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Brussels's rising rents:
A panel study on Airbnb's potential effect

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1. Introduction

In the media, Brussels is commonly used as a European Union (EU) synonym. Indeed, the city is the EU capital par excellence since it hosts several related institutions, such as the European Commission, Council of the European Union, and European Council, as well as the second seat of the European Parliament and the NATO headquarters (Cybriwsky, 2013). Amid these imponent buildings live the residents and, for shorter times, visitors from all over the world, coming for leisure, business, and diplomatic reasons.

Although migrations, the movements of goods, and travel have existed for centuries, in the last few decades, these flows have begun to pose a problem in several capitals and smaller cities: due to their increasing and sustained speed, some locals might ponder whether this is possibly becoming harmful to their hometowns, and at times, engendering tourism-phobia (Almeida-García, 2020).

Arbel and Pizam (1977), Bugalski (2020), and other researchers mention that most travellers stay near a city's famous sites, causing a higher density of short-stay accommodations downtown. Since Airbnb and equivalent platforms do not have the same legal restrictions as hotels, listings have recently expanded to residential areas, thus, inevitably diminishing the pool of long-term accommodations and raising housing costs (Bugalski, 2020; Gutiérrez, García-Palomares, Romanillos, & Salas-Olmedo, 2017; Almeida-García, Cortés-Macías, & Parzych, 2021).

Critics have then held the platform accountable for deteriorating residents' quality of life with rising amenities costs, the disappearance of traditional commerce and services, and negative externalities such as noise pollution and congestion (Barron, Kung, & Proserpio, 2018; Bugalski, 2020; Almeida-García et al., 2021). If pressing enough, the phenomenon could even engender the locals' displacement, possibly blighting the community's original characteristics (Bugalski, 2020).

Looking at the last years while occasionally referring to the pandemic of Covid-19, which undoubtedly affected the travelling industry, this thesis aims to use secondary data on the trends of Airbnb listings, the municipalities' real estate market and their residents to answer the following research question:

"Did Airbnb contribute to the rising rents of Brussels between 2015 and 2021?"

While the links between Airbnb and rising rents have been studied in many European cities (in particular, the Mediterranean ones like Barcelona; Garcia-López, Jofre-Monseny, Martínez Mazza, & Segú, 2019), as well as large US ones (e.g., the New York City case study done by Wachsmuth, & Weisler, 2018), only a few researchers seem explicitly be tackling the topic in Brussels; moreover, many of those who do, do not incorporate the effects of the pandemic. By providing an empirical approach to the abovementioned question, this thesis aims to contribute to the discussion regarding the platform's impact. It could also inspire further research on the matter and case studies in other

cities while providing insights to the urban policymakers of the Brussels-Capital Region and promoting the development of new initiatives for the European Cities Alliance on Short-Term Holiday Rentals.

The literature reviewed to formulate the hypothesis has three streams: the general drivers of the rise of real estate prices, how the effect of this phenomenon can vary depending on the location and the sociocultural traits of the residents (valuable to understand the possible social impact of this thesis and which control variables to use), and Airbnb studies relating to the rising rent prices, which will also be the foundation for the policy recommendations. Then, the thesis will dive into Brussel's specific characteristics (social, economic, cultural, and touristic). Once a clear background is laid out, the hypothesis is tested with balanced panel data regressions. The statistically significant results obtained with the best fitting models are then compared to the literature. The limitations of this research will also be discussed, particularly regarding the model and data used as well as the Covid-19 impact. This paper will conclude with potential advice to Brussels's authorities and a summary.

2. Theoretical Framework

2.1. General Drivers of Rising Real Estate Prices

Since the beginning of the millennium, real estate prices have increased faster than income in many developed countries (Geng, 2018). While the global financial crisis of 2007-2009 and the following European debt crisis (2009-2014) slowed this process in Belgium, the price-to-income ratio (nominal house price index divided by the nominal disposable income per head) did not significantly reduce (Geng, 2018; OECD Data, 2022a).

Previous literature indicates a positive relationship between long-run real estate prices and financial conditions as well as sociodemographic needs, while a negative one with households' costs and housing stock (Geng, 2018). For the scope of this research, it is also important to notice that the overall diminishing long-term interest rates have partially driven rising housing demand: in Belgium, the rates have gone down substantially and stayed below 1% between 2015 and 2020 (OECD, 2022b). Furthermore, housing investment returns and price-to-rent ratio (the nominal house price index divided by the housing rent price index) had both increasing trends (Geng, 2018; OECD, 2022a). Thus, it can be concluded that there has been an overall stimulation in buying properties as investments (e.g., to rent out). The rise in residential investment could not balance the demographic needs, which grew at a higher pace, engendering considerable housing supply shortages (Geng, 2018). Indeed, housing long-run supply's price elasticities can also affect real estate dynamics: cities with nearly inelastic curves do not provide a comparable number of new properties to those with elastic ones, engendering higher real estate valuations (Geng, 2018). This was shown to be the case in Belgium, where the estimated long-run housing supply elasticity was 0,3 when using 1989-2016 data (Geng, 2018). Some may think that rental properties could be less affected by the increasing housing prices

thanks to rental controls (e.g., the government establishing a limit on the value that can be asked for a long-term lease); thus, they might settle for not buying. However, this can cause a reduction in incentives to use housing efficiently, possibly still resulting in inflated real estate prices since rent controls could lead to tenants staying in a location providing more than their needs (Geng, 2018).

2.2. Rising Rents' Effects on the Residents of Certain Locations

The rising rents in specific neighbourhoods rather than others tend to be driven by gentrification. On this note, Clay (1979) used Pattison's theory (1977) to the phenomenon as linked to the constant (dis)investments in a neighbourhood, from the part of several stakeholders such as the buyers, the developers, the realtors, the local government and organisations, as well as financial institutions. This inevitably affects the residents' cultural and socioeconomic conditions and can result in the displacement of the initial inhabitants.

In the first two stages, Clay (1979) established that the public interest in moving into the location tends to be relatively low. Therefore, only a small group first takes the risk (pioneers) by relying on private capital to invest in house renovations and making minor community improvements concentrated in limited areas. This movement later increases in magnitude and includes a small scale of speculators seeking to renovate properties for resale or rental. While the initial incomers mostly took over vacant properties, with more available mortgages and unoccupied houses becoming scarce, the displacement effect tends to pick up and further changes the surroundings. Since it is not physically imposed, it can be considered exclusionary: a household vacates a residence which is then gentrified, hence preventing another household similar to the first one from moving in (Marcuse, 1986).

Clay's (1979) third stage takes over when the urban renewal attracts the arrival on a larger scale of individual investors, willing to restore houses as an investment and a place to live. These newer incomers tend to change the traits of the pioneers' organisation. At this point, the risk is generally neutral, and there is more attention to improving amenities such as physical community infrastructure, engendering a quick price rise. Hence, the displacement of the initial residents progresses, and some tensions begin between those staying and the incomers. In the last stage, the working class loses a significant allocation of the neighbourhood's real estate to people with generally better education and incomes. The incoming economic activities answering the new demands and the lack of appropriate regulations inflate the prices even further, which could create unaffordable living conditions for the initial residents. Thus, the displacement of renters and homeowners persists, while those staying suffer from a sense of alienation (Helbrecht, 2018).

In the context of this research, it is good to mention that Gotham (2005) later re-elaborated this concept with tourism as a possible driver (tourism gentrification). In his article, he considers the

phenomenon both commercial and residential since it displays new relationships between the authorities, the housing market, and the rest of the world: leisure and touristic activities brought a higher class to the neighbourhoods, increasing real estate values, attracting retail chains, and displacing the lower class while sullying the original characteristics of the French quarter of New Orleans (USA). The national and global socioeconomic changes created a competition for cities to appear as appealing tourist destinations with the aim to attract the investments of financial firms and entertainment corporations, which tend to develop tourism services and facilities in areas with rent gaps (difference between actual and potential economic returns to properties; Smith, 1987). Thus, gentrification and tourism become dependent on consumers, with activities such as shopping, food services, cultural amenities, and leisure venues (Gotham, 2005).

Considering that Pattison (1977) also specified that the incomers' characteristics vary between locations depending on the economic and cultural traits of the neighbourhood, we could suppose that the interest in the highly competitive Airbnb market could have led some investors to act as hosts and further emphasise stages 3 and 4, thus widening the rent gap and affecting the displacement rate. This was confirmed by past research, for example, Cocola-Gant's (2016) study, according to which the platform's consequences are comparable to gentrification since they slowly inflate an area's value to the disservice of the locals, many of whom relocate due to financial constraints. Indeed, in New York City, Wachsmuth and Weisler (2018) found that home-sharing raised a systematic investment flow into real estate and created rent gaps in neighbourhoods which are household names thanks to their culture.

In theory, gentrification could still be helpful to revitalise specific communities and increase the city's attractiveness to private investors. However, as mentioned previously, a new class taking over the area attracts others with the same conditions. Accordingly, the cost of living tends to increase and the purchasing power to reduce, engendering many low-income households to relocate to more affordable regions. Holme (2022) believes these zones tend to be segregated neighbourhoods with financial difficulties, often hosting economically and racially segregated schools offering a lower quality of education, which could reinforce intergenerational poverty. The children of the parents who decided to remain in their original homes and suffer the high rent burdens also tend to experience challenges that can affect their schooling and developmental outcomes, which could potentially transfer to adulthood (Holme, 2022).

These already pressing problems have become even more pronounced with the COVID-19 pandemic: the risk of eviction has boomed, particularly for marginalised and vulnerable families, which further highlights the need to focus on the matter (Joint Center for Housing Studies at Harvard University, 2020, as cited in Holme, 2022).

In brief, this sub-chapter offers a perspective on the impact of higher rents and highlights why the changes in average household income and sociocultural traits of a neighbourhood (e.g., percentage of tourist-related shops in the commercial activities; Gotham, 2005) could be considered as control variables: people tend to regroup with those having similar characteristics (e.g., educational level, having children, artists, and homosexuals in the Bay Village; Pattison, 1977; but also, nationality and race).

2.3. Airbnb's Potential Impact

In The Big Apple, Airbnb's 15 times smaller revenue would appear unable to compete with the hotel industry's; however, the latter has not been actively growing for years, and many believe it is partially linked to the exponential increment of short-term rentals (Wachsmuth, & Weisler, 2018). The rise in these properties in the pre-pandemic times has been very significant also in many European cities. For instance, in Amsterdam, over only four years (2013-2017), the number of listings increased from 4500 to 22000 (Eurocities, 2022). To address this phenomenon, cities such as Barcelona attempted to control this trend with checks to ensure the tax payments, thus possibly reducing the platform's competitive advantage over traditional accommodation (Gutiérrez et al., 2017). It comes then as no surprise that several other initiatives also developed to contrast this process: proposals for regulations (European Commission, 2021) and data availability (Eurocities, 2022) were solicited by the European Cities Alliance on Short-Term Holiday Rentals, which also counts both Barcelona and Brussels's city officials.

Foremost, we should ponder the reasons behind this rapid expansion. Using Barcelona as the centre of their study, Gutiérrez et al. (2017) highlighted that in 2015, Airbnb accommodations tended to be densely located downtown, which significantly depends on tourism and the amenities offered. However, with time, the listings' distribution started covering a wider area than the hotels: it also extended to very central residential districts and, in the case of other cities, to several areas offering well-known cultural elements (Gutiérrez et al., 2017; Wachsmuth, & Weisler, 2018). Indeed, in Spain, the geographical dispersion of Airbnb listings is correlated to areas with rent gaps: clusters are in the downtowns where the prices per night tend to be higher, or in working-class zones, which can be less expensive and provide prospects for investors if they remain easily accessible to the tourist sites (Gutiérrez, & Domènech, 2020). With the addition of these relatively central residential areas to those already strongly affected by visitors, Airbnb further intensifies its position on the market since it profits more than the competition from the nearness to the city's famous sites, and it spatially disperses the cash flows related to the tertiary sector (Garcia-López et al., 2019, Wachsmuth, & Weisler, 2018). It also contributes to worsening the sectoral labour conditions, specifically for people already in vulnerable positions (e.g. room cleaners), since the hosts usually perform these activities or outsource

them, stripping the workers of part of their union rights (Wachsmuth, & Weisler, 2018). Most crucially, the rising presence of Airbnb accommodations impacts the long-term rent prices. With several panel data regressions with fixed effects, Garcia-López et al. (2019) estimated this development in the real estate market, showing an increase in rents and housing prices, with more significant consequences on the latter. Indeed, according to Barron et al. (2018), in case of no negative externalities linked to home-sharing, the platform increases property values by letting the homeowners generate income from their excess capacity, thus, arising the price-to-rent ratio. Nonetheless, in Barcelona, an additional listing in a neighbourhood with an average Airbnb activity would still incur a rent increase of almost 2% and 7% in touristic parts of the city; however, this can only partially explain the aggregate rent increases experienced between 2012 and 2016 (Garcia-López et al., 2019). This leads to the following hypothesis:

H1: *An increase in the proportion of entire dwellings offered on Airbnb in relation to the total number of apartments in a municipality could have led to rising average rent prices.*

To later establish possible policy suggestions, it is worth acknowledging that several other studies on Airbnb have also attempted to demonstrate its effect on the supply side of the rental market by discerning the propensity to transfer properties in the short-term's one (Barron et al., 2018; Li, Kim, & Srinivasan, 2021; Koster, van Ommeren, & Volkhausen, 2021). Duso, Michelsen, Schäfer, and Tran (2021) further dived into the subject while inspecting the impact of professional landlords. Their results showed that Berliner hosts listing entire properties on Airbnb for more than six months harm the local rental market by crowding out the supply, thus leading to growing lease prices. The increment of one in the listings with high availability (most of the year) would have a positive, statistically significant effect on the average rent per square meter (rise of approximately 1,8%). When examining the effect of city regulations on short-term rentals, the authors found that with new policies limiting the extensiveness of nights' availability, the decline in Airbnbs engendered more affordable rents (30€ cheaper). This suggests that the outcomes deriving from the regulations to relieve the real estate market depend on the actual reduction of professionalism within the hosts.

The phenomenon of professional hosts, at times with multi-listing properties, highlights that real estate companies can use Airbnb's platform in their business model (Gil, & Sequera, 2020; Verhaeghe, & Endrich, 2022). In the context of Brussels, Verhaeghe and Endrich (2022) emphasised that while the total amount of listings reduced during the pandemic, those who suffered the most were unprofessional categories of hosts (private individuals offering a complete house for less than a third of the year, or apartment sharers). Their results showcase that before the pandemic, their number of listings seemed relatively stable on the market, while professional hosts had a rising trend.

The latter category tends to offer properties in neighbourhoods around Brussels's inner city or European institutions, while Brussel's canal, which approximatively follows the left contour of the municipality Bruxelles-Ville, appears to divide the deprived areas of the North-West with no significant predominance of Airbnbs, from wealthier zones with rent gaps and higher listings' concentrations (later touched upon with Figure 6. and 7.; Endrich, Verhaeghe, Costa, Imeraj, & Gadeyne, 2022). During the pandemic, the professional hosts, which often include companies, took over the most considerable portion of the Airbnb market (Verhaeghe, & Endrich, 2022). On this note, according to BNP Paribas Fortis (2021), despite the decrease of 4,8% between 2019 and 2020 in the number of real estate transactions in Belgium, the second residence housing market seemed still robust, with an increase in the average amount loaned by 3%. In Brussels, 74% of the secondary housing financed by the bank appeared to be going towards being rented. Since the professional hosts tend to be investors (buy-to-let), it is possible that with the Covid-19 crisis, they invested and obtained more significant parts of the market.

3. Methods

3.1. Geographical Structure and Population of Brussels

Brussels-Capital Region (BCR) regroups 19 "communes" (municipalities, Figure 1.), which are authorities exercising autonomously political powers on their territory while also subject to the control of the Government of the Region (Brussels-Capital Region, 2022). The goal of the grouping was to achieve economies of scale and higher efficiency of public services and goods. The municipalities later agreed to a further division into 145 "quartiers" (neighbourhoods) which can extend over several "communes" (IBSA, 2022b).

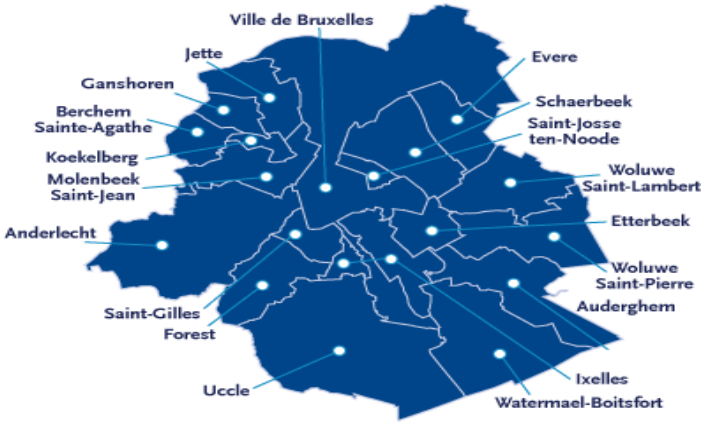

Figure 1. Brussels-Capital Region division in municipalities (Brussels-Capital Region, 2022).

According to the IBSA (2021a), the region has had continuous positive population growth since 1996. However, after 2011, the pace has seen a significant decrease, falling below 1% per year since 2016 (Figure 2.).

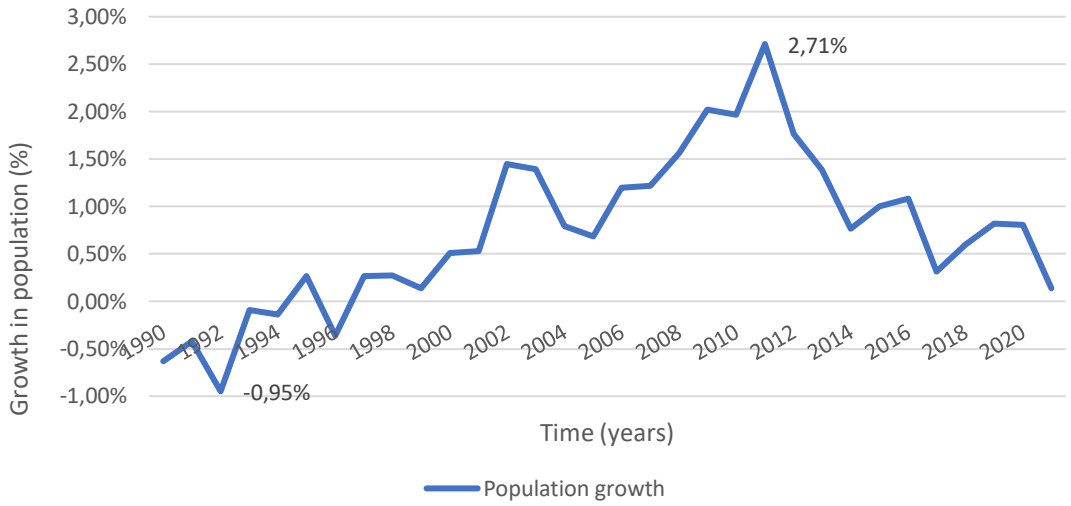

Figure 2. Population growth in Brussels-Capital Region from 1990 to 2021, with data labels on the peak and the trough. Data from IBSA (2021a).

Note. Calculated by taking the difference of two years' population values and dividing it by the earlier one.

Since immigration seems to be the most contributing factor to its population growth, it is not surprising that more than a third of the residents are currently foreigners (IBSA, 2020; section 8.1., Figure 1.). The city's dynamism is also due to its young population: the yearly average age is below 40, and the proportion of minors is around 22% (IBSA, 2021d). This is particularly true in the municipalities surrounding the city centre (Saint-Josse-ten-Noode, Schaerbeek, Molenbeek Saint-Jean, Koekelberg, while Anderlecht tends to have a slightly higher average age but a proportion of youngsters above 25%; for a geographical perspective consult Figure 1.).

The average household sizes also reflect the presence of larger families in the abovementioned areas, which tend to have lower incomes compared to those in the South and East sides of the city (higher proportion of people living in precarious conditions, Figure 3.), thus leading to high levels of inequalities within BCR, which can reach a difference of almost 35% units (2021). In the case of Anderlecht, it appears evident that between 2015 and 2021, there has been a significant impoverishment of the living conditions since the locals tend to be blue-collar workers employed mainly in the livestock market, the football stadium services, at the headquarters of Leonidas SA and Coca-Cola Benelux, and in smaller activities, all industries highly affected by the pandemic.

Regarding economic disparities and the real estate market, it is worth mentioning that in Belgium, only 4% of the total rental dwellings are social (OECD, 2020); furthermore, the majority of the residents of BCR live in apartments (around 80%) and are renters (Census2011, 2022).

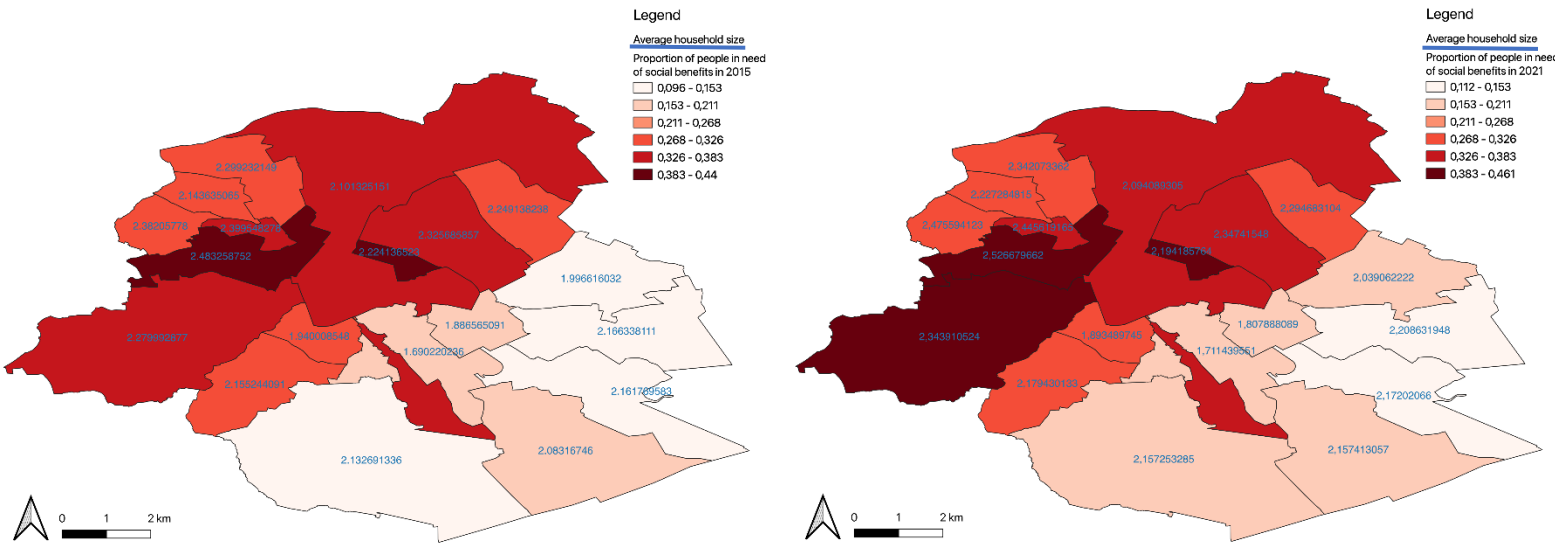

Figure 3. Two maps (right one 2015, left one 2021) of the Brussels-Capital Region with darker shades of red in the geographical areas with the largest proportions of people in need of social benefits. The data labels correspond to the average household size. Data from IBSA (2021b, 2021e) developed in QGIS.

For the Brussels-Capital Region, tourism accounts for 12% of its GDP, and it is the leading sector of job supply, especially for individuals with lower levels of education (visit.brussels, 2020b). However, the city's touristic attractions are primarily located around the central vertical axis Bruxelles Ville-Ixelles-Uccle (Figure 4.), which on average, tends to have higher incomes than the municipalities mentioned above. The city's heart offers leisure entertainment and hosts diplomatic and international organisations' buildings. Ixelles and Uccle provide several shopping streets and very popular woods, which are the destination of many locals and visitors for picnics and horse-riding tours. It is worth mentioning that Watermael-Boitsfort (South-East) appears to have significantly increased its tourist locations (almost by 14% in 6 years, Figure 4) thanks to the addition of historical monuments to the heritage register.

Regarding the demand side of tourism, it is again important to notice the city's substantial diplomatic and business role. According to visit.brussels (2020a), there were slightly more business tourists compared to visitors for leisure; however, this changed with the pandemic and the working remotely recommendations: this category appears slightly more affected than those visiting for pleasure (decrease by 78% in the number of overnight stays at hotels against 74%). The same source also highlights the significant impact of Covid-19 on the number of arrivals at licensed touristic accommodations (4.116.724 in 2019 against 1.046.916 in 2020) and their overnight stays (7.802.832 in 2019 against 1.880.595 in 2020).

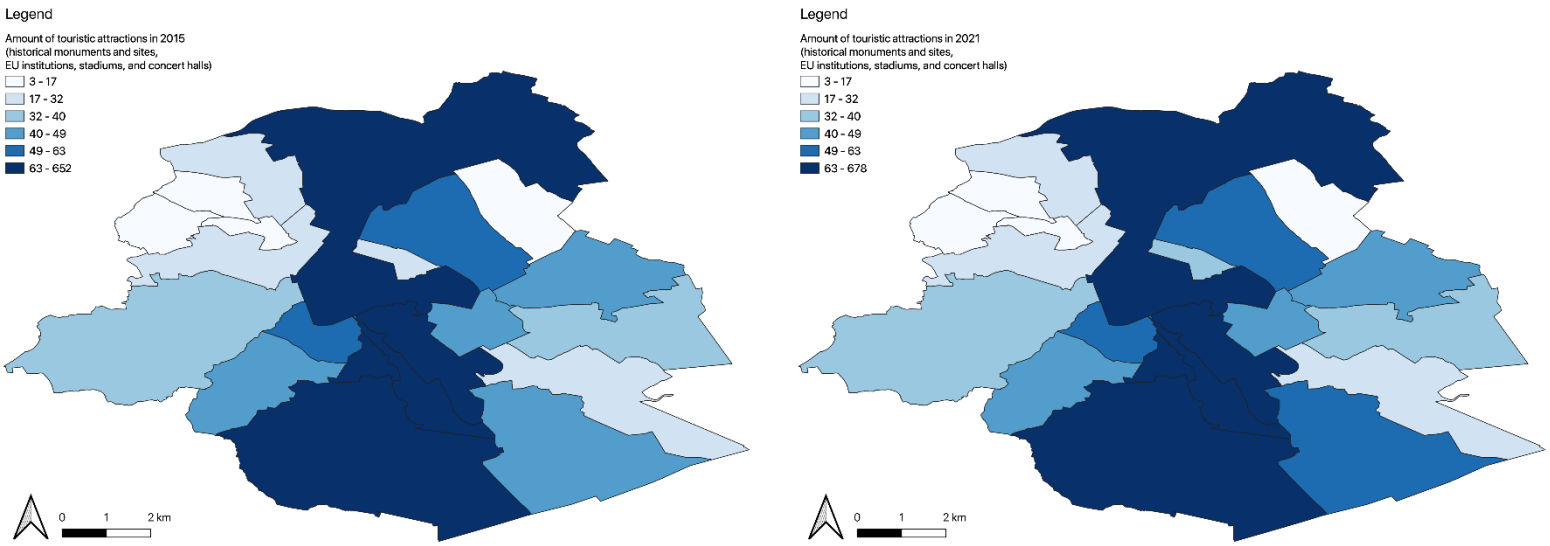

Figure 4. Two maps (right one 2015, left one 2021) of the Brussels-Capital Region with darker shades of blue in the geographical areas with the largest concentration of touristic attractions (historical monuments and sites, EU institutions, international organisations, stadiums, and concert halls). Data from Brugis (2022), visit.brussels (2022a, 2022b), European Commission (2022), European Parliament (2022), European Council and Council of the European Union (2022), and NATO (2022). Developed in QGIS.

3.2. Airbnb in Brussels

Airbnb is a platform founded in 2008 that millions of hosts and travellers use to list their properties and book accommodations (Airbnb, 2022). Since 2015, the popularity of Airbnb in Brussels rose with a fluctuating trend likely linked to seasonality (yearly peaks in July), which before 2020 seemed only externally affected by the terrorist attack in 2016 (Figure 5.). However, with the spreading of the Covid-19 pandemic in March 2020, the interest plummeted. One year later, it was still half in volume compared to the pre-Covid times.

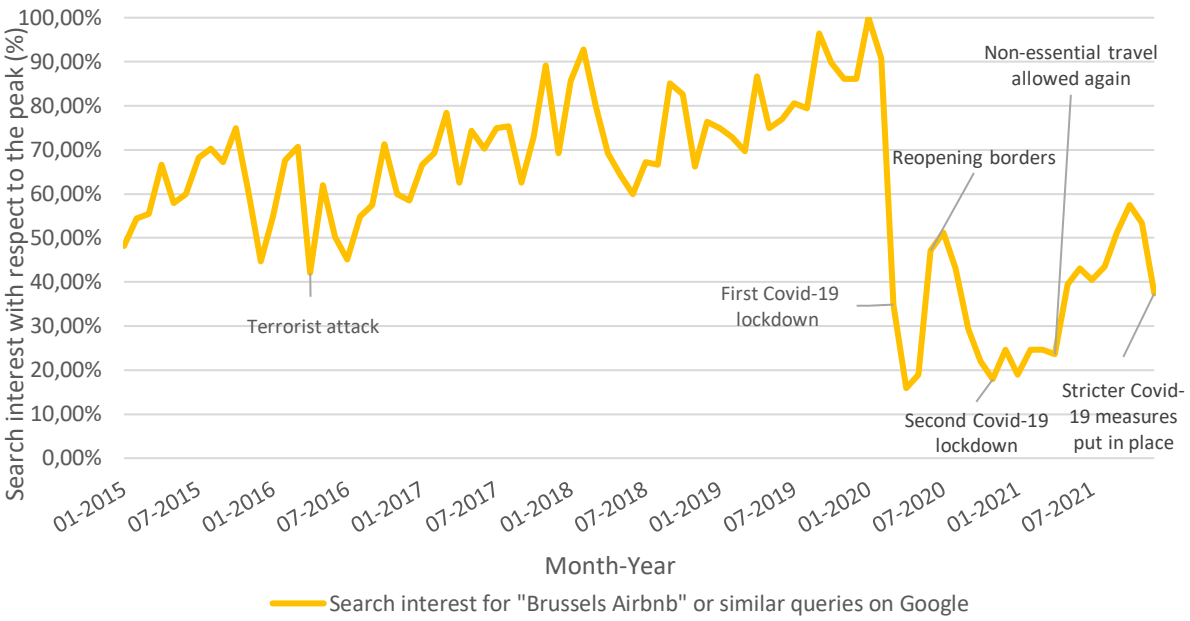

Figure 5. Representation for “Brussels Airbnb” or similar queries searched on Google between 2015-2021. Specific relevant external events are mentioned in the corresponding month. Data from Google Trends (2022).

As in other cities mentioned in the literature review, the spatial dispersion of Airbnb tends to be centred downtown, but with time, it also developed in nearby municipalities, such as Ixelles, Saint-Gilles, Etterbeek, Schaarbeek, Jette, and Woluwe-Saint-Pierre (Figure 6.).

As far as registered by Inside Airbnb (2018, 2020, 2021), June 2020 was the time with the most listed entire apartments in Brussels (Figure 7.). This could appear surprising at first, but Figure 5. provides insights on the matter: around May of the same year, speculations arose on the possible reopening of the borders and the relaxation of smaller measures. While international visitors in neighbouring countries could have taken the chance to come for getaway weekends, national visitors were also probably interested in spending some time nearby with not too limiting restrictions. Since Brussels also hosts many foreigners (section 8.1., Figure 1.), it could be that those who left to go back to their home countries decided to put their places up for short-term rental and gain passive revenue. It is also worth mentioning that the start of the pandemic appears to have had a more substantial impact on the peripherical listings (Figure 7.). This is particularly noticeable in the city's East and South sides, fairly residential areas well connected to the European institutions (concentrated within Bruxelles-Schaarbeek-Ixelles-Etterbeek). Thus, possibly implying that the working remotely requirements started in 2020 could have led to a decrease in demand from diplomatic tourists. Considering the pandemic effect on the unemployment rates and that many of those who offered entire apartments could not earn income by leasing them out to tourists, some hosts already collecting limited earnings may have settled to sell their vacant properties.

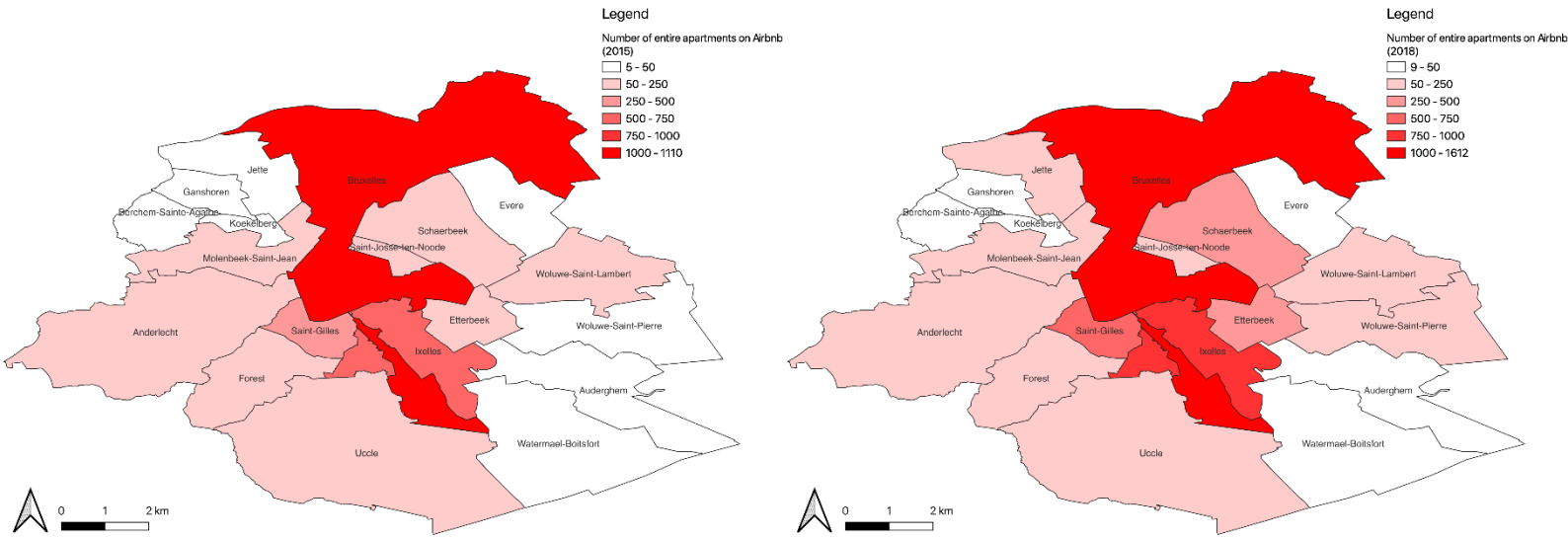

Figure 6. Evolution in the spatial distribution of entire apartments listed on Airbnb before the pandemic (2015, 2018). Data from Inside Airbnb (2018) developed in QGIS.

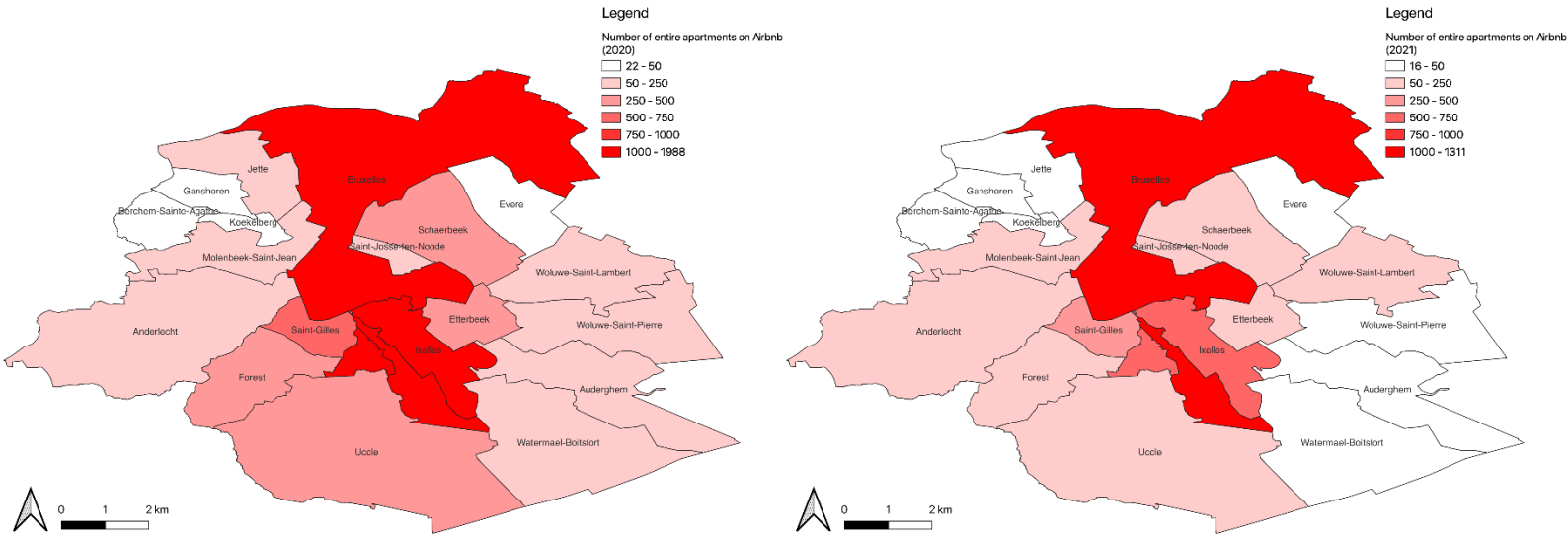

Figure 7. Evolution in the spatial distribution of entire apartments listed on Airbnb during the pandemic (2020, 2021). Data from Inside Airbnb (2020, 2022b) developed in QGIS.

3.3. Data

Due to a lack of available data per neighbourhood, the analysis is performed on a municipality level. The demographical and sociocultural indicators were retrieved from the Institut Bruxellois de Statistique et d'Analyse, also called IBSA, which collects data, produces and disseminates statistics regarding BCR while also pursuing socioeconomic analyses and evaluating public policies (IBSA, 2022a). The information on the real estate market was provided by SPF Finances (federal public service which administers the financial aspects of the Belgian state; SPF Finances, 2022b) and Statbel (Belgian statistical office which collects, produces, and distributes figures and databases regarding Belgian socioeconomic traits; Statbel, 2022a). The reliability of the sample depends on whether the

abovementioned agencies collected and consistently reported the data. Since they are official national or regional sources, we can expect this is the case.

The municipalities' yearly proportions of foreigners are obtained by dividing the number of non-Belgian citizens (*non_belgians*) by the population (*total_pop*; IBSA, 2021c), while the average household size (*average_hh_size*) was already available (IBSA, 2021b). The data linked to *rent* (average rent price of an apartment) was extracted from SPF Finances (2018, 2022a), while the total number of apartments in each municipality (*apartments*) from Statbel (2022b). *prop_precarious* was constructed by dividing the number of beneficiaries of social benefits (referred to as *need_benefits*, regrouping those obtaining income replacement and integration, guaranteed revenue for the elderly and contributions for mandatory health insurance) by *total_pop* (IBSA, 2021e; IBSA, 2021c). It was chosen as a proxy for revenue due to a lack of historical data on disposable income.

Regarding information linked to the short-stay rentals, a web scraping code was created in Python to obtain Airbnb's listings details (section 8.4.). However, it has many limitations, including a lack of historical data and repeated listings (each iteration of the code only provides around 150 new listings' information due to Airbnb advertising specific dwellings). This method becomes then inefficient and too time-consuming.

Hence, the best option was to use the Inside Airbnb datasets as done by many other researchers and institutions (e.g., Statistics Netherlands, 2019). Inside Airbnb was founded by Murray Cox, an activist driven by the idea of providing data to advocate and research Airbnb's impact on residential communities (Inside Airbnb, 2022). There are still limitations regarding the historical data (2016 and 2019 datasets are missing), which implies that the analysis will consist of a comparison of five years: 2015, 2017, 2018, 2020 and 2021 (Inside Airbnb 2018, 2020, 2022b). For the first three years, the data was already presented per municipality, while for the most recent ones, it was per listing. It must be acknowledged that this sample may contain only part of the total active listings available (around 12500 in 2021, according to Verhaeghe, & Endrich, 2022), and the pandemic, which effect is incorporated in the data rather than applied as a shock, has had an extensive impact on tourism, including Airbnb. This could affect the results and make them less robust than desired.

The datasets offered by the website have between 3175 (in 2015) and 5927 (in 2020) entire apartment listings and provide relevant information per municipality or listing, on the dwelling type, the average price per night, and at times the average price per month. *listings_prop* refers to the number of entire apartments offered on Airbnb (*listings_apart*, corresponding to the sum of all the entire apartments per municipality for the data of 2015, 2017 and 2018, or the count of every property being an entire apartment in the same location for 2020 and 2021 datasets) divided by the total number of apartments in a municipality (*apartments*). The average monthly price for an entire

dwelling on Airbnb (*monthly_price*) is obtained by multiplying the price per night (*price_night*) by 30 days, or if available, by using the monthly price.

Table 1. Relevant descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
apartments	95	16948,6737	11593,7549	4550,0000	58468,0000
average_hh_size	95	2,1860	0,2042	1,6863	2,5459
foreigners	95	0,3334	0,0904	0,1824	0,4949
listings_apart	95	228,3684	360,1388	5,0000	1988,0000
listings_prop	95	0,0111	0,0112	0,0006	0,0548
monthly_price	95	2358,3385	390,2527	1521,8912	3487,8947
need_benefits	95	18947,8647	17331,4869	3940,0000	65872,0000
non_belgians	95	22023,4316	16268,5763	4365,0000	69557,0000
price_night	95	80,4307	12,0547	58,5769	116,263
prop_precarious	95	0,3684	0,4849	0,0959	0,4761
rent	95	796,2208	104,7725	616,0197	1118,0845
total_pop	95	63197,1368	42333,1517	21525,0000	186916,0000

Other than the observations already mentioned in section 3.1., a notion from Table 1. that catches the eye is the significant difference between the listings' monthly price and the average rent per month (around three times more; for a graphical perspective, consult section 8.2., Figure 3. and 4.). This could be due to the data not fully capturing possible price discounts put in place by the hosts in case of extended stays. It is also true that while all Airbnb apartments offer a minimum amount of furniture, utilities and services, while a portion of the apartments in the long-term rental market does not, thus resulting in lower prices.

It is also evident that the number of entire apartments listed on Airbnb divided by the total amount of the same dwelling type in the same municipality (*listings_prop*) is relatively small compared to other cities suffering from over-tourism (just above 5% at the maximum value, Table 1.). However, this does not necessarily imply that Airbnb had a limited impact. As explained by Wachsmuth and Weisler (2018), in New York City, a maximum of 0,5% of the rental housing was converted to short-term rental but, considering the limited change in housing supply, the listings may have denied most of a year's worth of new housing supply.

Despite the proportion of foreigners and people needing social benefits having similar means and maximum values, it is evident that economic inequalities are more pressing than the segregation by nationality (standard deviation five times higher, Table 1.).

3.4. Methodology

The models used are balanced panel data regressions, where the variables are observed for each entity at each of the five periods. They appear appropriate since they allow for controlling part of the omitted variables without observing them (Stock, & Watson, 2020).

A similar approach to the ones of Garcia-López et al. (2019) and Maltchev (2021) will be taken to answer the research question and the hypothesis. STATA is used to test different models and select those which reflect the data more appropriately. A base regression (no lags nor controlling variables) with random effects (RE) and one with fixed effects (FE) are performed with the (in)dependent variables presented at the end of this subchapter. The Hausman test would then lead to identifying which is most appropriate. The test's null hypothesis implies that RE should be included in the model (difference in coefficients is not systematic); thus, if rejected at a statistically significant level of 0,05, FE would be preferable. A regression model with the latter could control part of the omitted variable bias (OVB, all time-invariant differences between municipalities), while a RE model could best fit the data if the omitted variables are uncorrelated with the independent ones (Stock, & Watson, 2020; Maltchev, 2021).

If the null hypothesis cannot be rejected, we can test whether a pooled OLS regression would be more appropriate than a RE one with the Breusch-Pagan Lagrangian multiplier test for random effects. Its null hypothesis implies that the former model is suitable; thus, if rejected at a statistically significant level of 5%, we can assume that the RE regression would be a better choice.

Then, a new regression with one lag of X (X_{t-1}) and one also incorporating the control variables will be run. With their addition, we could expect a more extensive explanatory power (R^2); however, they must be tested for multicollinearity with the variance inflation factors (VIF): if each independent variable's value is not above five, we could consider their correlation not alarming (Maltchev, 2021). The general models are built as follows.

i. RE regression: $y_{it} = \beta_0 + \beta_1 * x_{1it} + e_i$

ii. FE regression: $y_{it} = \beta_0 + \beta_1 * x_{1it} + a_i + v_{it} + u_{it}$

iii. Regression with a 1-year lag: $y_{it} = \beta_0 + \beta_1 * x_{1it} + \beta_2 * x_{2i(t-1)} + a_i + v_{it} + u_{it}$

iv. Regression with control variables:

$$y_{it} = \beta_0 + \beta_1 * x_{1it} + \beta_2 * x_{2i(t-1)} + \beta_3 * x_{3it} + \beta_4 * x_{4it} + \beta_5 * x_{5it} + a_i + v_{it} + u_{it}$$

Where i denotes the municipality, t is the time the variables are measured. e_i indicates the error term for the RE regression capturing the variance introduced by the unit-specific effect for each i (time-invariant) and the balance amount of error from all other sources (time-variant). a_i denotes the time-invariant elements as the FE of the municipalities, v_{it} incorporates the error term from the effects unique to each i, while u_{it} corresponds to the error term when measuring FE. β_0 is the regression constant (time-invariant), and β_1 the coefficient reporting the difference in Y per unit change in X_{1it}. In iii. and iv., β_2 is the coefficient of the 1-year lag in X (X_{t-1}), while β_3, β_4 and β_5, are the coefficients of the control variables. From the literature review in section 2.2., we can establish that *average_hh_size,*

foreigners, and *prop_precarious* could be appropriate for the role since they reflect possible changes in the socioeconomic and cultural traits of the municipalities.

To answer the first hypothesis, the dependent variable Y corresponds to *rent.* β_1 would then be the coefficient for the *listings_prop* (X_1), representing the difference in Y per unit change in the proportion of entire apartments listed on Airbnb compared to the total amount available. Once chosen whether to use fixed or random effects, the regression will be referred to as Model 1. Since rents tend to change yearly, it could be supposed that it would be more valuable to use the first lag of *listings_prop* to reflect the changes in the long-term rentals market. Thus, if β_1 found in Model 1. is not statistically significant, the second model will remove the non-lagged term of *listings_prop*. Model 2.'s β_1 would then become the coefficient of the lag of *listings_prop* and reflect the change in the average rent with the rise of 1 unit in the proportion of entire apartments listed on Airbnb compared to the total amount available the previous year. When adding the coefficients of *average_hh_size, foreigners*, *prop_precarious* (respectively be β_3, β_4, β_5), this will become Model 3.

We could then also navigate whether *rent* (Y) is influenced by the listings' prices (*monthly_price* corresponding to X_1) and not only by their presence with a similar approach as the one stated above. β_1 would then be the coefficient for the *monthly_price*, and β_2 the one of its lag, while β_3, β_4, and β_5 would correspond respectively to the coefficients of *average_hh_size, foreigners,* and *prop_precarious*. The results of this part can be found in section 8.2..

4. Results

From the base regression ($rent_{it} = \beta_0 + \beta_1 * listings\_prop_{it} + e_i$), the Hausman test (Table 2.) showed that only when adding the lag of the proportion of listings in the total amount of apartments, as well as the control variables, the models appeared suitable for fixed effects (p-value of respectively 0,0024 and 0,0001 against 0,05, null hypothesis rejected). Thus Models 2. and 3. can partially control the OVB (section 8.3., Model 2., and 3.).

Table 2. Results of the Hausman test.

Regression	Test statistic	P-value
(1) Base regression	0,00	0,9618
(2) 1-year lag of X_1	9,24	0,0024***
(3) 1-year lag of X_1 and control variables	23,88	0,0001***

Note. p<0.1*, p<0.05**, p<0.01***

The Breusch-Pagan Lagrangian multiplier test for random effects showed that while the base regression was not appropriate for fixed effects (Table 2.), it appears to fit a RE model rather than a pooled OLS's one (Table 3., p-value of 0,0000, thus smaller than 0,05). This will then be Model 1. (section 8.3., Model 1.).

Table 3. Results of the Breusch-Pagan Lagrangian multiplier test for random effects.

Regression	Test statistic	P-value
(1) Base regression	149,25	0,0000***

Note. p<0.1*, p<0.05**, p<0.01***

The variance inflation factors of the explanatory variables only had values below 5 (Table 4.); thus, the control variables can be added to the model.

Table 4. VIF values of explanatory variables.

Variable	VIF
average_hh_size	4,71
foreigners	3,02
prop_precarious	2,83
listings_host	2,53

Table 5. reports the results of the three regression models that appear to fit best the data (section 8.1., Model 1., 2., and 3.). The first column displays the values found for the base regression with random effects. The constant appears positive, statistically significant (5% significance level), and with a large coefficient. The coefficient of *listings_prop* is also positive but with a smaller magnitude (almost nine times less). As suspected, its value is not statistically significant and thus not appropriately interpretable.

In Model 2., the constant slightly decreases in value but remains firmly statistically significant and positive. Similarly, the coefficient of the first lag of *listings_prop* (β_1) appears to have a large, positive, and statistically significant effect (1% significance level) on the average rent prices. This is the case since it reflects the change in the dependent variable when the previous year's proportion of listings on the total number of apartments rises by 100%. Thus, to interpret it, the value must be divided by 100.

When adding the control variables to the abovementioned model, β_1 remains positive and statistically significant at the 1% significance level but decreases in magnitude by around 24%. Both *average_hh_size* and *foreigners* are positive and statistically significant (respectively at the 10% and 1% significance levels), implying that the average rent for an apartment in a municipality i at time t rises almost twenty-four times more with the addition of one member to the average household size than with the increases by a 1% unit in the proportion of non-Belgian residents. *prop_precarious* and the constant have a negative and not statistically significant effect on the average rents of the municipality.

Table 5. Regression results of the most appropriate models.

Variable	rent		
	Model 1.	***Model 2.***	***Model 3.***
listings_prop	91,6584		
listings_prop lagged		6246,3140***	4734,6550***
average_hh_size			477,3785*
foreigners			2022,7670***
prop_precarious			- 911,9879
constant	795,2063***	728,8629***	- 721,8487
observations	95	95	95
overall R^2	0,0004	0,0056	0,2375

Note. p<0.1*, p<0.05**, p<0.01***. The coefficients of *listings*_prop$_{i(t-1)}$, *foreigners*$_i$ and *prop_precarious*$_i$ must be divided by 100 to be interpreted: not doing so would reflect the change in the dependent variable when they increase by 100% units.

5. Discussion

5.1. Interpretations

This thesis investigated the effect of Airbnb on Brussels' rental market by analysing the increase in the proportion of entire dwellings offered on the platform in relation to the total number of apartments in a municipality and its effect on the average rent prices. On this note, it could be deduced that the average long-term rent in a municipality i at the time t is predicted to increase by 62,46€ if the proportion of apartments listed on Airbnb (compared to the total number of apartments) rose by a 1% unit the previous year (*listings_prop*$_{i(t-1)}$). This confirms that the presence of Airbnb listings can affect the residents' living costs. Thanks to the reviewed literature, it could be established which sociocultural traits of neighbourhoods would be more appropriate for this role: the proportion of non-Belgian citizens and people needing social benefits, as well as the average household size. The results are strongly statistically significant (1% significance level) both with and without control variables. The large magnitude of *foreigners* and *prop_precarious* is due to their proportional characteristic; thus, the coefficients must be divided by 100 to be interpreted. On that note, *average_hh_size* and *foreigners* have positive and statistically significant effects, implying that the average rent for an apartment in a municipality i at time t rises by around 477,38€ with the addition of one member to the average household size, and by 20,23€ if the proportion of non-Belgian residents increases by a 1% unit across time. This appears realistic considering that welcoming larger households engenders the need for larger spaces; however, the supply of long-term rentals remains limited. Furthermore, a higher percentage of foreigners tends to be characteristic of dynamic municipalities, which could potentially be starting a gentrification process (Pattison, 1977). While, as expected, the increase in the proportion of people needing social assistance to sustain themselves is deleterious for the rents, the value is not statistically significant, thus not appropriate to interpret. This could imply that in the context of Brussels, income does not play a primary role in the rent's evolution, which connects to the

reviewed literature showing that in Belgium, housing prices tend to rise faster than revenue even during possible financial crises (OECD Data, 2022a).

Models 2. and 3. contained the fixed effects, thus, allowing for heterogeneity: the reduction of the OVB in the coefficients and a more precise estimate. While the most complete model led to the most considerable explanatory power compared to the other versions, it is still constrained (around 24%). It can be deduced that the increase of only one listing will not practically represent an alarming decrease in the market for long-term rentals. It also must be considered that other listings' information may play a more significant role in determining rents. For example, there is a chance that the listing prices directly affect the long-term rents of a municipality (the latter rises by approximately 0,05€ if the short-term rent increases by 1€; section 8.2.). Despite the limited magnitude, the effect has a statistically significant value (1% significance level), and the explanatory power of the regression with the control variables is much larger (R^2 = 0,8469).

Hence, the effects measured in the models, which preferred ones are those with control variables, indicate that there is indeed a risk of Airbnb contributing to the rise of Brussels's rents in the years between 2015 and 2021. This showcases similar conclusions to those drawn by Barron et al. (2018), Garcia-López et al. (2019), and Duso et al. (2021) since the addition of the coefficient of $listings\_prop_{i(t-1)}$ to the average rent (Table 1.) estimated an increase of 8%, which is partially similar to the one in the US (1% rise in listings engenders rents 0,018% higher), Barcelona (7% per each new listing), and the Berlin (just below 2% per square meter with a new professional listing). However, it implies the need for a larger number of Airbnbs to obtain strictly comparable results: the independent variable reflects a proportion within the available rental market and not directly the number of listings.

5.2. Limitations

Nonetheless, there are several limitations to these results. Foremost, the data: *prop_precarious* had to be considered as a proxy for income since the specific values for the latter were unavailable for 2021. The incompleteness of the model could also have caused the coefficients to suffer from the omitted variable bias: despite the inclusion of fixed effects, the low R^2 suggests that other relevant control variables were missing in the regressions. If added, while still accounting for a moderate risk of collinearity they could have improved the explanatory power. While this could not be done due again to limited accessible data, including, for instance, the proportion of people with a higher educational degree or the percentage of tourist-related shops in the commercial activities could have made a difference (Holme, 2020; Gotham, 2005). The results would have also been further impactful if the analysis could have been done with more observations, for example, by having Airbnb's data on a listing level for all the years, including apartments marketed as separate listings (one per room), considering a more extensive historical range, and using neighbourhoods instead of

municipalities. Indeed, this thesis could not incorporate the possible spillover effects of the neighbourhoods on each other.

The models could have also been affected by reverse causality: the increase in the proportion of entire dwellings offered on Airbnb in relation to the total number of apartments in a municipality could be due to higher average rent prices. Considering the significant difference in prices between long-term and short-term rentals (Table 1.), it is possible that some homeowners might have found renting for long periods on the Airbnb market even more profitable than leasing to locals. This bias could have been avoided through an instrumental variable isolating the effect of the presence of Aribnbs on the rents. Similarly to what was done by Barron et al. (2020), the interaction between the Google Trends search index, and the amenities of each neighbourhood linked to tourism (e.g. establishments in the hospitality industry), could have been used. While the Google Trends indexes were easily accessible (Figure 1.), specific historical data regarding the evolution of the number of restaurants and hotels per municipality was unavailable. Another approach could have been using the Google Trends indexes specific to each municipality (e.g., "Airbnb Anderlecht"). However, this method would incur several problems, the first being that the central municipality of BCR is called Bruxelles-Ville (Brussels City) and, at times, even simply Bruxelles (e.g., IBSA, 2019). This implies that a user who does not know any better could have been searching for that specific query while seeking an Airbnb more generally located within BCR. The other issue is that many municipalities' names change from French to Flemish. Thus, the volumes would become hard to account for. It is also true that searches on Google tend to be done by looking for the city in general, and only once on the Airbnb website the user selects their preferred neighbourhood, either via the search bar or the map.

5.3. Covid-19

Since the results are statistically significant, this could imply that nonetheless the pandemic impact on tourism, the presence of Airbnbs still influenced the rent prices in Brussels. However, it is true that to slow the spread of the virus with the imposition of drastic measures on the tourism, culture, and catering sectors in mid-March 2020 (with some gradual lifting in spring and setbacks in autumn), Brussels had to deal with the absence international travellers, who used to account for nearly 78% of nights spent in hotel accommodations (visit.brussels, 2020a). The second lockdown lasted until April 2021, which welcomed the return of non-essential travels and softer measures; however, they were restricted again by the end of 2021. While the city officials have yet to provide quantitative data on the effect of Covid on tourism in 2021, we can already partially deduce from the figures in section 3.2. that the pandemic affected both the supply and the demand for short-term accommodations. This also implies that the months during which the data was extracted from the Airbnb website may have influenced the results.

Indeed, the models capture the effect of the Covid-19 pandemic without applying a direct exogenous shock in the rental market; thus, the coefficients are probably smaller in magnitude compared to those deriving from a counterfactual panel data model with two-way fixed effects: $y_{it} = \delta_{it} * D_{it} + \beta * X'_{it} + a_i + v_{it} + u_{it}$, where Y would be the outcome for the rent in municipality i at time t, D_{it} a dummy variable indicating whether the pandemic hit municipality i at time t, δ_{it} the pandemic effect on the municipality i at time t, X'_{it} a vector containing the values of the independent and control variables on each municipality i at each time t, β a vector regrouping their coefficients, and a_i, v_{it}, u_{it} would have the same characteristics as those explicated in the section 3.4.. This model would allow the pandemic's effect to be heterogenous across the municipalities and time. However, it was not used since in the months when the data was available (June 2020, and November 2021), the measures were rather relaxed but not necessarily similar, implying that the dummy variable would homogenise the outcomes, giving still insights with limited practical applicability. Furthermore, nowadays, it might be more interesting to wait a couple of years to analyse the long-term effects of the pandemic. In this regard, in 2020, Dolnicar and Zare (2020) believed that after the crisis, the demand for Airbnb's listings would recover swiftly but would not be comparable to the pre-pandemic level since, for instance, professional hosts bore long periods of user's costs while collecting limited to no revenues. However, according to the UNWTO (2022), international tourism continued to recover at a strong pace in January-March 2022, and Europe welcomed almost four times more international arrivals than in the first quarter of 2021. While these numbers are still below 2019 levels, the gradual recovery is expected to progress throughout 2022 and reach the pre-pandemic tourism levels by 2023–2024 (UNWTO, 2022). Considering that Covid-19 taught us that things change rapidly, it could be that Dolnicar and Zare's (2020) supposition will not be fulfilled, thus implying a possible future accelerated effect of Airbnb on the rents and the touristification of Brussels. On this note, the city officials have developed a recovery program focused on stimulating the tourist flow, providing an adequate and innovative offer, and diversifying the target population to become less vulnerable to future shocks (visit.brussels, 2020b).

5.4. Relevance and Recommendations

This thesis has foundations in the literature investigating the link between Airbnb and rent prices. However, most studies have focused on cities suffering high levels of touristic flows and with different sociodemographic conditions than Brussels, for instance, Southern European (Spanish and Italian ones in particular) and US's largest towns. The results highlight that this process is present in the heart of Europe; thus, officials should be aware of the potential consequences of not adjusting legal procedures linked to Airbnb. Indeed, in Brussels, the latest regulations appear the same as those established in 2016, which aimed to reduce the professionalisation of the hosts (Ridole, 2021). To do

so, a professional host must register the property as a tourist accommodation to Brussels's authorities. This implies providing several documents, such as a criminal record extract, a civil liability insurance contract, an agreement of all the owners, and a certificate of urban planning attesting the compliance of the property, which can be challenging to obtain considering the age of many of the buildings, and the requirements to register as touristic establishments. Indeed, to procure this certificate, a permit application is often needed. According to Ans Persoons (Ridole, 2021), around 60% of the requests received since 2016 have been denied.

Nonetheless, before the pandemic, the number of professional hosts had a rising trend, and with Covid-19 taking over, they obtained the largest share of the Airbnb market (Verhaeghe, & Endrich, 2022). This shows that despite the efforts of the urban policymakers, the current regulation is ineffective and needs adjustments, which becomes an even more pressing issue considering the significant impact on the long-term rents. As reported by Ridole (2021), there is the risk of high fines for those not respecting the urban procedures (ranging between 250€ and 100000€ for the offence, on top of a possible tax on unoccupied buildings, which can reach 530€ per square meter). However, these consequences depend on whether the host has been found guilty, and the authorities would always first attempt to reach an amicable solution, which can take extensive time. Thus, to moderate the transfer of rental housing stock to the short-term market, it would be best to reduce the bureaucratic fining process and tackle the problem directly by levying an occupancy tax on hosts renting their entire dwelling. Another option would be to attempt a similar approach as in Amsterdam: requiring a more restrictive rental permit. This regulation caps the maximum number of rental nights to 30 per year, the number of guests to 4, and the property must remain the host's primary residence (Gemeente Amsterdam, 2022). If Airbnb members do not obtain a permit but still list their property, they can incur fines less substantial than the Belgian ones (between 8700€ and 21750€). Since it appears that Brussels does not suffer from as many tourists as the Dutch capital, and the officials are attempting to further rise the number of overnight stays (the goal would be reaching 10 million per year; visit.brussels, 2020b), it is advisable to increase the restrictions more softly, by for instance only establishing a maximum number of guests, like in Amsterdam, or a maximum yearly availability in the number of nights, like also in Berlin (Duso et al., 2019). Considering the desire to improve the touristic attractiveness, it is also worth mentioning that the authorities should further support hotel-like structures with possible tax exemptions, thus partially shifting the investors' interest from short-term rentals.

Due to the limited data availability, the results should be considered an incentive to further research on the topic and inspiration for future case studies in other cities. Using more extensive data and complex methods could capture the exact effect of the phenomenon pre- and post-pandemic,

allowing BCR's policymakers to develop more specific future urban and real estate regulations. Entities such as the European Cities Alliance on Short-Term Holiday Rentals could then refine their needs regarding the analysis of the welfare of home-sharing, which could help preserve the affordability and original spirit of the neighbourhoods.

6. Conclusions

This research was based on literature showcasing the drivers and the effects of rising rental prices, as well as specific short-term rental studies. It aimed at understanding the possible impact of Airbnb on Brussels's long-term rentals since most of the analyses on the topic were made in cities already struggling with large tourist flows. In contrast, Brussels's competent authorities still want to reach higher influxes. The results prove that Airbnb is increasing long-term rents in the city but with a more limited intensity than in other metropoles, which could be partially due to the pandemic's impact on the data. Hence, policymakers should account for the potential consequences that further stimulating tourism could have on the residents if the regulations for short-term rentals are not adjusted.

On this note, possible recommendations would be limiting the number of guests, establishing a maximum yearly availability for the number of nights, reducing the bureaucratic fining process, or levying an occupancy tax on hosts renting their entire dwelling, while also supporting hotel-like accommodations to spark the interest in potential professional hosts in shifting markets.

The constraints of this research (data, model and scope wise) imply that the results should be regarded as incentives to investigate further in Brussels and other cities. Performing the analysis on a neighbourhood level with an instrumental variable and more complete data could capture the exact effects of the phenomenon, hence allowing policymakers of the Brussels-Capital Region to develop more specific and concrete future urban and real estate regulations.

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8. Appendix

8.1. Figures

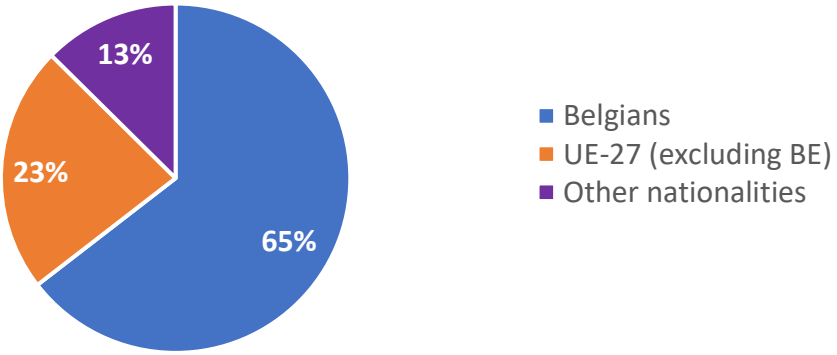

Figure 1. Percentage of the nationalities of the residents of Brussels-Capital Region in 2021. UE-27 refers to the European Union citizens, excluding Belgians and individuals from the United Kingdom. Data from IBSA (2021c).

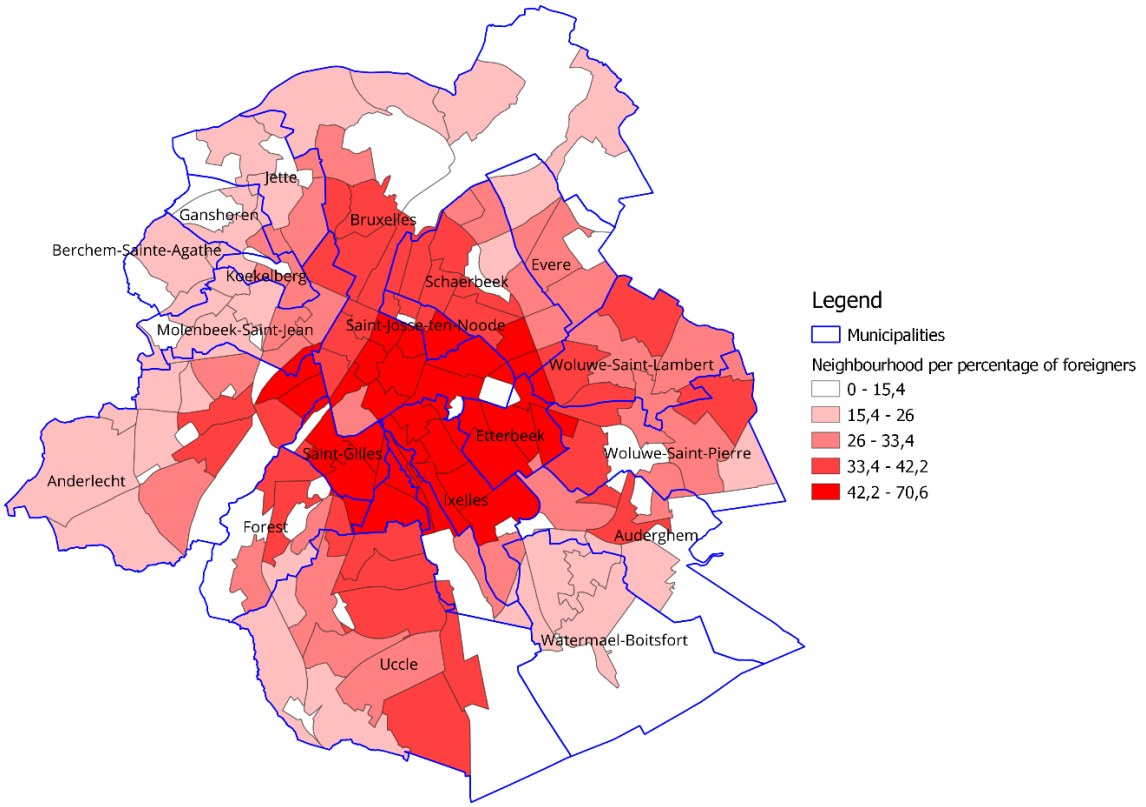

Figure 2. Brussels-Capital Region division in municipalities, and neighbourhoods with darker shades of red in the geographical areas with the largest percentages of foreigners in 2019. Data from IBSA (2019) elaborated in QGIS.

Note. The aggregate data was obtained by summing every indicator.

8.2. Rent and Listing Price

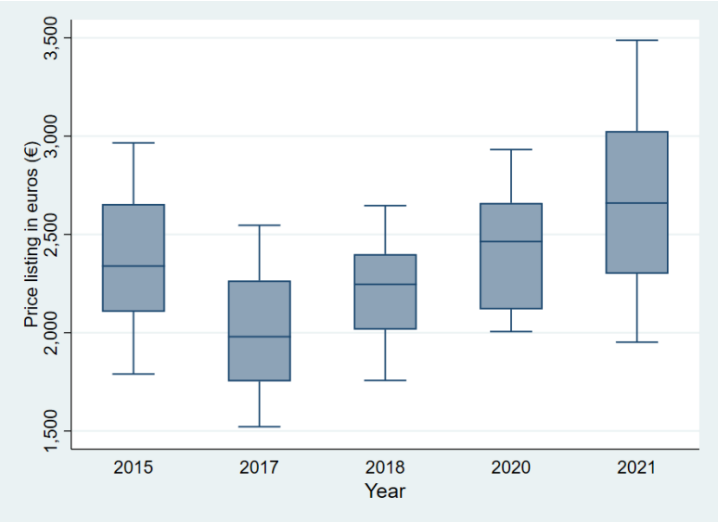

Figure 3. Boxplot of the short-term rent: the average monthly price per entire Airbnb apartment. The line in the middle of the coloured rectangles reflects the median. No significant outliers appear visible. Data from Inside Airbnb (2018, 2020, 2022b).

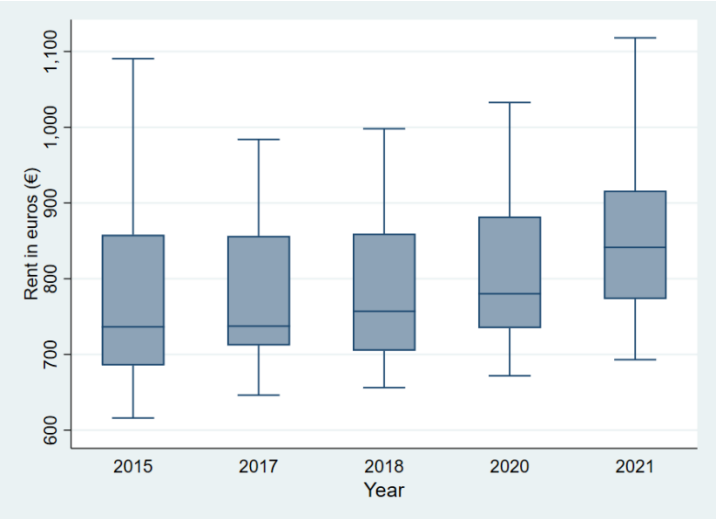

Figure 4. Boxplot of the long-term rent: the average monthly rent for an apartment. The line in the middle of the coloured rectangles reflects the median. No significant outliers appear visible. Data from SPF Finances (2018, 2022a).

Table 1. Results of the Hausman test.

Regression	Test statistic	P-value
(1) Base regression	0,37	0,5419
(2) 1-year lag of X_1	- 0,45	NA
(3) 1-year lag of X_1 and control variables	3,63	0,3040

Note. p<0.1*, p<0.05**, p<0.01***

Table 2. Results of the Breusch-Pagan Lagrangian multiplier test for random effects.

Regression	Test statistic	P-value
(1) Base regression	153,40	0,0000***
(2) 1-year lag in of X_1	95,26	0,0000***
(3) 1-year lag in of X_1 and control variables	68,53	0,0000***

Note. p<0.1*, p<0.05**, p<0.01***

Model 1.

$$rent_{it} = \beta_0 + \beta_1 * monthly\_price_{it} + e_i$$

Model 2.

$$rent_{it} = \beta_0 + \beta_1 * monthly\_price_{it} + \beta_2 * monthly\_price_{i(t-1)} + e_i$$

Table 3. VIF values of explanatory variables.

Variable	VIF
average_hh_size	3,49
foreigners	2,55
prop_precarious	1,89
monthly_price	1,03

Model 3.

$$rent_{it} = \beta_0 + \beta_1 * monthly\_price_{it} + \beta_2 * monthly\_price_{i(t-1)} + \beta_3 * average\_hh\_size_{it} + \beta_4 * foreigners_{it} + \beta_5 * prop\_precarious_{it} + e_i$$

Table 4. Regression results of the most appropriate models.

Variable	rent		
	Model 1.	***Model 2.***	***Model 3.***
monthly_price	0,0542***	0,0586***	0,0477***
monthly_price lagged		0,0329***	0,0217*
average_hh_size			192,8955***
foreigners			579,8672***
prop_precarious			-977,9314***
constant	668,3864***	588,3062***	298,5597
observations	95	95	95
overall R^2	0,0907	0,1229	0,8469

Note. p<0.1*, p<0.05**, p<0.01***

8.3. Models

Model 1.

$$rent_{it} = \beta_0 + \beta_1 * listings\_prop_{it} + e_i$$

Model 2.

$$rent_{it} = \beta_0 + \beta_1 * listings\_prop_{(t-1)} + a_i + v_{it} + u_{it}$$

Model 3.

$$rent_{it} = \beta_0 + \beta_1 * listings\_prop_{(t-1)} + \beta_2 * average\_hh\_size_{it} + \beta_3 * foreigners_{it} + \beta_4 * prop\_precarious_{it} + a_i + v_{it} + u_{it}$$

8.4. Web scraping Code Python

```
import requests
import json
import csv
import bs4
from bs4 import BeautifulSoup
import numpy as np
from numpy import zeros
import pandas as pd
import requests
import time

headers = {
   'Upgrade-Insecure-Requests': '1',
   'User-
Agent': 'Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/102.0.0
.0 Safari/537.36',
   'device-memory': '8',
   'dpr': '1.25',
   'ect': '4g',
   'sec-ch-ua': '" Not A;Brand";v="99", "Chromium";v="102", "Google Chrome";v="102"',
   'sec-ch-ua-mobile': '?0',
   'sec-ch-ua-platform': '"Windows"',
   'viewport-width': '1229',
}
params = {
   'tab_id': 'home_tab',
   'refinement_paths[]': '/homes',
   'flexible_trip_lengths[]': 'one_week',
   'query': 'Brussels, Belgium',
   'place_id': 'ChIJZ2jHc-2kw0cRpwJzeGY6i8E',
   'date_picker_type': 'calendar',
   'source': 'structured_search_input_header',
   'search_type': 'autocomplete_click',
   'section_offset': '2',
}

def find_key_parent(key, dic, has_child=False):
   if type(dic) == dict:
      if key in dic.keys():
         if not has_child or (type(dic[key]) == dict and has_child in dic[key].keys()):
            return dic
      for k in dic.keys():
         a = find_key_parent(key, dic[k], has_child)
```

```
            if a:
                return a
    elif type(dic) == list:
        for d in dic:
            a = find_key_parent(key, d, has_child)
            if a:
                return a
    else:
        return False
def get_info_from_id(i_d):
    print('Getting info from room: ' + str(i_d), end='\r')
    url = 'https://www.airbnb.com/rooms/' + str(i_d)
    response = requests.get(url, headers=headers)
    soup = bs4.BeautifulSoup(response.text, 'html.parser')
    data = json.loads(soup.findAll('script', {'type': 'application/json'})[-1].contents[0])
    json.dump(data, open('all_data_room_' + str(i_d) + '.json', 'w'))
    sections = find_key_parent('stayProductDetailPage', data, 'sections')['stayProductDetailPage']['sections']['se
ctions']
    #here, we will look for the place of where hostBasicInfos is stored
    place_basic_info = 0
    for i in range(len(sections)):
        keys = list(sections[i].keys())
        if 'section' in keys:
            keys = list(sections[i]['section'].keys())
            if 'hostBasicInfos' in keys:
                place_basic_info = i
                print(place_basic_info)
            else:
                i +=1
    place_basic_am = 0
    services_index = 0
    LONG_TERM = False
    for j in range(len(sections)):
        keys = list(sections[j].keys())
        if 'section' in keys:
            keys = list(sections[j]['section'].keys())
            if 'seeAllAmenitiesGroups' not in keys:
                j +=1
            else:
                place_basic_am = j
                for k in range(len(sections[place_basic_am]['section']['seeAllAmenitiesGroups'])):
                    if sections[place_basic_am]['section']['seeAllAmenitiesGroups'][k]['title'] == 'Services':
                        services_index = k
                        for l in range(len(sections[place_basic_am]['section']['seeAllAmenitiesGroups'][k]['amenities'])):
                            if sections[place_basic_am]['section']['seeAllAmenitiesGroups'][k]['amenities'][l]['title'] == 'Lon
g term stays allowed':
                                LONG_TERM = True
```

```
                    else:
                        l +=1
                else:
                    k+=1
    return_data = {
        'hostSince': sections[place_basic_info]['section']['hostBasicInfos'][0]['title'],
        'long stay allowed': LONG_TERM
    }
    print('Done')
    return return_data
pageNum = 15
ids = []
data_to_store = ['lat', 'lng', 'isNewListing', 'isSuperhost', 'title', 'name', 'personCapacity', 'avgRating', 'roomType
Category', 'priceData', 'roomData']
for i in range(pageNum):
    print('Page {}/{}'.format(i+1, pageNum), end='\r')
    params['items_offset'] = i * 20
    r = requests.get('https://www.airbnb.com/s/Brussels--Belgium/homes', params=params, headers=headers)
    try:
        soup = BeautifulSoup(r.text, 'html.parser')
        data = json.loads(soup.findAll('script', {'type': 'application/json'})[-1].contents[0])
        items = find_key_parent('section', data, 'items')['section']['items']
        for item in items:
            listing = item['listing']
            i_d = int(listing['id']) #retrieving room IDs for get_info_from_id
            ids.append(i_d)
            time.sleep(0.5)
    except Exception as e:
        print("Failure: {}".format(e))
        if r.status_code != 200:
            print("Server error: response code was ", r.status_code)
    print("page {} done.".format(i))
    time.sleep(0.5)
print(ids)
df_selected = pd.DataFrame(index=ids, columns=data_to_store)
for i in range(pageNum):
    print('Page {}/{}'.format(i+1, pageNum), end='\r')
    params['items_offset'] = i * 20
    r = requests.get('https://www.airbnb.com/s/Brussels--Belgium/homes', params=params, headers=headers)
    try:
        soup = BeautifulSoup(r.text, 'html.parser')
        data = json.loads(soup.findAll('script', {'type': 'application/json'})[-1].contents[0])
        items = find_key_parent('section', data, 'items')['section']['items']
        for item in items:
            listing = item['listing']
            i_d = int(listing['id'])
            #df_selected['id'][i_d] = i_d
            df_selected['priceData'][i_d] = [item['pricingQuote']['priceString']]
```

```
            df_selected['roomData'][i_d] = [get_info_from_id(i_d)]
            df_selected['lat'][i_d] = [listing['lat']]
            df_selected['lng'][i_d] = [listing['lng']]
            df_selected['isNewListing'][i_d] = [listing['isNewListing']]
            df_selected['isSuperhost'][i_d] = [listing['isSuperhost']]
            df_selected['title'][i_d] = [listing['title']]
            df_selected['name'][i_d] = [listing['name']]
                        df_selected['personCapacity'][i_d] = [listing['personCapacity']]
            df_selected['avgRating'][i_d] = [listing['avgRating']]
            df_selected['roomTypeCategory'][i_d] = [listing['roomTypeCategory']]
            time.sleep(0.5)
    except Exception as e:
        print("Failure: {}".format(e))
        if r.status_code != 200:
            print("Server error: response code was ", r.status_code)
    print("page {} done.".format(i))
    time.sleep(0.5)
print('done')
drops = df_selected[df_selected['lat'].isnull()].index
df_selected.drop(drops, axis=0, inplace=True)
duplicates = list(df_selected[df_selected.index.duplicated()].index)
len(duplicates)
df_selected_copy = df_selected.copy()
df_selected_copy.drop(duplicates, axis='index', inplace=True)
len(df_selected_copy)
df_selected_copy.to_csv('data_extraction.csv')
```