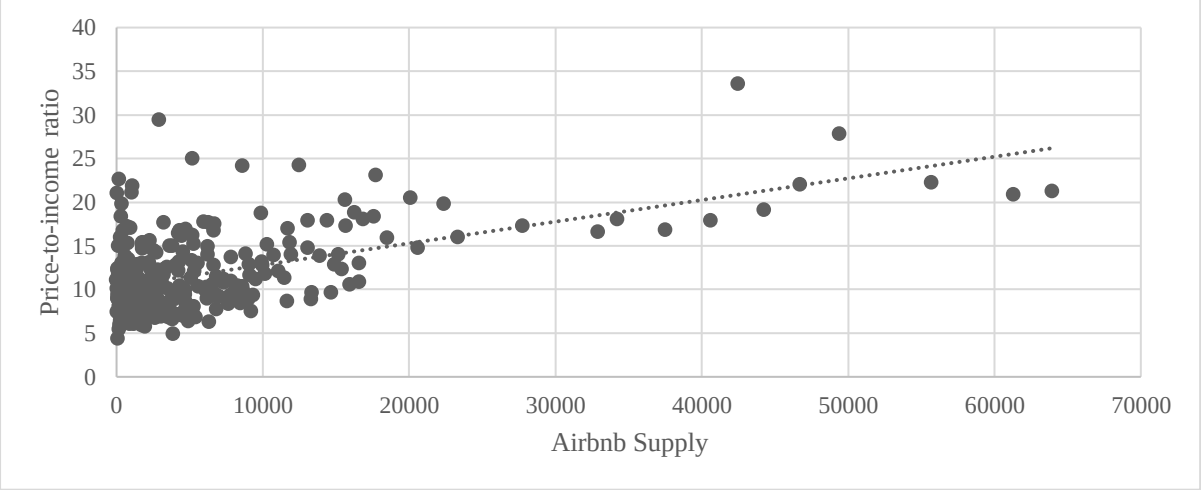

Figure 6 *The Relationship between PIR and Airbnb Supply at City Level in the 28 European cities, 2011-2020*

4.4 Methodology

In this section, we are going to present the methods used to estimate the impact of Airbnb supply on the PIR. Since our data is based on observations of cross-sectional units over several time periods, we will conduct a panel data analysis. Advantages of this type of analysis within our chosen topic are that we can estimate the changes in PIR in cities over time and we can take the heterogeneity effect within our chosen cities into account (Feng et al., 2020). There are three types of panel data models: Pooled OLS model, FEM and random effects model (REM) that can be used when approaching panel data. It is appropriate to use FEM as it accounts for the panel data dimension of the data, such as city-specific heterogeneous characteristics, by taking account differing intercepts (Gujarati & Porter, 2009). Additionally, including city fixed effect and year fixed effect allows us to account for time invariant heterogeneity, such as location or architecture of property across cities and years (Chang, 2020; Osland, 2013). Previous studies have also used a FEM when investigating the relationship between Airbnb supply and the housing market (Horn et al., 2017; Garcia-López et al., 2020).

However, FEM does not solve the endogeneity bias, which usually occurs if there are unconsidered factors, such as city preferences that simultaneously affect PIR and Airbnb supply. For instance, property owners living in high quality and more expensive cities may be less willing to rent their apartments on Airbnb because the platform could bring tourists which might increase the negative externalities of Airbnb such as increased noise and trash in the city. Additionally, endogeneity bias could occur through reversed causality if homeowners are more likely to short rent their apartment through Airbnb if the house prices are higher in their city (Chang, 2020).

Furthermore, since several factors cause house prices to vary, we have included control variables for GDP per capita, employment rate and short-term interest rate in our model, which are explained in the data section. Nevertheless, there might be some other external factors, such as, taxation or construction costs, that will make the PIR or Airbnb supply vary. Hence, we will control entity-specific omitted variables by adding α_i intercept that represents the unobservable characteristics of each city. We also believe that our variables change over time because of such as changes in government regulations and shocks in the housing market. Therefore, we will conduct a two-way FEM that controls for a time by adding a time dummy variable δ_t which

accounts for all the 9 dummies for each year from 2011 to 2020. When dealing with panel data it often has heteroscedasticity or autocorrelation, which we will account for by including robust standard errors in the FEM. To combine both entity and time-specific omitted variables we have formulated the FEM as follows:

$$PIR_{it} = \alpha_i + \beta_1 Airbnb_{it} + \beta_2 GDP_{it} + \beta_3 Employment_{it} + \beta_4 Interest_{it} + \delta_t + \mu_{it}$$

where:

- PIR_{it} is the Price to income ratio for city *i* in year *t*
- α_i represents unobservable characteristics of city *i*
- $\beta_1 Airbnb_{it}$ is the Airbnb supply for city *i* in year *t*
- $\beta_2 GDP_{it}$ is the Gross Domestic Product per capita for city *i* in year *t*
- $\beta_3 Employment_{it}$ is the Employment rate for city *i* in year *t*
- $\beta_4 Interest_{it}$ is the short-term interest rate for city *i* in year *t*
- δ_t is the time dummy variable for year *t*
- μ_{it} is the error term for city *i* for year *t*

Lastly, we will include two dummy variables: one for three cities with the most Airbnb listings and one for three cities with the least listings to see if Airbnb has a larger impact in cities where listings are higher. However, we cannot add dummy variables to our FEM due to a risk of collinearity issues as our FEM already takes care of the city fixed effects and therefore dummy variables would be collinear with the subject specific intercept. Hence, we will show the results of the dummy variables with a pooled OLS model. Pooled OLS allows us to include time-invariant dummy variables in our model and accounts for heterogeneity for our chosen dummy variables by allowing them their own intercept value. Nevertheless, the Pooled OLS ignores individual-specific effects as the intercept is assumed to be the same for all the cities which can make the coefficients biased (Gujarati & Porter, 2009). We have formulated our Pooled OLS with dummy variables as follows:

$$PIR_{it} = \alpha + \beta_1 Airbnb_{it} + \beta_2 GDP_{it} + \beta_3 Employment_{it} + \beta_4 Interest_{it} + DMostlistings_i + DLeastlistings_i + \mu_{it}$$

where:

- $DMostlistings_i$ is the dummy variable for London, Paris & Rome
- $DLeastlistings_i$ is the dummy variable for Bristol, Riga & Zurich

5. Results and Analysis

Table 3 shows the results obtained for the three regression models. We executed the models with logged variables as a log-log model offers clearly interpretable coefficients as elasticities. Hence, holding other things the same, if Airbnb supply increases by one percent, the mean PIR increases about one percent. This method has previously been used in Airbnb studies and competitive settings (Barron et al., 2021; Zervas et al., 2017). Additionally, all the models are controlled for time with time dummy variables as our variables change over time. Furthermore, we used robust standard errors in our FEM to account for autocorrelation and heteroscedasticity.

After showing statistically through a Hausman test[8] as seen in Appendix 5, a FEM is the most appropriate model for our study. First, we ran our initial two-way FEM including PIR, accumulated Airbnb supply and control variables as seen in table 3, column 1. The coefficient of Airbnb is statistically insignificant at the chosen 5% significance level and therefore, we cannot confirm the hypothesis of an existing relationship between the dependent and the focus variable. In other words, the null hypothesis is not rejected and we cannot determine if the results indicate that Airbnb supply has a relationship with PIR. Furthermore, we conducted a separate two-way FEM using Airbnb/POP as the focus variable. In this, the Airbnb supply is normalized by the city population, and we observe that the results have similar characteristics to the first model. This can be seen in table 3, column 2. As before, the coefficient of Airbnb/POP is statistically insignificant at a 5% significance level and therefore, we conclude that there is not enough evidence to determine the relationship between the focus variable and PIR. R-squared is 0.1444 in column 1 and 0.1536 in column 2, indicating that the variables in the models explain 14.44% and 15.36% of the variation of the dependent variable. Low R-squared could be explained by several other variables that can make PIR to vary which are not included in this study. In addition, low R-squared and a low number of degrees of freedom due to low amount of observations, could explain the insignificance of the control variables in columns 1 and 2.

Secondly, we executed a pooled OLS including PIR, Airbnb supply, control variables and the two dummy variables as seen in table 3 column 3. The dummy variable for cities with the most

[8] If the p-value is significant, the null hypothesis is rejected implying that FEM is preferred over a REM as the random effects can be correlated with the regressors (Gujarati & Porter, 2009).

listings has a positive relationship with the PIR and it is statistically significant with the chosen significance level. According to the results, the average PIR goes up approximately 0,5917% more in London, Paris and Rome compared to the rest of the cities. On the other hand, the dummy variable for cities with least listings turn out to be insignificant at a 5% significance level. The overall result of the model was statistically insignificant. Furthermore, all the control variables are insignificant except the control variable for GDP per capita, which has a negative relationship with the PIR. This indicates that a 1% increase in GDP would decrease PIR with 0,2961%. The sign of the coefficient was excepted as when GDP per capita increases, household income tends to increase and therefore, housing becomes more affordable. As the cities are heterogeneous the results of the pooled OLS are biased, but it is still an appropriate model to compare time-invariant variables such as cities to each other.

Lastly, to support the results, we conducted robustness checks on the models. In the first robustness check, we dropped the year 2020 due to COVID-19 shock to assay that COVID-19 did not affect our results. As seen in Appendix 6, column 1, results turn out to be statistically insignificant as the p-value of the accumulated Airbnb supply is larger than any conventional significance level. Furthermore, we conducted the same check for the pooled OLS and found a positive significant relationship between the dummy variable for most listings and PIR as seen in Appendix 6, column 2. In the second robustness check, we chose the years from 2011 to 2018 as our time period to be able to use city-level GDP per capita data in our two-way FEM and pooled OLS model with the dummy variables to ensure that our insignificant results are not driven by the country-level data. We got similar results compared to the main FEM and pooled OLS model. As seen in Appendix 7, the coefficient of Airbnb is statistically insignificant and therefore there is not enough proof that Airbnb does have a relationship with the PIR. Additionally, we conclude that the national data of GDP per capita represents well city characteristics.

Table 3 *Regression Results of a Two-Way FEM with Airbnb supply (1), Two-Way FEM with Airbnb/POP (2) & Pooled OLS with two dummy variables (3), 2011-2020*

Log PIR	1	2	3
Log Airbnb	-0.1442064	-.1726527*	.0160898
	(0.0990512)	(.0991633)	(.0266696)
Interest	.0127868	.0123171	.0784687*
	(0.0675774)	(.0661338)	(.0417148)
Log Employment	-.8751969	-.7445391	-.0423426
	(0.8568692)	(.8579121)	(.1381483)
Log GDP	.3840603	.3613296	-.2961093***
	(0.3391512)	(.3406595)	(.0746495)
DMostlistings	-	-	.5917687***
	-	-	(.0725464)
DLeastlistings	-	-	-.0265464
	-	-	(.0732499)
Constant	2.753914	.0632628	5.461671***
	(4.907536)	(5.244009)	(.6832117)
Observations	280	280	280
R-squared	0.1444	0.1536	0.4161

Note. Standard errors within parenthesis
* = Significant at 10%
** = Significant at 5%
*** = Significant at 1%

The insignificant results, differ from the previous studies of Barron et al. (2021) and Liang et al. (2022), who investigated the Airbnb impact on housing affordability and found a positive significant relationship. Nevertheless, Coyle & Yeung (2016), Chang (2020) and Franco & Santos (2021) found an insignificant impact of Airbnb supply on the housing market. Our results have several implications. Firstly, the insignificant results could refer to the implications that the European short-term rental market can be comparatively small compared to the long-term market and therefore, there is not enough evidence that Airbnb supply is associated with housing affordability. The supply reallocation from the short market to the long-term market could also be relatively small if most of the property owners temporarily rent their accommodations or only rent spare rooms of their accommodation and therefore, it would not interrupt the long-term market (Barron et al., 2021). Furthermore, as the Airbnb data is limited, we do not know if the listings are vacation homes or non-vacation homes. Consequently, the reallocation of non-vacation homes would have a larger impact on prices and housing affordability, whereas vacation homes would have to have a relatively large share of the short-term rentals to generate an effect (Barron et al., 2021). Hence, drawing on our results, we can

suggest the supply of vacation homes potentially exceeds the amount of non-vacation homes and does not occupy a large enough share of the market. Furthermore, a behavioral factor that could explain our insignificant results is that risk-averse property owners are excluded from reallocation (Coyle & Yeung, 2016). This might indicate that European property owners are risk-averse and therefore, the reallocation is not large enough to be significant. Nevertheless, Franco & Santos (2021) concluded that the high concentration of short-term rentals could explain the positive relationship and significant results for certain cities, which could be due to a larger reallocation effect or specific preferences by tourists who create extra demand for short-term rentals in certain locations. Thus, this could explain the positive significant results of the dummy variable for most listings in the pooled OLS model as the number of Airbnb listings and tourism level is high in London, Paris, and Rome.

Secondly, different housing market characteristics, such as the difference in home-ownership rates between countries could also support our insignificant result as emphasized by Chang (2020). According to the data from Statista Research Department (2020) and Eurostat (2021), the average home-ownership rate in Europe was 70% in 2020, which exceeds the average home-ownership rate of 65.8% in the US. Barron et al. (2021) argue in their study that the reallocation effect of Airbnb would be smaller in areas where the home-ownership rate is high, as owner-occupiers will rather rent their spare rooms than reallocate their whole property in the short-term market. Hence, the high owner-occupancy rate in Europe could explain our results. The home-ownership rate also differs between European countries, which might explain why our dummy variables got different results. According to the Statista Research Department (2021), the home-ownership rate was higher in the Czech Republic and Latvia compared to France and the United Kingdom, which can explain the positive relationship of the most listings dummy.

Thirdly, the new income stream created through Airbnb might not have an impact on housing affordability due to increasing regulations in Europe, making reallocation of apartments from long-term market to the short-term market harder and less compelling. Additionally, it is said that Airbnb encourages tourism and supports the demand for local companies and therefore, increases the household income of the citizens and the value of properties (Sheppard & Udell, 2016). Hence, our results could reflect that the positive externalities of Airbnb might not have a large enough impact to have an increasing effect on housing affordability. However, when analyzing the significant results of the most listings dummy variable, the positive externalities

could be higher in London, Paris and Rome due to large presence of Airbnb listings and high tourism level, which together support household income of the residents. Along with this, we acknowledge the data limitation for the household income and further encourage future studies of this in section 6. Moreover, Europe might still be preserved from the majority of the negative externalities caused by short-term rentals and hence, the results turn out to be insignificant.

Lastly, investigating empirically the relationship between Airbnb supply and housing affordability is not straightforward as several other factors have an impact on both housing affordability and Airbnb supply, such as, household income, number of households and taxation, which could explain the insignificant results. Additionally, as previous studies had used other housing affordability- and housing market measures, this could cause differing results. Since our dependent variable PIR is a ratio, Airbnb externalities can affect differentially household income and house prices and therefore we do not know if PIR could be negative even though there is an increase in house prices if the positive impact is higher on household income. Furthermore, we cannot disregard the fact that insignificant results can also occur due to insufficient data, but we believe this could be an area of improvement for the future when the data availability increases.

6. Conclusion

To conclude, this study focuses on investigating the relationship of home-sharing on housing affordability. The rapid growth of urban tourism and home-sharing platforms have recently generated much concern for policymakers to apply regulatory measures against sharing economy, especially in large touristic cities (Garcia-Lopez et al., 2020). To summarize our results, the two-way fixed effects model showed statistically insignificant results indicating that there is not enough evidence to conclude whether there is a relationship between Airbnb supply and PIR. Using a pooled OLS model, the dummy variable for London, Paris and Rome is statistically significant, but the dummy variable for Zurich, Riga and Bristol is insignificant, indicating that the higher the concentration of Airbnb listings is in the city, the larger the relationship is on housing affordability. Overall, the results indicate insufficient evidence of an existing relationship on a European level but suggest that there is a relationship on the local level in popular Airbnb cities. Furthermore, the empirical evidence of this study provides some useful information for the city planners and policymakers to consider whether and how to respond to the rapid expansion of the home-sharing market. Since we cannot determine whether

the overall Airbnb supply has an impact on housing affordability, this suggests policy makers to bypass implementing uniform European regulations to prevent the expansion of short-term rentals. Instead, local regulations adjusted to the city's needs in the event of rising short-term rental supply are recommended to ensure the access affordable housing.

There are also some caveats in this study. Firstly, the data used in this study generates limitations to our research. As the data found from Inside Airbnb does not provide information on the exact entry and exit of the properties it makes it difficult to estimate the accurate amount of listings. Despite the lack of information, many researchers have used the same method where the entry date is determined by the date the owner became a host (Zervas et al. 2017; Barron et al. 2021). Additionally, although we gathered all the available Airbnb data of European cities, the sample size is still relatively small, which can affect our results. Hence, we suggest that future studies include more cities and longer time periods when data availability increases. Furthermore, the dependent variable used in this study is a ratio, which creates limitations to interpret the results. Since we do not have data separately for house prices and household income, we cannot see which magnitude of Airbnb is affecting house prices and household income. Thus, an interesting future study would be separating the impact on house prices and income to further examine if an increase in Airbnb supply affects differently on the variables and include additional control variables such as, negative externalities of Airbnb, tourism level and taxation. There are also other home-sharing platforms besides Airbnb that we do not estimate in this study, which might cause an error to the measurement and therefore, our estimate of listings does not correspond to a true estimate of short-term rentals as a whole in Europe. Future research could extend the study by adding other home-sharing platforms to the study.

Finally, the continuing rapid growth of home-sharing and its impact on the housing market in the future is still an open question. Between the years of 2020 and 2021, COVID-19 hit tourism and Airbnb by decreasing listings in many countries while house prices continued increasing making housing less affordable. We still do not know if Airbnb will recover and further increase its market size or if COVID-19 increased investors' risk awareness and converted them to prefer the traditional long-term market in the future. Therefore, we encourage further studies to investigate the future trend of home-sharing after the recovery of COVID-19 to be able to make the right policy decisions for the future of the short-term rental market.

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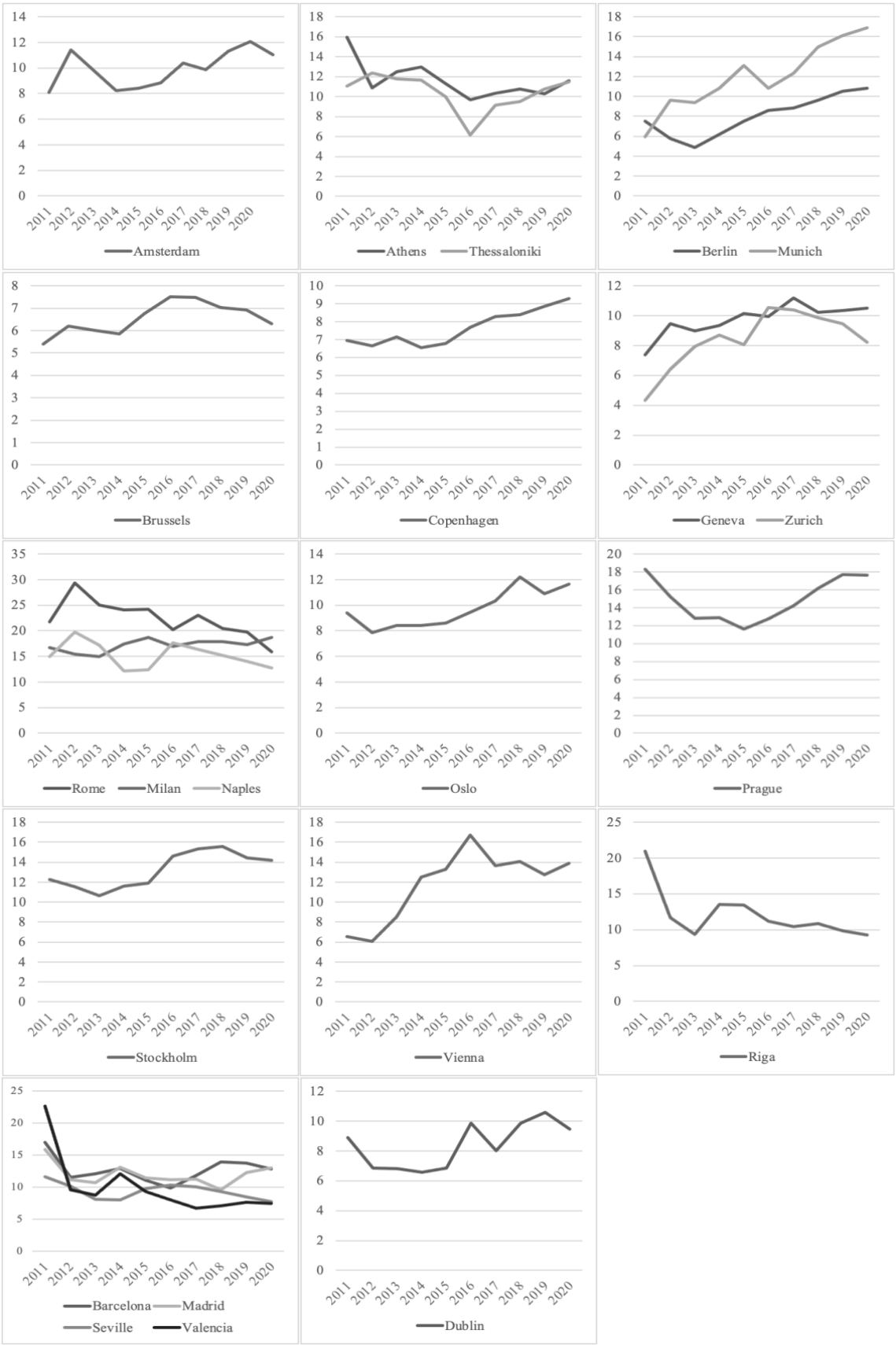
Appendix

Appendix 1 *European Urban Cities with the Accumulated Number of Listings in 2020*

City	Listings	Country
Amsterdam	5316	The Netherlands
Athens	9123	Greece
Barcelona	14879	Spain
Berlin	16597	Germany
Bristol	1507	United Kingdom
Brussels	4912	Belgium
Copenhagen	9320	Denmark
Dublin	6741	Ireland
Geneva	2052	Switzerland
Lisbon	17571	Portugal
London	63960	United Kingdom
Lyon	8622	France
Madrid	16603	Spain
Milan	16262	Italy
Munich	4741	Germany
Naples	6655	France
Oslo	3209	Norway
Paris	46729	France
Porto	9950	Portugal
Prague	6307	Czech Republic
Riga	2020	Latvia
Rome	23320	Italy
Sevilla	5126	Spain
Stockholm	2713	Sweden
Thessaloniki	2397	Greece
Valencia	5008	Spain
Vienna	10730	Austria
Zurich	1764	Switzerland

Appendix 2 *PIR Trend in 22 European Cities, 2011- 2020*



Appendix 3 *Descriptive Statistics for Cities with Most Listings*

	Variable	Mean	Std. dev.	Min	Max	Observations
Most listings	PIR	20.2	4.6	14.8	33.5	30
	Airbnb	24698.1	18999.7	1022.0	63960	30
	Airbnb/POP	0.002	0.001	0.00009	0.005	30
	Interest rate	0.2	0.5	-0.4	1.4	30
	Employment	67.1	4.8	60.5	76.3	30
	GDP	41796.9	4046.0	36091	49070	30
	POP	9013819	3459629	4117951	1.25e+07	30

Appendix 4 *Descriptive Statistics for Cities with Least Listings*

	Variable	Mean	Std. dev.	Min	Max	Observations
Least listings	PIR	10.2	2.8	4.3	20.9	30
	Airbnb	941.6	635.4	21	2020	30
	Airbnb/POP	0.0008	0.0006	0.00002	0.0021	30
	Interest rate	0.08	0.5	-0.7	0.9	30
	Employment	74.3	4.2	62.6	78.9	30
	GDP	45310.5	17281.58	19257	72034	30
	Population	1066640	188925.8	894582	1401783	30

Appendix 5 *Hausman Test*

Test	Chi-Sq.	Prob.
Hausman	24.75	0.000

Appendix 6 *Robustness Check for Dropping Year 2020: Two-Way FEM with Airbnb supply (1) & Pooled OLS with dummy variables (2), 2011-2019*

Log PIR	1	2
Log Airbnb	-.1379723	.119026
	(.0983943)	(.027817)
Interest	.0235962	.0781919*
	(.0691817)	(.0432599)
Log Employment	-1.419412	-.1122973
	(.868723)	(.1460314)
Log GDP	.5279892	-.2951539***
	(.3616021)	(.0797052)
DMostlistings	-	.6179116***
	-	(.07638)
DLeastlistings	-	.0050293
	-	(.0773279)
Constant	3.454772	5.758357
	(4.595799)	(.7235341)
Observations	252	252
R-squared	0.1522	0.4222

Note. Standard errors within parenthesis
* = Significant at 10%
** = Significant at 5%
*** = Significant at 1%

Appendix 7 *Robustness Check with city level GDP per capita data: FEM with Airbnb supply (1) & Pooled OLS with Airbnb supply and dummy variables (2), 2011-2018*

Log PIR	1	2
Log Airbnb	-.1407396	0.0414024
	(0.107914)	(0.0297561)
Interest	.0498454	0.1201571**
	(0.0932266)	(0.0543494)
Log Employment	-1.513861	-.5691303**
	(0.9119192)	(0.2195702)
Log GDP	.3515046	-.5691303
	(0.614621)	.0895365
DMostlistings	-	0.5906398***
	-	(0.0872949)
DLeastlistings	-	.1461683*
	-	(0.0880227)
Constant	5.593331	3.857135***
	(6.577216)	.5932692
Observations	224	224
R-squared	0.1349	0.03921

Note. Standard errors within parenthesis
* = Significant at 10%
** = Significant at 5%
*** = Significant at 1%