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# Airbnb and urban population change: an empirical analysis of the case of Stockholm, Sweden

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## ABSTRACT

Internet platforms enabling the short-term rental of private homes are an increasingly important provider of tourist accommodation and a challenge for urban policy. Airbnb is frequently blamed for encouraging property owners to remove their homes from the permanent housing market, thus contributing to the gentrification and displacement of local residents. Empirical research on this topic has been mostly represented by qualitative or indirect quantitative studies, which focus on changes in housing availability rather than the actual population. In our study, we fill this gap by presenting a study of the city of Stockholm, using two sources of georeferenced data: information on properties offered for rent on the Airbnb platform and micro-data on individuals and properties derived from the national statistical office. We verify whether the high number of apartment rental offers on the Airbnb website contributes to the high number of apartments that became uninhabited during 2012–2016. Using both aspatial and spatial autoregressive models, we find that the platform expansion does have a significant effect on the number of emptied apartments, and thus conclude that the presence of Airbnb contributes to the process of touristification, understood as the replacement of permanent residents with non-permanent populations. This confirms that when analysing urban population change and the gentrification process, mobile populations should be considered. Context-aware multiscalar and relational approaches are needed to understand the interrelation between human mobility, housing markets and regulations, and transnational internet platforms.

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## Introduction

The expansion of peer-to-peer accommodation platforms is having an increasing impact in modern cities (Guttentag 2019; Oskam 2019). The largest platform of this kind, Airbnb, markets several million rental properties worldwide (Airbnb 2022). It offers accommodation in all major European cities, in many of them outnumbering the capacity of the cities' hotels (Adamiak 2018), and is transgressing the traditional

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functional separation of buildings and spaces used for residential and tourist activities. The same dwellings can now be used as either permanent residence or tourist accommodation or serve both purposes at the same time. The competition between these uses slips away from regulations on zoning and housing, which lag behind the dynamic development of communication technologies (Goudin 2016; Oskam 2019; Quattrone et al. 2016). Studies have suggested that the presence of Airbnb drives up rents and property prices (Garcia-López et al. 2020; Wachsmuth and Weisler 2018) and causes a disturbance of residents (Cocola Gant 2016), leading to the displacement of the local population, which can be placed in the framework of the concept of tourism gentrification (Cocola-Gant and Gago 2021; Gotham 2005; Gravari-Barbas and Guinand 2017) or touristification (Sequera and Nofre 2018).

To date, empirical research on this topic has been wide yet inconclusive. Some previous studies have used indirect quantitative methods to measure the gentrification potential of peer-to-peer rental use of properties, estimating the differences between long-term and short-term rental revenues and the effects of short-term rental on housing prices (Garcia-López et al. 2020; Horn and Merante 2017; Wachsmuth and Weisler 2018; Yrigoy 2019). Others have employed qualitative methods to explore the perceived impacts of home-sharing platforms and how they affect residents' behaviour (Cocola Gant 2016; Jordan and Moore 2018; Mermet 2017; Mody, Suess, and Dogru 2019). Cocola-Gant and Gago (2021) used direct observations and interviews with residents to monitor the Airbnb-led displacement of the local population in a neighbourhood in central Lisbon.

No city-wide quantitative study to date has directly related the presence of Airbnb with the out-migration of residents from urban districts. In our study, we try to fill this gap by scrutinizing the city of Stockholm, using two sources of georeferenced quantitative data. Our aim is to empirically verify whether high peer-to-peer rental activity through the Airbnb platform results in the out-migration of permanent residents. Through this aim, we will contribute to the current debate on the relations between short-term rentals and gentrification and further implications of mobilities and international mobility to social urban changes.

To achieve this, we first review the available literature on tourism gentrification or touristification and the contribution of short-term rentals in this process, and provide a description of the study's territorial context. We then present our data sources and analysis methods and the results of our analyses. Finally, we discuss the results' importance for governance and theoretical implications.

## Literature review

### *Tourism, gentrification and urban population change*

In recent decades, the term gentrification has become widely used in describing the transformations occurring in urban areas. Since the initial coinage of the concept by Ruth Glass in 1964 (Glass 1964) to name the displacement of the working-class population by wealthier residents in central districts in London, both the evolution of the urban and social structures and the popularisation of the concept in different geographic contexts, has widely extended the scope of gentrification studies (Aalbers

2019; Harvey 1989; Lees 2003; Ley 1986; Marcuse 1985; Rogatka 2019; Smith 1979). The problem of gentrification is also increasingly multidimensional, multiscalar and relational (Lawton 2020). Slater (2017) and Sigler and Wachsmuth (2020) notice that with the growing mobility of capital and persons, transnational gentrification emerges where gentrifiers exploit international rent gaps and pro-growth politics in the conditions of international competition of places. Other researchers point at gentrification processes not related to permanent migration but to multiple forms of seasonal and mobile presence (Kocabiyyık and Loopmans 2021; López-Gay, Cocola-Gant, and Russo 2021). Such forms of mobility, including lifestyle migration, second home ownership and tourism, further problematise the definition of urban population and its change (Ba et al. 2021; Paris 2011; Sigler and Wachsmuth 2020). The importance of new forms of mobility and transnational flows for gentrification inherently links this branch of urban studies with tourism studies.

In recent decades, tourism has been identified as one of the major factors shaping urban processes contributing to urban gentrification, as well as its manifestation. Low-cost flights, the development of social media and urban entrepreneurialism made a large proportion of anyway impressive growth in tourism to concentrate in cities (Nilsson 2020). Adverse effects of tourism growth on urban quality of life have stemmed academic, media and policy debate on ‘overtourism’ (Milano, Novelli, and Cheer 2019; Nilsson 2020; Zmysłony and Kowalczyk-Anioł 2019), the term that revives the interest of tourism scholars on carrying capacity of tourist areas, earlier usually focused to natural areas (Wall 2020). Overtourism, in turn, in some cases fuels anti-tourist movements, sometimes called ‘tourismophobia’ (Blanco-Romero et al. 2019).

There are multiple interfaces between urban tourism and gentrification processes (Gravari-Barbas and Guinand 2017). On the one hand, tourism development may follow gentrification. According to Gravari-Barbas (2017), neighbourhoods that have been gentrified often become trendy locations for urban tourism activities: shopping (gourmet shops, designer shops, art galleries etc.), strolling (renovated public spaces), and dining out (trendy and decorated restaurants). On the other hand, tourism drives gentrification. Tourist influx attracts property developers and new tourism-oriented services, in extreme cases leading to the development of tourist enclaves (Judd 2003). Gotham (2005) introduced the term ‘tourism gentrification’ to describe the replacement of commercial activities (from resident-oriented to tourist-oriented). Yet, it also leads to changes in the use of housing, and therefore also in the demographics of urban districts: an increasing number of second homes in tourist cities or world metropolises are used as residences for tourists, or business stays by affluent or super-rich transnationals (Gotham 2005; Paris 2011). A similar phenomenon of displacement of the local population by second-home owners is claimed to occur in amenity-rich rural areas (Gallent, Mace, and Tewdwr-Jones 2005).

The labelling of tourism-related transformations in the framework of gentrification is being debated. Some authors prefer to use the term touristification rather than urban gentrification, pointing at significant differences between the two processes. They note that while gentrification leads to repopulation of districts by residents of different class backgrounds, touristification leads to depopulation driven by demand from temporary residents of diverse class structures (Sequera and Nofre 2018). The causal relationship between tourism growth and population displacement is also disputed, as historical

urban districts have often been outmigration areas for various reasons, even before the massive development of tourism (Zmysłony and Kowalczyk-Anioł 2019). In similar cases of amenity-rich second-home areas, empirical studies suggest that the growth of second-home tourism is a response to outmigration and depopulation, driven by poor job and service availability in rural areas (Marjavaara 2009).

### ***Home-sharing platforms and touristification of residential areas***

The development of Internet platforms connecting private homeowners with tourists, such as Airbnb or Vrbo, has opened new opportunities to supplement or change the use of residential resources, potentially opening a new mechanism of touristification or tourism gentrification. Even though the initial business idea of Airbnb (the largest of the home-sharing platforms) was to let residents rent out spare rooms in their homes to tourists during periods of high demand for accommodation (Gallagher 2017), it is now used as a selling platform for professional rentals. Globally, 75% of the platform offers are entire apartments rather than rooms, and almost 60% are advertised by hosts with more than one listing on the platform (Adamiak, 2019). The potential impacts of such activities on the tourism sector, housing market and quality of urban life have led to an increasing number of studies, media reports, and regulatory attempts to control peer-to-peer rental activities in line with urban housing and tourism policies.

Airbnb is frequently blamed for enabling homeowners to change the use of apartments from long-term rentals to permanent residents into more profitable short-term rentals to tourists. Further, it is argued that new profit opportunities attract investors to buy properties for short-term rentals, thus decreasing the housing supply. These effects lead to higher prices for both the purchase and rental of properties and more or less directly force less affluent residents to leave districts that are attractive to tourists – paralleling gentrification-led displacement (Marcuse 1985).

The mechanisms of Airbnb-induced displacement are somehow framed in the classic Smith's, 1979 rent gap theory framework (Cheung and Yiu 2022; Kondo and Miyamae 2022; Robertson, Oliver, and Nost 2022; Wachsmuth and Weisler 2018; Yrigoy 2019). The Internet platform creates a potential way to increase the return from properties, thus encouraging owners and investors to change the use of dwellings from residential to touristic. In contrast to the original mechanism of the rent gap described by Smith, which is based on a gradual decline in housing value and its subsequent restoration, the Airbnb rent gap appears quickly and can be exploited by investors without much investment. The short-term rental-induced rent gap is geographically uneven in cities. It affects the parts of the city most visited by tourists, typically central districts and historical residential areas with cultural and leisure amenities, often already having gone through the process of gentrification (Cocola-Gant and Gago 2021; Garcia-Ayllon 2018; Gutiérrez et al. 2017; Quattrone et al. 2016; Roelofsen 2018; Schäfer and Braun 2016; Wachsmuth and Weisler 2018).

The rent gap may induce direct displacement through the conversion of long-term rentals into short-term rentals by the property-owners. Yet often more important is Airbnb-induced exclusionary displacement (according to Marcuse's 1985 terminology): expected high returns from short-term rentals leading to the increase in property prices and rents, which limits their affordability for permanent residents. Even though Airbnb

is only one factor that contributes to the wider housing affordability crisis in cities (Blanco-Romero, Blázquez-Salom, and Cànoves 2018; Wetzstein 2017), a number of scholars have confirmed the contribution to increasing housing prices and rents in various geographic contexts, including US cities (Barron, Kung, and Proserpio 2018; Calder-Wang 2020; Horn and Merante 2017; Koster, van Ommeren, and Volkhausen 2021; Sheppard and Udell 2016), French cities (Ayouba et al. 2020), Iceland (Eliasson and Ragnarsson 2018), Portugal (Franco and Santos 2021; Goncalves, Peralta, and Santos 2022), Barcelona (Garay-Tamajón et al. 2022; Garcia-López et al. 2020), Berlin (Schäfer and Braun 2016), and London (Shabrina, Arcaute, and Batty 2022).

On a large scale, it is difficult to distinguish the effect of Airbnb from several other conditions that lead to the depopulation of such districts, including, e.g. immigration (Schäfer and Braun 2016), increases in highly mobile populations living temporarily in the cities, conversion of dwellings to office space, speculative investments, and changing structures of tenancy (Blanco-Romero, Blázquez-Salom, and Cànoves 2018). Moreover, the structure of Airbnb hosts is heterogeneous. Apart from external wealthy investors that fit the image of traditional gentrifiers, short-term rental accommodation is also provided by local residents, including low-income households who seek supplementary income by renting their flats on the platform (Cocola-Gant and Gago 2021; Katsinas 2021; Mermet 2022; Semi and Tonetta 2021). This leads to the conclusion that ‘Airbnbification’ is not entirely the same as gentrification (Mermet 2022). Nevertheless, a general trend of ‘gentrification of Airbnb’ (Bosma and N van 2022) is noted as hosting on the platform tends to benefit most upper-class households (Arias Sans and Quaglieri Domínguez 2016; Mermet 2021), and the growth of the share of professional hosts in Airbnb supply is noted resulting from platform reputation mechanisms, active platform policy, and the growing role of professional management companies (Anselmi, Chiappini, and Prestileo 2021; Cocola-Gant et al. 2021; Törnberg and Xue 2022).

Besides affecting housing affordability, the use of homes as vacation apartments is blamed for causing disturbance to local residents, including noise, decreased perception of safety, a reduced number of public facilities, and a loss of social networks (Blanco-Romero, Blázquez-Salom, and Cànoves 2018; Cocola Gant 2016; Jordan and Moore 2018; Namberger 2021; Törnberg 2022; Xu, Pennington-Gray, and Kim 2019). Impacts of short-term rentals on housing markets and urban quality of life, together with the lobbying of hotels and some property operators, leads to an increasing media, residents and political attention to the problem (Marques Pereira 2020; Wilson, Garay-Tamajon, and Morales-Perez 2022) and a growing number of city governments introducing regulations on peer-to-peer rentals (Dredge et al. 2016; Gil and Sequera 2018; Hajibaba and Dolnicar 2017; Oskam 2019; von Briel and Dolnicar 2021).

It is not clear how price changes and the disturbance affect the actual population change. Only a few studies addressed this problem, mostly by cross-sectional investigation of population numbers of numbers of inhabited and/or vacant dwellings in city districts (Garay-Tamajón et al. 2022; Garcia-Ayllon 2018; Kato and Takizawa 2022; Kondo and Miyamae 2022; López-Gay, Cocola-Gant, and Russo 2021; Marona and Tomal 2020; Parralejo and Díaz-Parra 2021; Yrigoy 2019). The cross-sectional nature of these studies, rough spatial resolution and no controlling for other factors that could trigger dwelling use and population change make them less suitable for drawing valid

causal relationships. The fact that Airbnb-induced population change is mainly researched through econometric or qualitative studies results from the contrast between high-accuracy data obtained from the platform through web-scraping or third-party data providers (Pawlicz and Prentice 2021) and traditional statistics which work on lower levels of spatial and temporal resolution and accuracy. Therefore, it falls within the broader question of quantifying gentrification-induced displacement (Easton et al. 2020), and we will address this void using a georeferenced population database and GIS techniques.

### ***Housing market and home sharing in Stockholm***

Studies show that Airbnb structure and impacts on cities are dependent on the context-specific factors that shape the structure and dynamics of both short-term rental market and housing market. In Sweden, the housing policy is strictly regulated and planned within the framework of the welfare state. For a major part of the 20<sup>th</sup> century, the Swedish housing market has been a state and municipal affair, where housing policy aimed to improve the housing standard among the population. This to eradicate unhealthy living conditions and limit speculation and volatility, by maintaining a large rental sector (Holmqvist and Magnusson Turner 2014). The publicly owned (mainly by municipalities) housing companies took an active part of this development (Boverket 2007), by providing affordable housing for both lower- and middle-class families (Grander 2017). During the 1980s and 1990s, the housing policy paradigm shifted towards market de-regulation, and the reduction of spending for public housing (Listerborn 2018). This resulted in a decrease in construction rates which, together with the population growth and rural-to-urban migration, led to the increase in housing prices, particularly in major metropolitan areas (Lind 2017). In recent decades, tourism has added further to the competition for space and housing resources in Nordic cities

Today there are mainly three categories of housing ownership in Sweden. First, there are the rental apartments, primarily owned by the municipal public housing companies, but also by private actors. In both cases, rents are regulated by collective agreements between property-owners and tenants unions, so that apartments of the same size and equipment should have equal rent (Englund and Flam 2021). Second, there are housing cooperatives, organised in economic associations, which own the buildings, while individual tenants own a share of the association. Finally, there are ownership apartments, where individuals own an individual apartment in one particular building. According to the National Board of Housing, Building and Planning (2023) there are some 5.1 million apartments in Sweden 2022. 38.5% are rental apartments, 24% are in housing cooperatives and 37.5% are ownership apartments. However, in multi-family housing, private ownership is almost inexistent, where 58% are rental apartments and 42% are housing cooperatives.

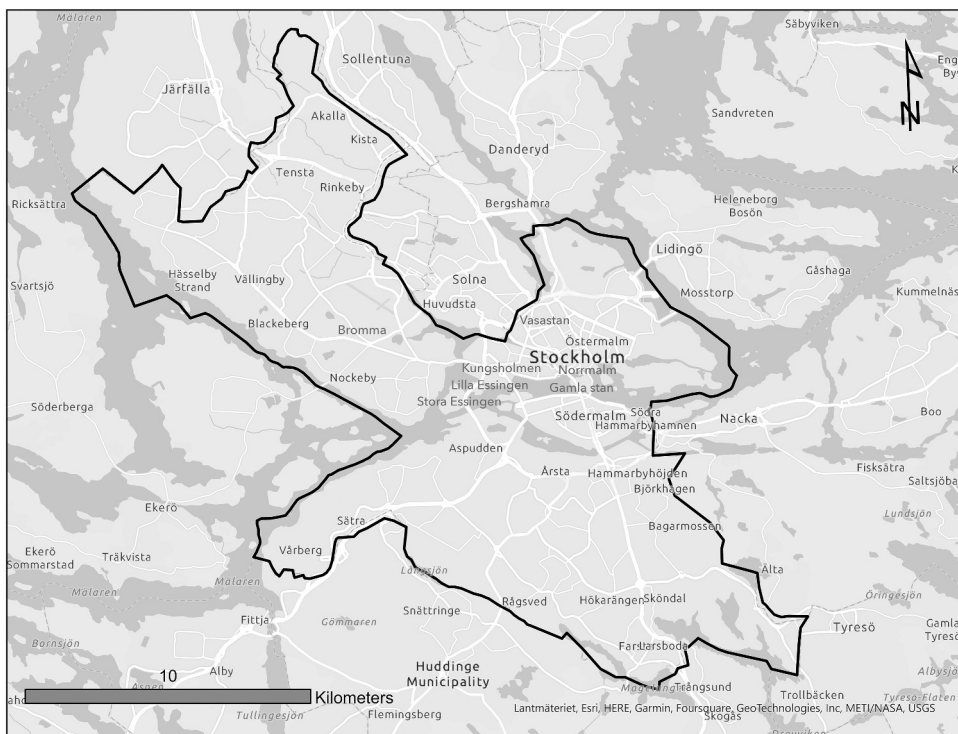
The ownership structure and rent regulations create specific conditions for short-term letting: first, the institutionalisation of the rental sector prevents direct shift from long-term to short-term rental as property-owners must obey the rent regulations. Second, short-term subletting is forbidden for both members of cooperatives and tenants in rental housing, if not explicitly agreed upon. Third, long-term rents regulation contributes to widening the potential rent gap between long-term rents and unregulated short-term rental returns, but simultaneously

hinders sharing profits from subletting between tenant and property-owners (Einefors 2018). This makes the letting of apartments in multi-family housing (which dominates central areas of large cities) practically illegal, and also excludes the possibility of direct displacement through change of use or buy-to-let investment for short-term rental. Yet, Airbnb hosting for long periods of time is practiced, and creates displacement pressure through the creation of potential return from renting or subletting an apartment. International comparisons confirm that Airbnb is less popular in Sweden compared to many other European countries (Adamiak 2018, 2020). In 2019, there were about 15.5 thousand active Airbnb offers in Sweden (Adamiak 2020). The vast majority of the offers are entire apartments (over 80%), and Airbnb offers are more often hosted by individual persons than professionals (almost 80% are offered by hosts with only one listing). Relatively low professionalisation is a common characteristic of Nordic countries (Adamiak, 2019).

Stockholm is the capital of Sweden and the centre of the country's largest metropolitan region. The county (*län*) of Stockholm is inhabited by some 2.3 million individuals, which accounts for around 23% of Sweden's entire population. In 2018, the municipality alone was inhabited by 962,154 residents. In the past 50 years, Stockholm County has increased its inhabitants by around 920,000, or 64% (Statistics Sweden 2019b). This has led to a real property boom. In the past 44 years, 124,373 new apartments have been built in Stockholm Municipality (2,826 per year; Statistics Sweden 2019a). During the 1960s, a major makeover of Stockholm begun, with older and low-density districts being torn down and redeveloped. An ambitious Million Homes Programme was launched in 1965 (Hedin et al. 2012) and resulted in the construction of new housing estates around major cities, including Stockholm (Hall and Vidén 2005). In the 1990s, many of the publicly owned rental apartments were converted into corporate ownership (Andersson and Magnusson Turner 2014) which, together with the accumulation of low income and immigrant groups in suburban housing estates leads to relatively high level of socio-spatial segregation (Musterd et al. 2017).

Stockholm is by far the largest tourist destination in Sweden, and in 2018 the county alone accounted for 22% of all commercial overnight stays in Sweden. 38% of visitors in the county were foreigners, which means that it is the most internationalised destination in Sweden. Some 90% of all overnight stays in Stockholm County are in hotels, which are mostly located in close proximity to central Stockholm (Tillväxtverket 2019). Stockholm is also the largest Airbnb market in Sweden, along with the other major cities such as Gothenburg and Malmö, as well as coastal areas in southern Sweden and in ski resorts in the mountains (Adamiak 2020). Specifics of the housing market and policy, high pressure of short-term rentals in combination with the availability of useful micro-level statistical data, make the city an interesting case for researching the influence of Airbnb.

The study is limited to the area of Stockholm, within its municipal boundaries. Figure 1 presents the geography of the study area. The historical centre (Gamla Stan, in English: the Old Town) and the central business district (Norrmalm) are both located in the eastern part of the municipality, surrounded by 19th- and 20th-century districts. More modern parts of the city extend to the south and northwest. Most of the city's suburbs are parts of separate municipalities, and are thus not included in the analysis.



**Figure 1.** The study area and important districts, delimited by the administrative boundaries of Stockholm Municipality.

## Data and methods

### Study design

Our study aims to test whether high peer-to-peer rental activity through the Airbnb platform leads to the out-migration of residents from the very same districts. We fulfil this aim by applying a spatial analysis of quantitative data on a low level of geographical aggregation. The spatial units of analysis are square grid cells of 100 m by 100 m in size. For each cell, we measured the extent of population loss using the number of apartments that stopped being used for permanent residence. There are two reasons for using the number of apartments instead of direct migration numbers. First, migratory change may be an effect of household structure changes (e.g. children grow up and move out of the family home). Second, we should only focus on emigration, not immigration, which is happening parallel to and independent of emigration, as far as it does not pertain to the same apartment (in such cases, new residents replace old ones). Thus, we defined our dependent variable `LOST_APARTMENTS` as the number of apartments that had been permanently inhabited for at least one year during 2012–2015 but were not permanently inhabited by anyone in 2016.

We assume that the value of the variable LOST\_APARTMENTS in a certain grid cell can be the result of various situations:

- (1) The redevelopment of residential stock. The demolition of existing apartments can result from the development of new housing, e.g. of higher density or quality. The development of new apartments can, but does not need to, result in the removal of the current population and the arrival of new residents. Thus, we expect that if a high number of new apartments appear in a given area, some parts of the existing apartments will be demolished and thus emptied. In either case, it will contribute to the appearance of LOST\_APARTMENTS. We measure the number of new apartments using the NEW\_APARTMENTS variable, defined as the number of apartments that were inhabited in 2016 but that did not exist or were not inhabited in 2012.
- (2) The conversion of apartments into non-residential uses, including commercial, public and touristic (hotels, etc.), either directly or through demolition and further redevelopment on the same site. We call the number of new non-residential properties the NEW\_NON\_RES variable. Note that the properties may be houses, plots, or single apartments. In the case of multi-family housing, the entire block of flats is typically one property with multiple apartments inside. Due to data availability, we only had information on the change in the number of non-residential properties between 2012 and 2015.
- (3) Out-migration from Stockholm. We assume that out-migration outside Stockholm County is caused mostly by amenity-seeking or reasons related to the family life cycle, such as retirement, change of job to another place, undertaking a distant job, or linking the family together. Such migrations in Sweden can also be permanent moves to properties previously used as second homes (Marjavaara and Lundholm 2016). Economic displacement due to increasing numbers of dwellings used as peer-to-peer short-term rentals will likely result in a move to another city district or a suburban location within Stockholm County. We label the variable measuring the number of migrants outside the county EMIGRANTS; this counts only if the entire population of an apartment (the last one living there) has moved out.
- (4) The number of homes used for touristic rental through peer-to-peer platforms. Here, we consider Airbnb listings representing entire properties (houses or apartments), not private or shared rooms, which may be parts of apartments otherwise permanently inhabited. We label this variable AIRBNB.
- (5) Other reasons. There may be a range of other reasons for emptying existing apartments, usually temporarily due to a change in residence or the sale of an apartment. We assume that the number of such cases is proportional to the total number of apartments in a given area. Thus, we add the last explaining variable, the total number of apartments in a given area in 2016, and label it TOTAL\_APARTMENTS.

### ***Data on population and housing***

We gathered data on migration and housing, which is used to construct all variables apart from AIRBNB, from ASTRID (2019). This is a statistical and georeferenced micro database held at the Department of Geography, Umeå University. The ASTRID

database includes annual data on individual properties, apartments, and residents for the entire population of Sweden. The locations of properties and places of residence are aggregated into grid cells of 100 m by 100 m. We only used the data on properties and residents living within the municipal borders of Stockholm; i.e. we took into account 22,447 grid cells located in Stockholm (partially or totally).

Because of the construction of the database, in the `LOST_APARTMENTS`, `NEW_APARTMENTS`, `EMIGRATION` and `TOTAL_APARTMENTS` variables, we include only the apartments that are parts of multi-family houses. No detached houses are measured here. The database distinguishes between properties (including detached houses) and apartments (excluding detached houses), and we had to choose between them. The structure of dwellings in the central part of the city, where the tourism activity is centred, is dominated by multi-family houses. Thus, we chose to use apartments as the entity in the database.

### ***Data on Airbnb listings***

We obtained information on properties offered for rent on the Airbnb platform from Inside Airbnb (2018), a website publishing web-scraped collections of data on Airbnb properties in multiple cities worldwide. The data was scraped on 18 April 2018 (it is the oldest dataset available) and includes data on 7,146 Airbnb listings in Stockholm. The data table includes coordinates of Airbnb listings, type of room, and several other pieces of information on the characteristics, price, and use of listings. As we were interested only in the distribution of entire apartments/homes, we limited the dataset to 5,929 ‘entire homes/apartments’ (83.0% of the total) after excluding ‘private rooms’ and ‘shared rooms’.

In some cases, the coordinates of Airbnb listings are not precisely depicted on the Airbnb website, making this also the case in the database. Depending on the host’s decision, Airbnb shows the ‘specific location’ or ‘general location’ of a listing (Airbnb 2018). In the first case, exact coordinates are saved in the scraping results. In the second case, the coordinates in the scraping results are those of a point located not further than about 500 m from the listing location. The database contains information on whether the location is exact or approximate. In our sample, 4,281 listings (72.2% of the sample) had an exact location assigned, and in the case of the remaining 1,648 listings (27.8%), we used approximate location, splitting them into multiple cells. In such cases, as listings could be located within one of 109 grid cells around the location in the database, we assigned values 1/109 to each of these grid cells. Hence, the `AIRBNB` values in individual cells are not always integer numbers.

### ***Timeframe of the analysis***

The timeframe of the analysis is determined by the availability of ASTRID data (2012–2016) but also by the evolution of Airbnb activity in Stockholm. The growth of platform supply follows a product life cycle path, and many Western European countries have already passed through the period of the most rapid expansion (Adamiak, 2019). The same characterizes Stockholm. According to Inside Airbnb (2018), the first Airbnb hosts in Stockholm, still active in 2018, registered on the platform in 2009. Initially, the

rental stock grew slowly. Only 3.4% of hosts joined the platform before 2012. A rapid expansion of the platform began after this and lasted until 2016. Of hosts active in 2018, 82.3% had joined the platform between 2012 and 2016, and the peak number of registrations occurred in 2015 when 24.6% of the hosts joined. After this, the increase in the number of hosts slowed. Even in 2022, after halving the number of active offers due to the COVID-19 pandemic, 60% of listings are hosted by hosts that offered accommodation already before 2017 (AirDNA 2022). Hence, the study period covers the period when the conversion into Airbnb could have the greatest impact on the use of housing resources so far.

### ***Regression model***

We start the analysis by verifying that each assumed independent variables correlated with the dependent one (see Table 1). There are also high correlations between several pairs of independent variables, but this does not lead to a multicollinearity problem (all VIF values lower than 2.1 and 2.0 in each model). We then build several statistical models to verify the independent impact of each variable on the number of lost apartments. First, we build a simple linear model. However, as the explained variable is count data, and a Poisson model also turns out not to be optimal due to a high overdispersion of the distribution of the count data (Zeileis, Kleiber, and Jackman 2008), we later use a negative binomial regression with the log link function.

As the analysis uses small spatial units, it is prone to the spatial autocorrelation of the dependent variable (as Table 2 indicates, the LOST\_APARTMENTS variable is actually consistently positively spatially autocorrelated), possibly resulting in the endogeneity of the model, as well as the modifiable areal unit problem (Yoo 2018). The first problem can be addressed by the use of spatial regression models supplementary to the aspatial models described above. We chose to employ spatial autoregressive (SAR) models (Cliff and Ord 1973; Kelejian and Prucha 1999). To solve the second problem, we estimated the models using various spatial weighting matrices, the queen-contingency matrix, and several distance thresholds: 250, 500, 1000, and 2000 m. We use R software with MASS (Venables and Ripley 2002) and spatialreg (Pebesma and Bivand 2023) packages for modelling and ESRI ArcGIS for spatial analysis and presentation.

## **Results**

### ***Description of variables***

Between 2012 and 2016, the population of Stockholm Municipality increased from 881,235 to 935,619 (Statistics Sweden 2019b). In 2012, there were 392.9 thousand inhabited apartments in the city. By 2016, an additional 57.2 thousand apartments had been built, but at the same time, 27.4 thousand were lost from the housing market (Figure 2). Hence, there was a net increase of 29.8 thousand (7.6%) apartments. The problem we are looking into is what happened with the apartments that were lost and how their location correlated spatially with the location of Airbnb listings.

In each 100 m by 100 m grid cell, the number of emptied apartments varied between 0 and 125. The distribution was highly skewed, with a mean value of 1.22 and

Table 1. Correlation between the values of explained and explaining variables.

	LOST_APARTMENTS	NEW_APARTMENTS	NEW_NON_RES	EMIGRANTS	AIRBNB	TOTAL_APARTEMNTS
Dependent variable:						
LOST_APARTMENTS	1.000	0.522	0.350	0.617	0.387	0.669
Independent variables:						
NEW_APARTMETNS	0.522	1.000	0.248	0.305	0.265	0.401
NEW_NON_RES	0.350	0.248	1.000	0.296	0.329	0.496
EMIGRANTS	0.617	0.305	0.296	1.000	0.317	0.550
AIRBNB	0.387	0.265	0.329	0.317	1.000	0.510
TOTAL_APARTMENTS	0.669	0.401	0.496	0.550	0.510	1.000

Source: ASTRID (2019) & Inside Airbnb (2018).

**Table 2.** Spatial autocorrelation of LOST\_APARTMENTS.

	Moran I statistic	p-value
Neighbourhood (queen)	0.245	<0.001
250 m radius	0.212	<0.001
500 m radius	0.157	<0.001
1000 m radius	0.109	<0.001
2000 m radius	0.069	<0.001

Source: ASTRID (2019) & Inside Airbnb (2018).

**Figure 2.** The dynamics of the apartment stock in Stockholm Municipality, 2012–2016.**Table 3.** Descriptive statistics of the variables in the model, aggregated on 100 m by 100 m grid.

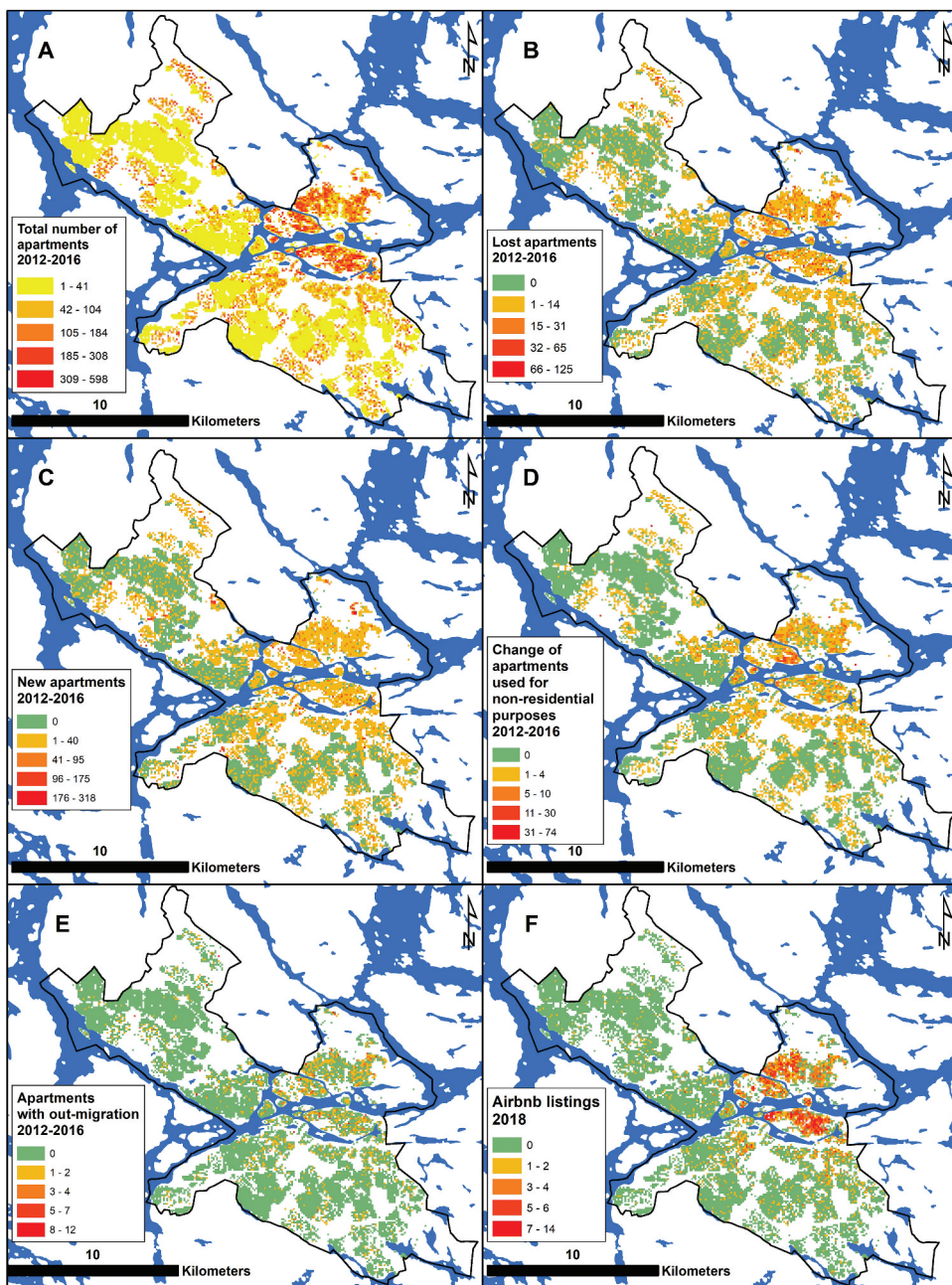
Variable	Min	Median	Mean	Max	Sum	SD
<i>Dependent variable:</i>						
LOST_APARTMENTS	0	0	1.22	125	27,427	5.05
<i>Independent variables:</i>						
NEW_APARTMETNS	0	0	2.56	318	57,625	12.21
NEW_NON_RES	0	0	0.35	74	7,845	0.41
EMIGRANTS	0	0	0.07	12	1,698	1.37
AIRBNB	0	0.02	0.25	13.7	5,711.8	0.81
TOTAL_APARTMENTS	0	0	17.5	477.0	392,842	43.58

Source: ASTRID (2019) & Inside Airbnb (2018).

a standard deviation of 5.05. Similar overdispersed statistical distributions characterized all variables used in the analysis as independent variables (Table 3).

### **Spatial analysis of variables**

The map of the spatial distribution of total housing units (apartments) in Stockholm Municipality shows a result of the city's historical evolution (Figure 3A). High housing density is characteristic of the city historically, from the beginning of the 20th century,



**Figure 3.** (A-F). Geographical descriptive development of number of apartments, apartments used for non-residential purposes, apartments suffering from out-migration, and number of Airbnb listings. Source: ASTRID (2019) & Inside Airbnb (2018).

which includes the Kungsholmen, Vasastan, Norrmalm, and Östermalm districts in the north. Södermalm, in the south, is separated from the mainland and the Old Town by a canal. Newer residential areas extending over the territory of Stockholm Municipality are less densely populated. Apartments which have been removed from housing use in recent years are more concentrated around the central part of the city (Figure 3B).

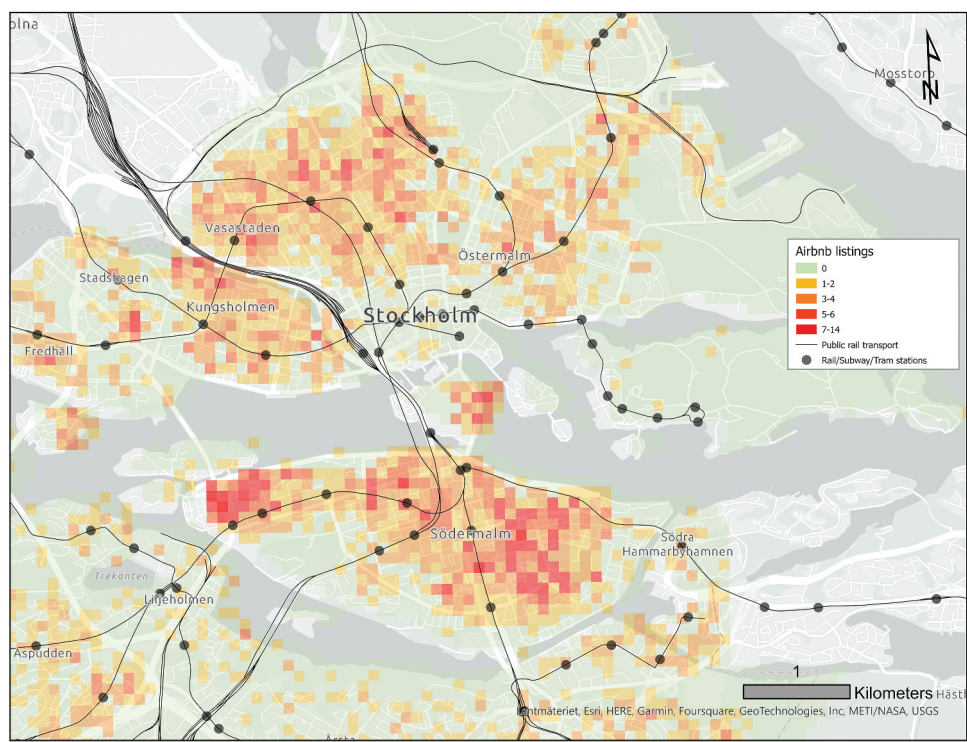
All factors that are assumed to have contributed to the increase in the number of lost apartments have similar central patterns of location. New apartments have been built, mainly in the northern part of historical Stockholm and in several clusters – new housing investments around the city (Figure 3C). A similar central pattern is characteristic of the distribution of properties turned into non-housing use. In this case, Kungsholmen stands out as a hotspot due to its good accessibility through the nearby central railway station and, hence, its popularity for office investments. Several clusters outside the city centre are also noticeable, including the industrial areas in Årsta southwest of the centre, Hammarbyhöjden in the southeast, and the islands of Lilla Essingen and Stora Essingen west of the centre (Figure 3D). The distribution of apartments that were emptied due to their residents' emigration presents no characteristic features different from the distribution of the population (Figure 3E).

The distribution of properties offered for rent on the Airbnb platform is concentrated in the historic central part of the city. This central pattern is much stronger than in the case of the distribution of the overall housing stock. The highest density of Airbnb listings is located in the Old Town as well as several locations in Södermalm, in its western and south-eastern parts (Figures 3F and 4). The distribution pattern is similar to those noted in other cities (Garcia-Ayllon 2018; Roelofsen 2018; Stors and Kagermeier 2017; Wachsmuth and Weisler 2018; Yrigoy 2019): on the one hand, it is concentrated in the historical centre, which is the main focus of international tourists; on the other, another concentration is Södermalm – an example of a once working-class district now transformed through gentrification into an international *café-hipster-culture* with good public transit and cultural amenities.

## Results of regression analysis

The analysis of the correlation between the dependent and independent variables in the model shows that all assumed factors are linked to the number of lost apartments (Table 1). Still, this correlation may result from the concentration of all values in the central part of Stockholm. In the following part of this section, we combine the data on all explaining variables to identify the individual effect of each of them.

The first regression model we developed is a single linear regression (Table 4). We see that all the explaining variables, except the number of new non-residential properties, have a highly significant influence on the number of apartments that left the housing market. The largest positive coefficient is characteristic of the number of EMIGRANTS. In linear regression, coefficients can easily be interpreted as the number of apartments that are lost due to a singular change in the value of the explaining variable. Thus, the parameter of the variable EMIGRANTS seems unbelievably high, as it indicates that one person migrating outside the Stockholm agglomeration leads to the deserting of over four apartments. The coefficient for AIRBNB is the second-highest,



**Figure 4.** Number of Airbnb listings in central Stockholm in 2018. 100 m by 100 m squares. Source: inside Airbnb (2018).

**Table 4.** Simple linear regression model explaining the number of EMPTIED\_APARTMENTS.

	Coefficient estimate	Std. Error	t value	p value
(Intercept)	−0.1545206	0.0232801	−6.637	<0.001
NEW_APARTMETNS	0.1107816	0.0019324	57.329	<0.001
NEW_NON_RES	−0.0222694	0.0178439	−1.248	0.212
EMIGRANTS	3.9645285	0.0627423	63.188	<0.001
AIRBNB	0.1513600	0.0308945	4.899	<0.001
TOTAL_APARTMENTS	0.0434856	0.0007092	61.312	<0.001

Residual standard error: 3.206 on 22,441 degrees of freedom.

Source: ASTRID (2019) & Inside Airbnb (2018).

and its effect seems stronger than that of the construction of new apartments. One Airbnb offer may contribute to the loss of 0.15 apartments from residential use.

In the next analysis stage, instead of a simple linear model, we employed a negative binomial model (Table 5), which is theoretically more correct to use with overdispersed count data, which is what we are dealing with here. The share of deviance explained by the model (68.7%) is much higher than in the case of the linear model (59.7%). The second model confirms the significant positive impact of all assumed variables on the number of emptied apartments. Unlike in the case of linear regression, the coefficients for this model are interpreted as multipliers. Hence, according to the last model, one additional Airbnb rental offer leads to an increase in the number of emptied

**Table 5.** Negative binomial regression model with log-link function explaining the number of LOST\_APARTMENTS.

	Coefficient estimate	Std. Error	t value	p value
(Intercept)	-2.1690051	0.02126292	-100.281	<0.001
NEW_APARTMETNS	0.0381755	0.0009174	41.611	<0.001
NEW_NON_RES	0.1771682	0.0086621	20.453	<0.001
EMIGRANTS	0.3885387	0.0300947	12.911	<0.001
AIRBNB	0.1029610	0.0162621	6.331	<0.001
TOTAL_APARTMENTS	0.0287929	0.0003610	79.759	<0.001

Null deviance: 31856.7 on 22,446 degrees of freedom.

Residual deviance: 9,982.8 on 22,441 degrees of freedom.

AIC: 34236.

Source: ASTRID (2019) & Inside Airbnb (2018).

apartments by 10.3%. This is a lower impact than that of emigration (38.9%) and the increase in non-residential properties (17.8%), but higher than that of the number of new apartments (3.8%) and total number of apartments (2.9%).

In the last part of the analysis, we developed spatial autoregressive models to control for the possible impact of the spatial dependence of the error in the model, which could be expected considering positive spatial autocorrelation of the numbers of Airbnb offers in cell sizes. Five models were constructed using various spatial weights matrices to control various areal units (Table 6). We noticed that the results were remarkably consistent across all five models and similar to the results of the linear regression model. With the increase in the neighbourhood size, the impact of Airbnb's presence remained at the same level of 0.11–0.16, along with the total number of apartments and the number of new apartments. The number of emptied apartments was particularly highly dependent on the emigration. Just like in the linear regression model, the number of new non-residential apartments did not positively affect the dependent variable. The lambda coefficients consistently close to 0 (within one standard error) point at the low spatial autocorrelation of the error.

## Discussion

The impact of the growth of home-sharing platforms on the housing and urban population is an essential topic of current urban tourism studies. To date, this has mainly been investigated using qualitative or indirect quantitative methods, studying economic indicators of housing affordability. This study is the first to examine the city-wide effects of Airbnb expansion on the actual change in housing usage in urban

**Table 6.** Spatial autoregressive models explaining the number of LOST\_APARTMENTS.

	Neighborhood	250 m	500 m	1000 m	2000 m
(Intercept)	-0.158***	-0.154***	-0.169***	-0.170***	-0.094
NEW_APARTMETNS	0.113***	0.114***	0.114***	0.112***	0.111***
NEW_NON_RES	-0.094	-0.027	-0.023	-0.042*	-0.033
EMIGRANTS	3.866***	3.877***	3.928***	3.499***	3.942
AIRBNB	0.153***	0.142***	0.158***	0.143***	0.114***
TOTAL_APARTMENTS	0.044***	0.044***	0.044***	0.044***	0.044***
Lambda estimate	0.021	0.012	0.027	0.006	0.001
Lambda SE	0.029	0.055	0.142	0.376	1.264
Residual variance	10.161	10.177	10.803	10.299	10.221

\* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

Source: ASTRID (2019) & Inside Airbnb (2018).

districts, utilizing actual data on the use of housing resources. We noted a concentration of Airbnb rental stock in the central part of Stockholm, particularly in the Old Town and gentrified parts of its neighbouring districts, such as Södermalm. Based on two statistical models, we confirmed that the higher number of Airbnb rentals correlates with the high number of apartments that ceased to be used as primary residences. This correlation is independent of other variables that could cause the emptying of apartments, such as housing redevelopment, the transformation of properties into non-housing use, and the emigration of residents outside metropolitan Stockholm.

When trying to generalise the results it is important to bear in mind the specific situation of the Swedish housing market. Rent regulation and limited competencies of housing cooperative members theoretically restrict listing entire flats in multi-apartment buildings on Airbnb. Even though platform data evidently suggests it happens in practice in grey area, the low professionalisation of hosting compared to other, particularly Southern European countries (Adamiak, 2019) means that the restrictive housing policy in Sweden indeed prevents the transfer of housing stock towards short-term rental by property-owners or buy-to-let investors and thus direct displacement of local population as e.g. in the Iberic Peninsula (Cocola-Gant and Gago 2021; Yrigoy 2019) or the U.S.A. (Wachsmuth and Weisler 2018). However, empirical correlation between the expansion of Airbnb offers and the decline of the permanent population suggests that migration pressure caused by possible higher return from informal renting or sub-letting apartments does encourage permanent residents to leave areas attractive for tourists. The decisions which lead to migration and, therefore, the causal relationship between the expansion of short-term rental platforms and the depopulation of central districts of Stockholm cannot be directly inferred from the current analysis. Emptying apartments could be a result, but it could just as well be a reason to rent out an apartment on Airbnb (in which case, it is still a reason not to return it to residential use). As most rentals in Stockholm are by single hosts (owning just one property), it is hard to tell if it drives people out of the centre or rather empowers them economically to purchase a house elsewhere.

The current study analyses the period of rapid increase in international tourist mobility and demand for short-term accommodation that was abruptly stopped by the spread of the COVID-19 pandemic at the beginning of 2020 (Gössling, Scott, and Hall 2021). Short-term rental platforms experienced a decrease in both the supply of offers by hosts and the demand by tourists. In Stockholm, the number of active rentals in 2022 was only half of that before the pandemic. The number of guest nights spent at short-term rentals offered via four major internet platforms decreased in 2020 by 56% in Stockholm County compared to 2019 (Eurostat 2022). However, not all segments of the market were equally affected. International tourism was particularly impacted due to border closures, while the number of domestic tourists staying in the kind of accommodation in Stockholm grew in 2020 by 58%. It is suggested that just as domestic trips substituted for international vacations (Seyfi, Hall, and Saarinen 2022), flats rented on Internet platforms were used instead of serviced accommodation, as they were preferred due to safety considerations (Bresciani et al. 2021). Many professionally oriented hosts have been particularly efficient in surviving the pandemic, lowering prices and attracting longer stays

than non-professional hosts (Boto-García 2022; Llaneza Hesse and Raya Vilchez 2022). Others chose to move flats to the mid-term or long-term housing market (Marona and Tomal 2020), which has halted the inflation in housing prices and rents and triggered hopes for lowering the pressure on housing market from tourists demand (Batalha et al. 2022; Buckle and Phibbs 2021; Shen and Wilkoff 2022; Trojanek et al. 2021). However, as Cocola-Gant (2020) and Sequera et al. (2022) suggest, the pandemic experience in switching between short-term and mid-term or long-term rentals may contribute to the expansion of property management companies and the use of platform intermediation for longer-term rentals, and thus further flexibilization of the housing market and pave the way for deeper platformization and internationalisation of property market that would further commodify housing and reduce its social value.

Bearing in mind that the spatial and temporal limitations of generalising the results, they contribute to the debate on touristification, tourism gentrification, and tourism-induced displacement in urban centres. We agree that the term gentrification, which includes the conflict element and class re-composition, is not entirely suitable for describing the changes occurring in central urban districts due to the proliferation of short-term rentals (Sequera and Nofre 2018). It is not the social structure of permanent residents that is mostly affected but rather the structure of residents in terms of the time pattern of their presence in the area. Also, the term displacement, which suggests involuntary out-migration, is not entirely suitable in this context as we have no proof that former residents are in any way forced to move out. However, the analysis of the spatial distribution of Airbnb listings in Stockholm does indicate a mutual relationship between touristification and gentrification, e.g. through a particularly high presence of short-term rentals in Södermalm, an old working-class district which experienced a classic gentrification process in the last decades of the 1970s (Franze 2005).

In the theoretical sphere, the results highlight the need to emphasise the mobility perspective, multiscalar and relational approaches in analysing of urban social transformations. It is impossible to understand the processes of Airbnb-induced touristification without considering the spectrum of non-permanent mobilities that includes not only classic tourist trips but also other forms whose importance has been even emphasised during the pandemic, such as second homes, temporal migrations, mobility related to hybrid work etc. Performing all these forms of mobility uses urban space and is involved in creating social power relations in the urban environment (Cresswell 2010). Accepting a multiscalar perspective prevents from ignoring the interactions between local contexts, including social relations and housing markets, and the agency of global corporations that serve not only as intermediaries but also the creators of new international markets and mobility imaginary (Sigler and Wachsmuth 2020; Smigiel 2020; van Doorn 2020). The Swedish case is a fine example of how the concurrence of a highly regulated rental market within a collectivistic society with a globalised and individualised platform capitalistic market model leads to processes that are place-specific yet paralleled with those observed in other geographical contexts.

The current research widens the range of methodological approaches used by scholars dealing with urban processes related to short-term rentals. By applying a high-resolution georeferenced statistical database it creates a link between the most popular approaches: spatial econometric studies using web-scraped data and

property market data on one hand and direct qualitative research on the other hand. It enables us to overcome the shortcomings of the two approaches: indirect links with population change in the case of econometric studies and small area and limited generalisability in the case of qualitative studies. Our method still has limitations. First, we measured the spatial co-occurrence of the event of emptying apartments with the location of Airbnb offers and other predictors. The concrete proof of a causal relationship between these events would require an analysis on the level of individual apartments – examining individual cases of apartments using register data or interviews. Both methods are beyond the scope of this study. In the future, wider employment of statistical microdata and georeferenced data, that could also grasp non-permanent mobility is required to overcome the problem of measuring and mapping displacement (Easton et al. 2020).

In the applied sphere, the study emphasizes the importance of integrating short-term rental regulation into housing policy and spatial planning to reduce the collisions and conflicting interests. To date, regulations are usually applied to individual cities (Hübscher & Kallert, 2022; Marques Perreira, 2020; von Briel and Dolnicar 2021), while national and supranational regulatory approaches are needed in order to match the scale of the platform activity. European cities call for policies applied on the level of the European Union (Eurocities 2022). It is also important that the regulations are a result of democratic control, considering the interests of various stakeholders. Whereas Airbnb activity benefits many groups, including tourists and apartment hosts, and the platform successfully organise this community to influence policies (McNeill 2016; van Doorn 2020), external effects on residents, local businesses and other interest groups should be represented in order to develop sustainable future of cities as places to stay for people holding various positions on the spectrum of the permanence-temporality of residency.

## Conclusion

In the paper, we presented an empirical study of the relationship between the number of Airbnb offers and the apartments that became uninhabited in Stockholm during the period 2012–2016. Using two sets of georeferenced data, four controlling variables, and three modelling techniques, including spatial autoregressive models, we concluded that Airbnb's presence has an independent impact on the number of apartments removed from the permanent housing stock. On average, one entire home rental offer on the platform is related to the disappearance of c. 0.15 permanently inhabited apartments. This effect is weaker than this of emigration, yet consistent across model types and specifications that we used. We thus find that the platform expansion does have a significant effect on the number of depopulated apartments. Thus, the presence of Airbnb contributes to the process of touristification as the replacement of permanent residents with non-permanent populations. This confirms that when analysing urban population change and the gentrification process, mobile populations should be considered.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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