The Effect of Airbnb in the Gentrification Process in Amsterdam

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THE EFFECT OF AIRBNB IN THE GENTRIFICATION PROCESS IN AMSTERDAM

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Hay algo que nunca le podrán arrebatar, lo aprendido, lo vivido.
There is something that can never be taken away from you, what you have learned, what
you have lived

Blanca, mi madre

EXECUTIVE SUMMARY

In a globalized world, the rapid development in digital technologies and finance has enabled the successful growth of Airbnb around the world. The basic idea behind this growth is to take advantage of the underused assets —houses, apartments, or rooms and to profit from them. The spectacular growth in main cities has caused the social fabric of the city was negatively impacted. The diminishing local welfare, shortage in the housing market, and to the need for identifying ways to regulate the operations are the major concerns of local government who perceive Airbnb as a disruptor of the main city subsystems —social, urban infrastructure, and governance. In this regard, it is important to understand the evolution in the adoption of Airbnb to explain the conditions that enabled the rapid absorption. Moreover, how people perceive houses as a profitable source of additional income becomes relevant in the discussion of commodification of housing. As a result, the connection with gentrification as an urban process that relates socio-economic conditions and the housing system emerges as a possible connection with Airbnb. The available data on Airbnb, households, and houses allows analyzing the potential correlations between Airbnb and the socio-economic conditions. This can help the decision-makers to understand the relationship between the role of Airbnb and the socio-economic conditions of a city. From a theoretical idea about the causes, effects, and facets of gentrification, this dissertation aims to bridge the gap between Airbnb as a socio-technical platform and the commodification of housing.

This study focuses on three main aspects. Firstly, the gentrification theory is revisited in order to determine the dimensions of gentrification that can be measured. The proposal is based on the measurable characteristics of households and housing. Consequently, income as a proxy of socio-economic conditions is used to identify gentrified neighborhoods. Moreover, a set of novel indicators are derived to quantify the main changes in household socio-economic characteristics and housing dynamics. The framework developed can be adapted to different city cases around the world. To study the relationships this dissertation applies the framework to the case study of Amsterdam by using data from 2007 to 2018.

Second, Airbnb has not evenly spread in the city. The concentration in some areas leads to think that there are neighborhoods more impacted than others. Specifically, the convergence of Airbnb operations and the gentrification process is important for finding potential relationships. The web-scrapped data from Airbnb for Amsterdam is used to make cross-comparisons with the indicators in gentrified neighborhoods from 2015 to 2018. The analysis focused on the total listings, prices, and expected revenue aggregated at the neighborhood level. Additionally, an analysis of the propensity of short-term rentals given the long term rentals is carried out to identify how Airbnb exert pressures in the existing housing system. The geographical visualization of results helps to identify the main relationships.

Thirdly, To shift from the idea that houses are part of common needs to be a prof-

itable income source represents a challenge for urban planners and governments. Therefore, since gentrification and Airbnb are urban phenomenons with potential impacts in the housing system, the research intends to find insights about the link with the commodification of housing. The analysis of relationships between the household characteristics and housing dynamics with Airbnb revenue aims to identify how some segments of the population benefit more than others. In this regard, three log-linear regression models explain the behavior in gentrified neighborhoods, other neighborhoods, and Amsterdam's city. The comparison is carried out using the growth percentage derived from the regressions to make the effect comparable.

In total 30 neighborhoods out of 98 were identified as gentrified by income growth by applying the methodology proposed. The first comparisons showed that gentrified neighborhoods have more Airbnb listings, higher prices per night, and revenue per year. However, gentrified neighborhoods with low and average income show higher revenues than high income. Moreover, the analysis of the price growth reveals that 11 neighborhoods coincide with neighborhoods gentrified by income. Besides, districts of Oost, Zuid, West, and Noord contains neighborhoods with this condition.

The detailed analysis using the indicators show that short-term rentals are unevenly distributed in the city. Further, this distribution is related to household characteristics and housing dynamics. In particular, the short-rentals growth per year is related to the characteristics of household compositions, age, ethnicity, migration, education level, housing living characteristics, property valuation, and property age. Further, the expected revenue per year shows relationships with these characteristics. However, aspects such as the neighborhood level of privatization are inversely correlated with the revenue in gentrified neighborhoods. Moreover, the growth in Airbnb revenue in gentrified neighborhoods helps identify potential rent gaps and opportunities to exacerbate gentrification patterns.

There are relationships between Airbnb and gentrification, which goes beyond the increment in rent prices. The quantitative analysis showed that some populations are profiting more than others because Airbnb has spread in neighborhoods with specific characteristics. For instance, neighborhoods with higher percentages of young-adults of western origin and highly educated are receiving more benefits from Airbnb. Moreover, Airbnb's concentration is characterized by neighborhoods with relatively small living spaces with medium property values. These findings help understand that people in neighborhoods gentrified are getting more benefits for Airbnb. Besides, these neighborhoods are also characterized by high social mobility and small-medium-sized living spaces with fewer private owners. Consequently, rental prices can increase because the housing market is pressured in two ways; by the ongoing gentrification and the exacerbation of short-term rentals. In this regard, people in these areas can perceive Airbnb as an incentive to shift the living house condition to an economic one.

Based on these findings, the municipality needs to revisit the regulation imposed on the whole short-term rentals. The necessity to evaluate the differential impact per neighborhood matters because some specific populations and houses have more propensity for Airbnb.

ACKNOWLEDGEMENTS

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INTRODUCTION

1.1. BACKGROUND & INTRODUCTION

The digital revolution has brought new types of data-driven innovations which have transformed market interactions. From the demand side, Internet has enabled consumers to access products and services adapted to their specifics needs and desires. And from the supply side, it has allowed entrepreneurs to innovate in the creation of services to keep pace with the dynamic needs of consumers and society. In this context, *Airbnb* identified a promising business in the housing market: using existing residential houses to offer short-term accommodation. The business model of the company is based on connecting hosts and guests around the world through an online marketplace. In the website, the host can post the house (offering either some rooms or the entire house) with a suggestive name, a detailed description containing facilities and amenities, and some pictures. In some cases, the hosts and guest share the spaces of the house and have direct interactions. The value added of the platform is that guest can learn from the direct local experience of the host to get a real taste of the place they are visiting. In this regard, the website also displays the reviews and comments of previous guests and their overall experience with the host and the place during their stay. Thanks to this information, potential new guests can compare different options and choose the most suitable for them. The booking and payment is made directly through Airbnb. This model promoted with the slogan "living like a local" positioned Airbnb as very attractive option for people seeking for more authentic touristic experiences (Gurran and Phibbs, 2017; Nieuwland and Melik, 2018).

The idea was a success. The business model offered an opportunity for homeowners to get an extra income from their house and for tourists to have a more comfortable place to stay during their trips. The unstoppable growth on Airbnb in leading cities worldwide attracted several investors who helped to consolidate the $31 billion company. By 2012, Airbnb accommodated more than 2.5M of customers, and by 2016 the number of people in the platform reached 29M (Business Insider, 2019; Statista.com, 2018; The Economist, 2013). Even though Airbnb has operated illegally in some places, its steep

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growth is based on the idea of gaining a market leadership position. Investors continue funding the online marketplace due to the expected long-term returns at the expense of short-term losses (Khan, 2016). Airbnb's success in more than 100,000 cities worldwide is related not only to the additional income made out of "underused houses" (partial or entire), but also with the additional demand for goods and services created by the influx of tourists and others new comers. In this sense, at first sight, the operation of Airbnb could bring important economic benefits to the cities, such as enhancing existing economic activities, triggering the development of new sectors, promoting diversification of labor, and fostering competitiveness.

However, beyond the argued advantages, the operation of Airbnb started to unveil societal and governance dilemmas linked to the social development of the cities. On the one hand, local communities started to resist against over-tourism arguing that it diminishes local welfare. On the other hand, the operation of the platform triggered structural problems related to its impact in the market (housing and lodging-hotel industry) and the challenges of its regulation as a data-driven business model (L. H. Gray, 2017; Nieuwland and Melik, 2018; Zuboff, 2019b). Further, one of the main concerns about Airbnb is that it has gained dominance in the market at the expense of exploiting basic needs and resources. Indeed, the interaction of people through this online marketplace consolidates Airbnb as a socio-technical system, which impacts several structural urban sub-systems (Figure 1.1).

Firstly, Airbnb impacts governance due to the difficulties of monitoring and controlling its growing activity and the interactions between different types of actors. The lack of institutions and rules to regulate the platform leads to an institutional void that must be filled by policymakers. By doing so, they must consider several policy options that include banning the company (risking to have legal actions for limiting economic activity) or cooperating with it to take advantage of its potential benefits while minimizing social risks. However, considering that policymakers cannot foresee all of Airbnb's impacts in the city when creating the regulation, it is likely that the policy approach could change in light of new circumstances or unexpected consequences. For instance, at first, Amsterdam followed a cooperative path to regulate Airbnb. However, now the rules are getting more strict, given the high impact of the platform's operation in the housing market and the company's lack of willingness to share the users' data with local authorities. This interplay between a complex set of actors and areas of regulation (the housing market, economic activity, and data privacy) exposes the main challenges that Airbnb brings in the field of governance.

Secondly, the level of urban infrastructure is affected because residential houses are perceived as an attractive asset not only by Airbnb, but also by other actors (such as investors and financial institutions). Consequently, residential houses are seen as an investment rather than as basic need. Investors spend resources in making buildings more attractive to potential guests leading to a modernization of the neighborhood. Furthermore, the city's infrastructure may also change due to the opening of cafes, restaurants, and other places targeted to satisfy the needs of tourists. One of the implications of this transformation of the urban infrastructure is that the prices arise, and locals cannot afford to live there anymore. In this sense, the changes in urban infrastructure play a central role in understanding gentrification.

Thirdly, Airbnb impacts socio-economic dynamics in several ways. Regarding demographics, the composition of the neighborhood changes, as more private investors have incentives for getting houses to rent them through Airbnb. The main driver of such investors is to pursue profit (Gurran and Phibbs, 2017; Maginn *et al.*, 2018; Wegmann and Jiao, 2017). This issue also raises questions about justice and equity since it becomes more difficult for low-income people to find an affordable place to live. Additionally, the operation of platforms such as Airbnb also transforms the concept of capital per se. Due to algorithms' use to influence consumer behavior, data becomes a valuable asset in the context of the so-called surveillance capitalism of digital companies (Zuboff, 2019b). In this sense, Airbnb has multiple sources of generating profits: providing a platform for short-term rentals and gathering information about such transactions.
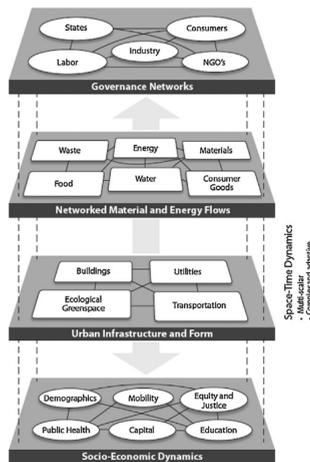
Figure 1.1: Simplified conceptual schematic of the urban system (Meerow *et al.*, 2016)

In this context, understanding the social impact of Airbnb requires establishing relationships with existing problems in the city. Gentrification is a process that emerges in cities since the urban environment becomes the place that enables development for regions. The existing problem can affect liveability, influencing displacement, and impacting urban planning. Gentrification was initially discussed in the 1960s as a process of neighborhood transformation. Nowadays, its complexity is part of worldwide agendas due to the cities' evolution and the increasing human densification. One of the main characteristics of gentrification is that it occurs through the reinforced feedback loop between socio-economic conditions and housing market prices. The absence of stability leads families to move; inequality exacerbates, and strata areas emerge. Besides, gentrification is shaped by the dominant complex economic and political system. Therefore, the idea of studying gentrification is challenging per se since the process change according to city evolution.

Although gentrification lacks a literal definition, some scholars have found insights about its causes and consequences on cities. One of them is the *exclusionary displace-*

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ment, which is related to the voluntary migration due to the living conditions in the neighborhood. The pressure created in areas attractive for private investment may lead to the emergence of suburbs where it is more affordable to live. This situation may result in uneven development: only some city areas will benefit from private investment and have better facilities and infrastructure. This uneven development needs to be revisited. For doing so, analyzing the consequences of gentrification and its policy side effects may provide relevant insights.

Here, it is critical to highlight that urban development and planning play a significant role since 85% of the population worldwide live in cities (Ritchie, 2018). The postmodern urban areas are defined not only by the number of people who live there but also by the cultural, economic, and social conditions that enable local development (Batty, 2018; Briney, 2019; Harvey, 1990). The objective of urban planning is to promote fundamental rights such as housing, jobs, recreation, and culture. Furthermore, it allows the economic development generated by technological innovations (Stevens Curl, 2006).

In this context, the emergence of digital innovations, such as Airbnb, adds a new layer of complexity to the existing discussions about urban planning's role in understanding socio-technical systems. The reason is that this platform exacerbated the existing dynamics of inequalities and uneven development within the city, which policymakers must address to guarantee that cities expand and develop in a way that fulfills the basic needs and rights of its inhabitants.

This dissertation seeks to analyze the potential pressure created by Airbnb in the existing dynamics of gentrification. The study focuses on Amsterdam because of its position as an economic and cultural hub, attracting investors, entrepreneurs, tourists, youngsters, and culturally diverse people looking for new opportunities and experiences. Moreover, Amsterdam represents an interesting case study because it was one of the first cities to regulate Airbnb's operation, changing its regulatory approach across time.

1.2. SOCIETAL RELEVANCE OF AIRBNB'S OPERATION

Airbnb is an online marketplace that operates through an extensive and complex network of users. The network allows people from different parts of the world to connect, interact, and share experiences. This flow of information is chained to Airbnb's economic activity. The system enables the monetary transaction for lodging services. In that sense, Airbnb does not take the whole responsibility for the service since the company does not own any property and does not have workers dedicated to the lodging service —transport, accommodation, cleaning, and so forth. In this regard, Airbnb's most valuable development is the digital platform that connects people with assets (houses). More precisely: the data is the most worthy asset. Airbnb uses data to make accommodation programmable; in other words, they amass infrastructural power without owning properties and taking associated risks. .

Airbnb's operation's type of economic activity is fundamental to understanding how a this private company influences society. In this regard, scholars have used different terms to define this type of company[1]: sharing-economy (Vith *et al.*, 2019), collaborative-

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[1]There are other companies which use the same peer-to-peer business model. Transport services: Uber, Lyft, Car2Go, Zipcar, Turo. Reselling services: eBay, Amazon, Craigslist, Poshmark. Food services: Uber eats, Too

economy (Ioannides *et al.*, 2019), peer-to-peer economy, platform-economy (Maginn *et al.*, 2018), crowd-based innovation (Cuppen *et al.*, 2019). For this dissertation's purposes, Airbnb is defined as a *Crowd-Based Innovations* (CBI) due to the following remark:

> *CBI is defined as social innovations that use digital platforms to allow for the active engagement of a large group of individuals in the production, exchange, or delivery of goods or services (knowledge, money, assets, etc)*(Cuppen *et al.*, 2019).

The above definition provides additional insights to understand Airbnb's impact on sub-systems interaction (Figure 1.1). Here, it is vital to keep in mind that the use of data through Airbnb is linked to the creation of wealth and surveillance capitalism, which has a relevant impact in socio-economic conditions, as will be explained below.

First, regarding surveillance capitalism, the term was coined by Zuboff (2019b) to explain how information companies have been able to create wealth by using data-driven approaches. This new way of accumulation does not have precedents due to the amount of information flowing in the network and the capacity of Information Technologies to storage, process, and target their products. The algorithms can use the vast amount of raw data and transform it into valuable information to understand the consumer's behavior. Indeed, big tech companies have been acquiring companies to not only enhance their technology but also to reduce competitiveness. In that sense, the amount of information is concentrated in only one company that can manipulate the market and influence consumer behaviors.

Under this definition, Airbnb may be considered one of these big tech corporations. The company can gather information on the demand and supply of houses and data from guests, hosts, expected prices, amenities, calendars, locations (host, guest, properties), and comments. Further, it can track cell-phone activity. In this sense, Airbnb's interest goes beyond the transaction fee paid by the guest and the hosts. It also seeks to gather data about people's preferences.

The new forms of accumulation of wealth prompted by information companies, including the CBIs, use the users' data as the process's primary input. Beyond having terabytes of people's data, the added value is fundamentally linked to human consumption behavior modification. For instance, Khan (2016) states —for the UBER's case— that prices are obtained through models that might not reflect the real supply and demand. They can be continuously manipulated and adjusted according to external situations. Moreover, the CBI might be able to adjust the prices through the algorithm that predicts the prices. The absence of regulation on how these platforms calculate the expected demand can further impact users' perception. In Airbnb, it can also lead to distort the rental prices and produce impacts on the economic asymmetry of information.

Second, regarding the societal impact of Airbnb's operation, Figure 1.1 shows the connection between different sub-systems. Indeed, as previously mentioned, Airbnb can impact the socio-economics dynamics of the city —living conditions, segregation, and displacement—, the urban infrastructure —specifically the residential infrastructure—, and the governance networks—the mechanisms to regulate the CBIs. A study

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Good to Go, Postmates, Delivery.com, Rappi, GRubHub. Accommodation: HomeToGo, HomeAway, Booking.com. Other services: Taskrabbit (handyman services), Lending Club (crowdfunding services), SitterCity (caregivers services).

conducted to analyze the role of Airbnb in main cities in US and Canada found that Airbnb impacts the socio-economic conditions in touristic areas —specifically touristic neighborhoods. Furthermore, Wachsmuth and Weisler (2018) found that Airbnb tends to influence the shift of long-term rental contracts to short-term rentals. This change is related to the higher profitability of rents through Airbnb in comparison to conventional rental agreements. Additionally, the study shows a significant impact on neighborhoods with predominantly African and Hispanic families. The reducing stock in the long-term rentals creates an unbalance in the supply of houses, which is evident through the rent prices. Another study found a correlation between the number of housing listings in Airbnb with higher socio-economic conditions (Alizadeh *et al.*, 2018; Wegmann and Jiao, 2017).

According to the above, the dynamics under which Airbnb operates raises essential questions such as: Do people make their own choices when they book a house? Or is this choice influenced by the algorithm? Is our data safe in the hands of Airbnb? How does Airbnb influence renting prices? Who can participate in the Airbnb market? Who are the people excluded due to the operation of Airbnb? Which neighborhoods benefit from Airbnb? All these questions have a social impact and involve ethical and moral aspects. Therefore, they become a relevant object of study.

Although studies have not demonstrated that Airbnb is causing substantial urban planning problems, the discussion needs insights about who benefits the most and the main mechanisms that allow it. In this regard, the uneven distribution of Airbnb operation growth can have a bigger impact in some areas than others. Moreover, some studies have tried to find the relationship between Airbnb and rental prices. However, this interaction with the household and housing levels leads to establishing further effects in the socio-economic and housing characteristics of the city. Moreover, the impact of Airbnb needs to be enlightened by the complex social processes in urban environments. Therefore, since gentrification is a process that influences households and housing dynamics, there is a link between the debate about the social impact of Airbnb and the ongoing gentrification process in cities.

This dissertation focuses on the second consideration: the societal impact of Airbnb. Consequently, this works seeks to enhance the discussion about Airbnb's role in gentrification and analyze to what extent its operation may impact socio-economic dynamics taking place in Amsterdam. The main idea is to identify relevant data to analyze to what extend the city may benefit from this digital innovation.

1.3. The case study: The city of Amsterdam

Gentrification in Amsterdam

The city of Amsterdam represents a suitable example of the gentrification discussion. The city as an economic and cultural hub attracts people culturally diverse who intent to live and work in this modern city. The characteristic of having a metropolitan city — The Dutch Randstad— has served as the mechanism to increase the influx of people with cultural-cognitive profiles that nourish the creative industries (Kloosterman, 2010).

The social, cultural, and economic conditions have shaped the city environment while the lever of welfare has maintained. The process of planning intends to main-

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tain an evenly socioeconomic status for households (Musterd and Ostendorf, 2003). The protection of housing, income, and employment are pillars in the policy design; through them, policymakers seek to reduce inequality and promote social mobilization. Besides, entrepreneurship embraces highly educated people who pursue new forms of business currently based on data-driven services.

Nevertheless, Amsterdam strives on patterns of segregation, gentrification, and displacement (Musterd and Ostendorf, 2003). The high quality of life is compensated with high salaries in a city with limited economic and environmental resources. Therefore, the pressure on welfare and life of the city due to the sharp increase in rent prices leads to population displacements (Hochstenbach, 2015; Wachsmuth and Weisler, 2018). Moreover, a permanent sub-urbanization and gentrification impacts the neighborhood composition. Agglomeration and stigmatization of certain groups of people are consequences of these phenomenons (Musterd and Ostendorf, 2003).

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The urban planning thus uses the *digital city* slogan to motivate the transformation of labor on flexible and dynamic activities. In that sense, digital businesses such as Airbnb can succeed in the city. The quick adoption of Airbnb attracted the attention of policymakers who perceived the potential benefits of having the big tech operation in the city. Further, the Municipality of Amsterdam could cooperate with the company to collect tourist tax for short-term rental. In the first attempt to regulate the platform's operation in the city, Airbnb proposed to cooperate with the locall government to tackle the illegal listings and reduce the residents' complaints about nuisance and safety (Kramer, 2019). The idea of the first agreement was to share data to improve decision-making and control Airbnb's spread. However, Airbnb's lack of cooperation to fulfill this agreement and the spectacular growth of the platform led the municipality to impose restrictions on the short-term rentals.

Airbnb attracted policy-makers' attention because it enhanced existing exclusion dynamics within the housing market, affecting urban planning. The short-term rental business became very attractive for homeowners and landlords, who saw Airbnb as an opportunity to make additional profit. Therefore, considering the impact of this new business in the housing market, there was a need to regulate the use of residential houses for economic purposes.

1.4. RESEARCH DESIGN

The knowledge gap that this dissertation seeks to address is related to the potential pressure of Airbnb's operation on Amsterdam's gentrification process. In particular, this study aims to analyze the relationship between Airbnb, the household features (composition and socio-economic conditions), and the housing market characteristics. The two components of the study are related to the potential exclusionary displacement caused by the gentrification process.

Many scholars have studied gentrification in the last 40 years. In practical terms, the importance of studying gentrification is related to the need to identify strategies to improve urban planning by avoiding segregation, the formation of low-income suburbs, and inner-city displacement; maintaining long term urban plans, and understand-
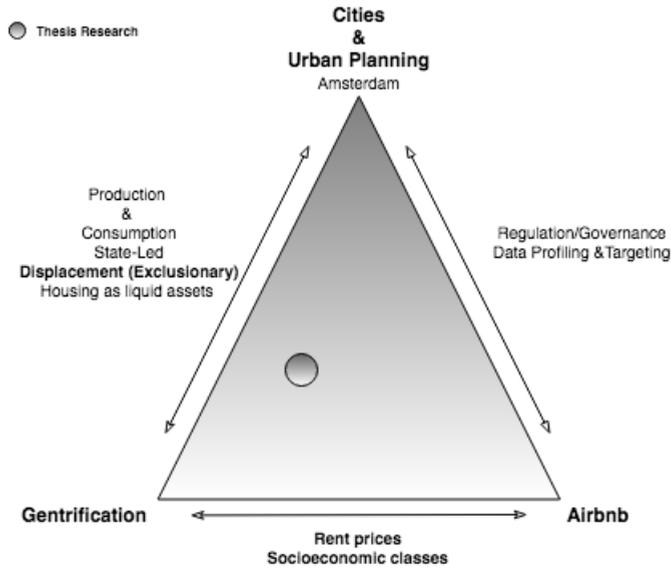
Figure 1.2: Knowledge gap representation

ing houses as a common need (Figure 1.2). The theorization mainly covers the production side —rent gap model— (Lees, Slater, *et al.*, 2008; Smith, 1987; Smith, 2012; Smith, 1997), an orthodox neoclassical approach explained through the consumption side (Lees, Slater, *et al.*, 2008; Lees, Slater, *et al.*, 2010; Ley, 1986), the state-led process (Hackworth and Smith, 2001; Musterd, 2014; Smith, 1997; Van Gent and Boterman, 2019) and the displacement as a manifestation of structural changes in neighborhoods (Marcuse, 1986; Slater, 2009).

In particular, for Amsterdam, the main studies highlight the importance of considering the context. It means that gentrification must be analyzed considering the social and economic features of the city. Gentrification is still taking place, and policymakers, alongside researchers, are currently discussing how to address it. However, the causing factors of this phenomenon do not obey a simple rule. The confluence of many factors, stakeholders, policies, and interactions makes gentrification a complex problem embedded in a complex system. From there, its relevance as an object of study.

Moreover, the discussion about socio-technical systems provides an additional dimension to establishing what gentrification means. For instance, CBIs can trigger new forms of gentrification, pushing the boundaries of its definition. The case of Airbnb is an example where the houses are not strictly renovated, but still, they are commodified as profitable investments (D. W. Gray and Wyly, 2020). In general, Airbnb's impact in gentrification has been studied for different cities —New York, Barcelona, Sydney, Utrecht, Amsterdam (Gant, 2016; Ioannides *et al.*, 2019; Nieuwland and Melik, 2018; Sheppard and Udell, 2016; Wachsmuth, Kerrigan, *et al.*, 2017; Yrigoy, 2019). Some of them have studied the effect through the touristification as the phenomenon that exacerbates the

number of cities' visitors. The increasing amount of people flows in cities causes not only the rising consumption of goods and services but also a steep demand for short-term accommodation (Gant, 2016; Ioannides *et al.*, 2019; Wachsmuth, Kerrigan, *et al.*, 2017). One of the main concerns about this is the increment in rent prices that eventually lead to unaffordable living areas. In this regard, Airbnb can exacerbate the rising in rent prices because it promotes the intensive use of residential areas for economic purposes (Wachsmuth, Kerrigan, *et al.*, 2017; Wachsmuth and Weisler, 2018). At this point, all these considerations are essential for policy-makers and urban planners (Figure 1.2).

Thus, considering gentrification as a complex process, the knowledge gap relates to understanding the commodification of housing as a product of gentrification. In particular, how the evolution of Airbnb operations may lead to changes in how people perceive housing: from a fundamental need to a commodity. Besides, there has been little research using data across time to capture Airbnb growth and its link with gentrification dynamics. In sum, to address the knowledge gap identified, this research will cover various issues in the field of urban studies and the governance of CBIs.

To sum up, this dissertation intends to explore the complementary household and housing gentrification dimensions and their relationship with Airbnb Amsterdam activity. Moreover, this work uses available data from 2007 to 2018 to explore gentrification and evolution of Airbnb 1.2.

Although other interesting knowledge gaps have been identified, they are not covered in this dissertation. Some examples are the regulation and governance of CBIs (Cuppen *et al.*, 2019; Nieuwland and Melik, 2018; Vith *et al.*, 2019), the implications of monopolistic patters of CBIs (Khan, 2016), and the misleading use of data from a surveillance capitalism perspective (Zuboff, 2019a; Zuboff, 2019b).

The main research question is formulated as ***How has the evolution of the Airbnb adoption influenced gentrification dynamics, and how does it relate to the commodification of housing in Amsterdam?***. The operational sub-questions that enables a suitable answer are described as:

- **Theoretical**. How can the gentrification process be measured using main neighborhood characteristics?

- **Quantitative**. Which gentrified areas of Amsterdam have been influenced by the introduction of Airbnb?

- **Quantitative**. What have been the relationships displayed by Airbnb on the commodification of housing in gentrified neighborhoods in Amsterdam?

The research flow in the figure 1.3 shows the scheme that configures the research questions, the set of methods and the expected outcomes.

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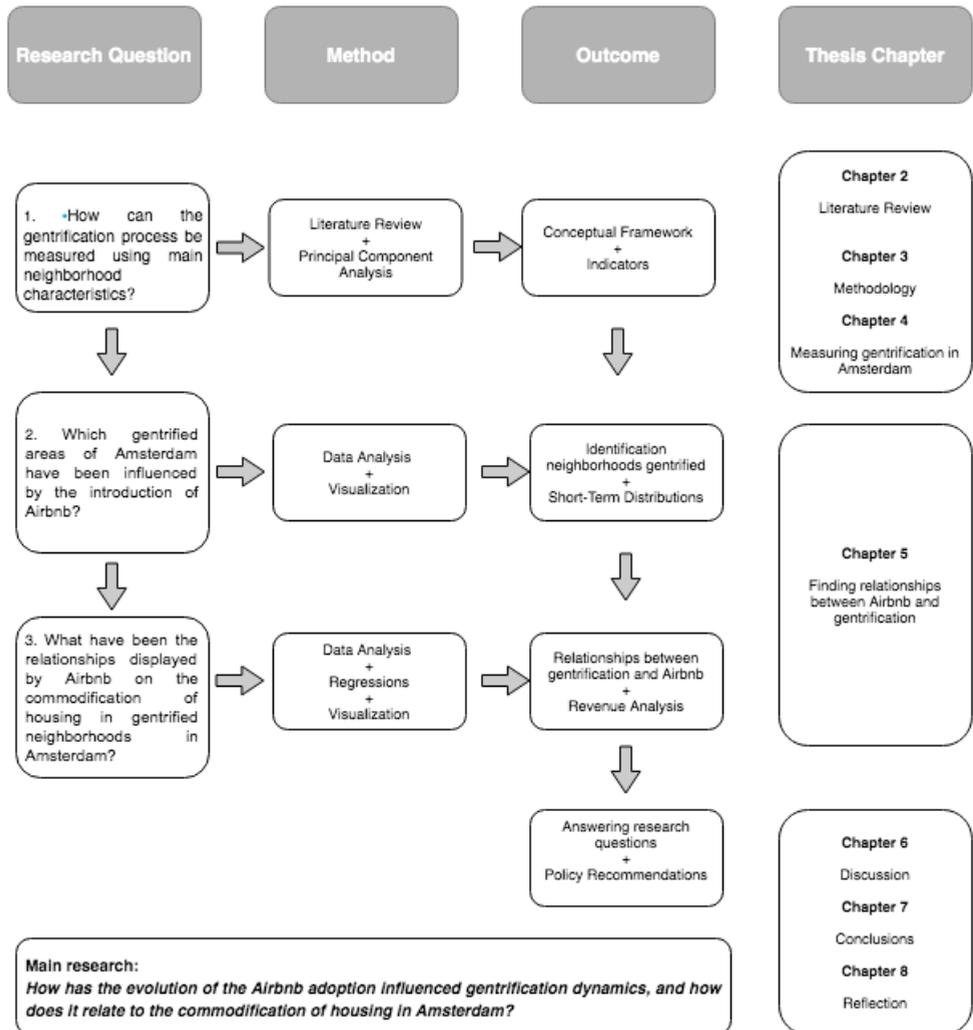
Figure 1.3: Research flow

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LITERATURE REVIEW

The idea of this section is to contextualize the research within the existing literature about gentrification and the impact of Airbnb in cities. Sections 2.1, 2.2.1, and 2.3 explains how to understand gentrification and move from the theory to the quantitative side. Section 2.4 shows relevant literature about the relationships and impacts of Airbnb in society.

2.1. THE *gentrification* MEANING, STAGES AND PROCESS EXPLANATION

The first approach to gentrification was framed accordingly to the rehabilitation of neighborhoods by the middle-class. Aimed at the acquisition of affordable old buildings for living purposes, the newcomers were usually wealthier than the residents. In that sense, the renovations eventually produce an effect on the neighborhood living conditions. Moreover, the homebuyers, developers, and landlords found in those neighborhoods an opportunity to gain additional profit (Lees, Slater, *et al.*, 2008). The increasing number of middle-class families started to exert pressure on the already working-class neighborhoods, which perceived the newcomers as displacers (Lees, Slater, *et al.*, 2008). The spirit of the neighborhood began to change by the so-called *gentry* people [1], who act as pioneers in the new life-cycle of the neighborhood. Thus, this process of displacement was called *gentrification.* This phenomenon was identified and coined in the 1960s by the sociologist Ruth Glass in London, who kicked-off the Anglo Saxon explanation for gentrification.

Even though gentrification is not a linear-causal set of stages, the prior neighborhood's states help to explain how this process change in time. *the Clay's Model* was used to describe it generally (Lees, Slater, *et al.*, 2008). The approach intends to explain gentrification as an inter-stage process that being more notorious through the time. Clay's model intends to explain that the neighborhood's constant investment and disinvest-

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[1] Gentry is a term used to refer to the nobility and upper-middle class in England

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ment in the neighborhood affect the social, cultural, and economical household conditions (Lees, Slater, *et al.*, 2008). The model centered on the explanation of the displacement was defined in four stages (see Figure 2.1). The first stage starts with a small group that takes the risk to move to the neighborhood. There is little public attention for acquiring houses that are bought using private capital, and mortgages scarce. Newcomers use their money to rehabilitate-renovate their houses with newer and artistic styles. This group of people, denominated pioneers in the neighborhood, undertake the transformation of the area. At this stage, the pioneers are usually depicted as artists with the idea of becoming a depressed and affordable neighborhood into the niche of artistic movements in the city. The second stage is characterized by a small influx of speculators who renovate house properties for their own use. Although the big capital investors still do not find a profitable business in the neighborhood, some speculators begin the renovation of houses in attractive locations. Displacement can occur more extensively, the mortgages start becoming available, and the renovation spread to neighbor blocks. The third stage corresponds to urban renewal that attracts individual investors who are willing to restore and renovate houses on a bigger scale. The neighborhood infrastructure is enhanced, and prices start increasing. At this stage, the capital gained by housing renovation and the potential real-estate business affects homes' perception as living spaces only. The different positions between the working and middle class become a critical problem. The displacement continues. Finally, in the fourth stage, the middle-class has a significant housing share in the neighborhood. The professional and education profiles are considerably higher. Economic activities start accommodating to the neighborhood demands; specialized retail and professional services are more visible. Prices escalate to become unaffordable anymore for some old residents. The displacement of residents and owners increases in numbers. The controversy states to displacement, absence of adequate regulations to control variations in prices. The perception of welfare diminishes for original residents and owners (Lees, Slater, *et al.*, 2008, p. 31).

In a mature gentrification stage, the process is characterized by newcomers who work as investors in the area pursuing higher rents, better living conditions or follow housing market tendencies. The renovation of properties by the middle-class, business companies, speculators, real estate agencies, or bank investing can exacerbate the normal in-migration and out-migration of the people. The continuous investment in neighborhoods is then evident by the changes in the socio-economic and demographic composition of the households. Housing rents, higher levels of education, displacement of racial groups, or higher income distributions are part of these neighborhood changes (Peacock and Galster, 1986). Moreover, at this stage the renovated infrastructure is attractive for newcomers who pursue higher living standards or investment opportunities. However, the potential steep on high housing market prices can lead to the declining of settled dwellings conditions, and the influx of better-accommodated families (Forrest and Williams, 1984).

The identification of stages is not easy. It is related to the inextricable economic and cultural transformations in the cities (Smith, 1987). Moreover, this process's complexity is time-dependent and only visible by the actions of many local actors and stakeholders. Gentrification can not be easily predicted, considering that it obeys social, economic, and cultural conditions, which are not necessarily the same in different areas. Although

Figure 2.1: Clay's Model

gentrification is generally non-desirable for urban planners and policymakers, it is an urban phenomenon that helps to change depressed neighborhoods, auto-control the creation of non-planned areas, and increase the city's attractiveness for private investors that bring capital captured via acquisition and taxation. Some additional considerations of the positive and negative effects are presented in Table 2.1.

One of the main concerns is the relationship between rent prices and gentrification. Scholars have found that rent prices are driven up in the Anglo-Saxon context because the areas become more attractive, stimulating the demand for houses and providing the incentives for the supply side to buy, built, and re-built old properties(Atkinson, 2004). Although the housing market reaction is probably the result of a mature stage of gentrification, researchers have focused more on the social impact of such fluctuations (Atkinson, 2000; Atkinson, 2004; Lees, Slater, *et al.*, 2008; Slater, 2009). The complexity is framed in the economic and cultural forces that create pressure conditions in the households to motivate an involuntary move from the neighborhood. They can be socio-economic since households can not afford to live in the same area, cultural-driven because families do not perceive the same attachment with newcomers or even profit-based when they can gain with the surplus by selling the property.

The in-migration and out-migration of families are characterized by using the displacement and replacement terminology. Displacement is not forced or physically imposed but triggered by the new higher class's pressure (Atkinson, 2004; Marcuse, 1986), and replacement of old residents by newcomers and the eventual out-migrants in their new places. The fundamental idea of displacement is once again motivated by the studies in the Anglo-Saxon line of thought, which deal with a more liberalized market —the US and UK during the 1980s are examples of it. In this regard, countries with more social policy frameworks embrace less strong inner-displacements —for instance, the Netherlands (Hochstenbach and Musterd, 2018). Displacement framed into gentrification process is defined through the name of exclusionary displacement. It differentiates from direct and chain displacement because they are understood in the light of being forced to move. The indirect displacement is linked to exclusionary displacement, where the individuals move because of their own decision. Marcuse (1986) defines exclusionary displacement as follows:

- Household perceive in its dwelling or surrounding area conditions that they can not control or prevent.

- Household is not able to meet all the conditions imposed on the occupancy.

2

- There is a concentration of fashion from changes in the housing market

- For the household is impossible to live in the neighborhood due to hazards or un-affordability.

Positive	Negative
	• Displacement through rent/price increases • Displacement and housing demand pressures on surrounding poor areas • Secondary psychological costs of displacement
• Stabilisation of declining areas	• Community resentment and conflict
• Increased property values • Reduced vacancy rates	• Loss of affordable housing • Unsustainable speculative property price increases • Homelessness
• Increased local fiscal revenues	• Greater draw on local spending through lobbying by middle class groups
• Encouragement and increased viability of further development	• Commercial-industrial displacement.
• Reduction of suburban sprawl	• Increased cost and changes to local services
• Increased social mix	• Loss of social diversity (from socially disparate to affluent ghettos)
• Decreased crime	• Increased crime
• Rehabilitation of property both with and without state sponsorship	• Under-occupancy and population loss to gentrified areas

Table 2.1: Positive and Negative effects of gentrification (Atkinson, 2004)

2.2. BACKGROUND FOR THE GENTRIFICATION DEBATE

This section covers tho main ideas for this dissertation. The first helps to understand gentrification's theorization as a complex process embedded in the higher economic and political dominant system. The importance of this part is linked to the policy discussion about the possible implications of Airbnb in gentrification. The second part talks about the analysis of mechanisms that can link gentrification with Airbnb, and its potential displacement effects. A variety of scholars have tried to formalize the concept of gentrification through finding causes and effects. In particular research has carried about the relationship with the economic transformation —production or consumption

side (Lees, Slater, *et al.*, 2008; Smith, 1987)—, the cultural effects that can influence people's decisions (Alizadeh *et al.*, 2018; D. W. Gray and Wyly, 2020; Hochstenbach, Musterd, and Teernstra, 2015; Ioannides *et al.*, 2019; Peacock and Galster, 1986; Wachsmuth and Weisler, 2018), and displacement (Lees, Slater, *et al.*, 2010; Marcuse, 1986).

2.2.1. PRODUCTION AND CONSUMPTION SIDE

THE PRODUCTION SIDE

In a neoclassical approach, gentrification is explained through the demand and supply side — the maximization of the utility constraint to available resources. Actors are willing to buy or rent houses according to their needs, and other actors understand consumer patterns to build, sell, and supply assets. The whole process expects families to afford the house, and suppliers can have an economic surplus. For some years, urban planners thought that people rationalize their choices entirely, and the market is cleared after some time (Lees, Slater, *et al.*, 2008). Hence, for instance, the shortage of housing could be possible, but the market itself would be capable of returning to an equilibrium point, or the wealthy population made choices insofar as the city centers are attractive due to the access of services or spaces (Lees, Slater, *et al.*, 2008). This foundation in consumerism, competition, and market clearing led to decision-makers and urban planners to shape urban life accordingly.

However, actors are willing to pay when there are some areas more attractive than others. The intervention of powerful actors can bias the fact that the market can clear automatically, and an unbalance is created. The continuous investment and disinvestment in the city can lead to an uneven development. The underlying capital investment can unveil how the property development, underdevelopment, and redevelopment change gentrification patterns across the neighborhoods (Lees, Slater, *et al.*, 2008; Schumpeter, 1911). This can be seen as a process of wealth creation and destruction. In that sense, houses started to be perceived as a commodity rather than a family need (Madden and Marcuse, 2016). The capital flows go through the housing market aimed to transform money into a stable long-term investment. Moreover, the expected profits can emerge from the property devaluation through the time and property revaluation by reinvestment. This economic behavior leads to taking advantage of existing rent gaps leveraged by the system's main stakeholders (Lees, Slater, *et al.*, 2008; Smith, 1997).

From a chaotic representation of gentrification as a set of multiple individual-rational decisions, the urban phenomenon was outlined as a social, economic, and political response. The decision-makers and urban planners resolutely focused on a utilitarian point of view started to perceive rapid urbanization, rising private ownership housing, and the loss of government intervention in the housing and land market (Lees, Slater, *et al.*, 2008; Musterd, 2014; Smith, 1987). The idea proposed by Smith (1987) gentrification states that gentrification is more likely linked with the process of economic creation. In particular, it is enhanced through the neoliberal ideas of the 1980s that have shaped the current economic system stage. Consequently, the decline in public housing and the rising prices in the private sector can be seen as a consequence of policies implemented during the last 40 years.

The inner-city evolves according to the economic, social, cultural conditions, which now are related to a more globalized world. The process is dynamic in the city, asso-

ciated to continuous and cyclical capital flow rather than a phenomenon in a specific neighborhood, (Smith, 2012; Smith, 1997). Even though the individual interest to acquire depreciated properties plays an essential role in the economic system, other important actors —private investors, real estate companies, builders, developers, landlords, financial sector, and even government— create the conditions of patterns of gentrification (Smith, 2012). In that sense, there is a direct connection between gentrification and the fundamental processes of urban economics and planning, political structures, and geographical conditions (Lees, Slater, *et al.*, 2008; Smith, 1997).

The *Rent Gap Model* emphasizes on how the ground prices are related to future values, and how investors can take advantage of it (Smith, 1987; Smith, 2012; Smith, 1997). The model states that the potential and capitalized ground rent assumes that the developments follow the "highest and best use" use of the land (Addie, 2017). Existing social, economic, and cultural conditions can determine how some areas are more suitable for capitalizing on capital investment in renovation or rebuilding. Therefore, the rent gap model intends to conceptualize the conditions that produce the divergence of the capitalized and potential ground rent (Figure 2.2). The foreseeable opportunities to capitalize on devaluated neighborhoods link the neighborhood's historical development with the current land market stage. Moreover, the construction time and property usage primarily determine the capital devaluation barely create the gap. Nevertheless, not only after the gap is sufficiently wide, the reinvestment is expected due to the small revenue derived from redevelopment (Smith, 1997). The model thus follows a the idea of "purchasing cheap to sell expensive". It includes the investment on builders cost, profit for rehabilitation, mortgage plus interest rates, construction loans, surplus to pay the developer, and so forth. As soon as this process finishes, the neighborhood starts a new cycle (Lees, Slater, *et al.*, 2008; Smith, 1987; Smith, 1997). In that sense, this explanatory theory for gentrification intends to point to the economic, political, and social systems. Thus, it situates the process as a result of the large scale economy, which is governed by mainstream ideas that eventually are visible in society (D. W. Gray and Wyly, 2020).

CULTURE AND CONSUMPTION SIDE

The transformation of manufacturing cities into more business, creative, and cultural places brought changes in the occupational, demographics, socio-economic characteristics, and consumer desires. Cities have evolved towards areas for people with many different occupational skills, family structures, liberal mindsets, cultural movements, and so forth. For instance, the period of deindustrialization brought that education plays an essential role in the rising household income, cultural richness, and the possibility of choosing their living places accordingly (Lees, Slater, *et al.*, 2008). Gentrification was associated with the displacement blue-collar by white-collar workers (Lees, Slater, *et al.*, 2010) by rising levels of education and income. In that sense, the continuous transformation of classes is companied by changes in the people's mindset (Caufield, 1989; Lees, Slater, *et al.*, 2008).

Gentrification is partly due to lifestyle preferences. In that sense, the socio-cultural transformation interacts continuously with the urban environment, and vice versa. For instance, middle-class people might prefer to move to the city center because of better distance, cultural activities, and infrastructure. The revitalization of old buildings to transform the consumption in some areas represents new opportunities for those who
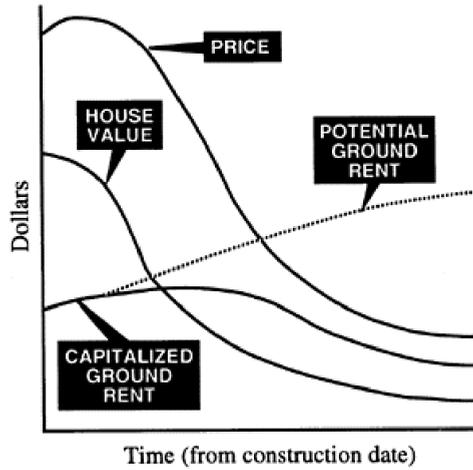
Figure 2.2: Evolution of the rent gap Smith (1997)

pursue new waves of the culture (Caufield, 1989). The city is a space for new forms of ideas, art, music, and culture, shaping devitalized neighborhoods and transforms them into bohemian places for artists. In this regard, the city's spirit remains essential for those interested in pursuing new forms of self-expression and design the city according to the local society's development (Caufield, 1989). Thus, the consecutive waves are characterized by the affluence of people interested in these new types of living conditions, which are more aligned to the fashionable and culture vibe. The change then influences the shift in the neighborhood mindset and the visual attractiveness of revitalized places. Therefore, some areas' gradual liberalization brought changes in demographics, ethnicity, aging, or even household composition (Ley, 1986). One more time, the interaction between the social and infrastructure layers opened new paths for the city's development.

2.3. QUANTITATIVE APPROACH TO GENTRIFICATION

The section 2.2 shows that people's social conditions are not static, and they depend on different factors such as education, ethnicity, gender, household compositions, demographics, socio-economic status, levels of inclusion or cohesion, religion, levels of liberalization, and so forth. Secondly, people can perceive how housing dynamics evolved. Their living preferences are constrained to cultural conditions, and the limits imposed the social, political, and economic systems. In this regard, there are feedback loops between people and the housing system that influence each other and shape most of their decisions. However, to quantify how multiple conditions evolved is challenging. Some scholars have conducted research either on the rent gap basis or measuring correlations between demographic and socio-economic characteristics. This section then includes a general overview of the second part.

2

The literature provides some guidelines to identify neighborhoods that have changed more than others, given the socio-economic conditions. Indeed, it can be either moving upwards or downwards. The structural change in the neighborhoods points out the possibility that new families are occupying the neighborhood, social mobility is taking place, or new economic activities help to form different socio-economic classes. This identification is linked with the question *Which neighborhoods are gentrified?*. The identification implies to inquiry for the main characteristics in these neighborhoods that explain further endogenous conditions for gentrification. For instance, changes in the demographic and socio-economic compositions, labor types, dominant or emergent economic activities in the area, safety, and so forth. The question linked to this second part is *How are the neighborhoods gentrified?*. The systematic literature revisited for this part is included in Table 2.2, it contains the main articles used to define each part of this section.

Table 2.2: Addressing the definition of Gentrification

Which neighborhoods are gentrified??	Slater (2009), Chapple (2017), Peacock and Galster (1986), Hochstenbach, Musterd, and Teernstra (2015), Easton *et al.* (2020)
How are the neighborhoods gentrified?	Marcuse (1986), Peacock and Galster (1986), Atkinson (2000), Hochstenbach, Musterd, and Teernstra (2015), Hochstenbach and Gent (2015), Opportunity (2016), Cohen and Pettit (2019), Rouwendal *et al.* (2018), Easton *et al.* (2020)

2.3.1. Characterization of gentrified neighborhoods (Which? and How?)

Which: According with Slater (2009) is a process that involve different "R"'s: Revitalization, Renaissance, Regeneration, Renewal, Redevelopment, Rejuvenation, Restructuring, Reurbanization and Reindustrialization. The main point is that all these processes are carried out by higher classes households. It is related to the cultural and consumption side, and Clay's Model —Section 2.2.1— which intends to establish the reasons of class formations and how wealthier families can shape their preferences for living spaces. The income disparity between high and low-status households can trigger the inmigration and out-migration from neighborhoods. Gentrification is characterized by attracting high-income households that increase the demand for houses in gentrified neighborhoods. Simultaneously, the pressure is turned from the market to the households when the residents can not afford to live in the same areas because the inner income inequality forces them to move out (Chapple, 2017). Consequently, the dominant class thrives in the area, attracting others with the same conditions. In fact, gentrification can be seen as a result of class inequality capture through the lenses of income inequality and to what extent income contributes to gentrification (Chapple, 2017; Slater, 2009).

Therefore, the increment in average household income might indicate that new families are moving into the neighborhood (Peacock and Galster, 1986). Some examples are found in Easton *et al.* (2020), who carried out a comparative study that compares the differences in income between the city and the metropolitan area of New York. More specifically, Hochstenbach, Musterd, and Teernstra (2015) calculates the income growth in Amsterdam's city during 1999 and 2008. This last study defines gentrified neighborhoods as those which exhibit a higher income growth than the overall city.

How: The Anglo-Saxon literature dominates the debate about the drivers and characteristics of gentrified areas. Notably, the UK and the US use approximations from a theoretical representation to a quantitative description of gentrification and its effects. One point of view is the class formation as a result of differential socio-economic, demographic, or cultural conditions (Easton *et al.*, 2020; Slater, 2009). In particular, cultural traits are linked with gentrification since people tend to group according to their characteristics—for instance, neighborhoods with major acceptance of gay, black, or migrants families— (Lees, Slater, *et al.*, 2008). Accordingly, the preferences for some areas can be explained by city attractiveness —closest to the city center—, city infrastructure (housing), values promoted, or geographic conditions (Atkinson, 2000; Peacock and Galster, 1986). Moreover, the formation of rent gaps is only captured by examining changes in land values, property valuations, and differences in land-property rents (Rouwendal *et al.*, 2018; Smith, 1997). From a macro to micro perspective, scholars have tried to find the social, economic, and physical characteristics that better describe neighborhood conditions. Consequently, the main characteristics have the purpose of showing the effects of having gentrification. One of them is the exclusionary displacement Marcuse (1986). For urban planners and policymakers, the gentrification characteristics associated with exclusionary displacement is important since one of the state principles is the maintaining welfare for everybody.

For the Netherlands, particularly for the city of Amsterdam, the theory has been adapted and produced to explain the causes and effects of gentrification. Some explanations include the study of city touristification, new business districts, type of migrant populations, variations in income distribution, education level, or side effects of past policy implementations — state-led gentrification—(Hochstenbach and Musterd, 2018; Ioannides *et al.*, 2019; Musterd, 2014). The socio-economic inequality linked with gentrification has been studied by linking it with the social, economic, and political urban profiles of cities (Musterd, Hochstenbach, *et al.*, 2020).

2.4. AIRBNB AND GENTRIFICATION

In general, for Airbnb, the research agenda has been focused on the enablers driven by Airbnb to cause problems in rising rent prices, the so-called touristification, the impact on the long-term rental market, and how the institutions have responded to the side effects of the CBI activities in the city (Cuppen *et al.*, 2019; Gant, 2016; Gurran and Phibbs, 2017; Maginn *et al.*, 2018; Wachsmuth and Weisler, 2018). Even though few studies

discuss the explicit relationship between gentrification and Airbnb, an implicit connection emerges because Airbnb operates at lower competitive prices, causing social fabric changes in neighborhoods.

Some studies have mentioned that the rise in rent prices can aggravate the existing housing affordability problems, producing forms of displacement of low-income residents (Gant, 2016; Gurran and Phibbs, 2017). Moreover, the propensity to remove the houses from the long-term rental can be caused by the lower prices in short-term rentals (Gurran and Phibbs, 2017; Wachsmuth, Kerrigan, *et al.*, 2017; Wachsmuth and Weisler, 2018) . The research intends to show the propensity to take out a house dedicated to residential purposes only and becoming part of the lodging business industry. Case studies in some cities in the US, Canada, and Australia show that Airbnb has been impacting the long-term rentals. In this regard, the role of the multi-listings properties —users with more than one property in Airbnb— suggests that private owners such as real estate companies can be taking part in the Airbnb business model (Wachsmuth, Kerrigan, *et al.*, 2017; Wachsmuth and Weisler, 2018). It implies that potential rent gaps started to be perceived in residential properties representing new forms of gentrification and commodification of housing (Gant, 2016). Wachsmuth and Weisler (2018) provides a quantitative approach that combines the geographic distribution of listings with the segmented properties characteristics —the type of houses supplied, the revenue of single and multi-listing, rent periods — as well as the level of impact of short-term in the long-term rental market. Quantitative studies approximate the effect of Airbnb on the rent prices by using variables related to the housing infrastructure, income, employment, and Airbnb itself (Rouwendal *et al.*, 2018; Van der Bijl, 2016).

Additionally, the relationship between gentrification and Airbnb includes the study of further implications. Studies about the implications of tourism and economic activities in exacerbating Airbnb spread patterns have been carried out (Ioannides *et al.*, 2019; Wegmann and Jiao, 2017; Yrigoy, 2019). They showed that Airbnb is correlated with the location of touristic attractions implying a potential connection with forms of gentrification by over-tourism. Therefore, the characteristics of neighborhoods (wards, districts, or even cities) have been used to identify the populations who are impacting or benefiting more from the Airbnb activity. Moreover, some of them have shown that Airbnb has increased more in neighborhoods with predominant high-class people (Alizadeh *et al.*, 2018; Wachsmuth and Weisler, 2018). In some touristic cities such as New York, Barcelona, Sidney, or Amsterdam, the tourist attractor areas — such as the city center— correspond with neighborhoods where people with high socio-economic conditions live. Precisely, these areas match where Airbnb is denser (Alizadeh *et al.*, 2018).

3

METHODOLOGY

3.1. INTRODUCTION

Gentrification is a process that can not occur in short periods. The evolution of it requires noticeable changes in the community to be visible through statistics. Moreover, the window of time helps to frame the phenomenon in specific situations. Airbnb is a relatively new company operating in Amsterdam since 2011. Therefore, this dissertation is based on the sufficient and available information available during the period 2007 to 2018. In this regard, this methodology main objectives are to identify neighborhoods gentrified, propose-calculate indicators to provide additional details about gentrified neighborhoods and their causes and materialize some comparisons with Airbnb operations in the city.

The methodology scheme presented in Figure 3.1 summarizes the proposal to study the relationship between gentrification and Airbnb. It includes two main parts: the first intends to capture the evolution of gentrification by using the literature reviewed in section 2.3.1. Section 3.2 includes the procedure to identify neighborhood gentrified —*which*— and the method to measure the main characteristics associated with gentrification –*how*. Section 3.3 —the second part of the scheme in Figure 3.1— discusses the overarching process of analyzing the operations of Airbnb with gentrification. Finally, the data highlighted the scheme is described in section 3.4.

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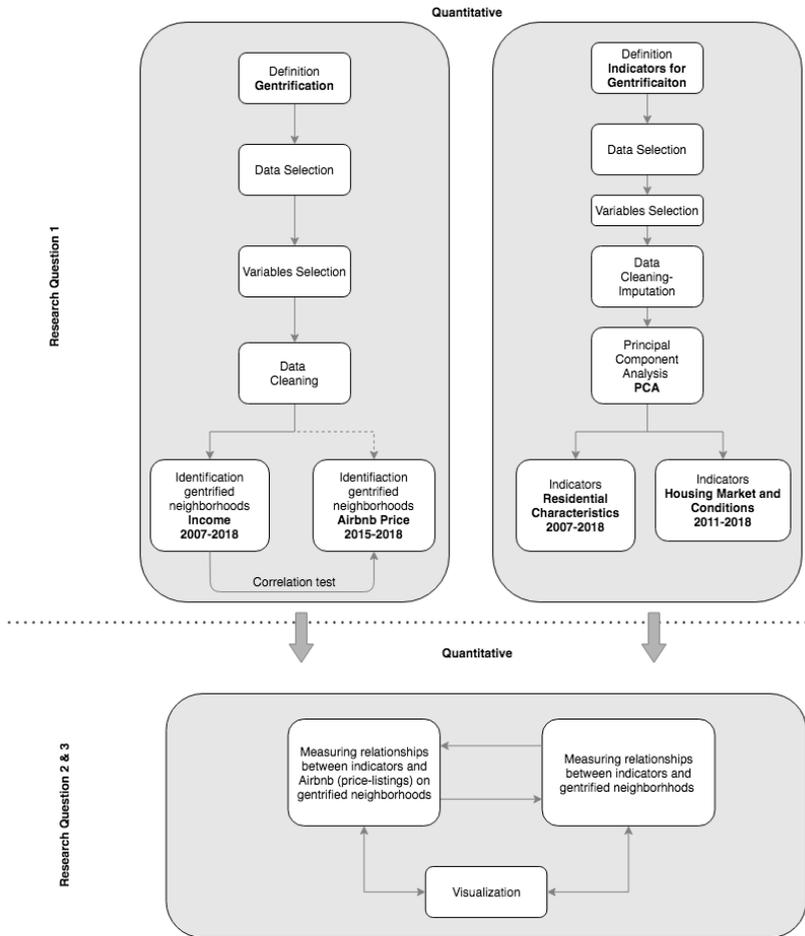
Figure 3.1: Methodology Scheme

3.2. QUANTITATIVE APPROACH TO GENTRIFICATION

3.2.1. IDENTIFICATION OF GENTRIFIED NEIGHBORHOODS (WHICH?)

This section includes the approach used to identify gentrified neighborhoods. The proposal is based on the work of Hochstenbach, Musterd, and Teernstra (2015), who provides an approach using income growth during the 2000s decade. The *which* question requires to capture the socio-economic tendencies along the time. Neighborhoods are constantly influenced by different social, economic, and political conditions that make

the change dynamic and interdependent. In that sense, people try to pursue better living standards that better adapt to their needs and desires. For instance, people can decide where to live based on their socio-economic limitations and expectations.

Disposable income (income) is defined as gross income minus current transfers paid (like alimony payments to an ex-partner), income insurance premiums, health insurance premiums, and tax on income and wealth (Gemeente Amsterdam, n.d.[a]).The disposable income reflects the differences among individuals given their socio-economic activities in society and allows people to access goods and services, which is a fundamental part of the economic system. Since income reflects labor or side economic activities, this socio-economic measure aims to capture the household living standards. Moreover, income can show different socio-economic status in the population, reflecting certain social conditions that make possible income increase or decrease. For instance, social mobility is intertwined with income distribution, related to the education level or the type of labor (white-collar, blue-collar). Moreover, the class formation can be derived by the income distribution and how it shapes their living standards. In this regard, income serves as a numerical approximation to gentrification dimension of class formation and the socio-economic structures on neighborhoods (Hochstenbach, Musterd, and Teernstra, 2015).

Hochstenbach, Musterd, and Teernstra (2015) proposed to identify gentrified neighborhoods according to income growth. The works include calculating the average income growth per neighborhood and the city and identifying which neighborhoods have increased more than the city. It implies that gentrification is always expected since there will always be some neighborhoods with that condition. This dissertation adopts two complementary ways to identify gentrified neighborhoods; the income growth and the proportion growth along the time T. Both approximations result in two sets of neighborhoods that are compared and paired to materialize the identification.

Defining N_i as the i-th neighborhood. Figure 3.2 shows a graphic representation on how the identification will be carried out. The analysis aims at determining those neighborhoods that exhibit a higher income growth given the city average. The N_i has risen faster than Amsterdam , whereas the N_j has not. It means that socio-economic conditions in N_i has risen rapidly and it might correlate to a transformation in the socio-economic structure in the population.

It is not easy to identify the homeowners or landlords who benefit more from Airbnb activity because the company is not willing to share the data with regulatory authorities. However, the aggregated information can tell whether increments in the prices represent an additional income for particular segments of household populations. For instance, Alizadeh *et al.* (2018) investigated that socio-economic conditions have a positive relationship with Airbnb listings and prices in an aggregated level. It implies that families with better socio-economic status at the neighborhood level with properties offered in Airbnb tend to set higher prices. In that sense, neighborhoods that have grown prices per night rapidly can be associated with the profitable and competitive incentive to have Airbnb in the community.

The detailed explanation about the computational procedures is described as follows:

The explanation is summarized as follows:
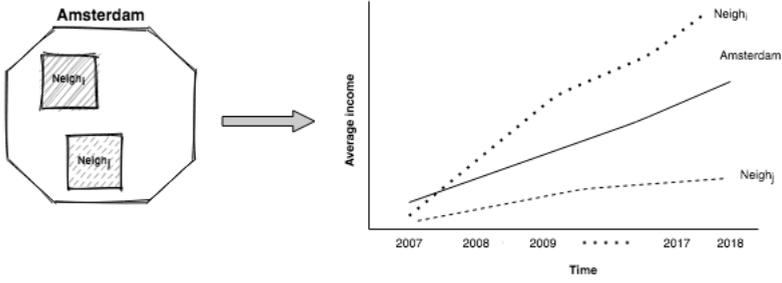
Figure 3.2: Identification of gentrified neighborhoods. Example for the city of Amsterdam

1. **Areas-Time:** select the neighborhoods level and extract the average income at this level. $I_{i,t}$ represents the average income; $P_{i,t}$ for average Airbnb price per night, for the neighborhood i at time t.

2. **Measuring the increment per neighborhood and overall city:** this step is formulated in two connected stages:

   (a) **Calculate the income growth** $I_{i,t}^g$. $t = t_1, t_2, \ldots, t_T$.

   $$I_{i,t}^g = \frac{I_{i,t} - I_{i,t-1}}{I_{i,t-1}} \tag{3.1}$$

   Additionally, $I_{Ams,t}^g$ represents the overal city income growth.

   (b) **Growth per neighborhood and overall city:** the complementary step is based on regressions models that aim to measure the income growth ratio during 2007-2018. The regression is formulated according to the following equation:

   $$I_{i,t} = \beta_{0,i} + \beta_{1,i} T_j + e_{it} \tag{3.2}$$

   Additionally, the overall city regression model is defined as follows:

   $$I_{Ams,t} = \beta_{0,Ams} + \beta_{1,Ams} T_j + e_{it} \tag{3.3}$$

   where T_j is the year and e_{it} the random error with distribution $N(0, \sigma^2)$.

3. The neighborhood i (N_i) is defined as gentified by income according to the following rule:

   $$G_i^I = \begin{cases} Gentrified & \text{if} \quad \overline{I_{i,\cdot}^g} > \overline{I_{AMS,\cdot}^g} \\ & \qquad or \\ & \qquad \beta_{1,i} > \beta_{1,Ams} \\ Other\,Neighborhood & i.o.c \end{cases} \tag{3.4}$$

4. In the case of Airbnb, the methods are applied by using $P_{i,t}^g$, the regression model for $P_{i,t}$ with parameters ($\beta_{0,i}^{Airbnb}$, $\beta_{1,i}^{Airbnb}$), and the getting G_i^A by using the definition in Eq. 3.4.

3.2.2. INDICATORS FOR GENTRIFICATION: HOUSEHOLD CHARACTERISTICS AND HOUSING DYNAMICS (HOW?)

The *how* question is linked to the concept of exclusionary displacement and displacement pressure (see section 2.1). Even though the quantification is not easy to calculate since the reasons why families move are wide to explain, the idea is to anticipate the general tendencies in the neighborhood and inspect in detail the conditions that trigger potential displacement patterns. Gentrification is related to class formation and the type of households or citizens who can move to the most demanded places. In this regard, the newcomers' pressure to the local community explains why people decide to leave or not being able to enter again to the area due to the invisible conditions imposed by new residents. Therefore, describing the neighborhoods throughout a set of indicators helps explain and monitor changes in the city.

Cohen and Pettit (2019) and Opportunity (2016) defines a set of indicators to monitor displacement and gentrification. For this dissertation, the two main indicators are defined as follows:

- *Household characteristics*: it is about knowing who lives in the neighborhoods and monitoring the neighborhood evolution in time. For instance, families with low income, older adults, low levels of formal education, and non-white families can be potentially displaced households. On the other hand, families with high incomes, high levels of education, and white-people can be potential gentrifiers.

  The variables are part of: population composition and totals, household composition, race and ethnicity, population age cohorts, and education level. Some of these variables have been used in different studies (Alizadeh *et al.*, 2018; Easton *et al.*, 2020; Marcuse, 1986; Peacock and Galster, 1986). The Figure 3.3 summarize the main type of variables for this indicator.

- *Housing dynamics*: potential gentrifiers usually can afford higher ground and rent prices. This indicator indicates that landlords can be interested in redevelopment or renovation due to the potential rent gap created (Musterd, 2014; Smith, 1997; Wachsmuth and Weisler, 2018). For instance, fewer subsidized houses, privatized areas suitable for private investment, and type of tenure are usually factors intertwined with gentrification. The variables are related to: the share of housing stock market (total of hoses, and social, private, homeowner houses), ground rent prices (**WOZ** for the Dutch context), homes on sale, construction year, number of residents occupying these houses. The Figure 3.3 summarize the main type of variables for this indicator.

This dissertation proposes to capture the evolution of these two components to measure gentrification. By using the data available, the indicators track the changes of the characteristics measured. This complementary view complements the identification
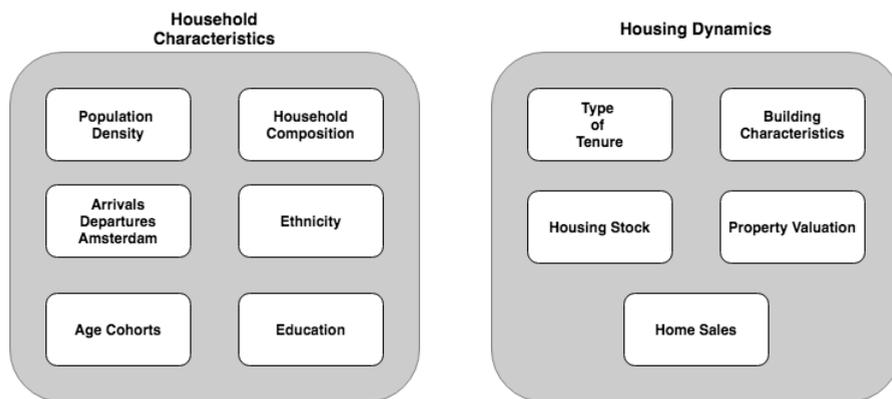
Figure 3.3: Type of variables for the Indicators

of gentrified neighborhoods and supports the explanation of gentrification as a time-dependent process. Therefore the indicators measure the change year per year according to the Household characteristics and Housing Dynamics of year t.

COMPUTATIONAL FRAMEWORK-PCA

To analyze the household characteristics and housing dynamics, the proposal is to use a Principal Component Analysis (PCA). This method is applied to reduce the high number of variables into two leading indicators per topic. The PCA is suitable to find weights derived from the statistical decomposition of the correlation matrix that shows an optimal linear combination of variables. This weighted linear combination represents the indicators for each case. Further, the PCA can be visually represented, helping to find interpretations of the indicator values. It includes the visualization of the correlation of variables and how the neighborhoods are characterized. The following paragraphs describe the statistical procedure.

Principal Component Analysis (PCA) is a statistical method used to reduce the number of original variables into a reduced number of factors or components. PCA was developed to optimally represent the correlation among K variables in S orthogonal factors. Let's suppose that X, with dimensions $I \times K$, represents the original numeric dataset. The fundamental idea of PCA is to search the plane projection P that best represents the I individuals without losing the distances in the K space. In that sense, the distance between two points is related to the correlation between the variables. Therefore, the diagonalization of the correlation or covariance matrix returns another matrix U, with dimensions $K \times K$, with factors u_s, which are linear combinations of the original variables x_i.

Each factor u_s has associated an eigenvalue λ_s, that are ranked in descending order. Since the correlation matrix represents the combined variability between variables, each λ_s is the variance of the factor u_s. In that sense, the sum of all K eigenvalues should be

equal to the total variance in the K original variables. This is related to how the first components best represent the original dataset and how the selection of S factors can be used as a X representation.

The standardization of the matrix X in columns with mean 0 and variance 1 lead to a simple representation of u_s factors in a hyper-sphere with radius 1. The projection of each variable in the factor u_s facilitates the interpretation of the correlations between variables according to their proximity in the circle.

Additionally, PCA not only helps to represent variables but also the individuals in the same P. The equations that enable the relationship between the variables I-dimensional space with the individuals space in K-dimensional space are defined as follows:

$$F_s(i) = \frac{1}{\sqrt{\lambda_s}} \sum_{k=1}^{K} x_{ik} G_s(k) \tag{3.5}$$

$$G_s(k) = \frac{1}{\sqrt{\lambda_s}} \sum_{i=1}^{I} \frac{1}{I} x_{ik} F_s(i) \tag{3.6}$$

where $F_s(i)$ is the coordinate of individual i in the factor s, and $G_s(k)$ is the coordinate of the variable k in the component s. Therefore, the set of weight per each component follows the equation:

$$W_s(k) = \frac{1}{\sqrt{\lambda_s}} G_s(k) \tag{3.7}$$

Besides, to improve the interpretation in the factors u_s, this dissertation proposes to re-scale them into components with an average of 50 and standard deviation of 15. It is possible following the equation:

$$H_s(i) = \frac{F_s(i)}{\sqrt{\lambda_s}} * 15 + 50 \tag{3.8}$$

3.3. MEASURING THE INFLUENCE OF AIRBNB IN THE GENTRIFICATION PROCESS

The comparison is divided into two parts. The first includes an exploration of the characteristics of Airbnb in gentrified neighborhoods by income —the exploration of Airbnb in gentrified neighborhoods, *which*. The second extends the analysis using the gentrified neighborhoods by income and the additional gentrification dimensions to find out the distribution patterns of Airbnb —exploration and modeling that combines *which* and *how*.

Airbnb in gentrified neighborhoods, *which*. The research is carried out by comparing sets of neighborhoods identified with high growth in either income or Airbnb price per night —G_i^I and G_i^A (Table 3.1). The comparison can help understand which neighborhoods experiment reinforced patterns of changes in the socio-economic conditions and the shifts in the supply and demand for Airbnb properties. The results are represented in maps with information about the spatial distribution of G_i^I and G_i^A. Moreover,

the distribution of Airbnb listings, prices, and revenue is contrasted with the gentrified neighborhoods.

Table 3.1: Typification of gentrified neighborhoods

Type of gentrification	Description	Label-Visualization
Gentrified by income and Airbnb rental price	if N_i is classified as gentrified by income AND Airbnb price per night	Income + Airbnb

Airbnb - exploration and modeling that combines *which* and *how*. The analysis focuses on the cross-comparison between the numbers derived from the indicators —housing characteristics and housing dynamics— and the Airbnb listings characteristics. Firstly, the proportion of short-term rentals in Airbnb given the long-term rental market is calculated, then it is compared with the indicators in gentrified neighborhoods. This analysis aims to determine the neighborhood conditions that have enabled the adoption of Airbnb. Moreover, the exploration seeks the city areas with a high propensity for short-term rentals that can eventually affect the long-term rental market. Secondly, log-linear models are used to understand the household characteristics and housing dynamics that are more related to the revenue by Airbnb. The regression results attempt to infer the neighborhood characteristics that are receiving more monetary benefits from the short-term rentals operations.

3.4. DATA

The data selection was carried using the criteria of quality, comparability, and completeness. Given this dissertation intends to capture major changes in gentrification and Airbnb operations in time, the comparison is materialized according to the data availability. The schematic viw of the information available for this work is presented in Figure 3.4. It shows that some outcomes are only possible in different periods. In particular, the measurements derived from the Airbnb operations are limited to the period 2015 to 2018. The process of obtaining the data is explained in further detail in the next sections.

3.4.1. HOUSEHOLDS AND HOUSING SOURCES

This study is based on open data published by the *Geemente Amsterdam Amsterdam* —Municipality of Amsterdam (Gemeente Amsterdam, n.d.[b])— and the *Centraal Bureau voor de Statistiek* —CBS , the National Statistical Office for Netherlands—. The Figure 3.5 shows the source and type of data and how it is used to answer the research questions.

This data is used in two ways: firstly, to identify the neighborhoods gentrified (research question 1). Secondly, the data is used to calculate the indicators used to described the process of gentrification in the city (see Table 2.2).

The Municipality of Amsterdam gathers around 800 variables in the dataset. According to this information the Municipality pays special attention on topics related to Commercial activities, Population and Housing. Moreover, some of this data is gathered

Figure 3.4: Timeline for the measurements constrained to the data available
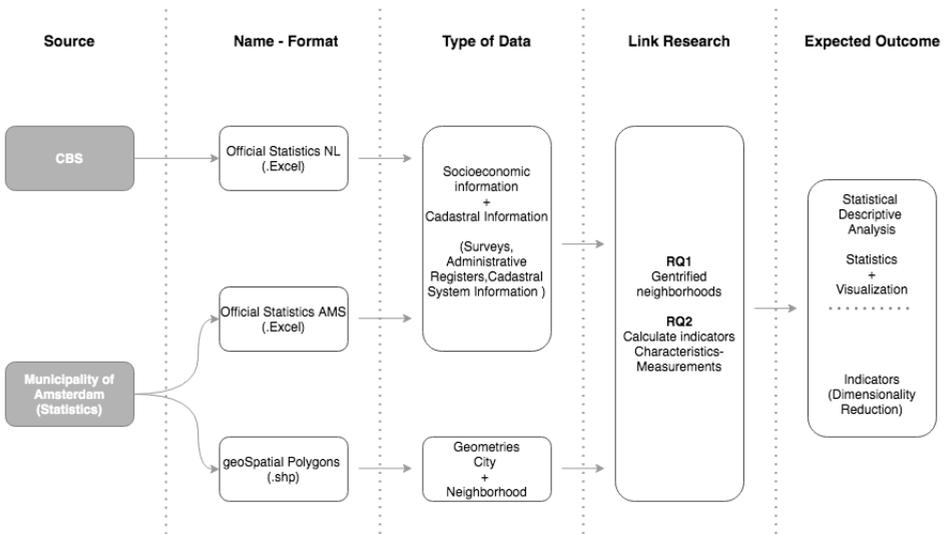
Figure 3.5: Data source used for RQ1 and RQ2

through the time, for instance population is surveyed since 2001 and has projections until 2040. Other variables are only recorded every two years or were recently added to the database. The selection in this case corresponds to the rows that includes information about the neighborhood (*Wijken*) level.

The CBS also makes public the official statistics per neighborhood at the *Statline* webpage. In this case the data is published separately per year in Excel format. Therefore, the data were downloaded on the periods 2007-2018, organized per neighborhood (*Wijken*), formatted, and standardized to make it readable for the analysis.

Remark about official statisics: Additionally, the national and local statistical offices are ordered to protect the available data to safeguard the privacy of population. More-

over, the information provided will not be used to mislead or being addressed to harm other people. For this reason, the availability of data for this study is limited to use aggregated at neighborhood level - *Wijken*.

VARIABLE SELECTION - GENTRIFICATION

The variables selected for this study are based on the relevance criteria for each step. This section differentiates the variables used to identify gentrified neighborhoods and the indicator calculation.

3

Which? The variable *Mean disposable household income* (income) is measured from 2007 to 2018 (Gemeente Amsterdam, n.d.[a]). The data have been gathered at different levels in the city. This dissertation seeks to study the neighborhood level thus the data is selected and filtered accordingly.

How? The variables for **Household Characteristics** and **Housing Dynamics** were selected according to the importance of the explanation of gentrification, exclusionary displacement and pressure (Opportunity, 2016). *Variable Selection* was made according to the grade of the relationship between the definition and the relevance for each indicator. There was necessary to review the list of official statistics and the degree of association with each topic. Moreover, quality checking was part of the selection process since some are captured through surveys with high rates of non-response. It implied that some neighborhoods do not have enough data during the observation period, which affects the quality of the statistics produced in this dissertation. Therefore, the balance between availability and quality are part of the rules followed during the selection process.

The **Household characteristics** indicator uses information from the Municipality of Amsterdam dataset. The list of variables that composed each sub-component are in Figure 3.6 (explained in detail in Table A.1). Since data is available in most of the periods, the information selected corresponds to 2007-2018 (Figure 3.4). .

The **Housing Dynamics** indicator uses information from the Municipality of Amsterdam dataset and the CBS. The list of variables associated to the five sub-components are in Figure 3.6 (explained in detail in Table A.1). In this case, it was necessary to combine both sources to have a complete overview of the characteristics and housing price valuation. The data is collected by using biennial surveys, and it is limited to a minimum of fifty (>50) respondents. Therefore, all the information for all the years and neighborhoods is not available and it is required to impute missing values. In order to maintain the results quality information processes is carried out only from 2011-2018 (Figure 3.4) .

Quality verification was based on the percentage of missing values; the discarding decision is based on an admissible of 30% of missing values. This rule was applied after a completion process was carried out. The *Data Cleaning- Imputation* is based on identifying possible outliers or neighborhoods with higher percentages of missing values. The procedure for *missing values imputation* was carried out by using a Multivariate Imputation Method (Buuren and Groothuis-Oudshoorn, 2011).

Figure 3.6 shows the list of variables for each component with a short description and the label used for results and analysis. results.
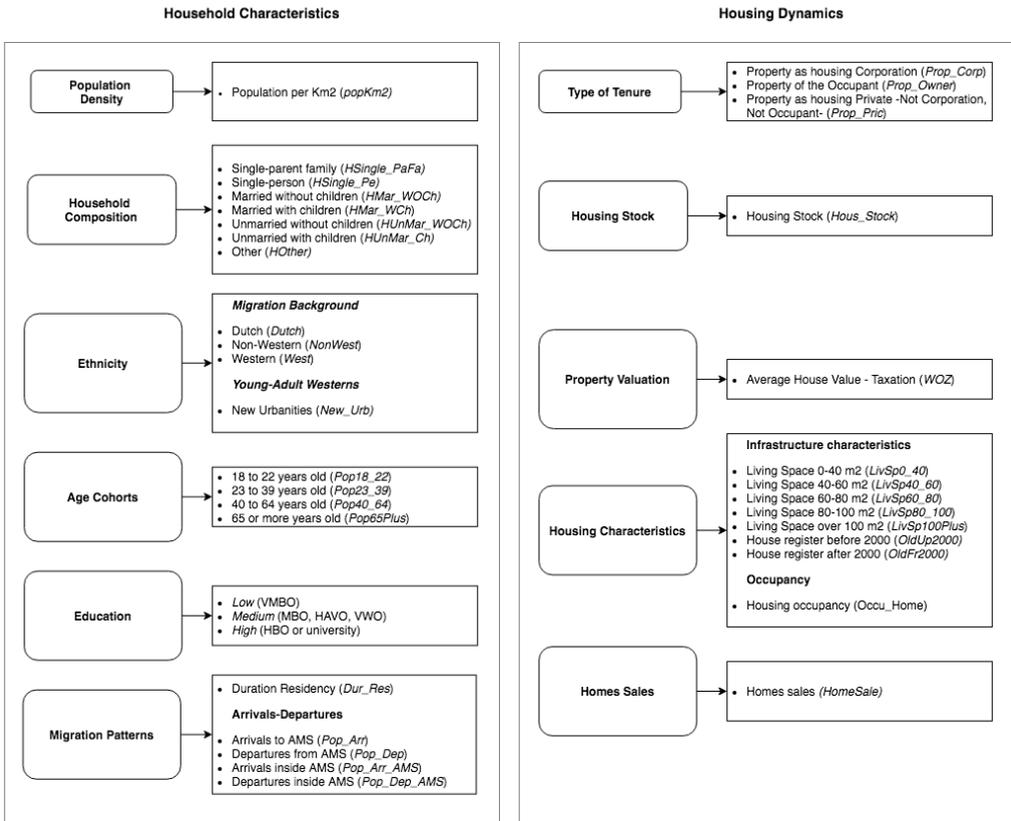
Figure 3.6: Variable description

PROCESSING THE DATA

The cleaning data helped to selected variables with low percentages of missing values (lower than 30% were included). The variables had systematically around 25% of missing values, which were estimated by a multiple imputation procedure (Buuren and Groothuis-Oudshoorn, 2011). The processing was carried out independently to housing characteristics and housing dynamics the Figures A.1 and A.2 show a density comparison of the imputed (red line) and the original source of information.

3.4.2. AIRBNB

Airbnb has an online website that allows the interaction between users. All this information shows the availability of houses for renting in real-time, making comparable a variety of properties. Users can be hosts by posting their properties and main characteristics, or guests by accessing the information and making choices on the short-term rental market. Private policy standards govern this information, giving Airbnb the option to store, processing, transform and use all the vast data gathered using the website. Therefore, one of the ways to access this information is via web scrapping. The algorithms can scan the Airbnb web page and extract the data from the HTML source code. This procedure implies that all the data capture is processed and organized in CSV files to be accessed using different software. It contains all the characteristics visible on the website: information about the host, guest, apartment (photographs, description, location), the price per night, transaction cost, dates, number of guests, minimum and maximum days for renting, comments, and so forth. However, the algorithm can only return information when it is running. For instance, if the algorithm is running today, it can only return data from today onwards, but it can not check which properties were rented yesterday. Thus, some properties can not be capture implying a diminishing in the completeness of the short-rental market. Spite of some limitations are given to the data, scholars have carried out their research using scrapped data (Alizadeh *et al.*, 2018; Gant, 2016; Gurran, 2018; Ioannides *et al.*, 2019; Wachsmuth, Kerrigan, *et al.*, 2017; Wachsmuth and Weisler, 2018). For this dissertation the data is obtained from the website http://insideairbnb.com which was built by the housing activist Murray Cox.

The data structure has three main datasets. Listings contain all the information about the properties listed in Arbnb uniquely identified. The information about the host, prices per night, amenities, location, room types, and calendar availability are available in this table. This table summarizes all the activities in Airbnb, which is visible for users, and it is the main table in the whole web-scrapping process. Reviews contains all the reviews dates per each property. The Calendar table offers an overview of the variation on prices one year ahead. This dissertation focuses on the use of Listings and Revies tables.

The data availability for the city of Amsterdam is given for 2015 to 2018. All the information was downloaded, used, and processed during this period. Table 3.2 shows all the information obtained from the website.

Table 3.2: Airbnb since 2015-2018

2015	2016	2017	2018	Total
6	10	12	9	37

A short description of the number of different properties available per type of room is presented in Table 3.3. It shows that the total of listed properties has risen two consecutive years since 2015. Additionally, it indicates that Entire homes or apartments dominate the short-term rental in Airbnb.

VARIABLE SELECTION - AIRBNB
It corresponds to the columns *price per night* and the number of properties listed on the platform. Additionally, it is not possible to obtain the exact revenue directly for each
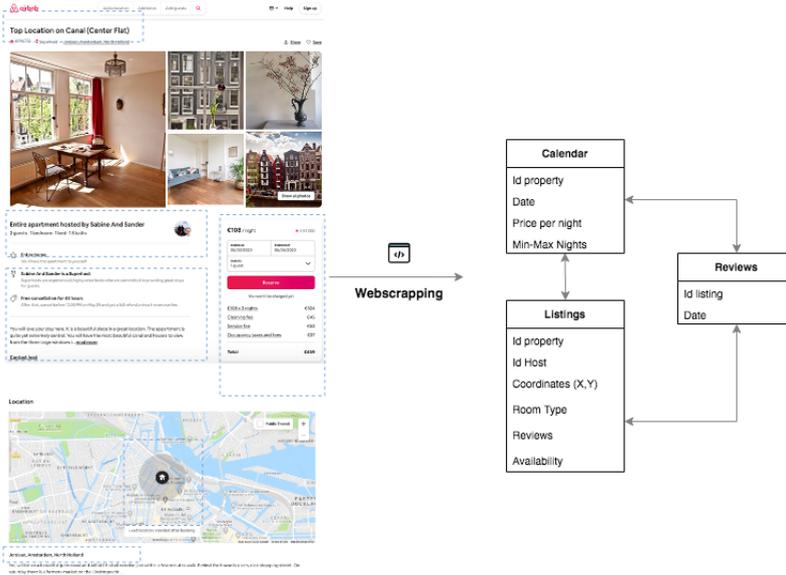
Figure 3.7: Aribnb- Web Scrapping

property during the year. Since this variable is important in this dissertation, an approximation is proposed by Equation 3.9. It includes a combination of *average monthly reviews, minimum night for renting,* and *price per night*. It assumes that each review is related to different rent times, so for instance, an average monthly review for property A of 2.15 means that at least $12 * 2.15 = 25.8 \approx 26$ days the house was rented in one year.

$$E_t(R) \approx 12 * \max(W)_t * \max(O) * \overline{P} \tag{3.9}$$

where $E_t(R)$ is the expected minimum revenue per year, $\max(W)$ is the maximum number of reviews the reviews per month in the year t, $\max(O)$ is the maximum of the minimum number of nights specified in the platform in the year t, and $\overline{P}$ the average price per night in the year t.

PROCESSING AND LIMITATION OF AIRBNB DATA
To produce statistics with high-quality cleaning processing is required, especially the Airbnb web-scrapping dataset contains noisy individuals (properties) with duplicates, incomplete, or inaccurate information.

- **Cleaning**: Firstly, identify all the properties that spatially are in the Amsterdam's geometry. It included mapping the coordinates in the polygons, and determine

Table 3.3: Listings Airbnb since 2015-2018

Type of property	2015	2016	2017	2018
Entire home/apt	11432	17004	20355	18784
Private room	2819	4337	5497	4837
Shared room	99	140	117	73
Total	14350	21481	25969	23694

3

the neighborhood for each property. This part reduce the dataset to the accurate locations in the city.

Secondly, the prices can have incorrect values. Thus, a set of boxplots were used to identify outliers. In this case, a boxplot was generated for the price per night per each month-year data. In total, 37 boxplots were calculated. All the points that were outside of the whiskers were considered as outliers. In total, 6.35% of properties were removed from the consolidated dataset.

• **Limitations**: Since Airbnb has operations in a reduced number of neighborhoods, the comparison proposed is limited not only by the period of time —from 2015 to 2018—but also the neighborhoods need to have several properties according to the distribution of the city. This condition proposed assumes that a low number of properties do not exert a large influence in the long-term rental market. Moreover, this limitation leads to calculating the statistics to the neighborhoods with Airbnb operations. Chapter 6 revisits this assumption.

Neighborhoods with a low rate of properties in Airbnb. The ratio

$$R_i = \frac{\overline{L}_i}{\overline{H}_i}$$

where $\overline{L}_i$ is the average number of Airbnb listings and $\overline{H}_i$ is the average housing stock for neighborhood i from 2015 to 2018. To calculate percentile 10; it means the percentage of observations that falls in 10% of the lowest values of the Airbnb price per night. It was calculated for R and the $Average Properties Airbnb$. The limit values were 1% of Airbnb properties in the housing market and 17 houses per neighborhood from 2015 to 2018. Therefore, neighborhoods with

$$R_i < 1\% \text{ or } \overline{L}_i < 17$$

where were discarded from this analysis. Out of the 99 neighborhoods that compose the city, 15 were excluded to the identification of gentrified neighborhoods: **Slotermeer-Zuidwest, Geuzenveld, Eendracht, Osdorp-Oost, Osdorp-Midden, De Punt, Middelveldsche Akerpolder, Betondorp, Waterlandpleinbuurt, Buiksloter-meer, Bijlmer Centrum (D,F,H), Bijlmer Oost (E,G,K), Holendrecht/Reigersbos, Gein, and Driemond**. The total number of unique properties per year is listed in the Table 3.3. This final dataset was used to identify the neighborhoods gentrified and subsequent analysis.

The Figure 3.8 shows the map with the results of the processing and selection of neighborhoods data. It shows that the number of listings decrease with the distance to the center. The city center, Zuid, and West concentrate more listings than other districts.
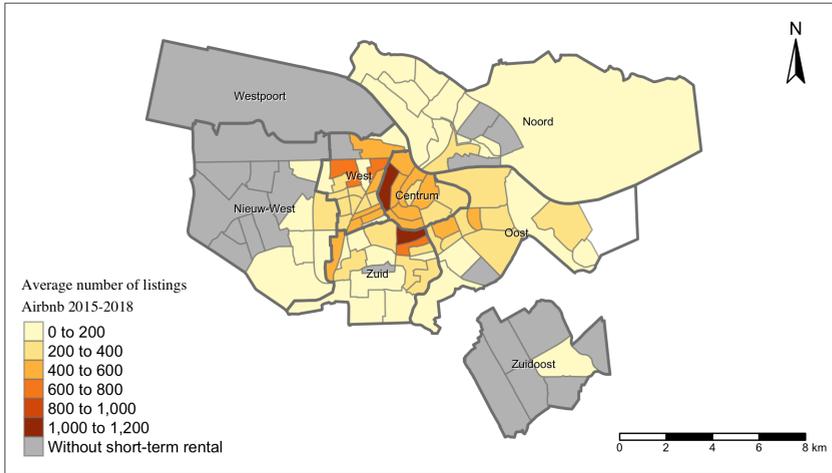

Figure 3.8: Distribution of average number of Airbnb listings (2015-2018) after the processing

3.5. CONCLUSIONS

The methodology aims to capture the gentrification process and how it is related to Airbnb operations. The approach can be used to study different cities, being Amsterdam the case study for this dissertation. The process intends to capture the dynamic conditions of both processes in the city. Firstly, gentrification is a process that involves changes in the socio-economic and housing conditions. It is measured through changes in income and described using a framework developed for the household characteristics and housing dynamics. Secondly, Airbnb has evolved as a socio-technical system that influences the social fabric of neighborhoods. Therefore, this dissertation proposes a variety of comparisons to evidence of the relationship with gentrification through the time. The identification and characterization of neighborhoods are based on the distribution of Airbnb listings, prices, and expected revenue on gentrified neighborhoods (which), households' socio-economic and housing characteristics.

4

MEASURING GENTRIFICATION IN AMSTERDAM

This chapter is focused on providing the gentrification framework that is used to make further comparisons. The theoretical foundations of gentrification is applied in this section to answer the first research question. Firstly, the identification of neighborhoods gentrified is carried out by using the method explained in section 3.2. It corresponds to the question *which neighborhoods are gentrified?*. The second part is related to the *how are the neighborhoods gentrified?*. For this second part, the data is used to calculate the whole city indicators using the PCA approach (section 3.2.2). The distribution of the indicators is compared with the gentrified neighborhoods and the city to evidence the different gentrification facets. The chapter finishes with some ideas as a conclusion. All the variables analyzed in this chapter are detailed described in Table A.1

Remark: The data used for the gentrification study —*which* and *how*— corresponds to all the 98 neighborhoods in Amsterdam.

4.1. IDENTIFICATION OF GENTRIFIED NEIGHBORHOODS USING INCOME (WHICH?)

The mean disposable income per household (income) is used to identify gentrified neighborhoods according to the methodology in section 3.2.

The income analysis reveals an increment during the observation period (Figure 4.1). The real income[1] shows that the average and median has increased. The average real income grew from €35,728 in 2007 to €40,796 in 2018 (14.18%). The income distribution shows the asymmetry in large income values. However, from 2007 to 2010, the income shows a more concentrated distribution than 2011 onwards that income is more dispersed (including the cloud of high incomes depicted as outliers). Some of these neigh-

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[1]The Consumer Price Index was used to make comparable income per year discounting inflation. The year base is 2015.

borhoods are located in the Zuid district (Apollobuurt, Willemspark, Prinses Irenebu-
urt, Museumkwartier) and West (Vondelbuurt). The outlier in 2008 is the neighborhood
Bedrijventerrein Sloterdijk which reported an average income under €19,800. In general,
both measures show that Amsterdam families had income growth that was not strictly
related to inflation. Moreover, two phenomenons are visible in the plot; the city socio-
economic conditions changed, becoming better for the families, and there was an ex-
pansion in the range of neighborhoods with low-income compared to the high income.

The study of gentrification using income growth leads to identify 30 neighborhoods.
The Figure 4.2 shows the spatial distribution of them with a further characterization of
income levels ^{2}. Figure 4.2 shows the highest number is located in the West district,
which is next to the Centrum area. This area has a variety of income distributions; low
and average income. High income gentrified neighborhoods are mostly in Niew-West,
Zuid, Centrum, Oost, and Noord east. Niew-West, and Zuidoos have less number of gen-
trified neighborhoods. The number of gentrified neighborhoods is distributed through-
out the city. It shows that the socio-economic conditions changed in all three income
ranges (low, medium, and high). Further, the neighborhoods are dispersed city-wide,
indicating that the income steep is not concentrated in only one area. However, the in-
fluence of the city center is evident because some of them are surrounding it.
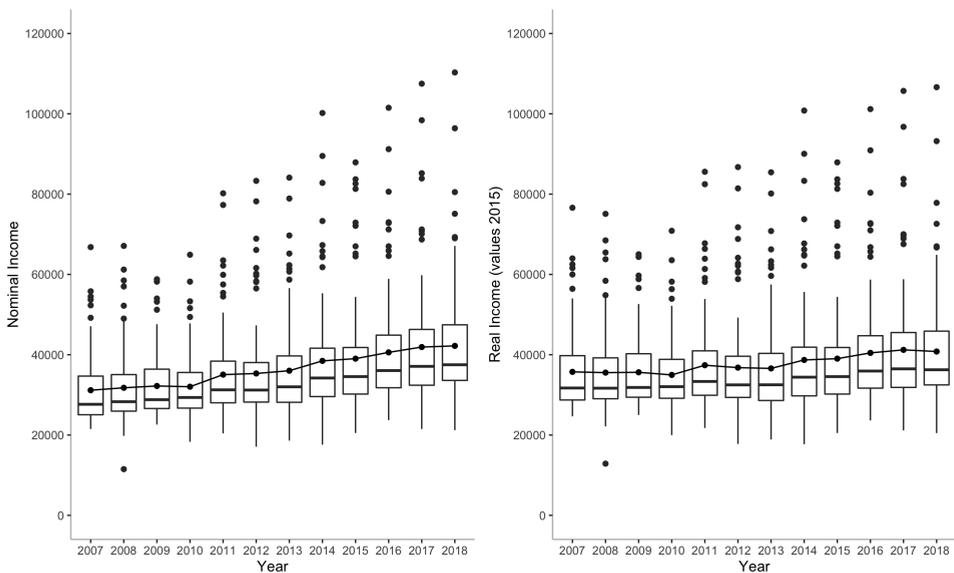

Figure 4.1: Nominal and Real Income (Using Consumer Price Index -CPI— 2015) distribution 2007-2018

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^{2}Low income are neighborhoods with values lower than €32,249, average are between €32,249 and €40,370,
and high income are above €40,370

District	Low	Ave.	High	Total
Centrum	0	1	1	2
Nieuw-West	0	0	1	1
Noord	1	1	3	5
Oost	2	1	1	4
West	5	4	0	9
Westpoort	0	0	0	0
Zuid	1	1	6	8
Zuidoost	1	0	0	1
Total	10	8	12	30
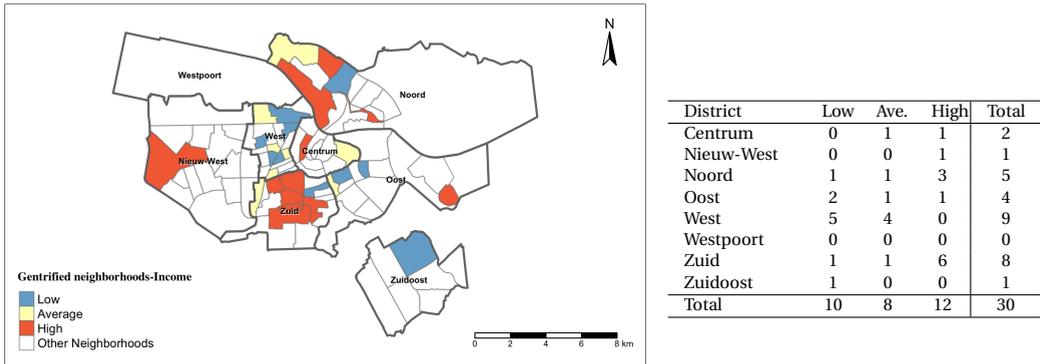
Figure 4.2: Gentrified Neighborhoods - Income classification

4.2. PRINCIPAL COMPONENT ANALYSIS - INDICATORS (HOW?)

The PCA analysis requires a statistical univariate analysis with the main statistics to find a better result interpretation. Some comparisons are made given the set of gentrified neighborhoods, other neighborhoods, and the city level. Secondly, the PCA is applied to find the optimal weights according to each topic: Household Characteristics and Housing Dynamics (section 3.2.2). The indicators are standardized using a mean of 50 and a standard deviation of 15. The results are visualized and summarized using quintiles to improve the interpretations of the results.

4.2.1. STATISTICAL UNIVARIATE ANALYSIS

HOUSEHOLD CHARACTERISTICS

Table 4.1 shows some statistics for gentrified neighborhoods and the overall city. Composition household has negative growth on gentrified neighborhoods in more than 2% on single parent and households without children; it has higher than 2% of growth on married with children, unmarried without children, and unmarried with children. Additionally, Amsterdam is a city characterized by having 52.5% of Single Parent Households. Furthermore, 77.45% of the population is between 23 and 64 years, on average. Additionally, in gentrified neighborhoods, the population of 65 or more years has increased by 2% along the 12 years. Even though the population is 55% Dutch, the increments on gentrified neighborhoods have been on non-western and western populations. It corresponds with the values of migration patterns (arrivals and departures from Amsterdam). On gentrified neighborhoods, the outside migration has reached 3.74% and 4.47% from arrivals and departures, respectively. It also corresponds to the diminishing Duration of Residency, which is slightly less in gentrified neighborhoods —0.03 years less than the average city. New urbanities has 4.3% more related to people from Dutch or western nationality who move to Amsterdam. Finally, Education shows some interesting results because Amsterdam is characterized by having highly skilled workers—highly educated (40.98%)— and shows that in gentrified neighborhoods, it increases in 3.18%. In contrast, low and medium educated population decreased in 4.16% and 1.51%. Moreover, high educated people are concentrated in gentrified neighborhoods (7.24% above the

city average).

For Other-Neighborhoods, the migration patterns exhibit values above the city average, showing a big difference with gentrified neighborhoods. Additionally, less concentration is perceived in Other-Neighborhoods since it has 798 people less per square kilometer.

Table 4.1: Statistics household characteristics variables - Comparison gentrified neighborhoods

Variable	Average	Standard Dev.	Difference Average (Gentrified)	Difference Average (Other Neigh.)	Average Growth (Gentrified)
HSingle_PaFa	8.35%	0.64%	-0.8%	0.36%	-2.32%
HSingle_Pe	52.5%	1.02%	-0.75%	0.33%	-0.17%
HMar_WOCh	10.89%	1.29%	-0.03%	0.01%	-2.14%
HMar_WCh	11.55%	0.42%	-0.16%	0.07%	2.04%
HUnMar_WOCh	10.51%	0.83%	1.18%	-0.52%	2.03%
HUnMar_Ch	4.8%	0.26%	0.49%	-0.21%	4.09%
HOther	1.4%	0.11%	0.08%	-0.03%	-1.7%
Pop18_22	8.56%	0.32%	-1.04%	0.46%	-2.23%
Pop23_39	38.18%	0.8%	2.17%	-0.96%	0.43%
Pop40_64	39.27%	0.98%	0.26%	-0.11%	-0.62%
Pop65Plus	13.99%	0.55%	-1.38%	0.61%	2%
Dutch	55.45%	2.42%	3.53%	-1.56%	-0.87%
NonWest	26.74%	1.14%	-4.61%	2.03%	0.87%
West	17.81%	1.29%	1.08%	-0.48%	1.76%
Pop_Arr	638.33	91.16	-6.09	2.69	3.74%
Pop_Dep	585.95	94.82	2.09	-0.92	4.47%
Pop_Arr_AMS	822.45	32.62	-20.14	8.88	1.08%
Pop_Dep_AMS	825.41	29.12	-15.47	6.83	0.48%
Pop_Mig_Ar	220.47	56.08	-35.94	15.86	15.49%
Dur_Res	8.3	0.15	-0.03	0.01	0.0%
popKm2	9443.64	401.82	1808.99	-798.08	-1.24%
New_Urb	31.78%	0.46%	4.73%	-2.08%	0.19%
EDU_Low	25.19%	2.51%	-4.12%	1.82%	-4.16%
EDU_Medium	33.83%	1.07%	-3.16%	1.4%	-1.51%
EDU_High	40.98%	3.52%	7.24%	-3.19%	3.18%

The correlation of Housing Characteristics variables shows strong associations between the Household Composition and Ages. Single parent households are correlated with populations between 23 and 39 years old and negatively with people older than 40. On the other hand, adult people with households with married and children people. Dutch and Western populations are negatively correlated with single parent households, opposing to Non-Western populations, which is positive. Moreover, low-education is positively associated with single and married with children households. It differs from the high-educated population, which is correlated to single person and unmarried without children Households. Migration patterns are also positively correlated, showing that more departures relate with more arrivals and vice versa. Moreover, Non-Western is neg-

atively correlated with new urbanities. In terms of education, low levels imply higher percentages of Dutch and Western populations. Non-Western populations exhibit a positive correlation with Low-Education levels and negatively with high-education levels (See Figure 4.3).
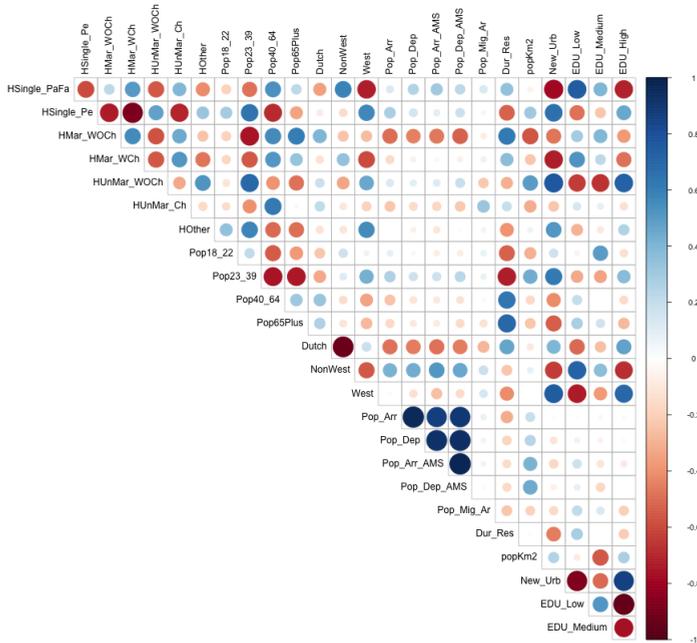

Figure 4.3: Correlation matrix for variables - Household Characteristics

HOUSING DYNAMICS

The analysis of the period 2011 to 2018 lead to tendencies capture through some statistics. Table 4.2 shows that on gentrified neighborhoods, the housing composition is changing dramatically. Even though housing corporations represent 40.83% in average, it has negative growth in 3% in eight years. Furthermore, private and homeowners dominate the market share in gentrified neighborhoods; 3.5% and 6.24%, respectively. Additionally, small living spaces are less concentrated in gentrified neighborhoods (0-80 square meters). Bigger houses — above 80 square meters—are above the average in the overall city, which also corresponds to older infrastructure. In that sense, the housing stock is slightly less distributed in gentrified neighborhoods. Interestingly, houses located in these neighborhoods are expensive compare with other neighborhoods. The WOZ value used for taxation only makes it useful to identify that people interested in buying houses might pay €59,770 more. The market acquisition also shows an attractiveness due to home sales are 6.57% above the average. Therefore, the housing dynamics on gentrified neighborhoods are characterized by selling big and expensive houses that are not only part of the private market but also are attractive on prices due to housing prices are rising

rapidly (5.38% in average).

An inspection on the correlation matrix there are some existing structures which are important to highlight. Figure 4.4 shows that housing corporations are more predominant in small and medium living spaces (0 to 80 square meters). The valuation property has a negative correlation implying that neighborhoods with less housing corporations tend to have more significant WOZ values. Hence, home sales are corresponding less in proportion. A complete opposite pattern is identified in the private sector. Additionally, the high value in the correlation between home sales and homeowners proportions suggests that the acquisitions are for people who desire to be the house main occupant. Another notable result is that new houses —from year 2000 onwards— are characterized by having smaller (0 to 40 square meters) or bigger (above 80 square meters). It intrinsically is related to property valuation —WOZ.

Table 4.2: Statistics Housing Dynamics - Comparison gentrified neighborhoods

Variable	Average	Standard Dev.	Difference Average (Gentrified)	Difference Average (Other Neigh.)	Average Growth (Gentrified)
Prop_Corp	40.83%	2.82%	-9.74%	4.3%	-3%
Prop_Priv	29.13%	1.85%	3.5%	-1.54%	1.72%
Prop_Owner	30.03%	1.13%	6.24%	-2.75%	1.08%
LivSp0_40	8.8%	1.34%	-1.39%	0.61%	6.53%
LivSp40_60	26.17%	0.46%	-0.48%	0.21%	-0.83%
LivSp60_80	26.04%	0.22%	-3.15%	1.39%	1.09%
LivSp80_100	17.6%	0.39%	0.39%	-0.17%	0.77%
LivSp100Plus	18.87%	1.37%	4.65%	-2.05%	2.47%
OccuHome	2.06	0.04	-0.07	0.03	0.55%
HousStock	4351.13	84.03	-34.26	15.12	0.18%
WOZ	272.58	37.98	59.77	-26.37	5.38%
HomeSale	29.87%	1.74%	6.57%	-2.9%	1.69%
OldFr2000	14.99%	2.22%	-0.16%	0.07%	5.84%
OldUp2000	85.01%	2.22%	0.16%	-0.07%	-0.8%

4.2.2. PRINCIPAL COMPONENT ANALYSIS

HOUSEHOLD CHARACTERISTICS

The PCA results used for Household Characteristics the 25 variables and District as a supplementary qualitative variable [3]. It captures in the first two dimensions the 57.57% of the total variance, and they define the two indicators for this topic. The indicators are scaled to an average 50 and a standard deviation 10.

The first indicator is named *Residential Mobility*. Table 4.4 shows the correlation between variables and Residential Mobility Indicator. Higher values of it are positively associated with high values of departures and arrivals, younger population (12 to 39 years), high-education, population per square kilometer, and household diverse (unmarried

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[3]Supplementary variables are useful to guide the visualization of the results. They do not intervene in the main calculations using the main variables. The procedure admits qualitative or quantitative supplementary variables
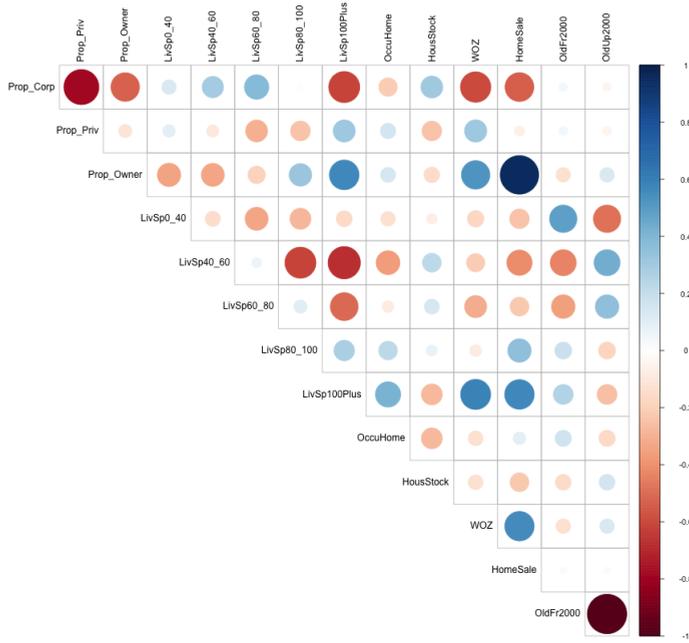
Figure 4.4: Correlation matrix for variables - Housing Dynamics

without children, single person, other types of households, and western population). Lower values in the indicator are related to higher values on low-education levels, households composed by a couple (married or unmarried) with children, populations older than 40, and residency duration. Furthermore, this indicator intends to identify neighborhoods with fewer settled families who might move more freely compared with more settled households. Additionally, the indicator can also capture changes in young and education, which is one of the characteristics of exclusionary displacement. Hence, this indicator captures the pressure exert on population classes characterized for older, low educated, and non-western populations who cannot reside or settle with a family for a long period.

The second indicator is named *Foreign Vibrant*. Higher values are associated with higher numbers in non-western populations, in-out migration to the city, and inside as well (departures and arrivals). Young population (18 to 39 years old), with low or medium education level, and higher population density. On the other hand, lower levels are correlated with higher values on dutch and western populations, older than 40, married or unmarried families with(out) children (Table Table 4.5). This indicator measures the neighborhood propensity to be composed of a vibrant population from multicultural origins (Dutch, Western, and Non-Western) and mixed education. In that sense, the pressure is related to the influx of non-Dutch populations, which act as pioneers in the neighborhoods and exclusionary displacing local communities.

Table 4.3 shows the limits using the quintiles of the distribution for each indicator.

Additionally, an analysis per district can be carried out by using Figure 4.5 and Tables A.1 and A.2. Centrum district is getting more propensity on Residential Mobility. In Nieuw-West the Foreign Vibrant dominates the characteristics. Noord keeps the more settled families due to low values in both indicators. Oost is not getting far from the overall city representing by a dominant medium status in both indicators. West shows medium extremes and it has more propensity to Residential Mobility. Westpoort characterizes by the Dutch population. Zuid has similar patters as West. Zuidoost doest not show big values in residential mobility but a high propensity of cultural mixing.
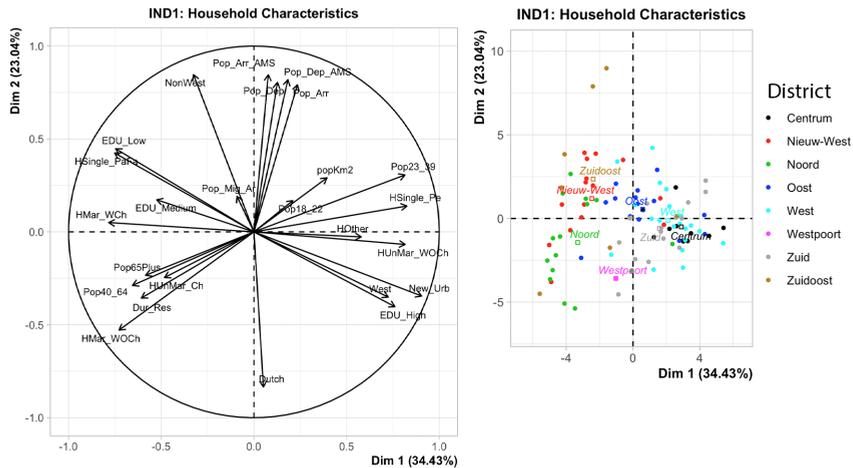

Figure 4.5: ACP results. Correlation circle and neighborhoods projections on factors. Indicator Household Characteristics

Levels	Residential Mobility	Foreign Vibrant
Low	$(-\infty, 35.08]$	$(-\infty, 39.48]$
Medium-Low	$(35.08, 45.73]$	$(39.48, 46.16]$
Medium	$(45.73, 56.63]$	$(46.16, 51.66]$
Medium-High	$(56.63, 64.29]$	$(51.66, 60.76]$
High	$(64.29, \infty)$	$(60.76, \infty)$

Table 4.3: Categories for the Housing Characteristics indicators

HOUSING DYNAMICS

The PCA for housing dynamics is visualized in Figure 4.6. Each axis composed the two main indicators for this topic. They capture 51.82% of the variance, which is sufficient to explain some characteristics of Amsterdam's housing distribution. These indicators are also re-scaled using a city average of 50 and a standard deviation of 15.

Variables	Correlation	p.value
New_Urb	0.90	0.00
HSingle_Pe	0.83	0.00
HUnMar_WOCh	0.82	0.00
Pop23_39	0.81	0.00
EDU_High	0.76	0.00
West	0.72	0.00
HOther	0.58	0.00
popKm2	0.39	0.00
Pop_Arr	0.24	0.02
Pop18_22	0.21	0.04
Pop_Dep_AMS	0.18	0.07
NonWest	-0.33	0.00
HUnMar_Ch	-0.48	0.00
EDU_Medium	-0.52	0.00
Pop65Plus	-0.58	0.00
Dur_Res	-0.61	0.00
Pop40_64	-0.66	0.00
HMar_WOCh	-0.73	0.00
EDU_Low	-0.75	0.00
HSingle_PaFa	-0.75	0.00
HMar_WCh	-0.78	0.00

Table 4.4: Correlation test between Residential Mobility and composed variables

Variables	Correlation	p.value
NonWest	0.85	0.00
Pop_Arr_AMS	0.85	0.00
Pop_Dep_AMS	0.82	0.00
Pop_Dep	0.80	0.00
Pop_Arr	0.79	0.00
EDU_Low	0.45	0.00
HSingle_PaFa	0.42	0.00
Pop23_39	0.31	0.00
popKm2	0.29	0.00
Pop_Mig_Ar	0.19	0.06
EDU_Medium	0.17	0.09
Pop18_22	0.17	0.10
Pop65Plus	-0.23	0.02
HUnMar_Ch	-0.25	0.01
Pop40_64	-0.29	0.00
New_Urb	-0.35	0.00
West	-0.35	0.00
Dur_Res	-0.36	0.00
EDU_High	-0.40	0.00
HMar_WOCh	-0.53	0.00
Dutch	-0.83	0.00

Table 4.5: Correlation test between Foreign Vibrant and composed variables

The first indicator *Housing Marketization* is mainly composed of private housing influence, private owners, homeowners, increasing values in home sales, attractive housing infrastructure characterized as old constructions, and bigger living spaces. Additionally, this indicator has a significant correlation with WOZ, which means that higher values in the indicator measure attractive properties that can be marketed. On the other side, negative values are strongly influenced by properties with less value in WOZ (Table 4.7). Furthermore, the segment of housing corporations strongly determines the other side of the housing market. The main characteristic here is that these houses can not be sold but are dominant in the total housing stock. This indicator measures the pressure related to the privatization of the housing markets and the characteristics of these houses. Indeed, the higher values of property valuation relate to the pressure on this segment that makes it more attractive for investing purposes.

The second indicator is *Housing Acquisition Interest*. The indicator measures the housing propensity to be acquired due to its physical characteristics. In that sense, old houses with either smaller or bigger living spaces are better valued and targeted by investors or homeowners. The negative correlation with the number of occupants (OccuHome) suggests that neighborhoods with expensive houses are not occupied all the time (Table 4.8). Lower values in the indicator unveil that newer houses are not attractive to be acquired in the market, which also is related to the fact that housing corporations still dominate the overall housing market.

Table 4.6 contains the quintiles for further comparisons and neighborhood characterization. An overall analysis per district reveals that Centrum is close to not far from the general behavior in Housing Interest Acquisition, and it is being privatized —medium-high on *housing marketization*. The Niew-West district addressed the fact of Medium-

High levels of privatization and Medium-Low values on acquisition interest. Noord and West are not far from the overall city with around 50% on housing corporations, 20% of private housing, leading by small living spaces, and city average property valuation. The same case for Oost district regarding *housing marketization* but having Low interest in housing acquisitions. Westpoort is highly privatized, especially by homeowners, and either smaller or bigger living spaces characterize the housing infrastructure. Zuid has a mixing of housing distributions (Medium-High *housing marketization*) and tends to be attractive due to old houses with high valuation prices. Zuidoost tends to have older infrastructure that is less attractive in the market due to the dominant presence of housing corporations (Figure 4.6 and Tables A.3 and A.4).
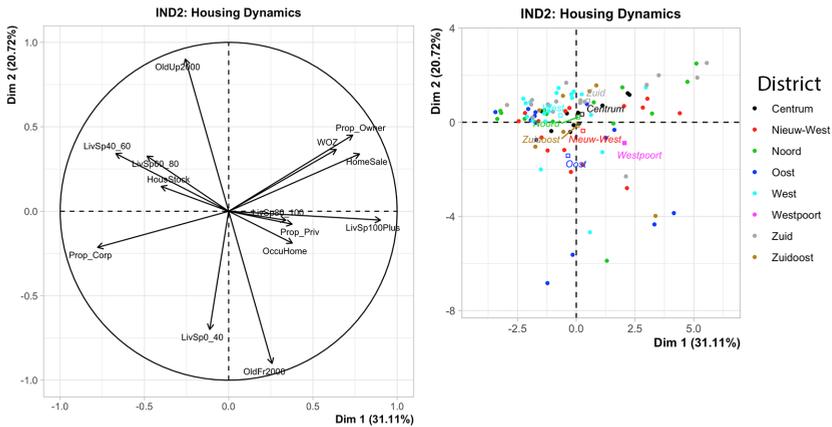

Figure 4.6: ACP results. Correlation circle and neighborhoods projections on factors. Indicators Housing Dynamics

Levels	Housing Marketization	Housing Acquisition Interest
Low	$(-\infty, 37.36]$	$(-\infty, 45.12]$
Medium-Low	$(37.36, 42.74]$	$(45.12, 52.28]$
Medium	$(42.74, 50.61]$	$(52.28, 55.04]$
Medium-High	$(50.61, 64.40]$	$(55.04, 58.99]$
High	$(64.40, \infty)$	$(58.99, \infty)$

Table 4.6: Categories for the Housing Dynamic indicators

Variables	Correlation	p.value
LivSp100Plus	0.90	0.00
HomeSale	0.78	0.00
Prop_Owner	0.74	0.00
WOZ	0.64	0.00
OccuHome	0.38	0.00
Prop_Priv	0.38	0.00
LivSp80_100	0.34	0.00
OldFr2000	0.26	0.01
OldUp2000	-0.26	0.01
HousStock	-0.40	0.00
LivSp60_80	-0.48	0.00
LivSp40_60	-0.67	0.00
Prop_Corp	-0.78	0.00

Table 4.7: Correlation test between Housing Marketization and composed variables

Variables	Correlation	p.value
OldUp2000	0.90	0.00
Prop_Owner	0.45	0.00
WOZ	0.37	0.00
LivSp40_60	0.34	0.00
HomeSale	0.34	0.00
LivSp60_80	0.33	0.00
OccuHome	-0.19	0.06
Prop_Corp	-0.21	0.03
LivSp0_40	-0.70	0.00
OldFr2000	-0.90	0.00

Table 4.8: Correlation test between Housing Acquisition Interest and composed variables

4.3. CONCLUSION

A literature review was used to answer this question. Firstly, income represents not only the mechanism that enables the consumption in the economy but also it expresses household wealth and the formation of similar groups denominated socio-economic status. Gentrification is related at this point because the process is visible when there are groups of people with better off conditions who can shape the environment affecting the living conditions of others. The literature supports the idea that gentrification is related to the uneven accumulation of wealth in the housing market, enabling the formation of high-income classes that can displace low-income residents. Insofar to identifying neighborhoods, measuring the income growth per areas during a sufficient period can lead to establishing the households with better socio-economic conditions. Therefore, households in these types of neighborhoods can be considered as potential gentrifiers. Applying the concept of income growth to the Amsterdam case during 2007 to 2018, thirty (30) neighborhoods were identified as gentrified. Low (10), average (8), and high (12) income neighborhoods compose the set. These changed their status given the overall city growth.

Secondly, even though income represents a precise measure of the socio-economic change at the neighborhood level, household features such as education level, ethnicity, or the house characteristics are related not only with income but also with gentrification. The representation of gentrification through additional measures improves how the process of class formation takes place in cities. Based on previous research, this dissertation proposes to study and measure **housing characteristics** and **housing dynamics**, which help characterize the gentrification process. **Two indicators for Housing Characteristics** were designed and calculated from 2007 to 2018: *residential mobility* and *foreign vibrant*, and **two for Housing Dynamics** were designed and calculated from 2011 to 2018: *housing marketization* and *housing acquisition interest*.

By definition, the indicators are calculated to distinguish characteristics associated with gentrification. For instance, areas with potential future gentrifiers: western young adults who are highly educated living in small spaces and willing to migrate quickly from the area. The four indicators measure different characteristics of the households and

housing system, showing a positive relationship with gentrified areas. Hence, in the vision of this framework, proposed gentrification is captured along the period of observation.

4

5

FINDING RELATIONSHIPS BETWEEN AIRBNB AND GENTRIFICATION

This chapter intends to find the quantitative relationships between Airbnb and gentrification. The analysis is divided into two parts. The first one shows the distribution of main Airbnb's characteristics (listings, prices, revenue). Section 5.1 aims to find out Airbnb differences between the classification of the gentrified neighborhood —*which*. The second part goes further in the exploration of relationships by including the indicators proposed. This part is carried out by studying the propensity of short-term rentals given the indicators and the gentrification conditions with more revenue incentives. Section 5.2.2 shows the results by applying a log-linear model for gentrified neighborhoods, other neighborhoods, and the city level.

Remark: The data used in the comparison corresponds to the data available geographically and in time. The 76 neighborhoods involved in this comparison were the output of the data processing. Moreover, the comparison is made from 2015 to 2018.

5.1. ANALYSIS OF AIRBNB IN GENTRIFIED NEIGHBORHOODS

The distribution of Airbnb has grown since 2015. In 2016 the number of listings increased by 49.7%, passing from 14,350 to 21,488. In 2017 the increment was 20%, and in 2018 it shows a decrease in 8.7%. The numbers lead to establishing a relationship with higher prices (Figure 5.1). Additionally, considering that prices are also affected by the inflation fluctuations, the price per night was also transformed using the CPI. In both cases, the growth is undoubted, rising 13.7% from 2015 to 2018. Indeed, the boxplot shows no atypical average prices per neighborhood; these values are calculated after the cleaning and process described in section 3.4.2.

The price per night is assumed to have a certain relationship with the household socio-economic conditions (Alizadeh *et al.*, 2018). In this regard, the price per night tends to grow after scrutinizing the income change throughout the years. Notwithstanding, the affirmation of a causal relationship is not directly addressed due to the number
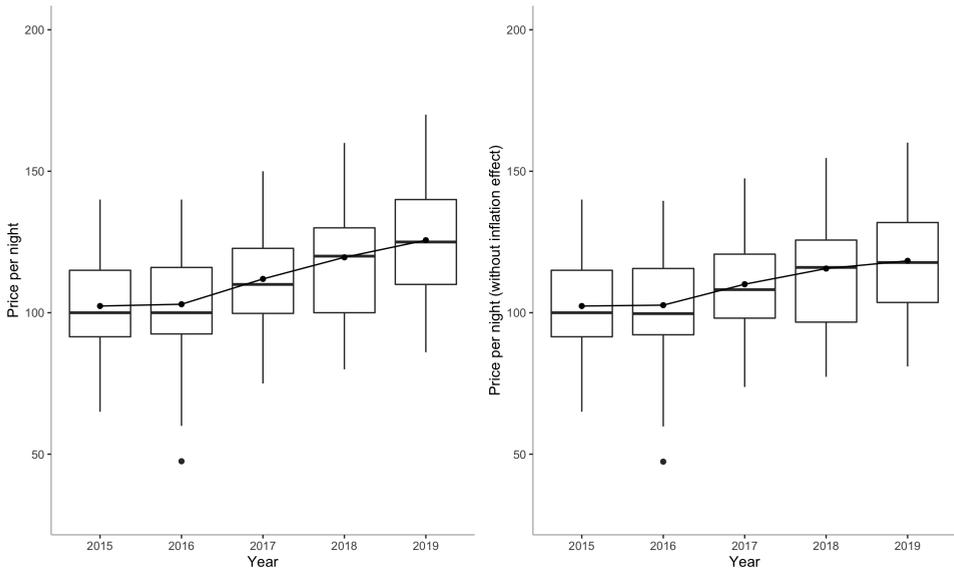
Figure 5.1: Comparisons between Airbnb prices per night. Left raw price per night. Right price without the effect of inflation 2015-2018

of additional factors not captured. Tow analysis showed an existing significant correlation between both characteristics. The study per year (Table 5.1) shows a linear relationship of $\rho \approx 0.45$, which is statistically significant in all the years. Moreover, an Analysis Of Variance (ANOVA) shows that discounting years' effect, the relationship between income and price per night is significant (Figure 5.2).

Table 5.1: Correlation test between Income and Airbnb Price per night 2015-2018

Correlation	Year	95% Confidence Interval	Significance
0.443	2015	(0.248, 0.604)	3.74E-05
0.353	2016	(0.145 , 0.53)	0.001239
0.487	2017	(0.301, 0.636)	3.55E-06
0.533	2018	(0.359, 0.671)	2.08E-07

The methodology applied to the Airbnb price per night result in the identification of 28 neighborhoods gentrified from 2015 to 2018. This exploratory analysis helps to identify 11 neighborhoods gentrified by price and income (Figure 5.3). These neighborhoods are mostly located in West, Zuid and Oost; the map also shows proximity to the city center, leading to a relationship with the high number of listings. The neighborhoods identified are presented in Table 5.2.

```
Analysis of Variance Table

Response: medianPrice
            Df Sum Sq Mean Sq F value    Pr(>F)
IHHINK_GEM   1 23779 23779.1  94.029 < 2.2e-16 ***
year         3 13230  4410.2  17.439 1.633e-10 ***
Residuals  321 81178   252.9
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```
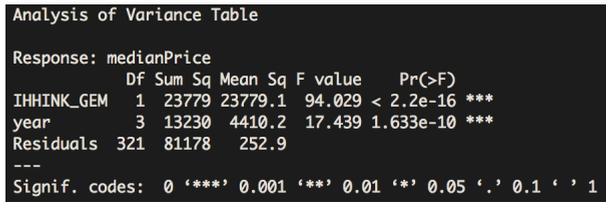
Figure 5.2: Anova - Regression price explained by income

Table 5.2: Neighborhoods gentrified by income and Airbnb price per night growth

Code	Neighborhood	District	Income category
E17	Da Costabuurt	West	Average
E18	Kinkerbuurt	West	Low
E38	Erasmuspark	West	Low
E40	Geuzenbuurt	West	Average
K25	Nieuwe Pijp	Zuid	Low
K46	Willemspark	Zuid	High
M28	Oosterparkbuurt	Oost	Low
M31	Indische Buurt West	Oost	Low
N66	Oostzanerwerf	Noord	Average
N67	Kadoelen	Noord	High

District	Neigh. Gentrified Price
Centrum	1
Nieuw-West	1
Noord	3
Oost	5
West	10
Westpoort	0
Zuid	5
Zuidoost	0
Total	28
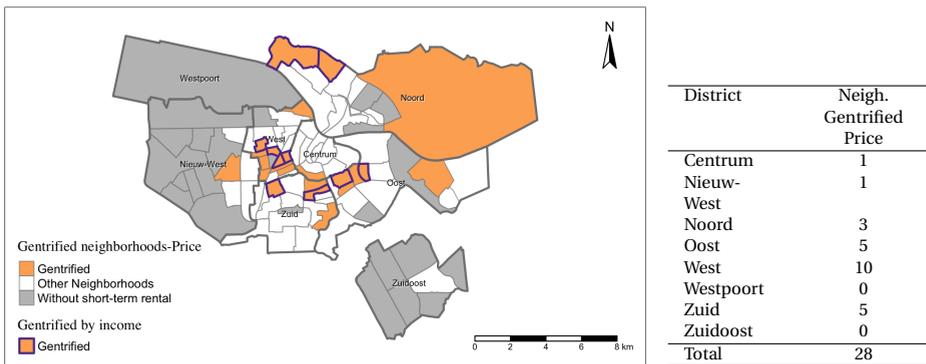
Figure 5.3: Gentrified Neighborhoods by Airbnb price. Neighborhoods gentrified by income are border highlighted

5.1.1. COMPARISON BETWEEN GENTRIFIED NEIGHBORHOODS AND AIRBNB

The first comparison between the listings and price per night in gentrified neighborhoods per income have slight differences (Figure 5.4 and 5.5). The number of properties shows similar distributions regarding the quartiles (25% and 75%); however, the median of the number of properties is higher in gentrified neighborhoods. Specifically, in 2017 the median notably exceeds the median on other types of neighborhoods. In 2018 the

distribution is similar to 2016, showing that Airbnb's intensity was reduced in the overall city. Furthermore, the price per night distribution indicates similar patterns related to the differences in the median. In this regard, the prices' distribution looks less dispersed, which is related to a more homogeneous number of properties in those neighborhoods. Moreover, the Figure 5.6 shows the expected total revenue distributed in gentrified and other neighborhoods. The plot shows an slightly higher revenue captured on gentrified neighborhoods.

Figure 5.7 shows a different pattern since the distribution in gentrified neighborhoods by income category is inversely related. Neighborhoods with low and average income have more annual revenue than those with high incomes. In this regard, gentrified neighborhoods with low-medium income tend to capture the main Airbnb revenue benefits.
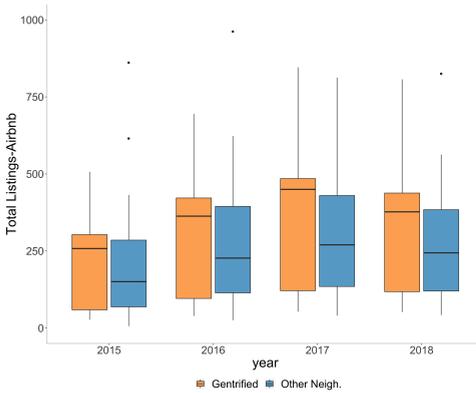

Figure 5.4: Average number of listings per neighborhood in gentrified and other neighborhoods
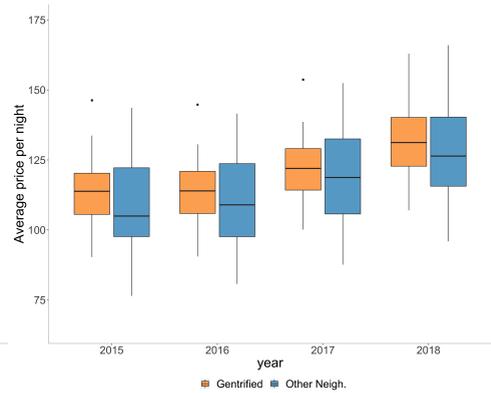
Figure 5.5: Average price per night per neighborhood in gentrified and other neighborhoods
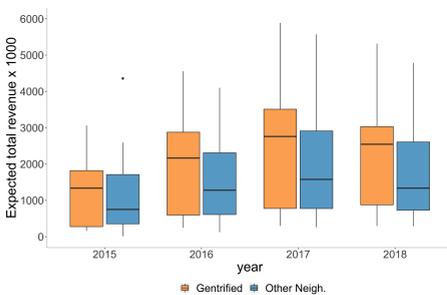

Figure 5.6: Expected total revenue per neighborhhods in gentrified and other neighborhoods
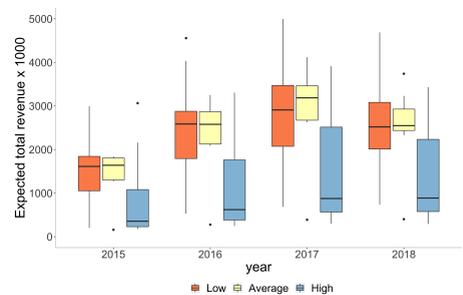
Figure 5.7: Expected total revenue per income categories in gentrified neighborhoods

COMPARISON INDICATORS WITH GENTRIFIED NEIGHBORHOODS

A quick overview of the distribution of indicators per gentrified and other neighborhoods is presented in Figures A.3, A.4, A.5, and A.6. *Residential mobility* shows higher

values in gentrified neighborhoods in all the years. Moreover, gentrified neighborhoods are slightly over the average, whereas the remaining areas are below average until 2014. The *foreign vibrant* indicator shows that gentrified neighborhoods are below the average without a marked tendency. The numbers remain constants along the observation period. Additionally, the plots do not exhibit notable differences between the medians for both neighborhood categories. *Housing marketization* is rising in both types of neighborhoods. In particular, by 2011, gentrified neighborhoods show a pattern below the average. The continuous growth in the indicator shows that these neighborhoods are above the average by 2018. This indicator also exhibits higher values in gentrified neighborhoods. Similar differences with other neighborhoods are presented for *housing acquisition interest*. In this case, gentrified neighborhoods are always over the average, steadily rise until 2018.

5.2. IDENTIFYING RELATIONSHIPS BETWEEN INDICATORS AND AIRBNB CHARACTERISTICS

The comparison between the Household Characteristics indicators and Airbnb pice distribution are presented in Figures 5.8 and 5.9. In general, plots show important relationships between the values in the indicator with the Airbnb characteristics.

Higher prices grow while *residential mobility* increases. That condition is maintained on all the years—2015 to 2018. The medium and high categories (essentially single-person households, high education, and Dutch population, population between 23 and 39 years old) exhibit large values in the price per night. For *foreign vibrant* indicator, neighborhoods in the medium-low and low categories (mostly western or non-western, low levels of migration, highly educated, high residency duration) are associated with higher Airbnb prices.
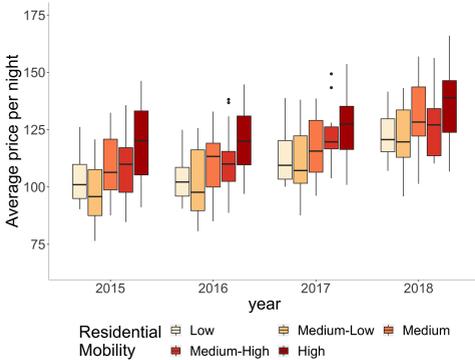

Figure 5.8: Distribution price per night on *residential mobility* categories
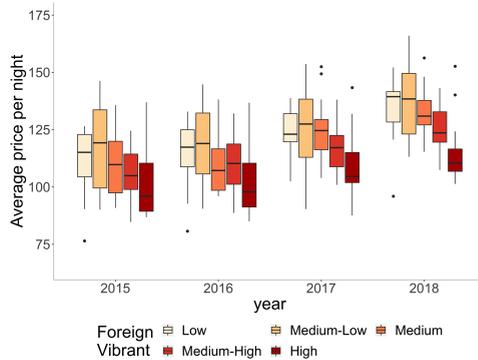
Figure 5.9: Distribution price per night on *foreign vibrant* categories

The indicator for *housing marketization* indicates that higher prices correspond to large values in the indicator. This indicator also shows that prices follow a clear tendency according to the time. In 2015 the privatization level did not relate with the prices since neighborhoods with a medium-low level had similar values compared to the medium-

high. However, by 2017 and 2018, the neighborhoods exhibit a clear tendency defined by higher prices per night (Figure 5.10). In the case of the total listings (Figure A.9), there is an inverse U shape in the outcomes. Neighborhoods in the low and higher cluster tend to have a similar number of properties. In contrast, those in the middle-low, middle, and middle-high contains a more significant average of total listings.

The indicator *housing acquisition interest* indicates that neighborhoods in the medium category tend to have lower values than the medium-low ones. Even though there is a relationship on each category's prices, the quartiles show similar numbers across the different neighborhood categories (Figure 5.11). The number of properties per each class indicates that the low category differentiates from the rest. Thus, houses between 0 to 40 and higher than 100 square meters, on neighborhoods with lower WOZ and mixing of housing ages, are those with lower Airbnb listings (Figure A.10).
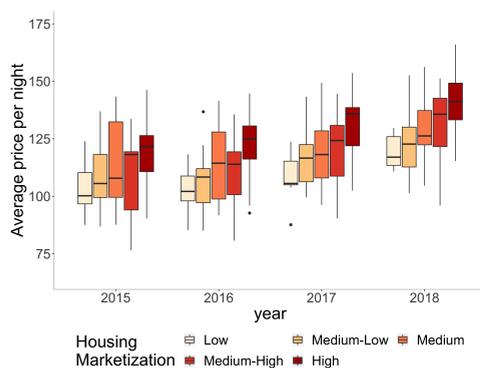

Figure 5.10: Distribution price per night on *housing marketization* categories
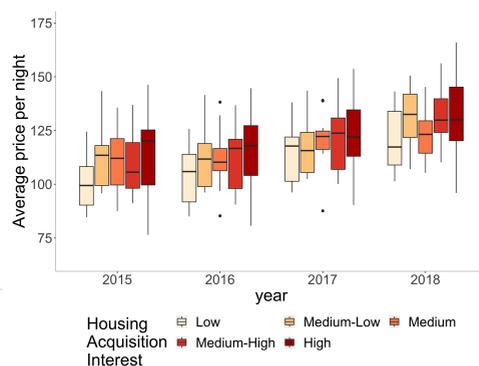
Figure 5.11: Distribution price per night on *housing acquisition interest* categories

5.2.1. RELATIONSHIPS BETWEEN THE SHORT-TERM RENTAL AND LONG-TERM RENTAL ON GENTRIFIED NEIGHBORHOODS

Since the short-term rentals are evenly spread in the city, this section points out to determine the city's sectors with a high propensity to Airbnb, given the household characteristics and housing dynamics. The exploration is subjected to gentrified neighborhoods to see the impact on the ongoing gentrification process.

Table 5.3 shows the distribution of the different years and each indicator class. The Housing Characteristics set of indicators exhibit patterns in the Medium and Medium-High classes.

The *residential mobility* indicates that neighborhoods in the medium-high and high class tends to take long-term houses and transform into the short-term. Indeed, the numbers increase over the years, showing Airbnb's growth on all the types of gentrified neighborhoods. The only category that shows an increment in 2018 is the medium-high (16.30%). Neighborhoods in other categories point out a minor change in the percentages. The *foreign vibrant* indicator is characterized by having steady increments from 2015 to 2017 on all the classes. In 2018 the numbers decreased to similar values in

2016 despite an increment of 0.3% in the Medium-High neighborhood types. Furthermore, the highest numbers are concentrated in the Medium and Medium-High neighborhoods, except for 2015, which is the lowest.

Housing Dynamics indicates large numbers in the low, medium-low, and medium class. Also, it shows that the numbers increase with the time from 2015 to 2017; in 2018, the pattern is reduced in some decimal points. For instance, for *housing marketization*, strong increments are noticeable from 2015 to 2017 in the low category passing from 11.06% to 19.63% and doubling in the Medium category to 11% in 2018. The high category showed steady increments to 6.23% in 2017. By 2018, it decreases to the 5% range. The highest percentage is in the low category in 2017, with 19.63%. For *housing acquisition interest*, the low and high categories show similar numbers in 2015 and 2016. By 2017, the difference is at least 4% larger in the high category. The medium category dominates the short-term propensity with values above 10% from 2016 onward and passing from 8.41% in 2015 to 17.60% in 2017. Interestingly the low category shows in 2018 a lower percentage compared with 2015.

Indicator	Year	Low(%)	Medium-Low(%)	Medium(%)	Medium-High(%)	High(%)
Residential Mobility	2015	2.40	2.16	6.26	8.83	6.67
	2016	3.67	4.80	8.26	14.86	9.79
	2017	4.85	6.28	9.17	14.74	11.99
	2018	4.81	6.15	7.48	16.30	10.52
Foreign Vibrant	2015	5.35	5.57	4.68	8.05	5.20
	2016	6.45	9.45	8.64	11.51	6.73
	2017	7.96	9.90	12.92	12.09	10.82
	2018	6.97	9.28	8.58	12.39	7.52
Housing Marketization	2015	11.06	9.20	5.82	5.88	3.24
	2016	17.84	13.32	9.29	7.85	5.02
	2017	19.63	17.28	11.48	9.56	6.23
	2018		16.22	11.08	10.08	5.14
Housing Acquisition Interest	2015	5.86	6.33	8.41	6.56	5.20
	2016	7.78	9.46	14.98	8.18	7.60
	2017	5.60	11.00	17.60	10.13	9.94
	2018	5.22	7.09	15.09	15.42	7.78

Table 5.3: Average of proportion of Airbnb Entire Houses rented given long-term rental in gentrified neighborhoods. Distribution among the indicator classes

The dynamic analysis shows different areas characterized by the indicators. According to Table 5.3 results, the areas with bigger impacts on the long-term rental are disaggregated by the neighborhood characteristics measured through the indicators. For *residential mobility* is the medium-high area, *foreign vibrant* is medium-high, *housing marketization* is the low and medium-low area, and *housing acquisition interest* is the medium area. Figures 5.12 to 5.15 show the geographical distribution of each area accordingly. Table 5.4 shows the distribution of the neighborhoods with higher impacts of short-term rental in the long-term rental market. The neighborhoods Kinkerbuurt, Nieuwe Pijp, Oosterparkbuurt, and Indische Buurt West are highlighted because they

are also identified as neighborhoods gentrified by income and Airbnb price per night. Interestingly these neighborhoods are in the low income categories.
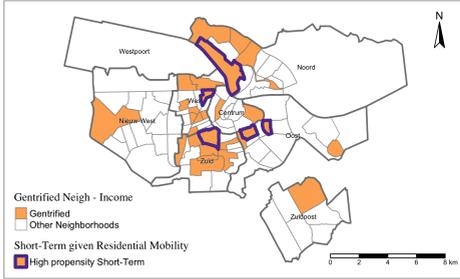
Figure 5.12: Neighborhoods gentrified with high propensity to short-term rentals given the *residential mobility*
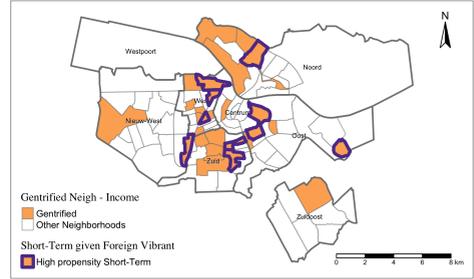
Figure 5.13: Neighborhoods gentrified with high propensity to short-term rentals given the *foreign vibrant*
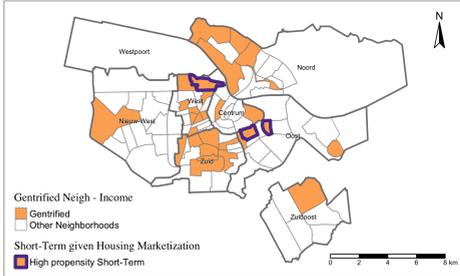

Figure 5.14: Neighborhoods gentrified with high propensity to short-term rentals given the *housing marketization*
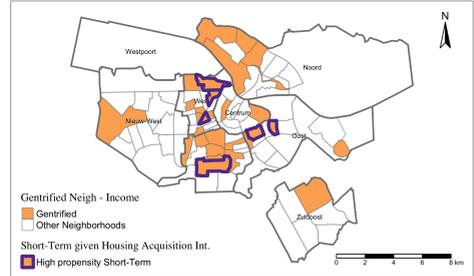
Figure 5.15: Neighborhoods gentrified with high propensity to short-term rentals given the *housing acquisition interest*

5.2.2. RELATIONSHIPS BETWEEN THE INDICATORS AND AIRBNB REVENUE

The analysis derived from the expected revenue on gentrified neighborhoods suggested that revenue had steadily increased from 2015 to 2017 and drop in 2018. Moreover, the differences in the revenue distribution among income classes indicate that other characteristics influence such a divergence. For this step, a log-regression model[1] is used to establish what type of differences can be found in the gentrified and other neighborhoods. Therefore, the idea is to find the correlation structure between the revenue and Household Characteristics and Housing Dynamics indicators. The analytic expression for the set of regression follows

$$\log(E_{ij}(R)) = \beta_0 + \sum_{k=1}^{4} \beta_k X_{ij}^k + \beta_5 T_j + e_{ij} \tag{5.1}$$

---

[1]The decision for this model is followed after carried out a Box-Cos test. The results of the logarithmic transformation are presented in Figures A.11, A.12, and A.13

Code	Neighborhood	District	Income cat.	RM	FV	HM	HAI
A09	Oostelijke Eilanden/Kadijken	Centrum	Average		✓		
E13	Spaarndammer- en Zeeheldenbuurt	West	Low		✓	✓	✓
E14	Staatsliedenbuurt	West	Low	✓	✓		✓
E18	**Kinkerbuurt**	West	Low		✓		✓
K23	Zuidas	Zuid	High				✓
K25	**Nieuwe Pijp**	Zuid	Low		✓		
K44	Hoofddorppleinbuurt	Zuid	Average		✓		
K47	Museumkwartier	Zuid	High	✓			
K52	Scheldebuurt	Zuid	High		✓		
M28	**Oosterparkbuurt**	Oost	Low	✓	✓	✓	✓
M31	**Indische Buurt West**	Oost	Low	✓		✓	✓
M51	IJburg Zuid	Oost	High		✓		
N70	Banne Buiksloot	Noord	Low		✓		
N71	Noordelijke IJ-oevers West	Noord	High	✓			

Table 5.4: Unique set of neighborhoods identified with high propensity to short-term rentals. Residential mobility (RM), Foreign Vibrant (FV), Housing Marketization (HM), Housing Acquisition Interest (HAI), Income category (Income cat.)
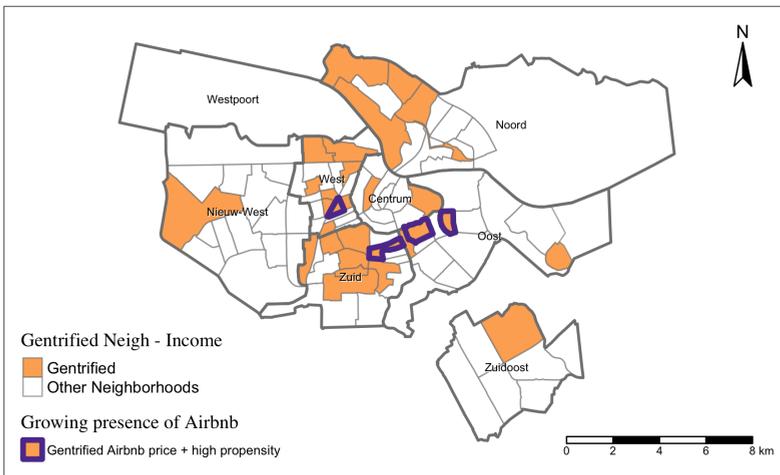

Figure 5.16: Neighborhoods gentrified by income and Airbnb price with high propensity to short-term rentals (Table 5.4)

where $i = 1, \ldots, n$, with n the number of neighborhoods for each case. The dummy variable $T_j = 2015, 2016, 2017, 2018$. The Amsterdam model is composed by 76 neighborhoods, the gentrified neighborhoods model has 25, and other neighborhoods model has 48. The value X_{ij}^k corresponds to the indicator k (*residential mobility, foreign vibrant, housing marketization,* and *housing acquisition interest*). Thus, $E_{ij}(R)$ represents the revenue for neighborhood i in year j, and e_{ij} is the random error assumed that follows a $N(0, \sigma^2)$.

Table 5.5 shows the final values for interpretation. Since it is a log-normal regression model the estimations are obtained via $(e^{\hat{\beta}_i} - 1)\%$, the exact values are described in Table A.9, A.10 and A.11.

The results can be analyzed comparing the percentage of the increment (positive percentage) or decrement (negative percentage) with the Reference (Low) value, which is the estimation if all the categories are low. For instance, one gentrified neighborhood on a medium-low category in *residential mobility* is expected to increase its revenue in 547.9% from €100,157.58 (€100,157.58 *5.479 = €548,763.4). Moreover, the regression model identifying some variables that are not significant (*ns*: non-significant) or significant at $\alpha = 0.1$ (*s10*).

The results show that categories for *residential mobility* are higher in the medium-low and medium-high categories for gentrified neighborhoods; the increment is above 5 times more from €100,157.58. For other neighborhoods, the revenue in low categories starts at €37410.25 with the highest increment in the high category. Comparing gentrified with overall Amsterdam in almost all the categories, the increments are larger. The *foreign vibrant* indicator shows interesting results since the major changes are occurring in Other neighborhoods. For gentrified areas, the only significant difference is identified in the medium-low class that is 50.7.%, which is the biggest increment across the whole categories. In this regard, it is below the city estimation, which is 97.83%.

In the case of *housing marketization* the overall results show negative growth in all the categories. The lower growth is identified in the medium-high that shows similar values to the high category. The interesting results are found in the significance when the model is split in gentrified and other neighborhoods. The *housing acquisition interest* exhibit a rise in the growth percentages. Medium-low and high categories have values above 300% increment, which contrasts with lower values in other neighborhoods and even Amsterdam.

Finally, another important finding is that year estimation improves, capturing the different changes. The Amsterdam model shows that in 2018 the increment is less compared with 2017. Other neighborhoods follow the same patters reaching 129%. However, gentrified neighborhoods exhibited a constant increment from 83.6% in 2016 to 143.8% in 2018.

Indicator	Estimation/Category	Gentrified	Other-Neigh.	Amsterdam
Reference	Intercept	100157.58	37410.25	39160.52
Residential Mobility	Medium-Low	547.9%	$21.7\%^{ns}$	69.95%
	Medium	223.9%	144.5%	229.98%
	Medium-High	519.3%	300.5%	410.76%
	High	468%	435%	462.32%
Foreign Vibrant	Medium-Low	50.7%	122.1%	97.83%
	Medium	$23.2\%^{ns}$	165.3%	89.2%
	Medium-High	$38.3\%^{ns}$	241.6%	163.87%
	High	$-20.5\%^{ns}$	313.8%	156.18%
Housing Marketization	Medium-Low	$-36.3\%^{s}10$	$19.4\%^{ns}$	$21\%^{ns}$
	Medium	-53%	32.8%	$22.42\%^{ns}$
	Medium-High	-65.6%	$9.7\%s10$	$-5.38\%^{ns}$
	High	-60.9%	$134.2\%^{ns}$	$61.54\%^{ns}$
Housing Acquisition Interest	Medium-Low	424.1%	251.1%	245.22%
	Medium	190.7%	155.8%	159.86%
	Medium-High	308.8%	137%	159.26%
	High	324.1%	110%	167.14%
Year	2016	83.6%	78.4%	73.66%
	2017	139%	129%	125.23%
	2018	143.8%	98.6%	99.94%

Table 5.5: Estimated increment per Indicator-Category. Log-linear regression outcomes. Extended results in Table A.9, A.10 and A.11. *ns* means non-significant, *s*10 means significant at $\alpha = 0.1$

5.3. CONCLUSION

Firstly, the areas with high impact by the short-term rentals are mostly those that surround the city center. The districts Zuid (five neighborhoods), Oost and West (three neighborhoods), and Centrum (one neighborhood) show connections with the distance with the city center. The district Noord (two neighborhoods) shows distant neighborhoods with a high presence of Airbnb. The districts mentioned are characterized by their relationships with the indicators proposed. These areas were classified with medium-high values in *Residential mobility* and *foreign vibrant* , low and medium-low in *housing marketization* and medium in *housing acquisition interest*.

Moreover, there are four neighborhoods —Kinkerbuurt, Nieuwe Pijp, Oosterparkbuurt, and Indische Buurt— the most impacted neighborhoods by Airbnb regarding the long-term rentals. Moreover, these neighborhoods are low-income, which implies a significant pressure in the socio-economic distribution. Therefore, some changes in the household characteristics and housing dynamics can take place since the relationship with the additional dimensions of gentrification.

Secondly, the analysis showed a relationship between the household and housing characteristics with the short-term rentals business in Airbnb. Regression analysis helped to identify the increments in revenue given the indicators proposed. Different household and housing characteristics enable more revenue. Household composition, education, migration, age, and ethnicity influence Airbnb's revenue growth (*residential mobility*). Moreover, changes in the housing infrastructure, property valuation, and home sales

percentage influence the total revenue growth. An additional finding points out that neighborhoods with lower *housing marketization* (near the city center and gentrified) show higher revenues. Moreover, the neighborhoods with living spaces between 40 and 80 square meters, a higher share of housing stock, lower property valuations, and older infrastructures are profiting more and affected by Airbnb short-term rental market. Indeed, the incentive to have Airbnb in these areas are related to how people perceive the house as a common need. The potential increments in revenue, which should account for additional income, can exacerbate gentrification patterns in these areas. Therefore, the commodification of housing can exist in sub-populations that reside in neighborhoods with said characteristics.

5

6

DISCUSSION

The scientific research towards understanding gentrification and how Airbnb has been related to this process motivated this dissertation. Scholars have studied the evolution of gentrification as a social, economic, and political process that impacts the population and housing systems in cities. Besides, scholars have studied how Airbnb has spread and disrupted the city as a socio-technical system. Specifically, the studies have researched how to address the regulation of CBIs, the impact on the housing rental prices, and the relationship with cities' socio-economic characteristics. Concretely, gentrification appears in the literature to strengthen the debate about Airbnb theoretically; where and how the rent gaps emerge in the context of the consequences of the Airbnb business and data-driven model. However, there is little research about the dynamic relationship between Airbnb and gentrification and the role of the discussion about the commodification of housing. This dissertation intends to enlighten the debate through a quantitative approach by studying the evolution of these phenomenons in time.

6.1. REVISITING RESEARCH QUESTIONS

RQ1 (Theoretical): *How can the gentrification process be measured using main neighborhood characteristics?*

A literature review was used to answer this question. Firstly, income represents not only the mechanism that enables the consumption in the economy but also it expresses household wealth and the formation of similar groups denominated socio-economic status. Gentrification is related at this point because the process is visible when there are groups of people with better off conditions who can shape the environment affecting the living conditions of others. The literature supports the idea that gentrification is related to the uneven accumulation of wealth in the housing market, enabling the formation of high-income classes that can displace low-income residents. Insofar to identifying neighborhoods, measuring the income growth per areas during a sufficient period can lead to establishing the households with better socio-economic conditions. Therefore, households in these types of neighborhoods can be considered as potential gentrifiers.

Applying the concept of income growth to the Amsterdam case during 2007 to 2018, thirty (30) neighborhoods were identified as gentrified. Low (10), average (8), and high (12) income neighborhoods compose the set. These changed their status given the overall city growth.

Secondly, even though income represents a precise measure of the socio-economic change at the neighborhood level, household features such as education level, ethnicity, or the house characteristics are related not only with household wealth but also with gentrification per se. The representation of gentrification through additional measures improves how the process of class formation takes place in cities. Based on previous research, this dissertation proposes to study and measure **Housing Characteristics** and **Housing Dynamics**, which help characterize the gentrification process. **Two indicators for Housing Characteristics** were designed and calculated from 2007 to 2018: *residential mobility* and *foreign vibrant*, and **two for Housing Dynamics** were designed and calculated from 2011 to 2018: *housing marketization* and *housing acquisition interest*.

By definition, the indicators are calculated to distinguish characteristics associated with gentrification. For instance, areas with potential future gentrifiers: western young adults who are highly educated living in small spaces and willing to migrate quickly from the area. The four indicators measure different characteristics of the households and housing system, showing a positive relationship with gentrified areas. Hence, in the vision of this framework, proposed gentrification is captured along the period of observation.

RQ2 (Quantitative based): *Which gentrified areas of Amsterdam have been influenced by the introduction of Airbnb?*

The areas with high impact by the short-term rentals are mostly those that surround the city center. The districts Zuid (five neighborhoods), Oost and West (three neighborhoods), and Centrum (one neighborhood) show connections with the distance with the city center. The district Noord (two neighborhoods) shows distant neighborhoods with a high presence of Airbnb. The districts mentioned are characterized by their relationships with the indicators proposed. These areas were classified with medium-high values in *Residential mobility* and *foreign vibrant*, low and medium-low in *housing marketization* and medium in *housing acquisition interest*.

Moreover, there are four neighborhoods —Kinkerbuurt, Nieuwe Pijp, Oosterparkbuurt, and Indische Buurt— the most impacted neighborhoods by Airbnb regarding the long-term rentals. Moreover, these neighborhoods are low-income, which implies a significant pressure in the socio-economic distribution. Therefore, some changes in the household characteristics and housing dynamics can take place since the relationship with the additional dimensions of gentrification.

RQ3 (Quantitative based): *What have been the relationships displayed by Airbnb on the commodification of housing in gentrified neighborhoods in Amsterdam?*

The analysis showed a relationship between the household and housing characteristics with the short-term rentals business in Airbnb. Regression analysis helped to identify the increments in revenue given the indicators proposed. Different household and housing characteristics enable more revenue. Household composition, education, migration, age, and ethnicity influence Airbnb's revenue growth (*residential mobility*). Moreover, changes in the housing infrastructure, property valuation, and home sales percentage

influence the total revenue growth. An additional finding points out that neighborhoods with lower *housing marketization* (near the city center and gentrified) show higher revenues. Moreover, the neighborhoods with living spaces between 40 and 80 square meters, a higher share of housing stock, lower property valuations, and older infrastructures are profiting more and affected by Airbnb short-term rental market. Indeed, the incentive to have Airbnb in these areas are related to how people perceive the house as a common need. The potential increments in revenue, which should account for additional income, can exacerbate gentrification patterns in these areas. Therefore, the commodification of housing can exist in sub-populations that reside in neighborhoods with said characteristics.

Main RQ: *How has the evolution in Airbnb's adoption influenced gentrification's dynamics, and how does it relate to the commodification of housing in Amsterdam?*

Firstly, the relationship between income and price per night led to establishing neighborhoods with higher growth in both conditions. Even though the relationship is not explicit, better socio-economic conditions can be related to having more renovated houses or located in demanded places. Thus, higher Airbnb prices can be expected in the form of additional income returns. Since gentrification is related to profitable potential gaps from the housing rental market, Airbnb works as a stimulus in some gentrified neighborhoods.

Secondly, the analysis of the data collected allowed the identification of common features among the residents of the houses offered through Airbnb. The residents who are more willing to rent the house in the platform are young-adult people with high social mobility and in the stage of family forming (18-39 years old, single families, couples without children, highly educated, western or Dutch). The houses where these people live are located mostly in low-income neighborhoods. This finding allows to argue that Airbnb spread is facilitated by people who are starting to consolidate their personal and professional life. Further, some neighborhoods with these characteristics are low-income areas. This analysis leads to thinking that Airbnb can be spread in areas where people move to start to consolidate their personal and professional life. Besides, they can perceive Airbnb as the opportunity to get an additional income from the house.

Thirdly, gentrification and Airbnb are linked through the housing market. Some neighborhoods have higher percentages of long-term rental properties destined for Airbnb short-term rental. It implies less availability of houses for living purposes only. In that sense, the lack of housing combined with an uncontrollable Airbnb activity can affect the housing system's functioning. The potential pressure can exacerbate the prices and transform the living areas into unattainable places for lower-income families and only affordable for a particular segment of the population. Thus, forms of exclusionary displacement can be triggered by either pushing out low socio-economic families or avoiding them to reside in the area.

6.2. Scientific implications

Airbnb is a socio-technical system directly related to housing infrastructure and socio-economic people sub-systems (Figure 1.1). The interaction between the company with the urban environment has led to emergent economic activities, which at the beginning was perceived as simple sources of additional profit from underused assets. However,

the adoption growth has attracted the attention of regulatory agencies and scholars who want to understand the role of this type of CBI in urban planning and design.

- Scholars have tried to understand the role of Airbnb in *gentrification processes* in cities. Gentrification involves the changes in the socio-econonomic conditions at the neighborhood driven by in the physical, social, economic, and political city sub-systems (Atkinson, 2004; Hochstenbach and Musterd, 2018; Lees, Slater, *et al.*, 2008; Lees, Slater, *et al.*, 2010; Musterd, 2014; Raman, 2014; Smith, 1997). The socio-technical characteristic of Airbnb has opened the debate towards the disruptive effects of the platform in the social fabric of the city. Thus, the role played for Airbnb in the explanation of access to urban spaces is central to understand the evolutive form of gentrification. In that sense, Airbnb can influence how, when, and under what conditions the gentrification stages are explained.

From the above explanation, this dissertation intended to find explanations about how Airbnb adoption and the evolution of gentrification are related. The relationship was novelty studied using time as another dimension of the processes. In that sense, one of the main discussions goes towards the question of disruption by Airbnb. The findings showed that the interaction between the city of Amsterdam and Airbnb enabled that the CBI was able to accommodate to the city conditions and success through the data-driven business model. Since the Internet network facilitates the connection of users worldwide to provide services in Amsterdam, Airbnb could adjust their operations to the Amsterdam form and function. The adoption process points out that an uneven distribution of benefits can be established, and those who receive more are specific neighborhoods with special household and housing characteristics.

At this point, the link with gentrification is notorious. The socio-economic changes in neighborhoods showed some relationships with the evolution in Airbnb's spread and its main characteristics. Moreover, from a theoretical perspective, Airbnb could be related to potential rent gaps. Houses can be slightly rebuilt or renovated to make it attractive for short-term rental, increasing the income of homeowners and landlords. Especially young adult populations with high education levels and reduced households (single person, without children, or other composition types).

Additionally, the discussion of gentrification in the era of digital platforms is revisited because the cities have been deindustrialized —post-industrial era— and become more service-oriented. In this regard, Airbnb represents the new forms of data-driven services that operate in a globalized and urbanized world, being able to grow because of the number of users and potential transactions using the platform. The results for Amsterdam showed that Airbnb found a niche in the city that allowed the operation to grow. Therefore the debate needs to be shifted from the disruptive character of Airbnb towards a discussion about how Airbnb adapts its operations given the platform users' characteristics. In that sense, this dissertation opened the lens to quantify the relationship between gentrification as a social, economic, and political consequence and Airbnb as a socio-technical system. The findings show that privileged populations are related to successful Airbnb operations in the city. Thus, these results are aligned with the arguments provided

by D. W. Gray and Wyly (2020) and Lees, Bang, *et al.* (2016) to the explanation of planetary gentrification and the reproduction of neoliberal logic worldwide in the digital era of big-tech industries.

- The implications of these findings on the governance of digital platforms are linked with state-led policy research. The Amsterdam case is particular since it was the first city to adopt Airbnb formally. The implications of decisions are evident on the steep number of listings until 2017 when the new normative entered to restrict the operations for a limited number of rented nights per year (less than 60) and guests (maximum 4 people). The effect of this restriction is reflected in the numbers of 2018 when the listings and revenue decreased. In this regard, the reduced involvement of the municipality of Amsterdam —laissez-faire approach— which gradually moves to ban the CBI partially (Nieuwland, 2017) impacting the platform performance in the city. At this point, the findings identify neighborhoods with a high propensity to short-term rentals, this finding provides insights to the improvement of governance measures to counter the impact of Airbnb. Moreover, governance studies can use the results about the relationship between the potential short-term activities and the household, housing, and socio-economic characteristics.

6.3. POLICY DISCUSSION-RECOMMENDATIONS

Firstly, it is important to acknowledge that The Municipality of Amsterdam (*gemeente*) —the client— has played an important role in the evolution of Airbnb in Amsterdam. The agreement between the municipality and Airbnb have had changes during the last ten years. Firstly, it was stated under a cooperation agreement that Airbnb would share its data to tackle illegal activities in the city (Kramer, 2019). In retribution, the CBI could be able to operate in the city. However, the number of complaints increased: nuisance, safety, and problems with livability, due to the increasing amount of listings that promoted the over-tourism. The regulation included gathering the tourism tax through the platform when the guest is booking the house. The regulation became more strict by limiting the number of nights per night (less than 60 in 2017, and new enforcement to a maximum of 30 from 2019), allowing only four (4) guests in the house, the landlord has to be in the house by the renting time, and making compulsory the submission of a form by the host with the information about the property rental (Het Parool, 2015b; Kramer, 2019; NOS, 2017). Moreover, the *gemeente* was aware of the enormous business behind tourism in the city that depends on the consumption of goods and services. Thus, the agreement considered the transaction of over €25 million in tourist tax since 2015. This income to the *gemeente* compensated the side effects of Airbnb in the city (Airbnb, 2019; Het Parool, 2015a).

The results showed that the implemented regulation in 2017 reduced the listings in 2018 from 25,969 to 23,694. However, the findings showed that prices remained growing, and the revenue was sustained stable —especially in gentrified neighborhoods. Interestingly, the analysis shows that the centrum district neighborhoods were not experiencing major changes in the listings and prices. The impacts started to be perceived in the surrounding districts, where Airbnb started to be adopted. Moreover, neighborhoods

in West (Kinkerbuurt), Zuid (Nieuwe Pijp), and Oost (Oosterparkbuurt, Indische Buurt West) districts could be impacted more by Airbnb. The analysis showed that Airbnb could impact gentrified neighborhoods located far from the city center (more than 2 Km) in Zuid and Noord districts.

From the arguments above, the *gemeente* needs to revisit the regulation framework about the short-term rental companies. The simple approach based on a one-fits-all solution can not counter the side effects of Airbnb. Moreover, to ban the activity in the city center can have a major impact in the mentioned areas; in 2019, the *gemeente* banned the Airbnb operations in some neighborhoods in the centrum district —Burgwallen Oude Zijde, Burgwallen Nieuwe Zijde, and Grachtengordel Zuid. The measures need to consider that the supply of short-term rentals can move to the nearby districts where the gentrification phenomenon has also impacted the residents. In that sense, urban planners can make effective use of the relationship between Airbnb and the socio-economic conditions determined by household characteristics and housing dynamics. It can help them go one step ahead of Airbnb's operations and prevent the uncontrollable spread.

Finally, the regulation needs to revisit the concept of disruptive technologies despite the high impact of CBIs in cities. Airbnb is an example of a technology that enabled the mechanisms to use the platform easily. Although it is explicit that the company needs the users' data to operate, Airbnb functioning depends on the degree of users interaction with the platform. Consequently, both actors (people and Airbnb) mutually shape the operations making the side effects less evident to identify.

6.4. LIMITATIONS AND FUTURE WORK

6.4.1. LIMITATIONS

There are several limitations listed as follows:

- **Quantitative approximation:** the approach to identify gentrification through quantitative methods is always challenging. The number of factors that intervene in this process is unaccountable and not directly measured. At the macro-level, the social, political, and economic conditions can affect the micro-level patterns related to socio-economic development of families. It imposes a limitation to quantitative methods that can offer a limited view of this phenomenon. For instance, statistical methods reflect factor tendencies, but they do not capture the complexity behind other relationships between the macro and micro levels.

- **Theory:** even though gentrification has been widely studied, the Anglo-Saxon explanation dominates the mainstream discussion. For example, the rent gap model explains the process by using capitalism's political and economic theory to argue that the neoliberal model has found room to disrupt welfare social conditions and the housing market. In this regard, this dissertation explains potential rent gaps by Airbnb only visible through the socio-economic relationships with Airbnb operations. However, the theoretical limit is related to the type of dominant political and economic model —which can be seen as partially neoliberal— and how it is related to the potential rent gaps by Airbnb in Amsterdam.

- **Data:** the variables used to measure **gentrification** are highly aggregated to the neighborhood level. It makes difficult micro-level comparisons, for instance, at the household level. The cross-comparisons offer an additional dimension to the household and housing characteristics that can not be captured using statistics per neighborhood. In that sense, CBS consolidates this information through databases that combine surveys and administrative registers, which have more information about the local dynamics. Additionally, some important variables for education, infrastructure, and market rental prices were discarded because they have high percentages of missing values. They depend on biennial surveys that are only published according to the number of respondents.

  The **Airbnb** data was obtained via the website `insideairbnb.com` that makes web scrapping only a few times in the year. Hence, variables such as revenue or seasonal tendencies are not easy to capture. The data is available since 2015 for Amsterdam. For this reason, the comparison is limited to the period of time and availability per year. An alternative is to access the information of `AirDNA.co` that is a company dedicated to data analytics for short-term rental markets.

6.4.2. FUTURE WORK

- **Airbnb city operations:** The capacity of digital platforms to adjust to the local conditions can open the discussion about the idea of understanding these types of companies to the particular conditions in different cities. The social and economic activities can help understand how Airbnb can adjust to the local conditions and whether it depends on different sub-populations, housing, and institutional conditions. A further comparison using the indicators developed in this dissertation can help compare the evolution of the Airbnb adoption in time. This future research can be linked to the fields of governance of CBI and technological and economic change.

- **Exclusionary displacement:** further explanations are needed to establish conditions that make it difficult for some populations to access the housing market in certain neighborhoods in Amsterdam. Moreover, to find relationships with the process of a new societal class formation and its connection with Airbnb. This future research can be connected with urban studies and how socio-technical systems can be related to existing or new phenomenons in cities.

- **Qualitative and Quantitative approaches:** research can be carried out by using a combined approach since the institutional framework that allowed Airbnb in the city changed and influenced it over time. For example, the use of Agent-Based models can help to understand complex interaction on different levels. Further, from a more qualitative side, mapping the main actors is needed their role in the system. From a qualitative side, there is potential research about the validation of the current results. Combining a field study that includes the citizens' perception and the socio-economic conditions can be useful to propose better regulation frameworks. This future research can be liked with better modeling-simulation techniques, urban studies, and the governance of CBIs.

6

- **Predicting the impacts in other neighborhoods:** The comparative study was based on the data available to study the relationship between gentrification and Airbnb. In that sense, some areas were not possible to study in detail. However, these areas correspond to neighborhoods with special characteristics: old populations, migrants, and low income. Further analysis can go deep in research about the consequences of Airbnb spread in the areas without sufficient information.

6

7

CONCLUSIONS

This dissertation addresses an umbrella question about the commodification of housing and the role of socio-technical systems. Two unpredictable processes were discussed: the growth of Airbnb and gentrification. The dynamic policy-making process carried out by the Municipality of Amsterdam motivated the study of gentrification and Airbnb for the city of Amsterdam. The quantitative approach aimed to find insights about the relationship between both processes.

The framework developed to study gentrification was based on the inextricable connection between the socio-economic characteristics of households and housing attributes. The process is linked with the evolution of the class formation and how it shapes the housing conditions at the neighborhood level. The study of income growth allowed to identify 30 gentrified neighborhood. These areas showed relationships with two main dimensions of gentrification: household characteristics and housing dynamics.

By using the framework, the Airbnb main characteristics were analyzed, showing that the evolutions of Airbnb and gentrification have a relationship on different levels. The benefits from the revenue of the short-term rentals are concentrated in low and average-income areas. Besides, neighborhoods with a high proportion of new western urbanities formed by young-adult populations composed of small families and highly educated —for instance, single person or married without children — are more willing to transform the long-term residencies into short-term rentals. Specifically, they show a higher impact in gentrified neighborhoods. The potential class formation influence not only mature stages of gentrification but also bigger transformations supported by the Airbnb operations. These findings were presented in different levels related to the household characteristics and housing dynamics indicators. Some neighborhoods located in districts surrounding the city center were more impacted by the relationship between gentrification and Airbnb — West (Kinkerbuurt), Zuid (Nieuwe Pijp), and Oost (Oosterparkbuurt, Indische Buurt West). Moreover, these areas correspond to low-income neighborhoods. Therefore, gentrified areas also have a differential relationship with Airbnb determined by the socio-economic characteristics of the population where they are residing.

The revenue benefits are related to housing and housing conditions. The expected revenue increases according to characteristics in the population. For instance, from populations with non-western families (adult-old families with children) to western and highly educated young urbanities. Another interesting finding is that revenue decreases in neighborhoods where there are more private homeowners than housing corporations. Further, these houses are predominantly small spaces and old infrastructure. It concludes that the housing market can experiment with higher pressures since the rental prices affect the private market. Consequently, the potential rent gaps can be formed since the acquisition of houses becomes an attractor for investors who pursue high returns. Moreover, it can eventually cause the steep in the gradual liberalization of social housing promoted by the partial neoliberal housing policies implemented years ago by the country. Therefore, the relationships between the structural determinants of gentrification and Airbnb are connected through the socio-economic conditions and housing dynamics of the city.

Since Airbnb is a platform fed by users' data transactions with high impact in the housing market, the policy-making needs to improve the regulation. The design and implementation of regulatory measures need to incorporate the potential effects in gentrified neighborhoods. Moreover, they have to vary according to the differential impacts conditioned to the household socio-economic characteristics and each neighborhood's housing features.

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REFLECTION

The reflection intends to provide additional thoughts about this dissertation.

- **About**: *Globalized world.* Globalization has brought many advantages to the current world; the Internet is one of them. Beyond the technology that enables such a complex network to connect millions of people, the vast amount of information produced flows through the network and reaches every corner of the world. The term flattering the world (Friedman, 2005) was used to describe how space has been shrunk because of the development of faster avenues of communication. Besides, the interconnection has helped to connect on different sides of the world the people who demand and supply for goods and services. Even though this economic transformation represents a peak in human development, the problems and side-effects have also been escalating quickly. For instance, Airbnb was able to permeate the social fabric of the cities because people can easily join the short-term network. Moreover, the rapid Airbnb adoption surpassed the old-fashioned regulation designed during the industrial era. Another example is gentrification which has transformed main cities around the world, converting the city centers into attractive places for high-class people and hiding in the suburbs the inequality as one of the main consequences of such a globalized world (Stiglitz, 2014). Phenomenons are becoming global, but policy-making still remains local. This represents a challenge for policy-makers, urban planners, researchers, and statisticians interested in improving living conditions in cities.

- **About**: *Times of uncertainty.* The Coronavirus Disease (COVID-19) impacted the whole world in many different ways. The uncertain times have forced people to stay at home, far from the idealistic consumerism promoted by the economic model imposed on our ancestors decades before. However, the pace at which the system was reduced, the uncertainty began to grow. People are losing their jobs, small business initiatives are in bankruptcy, stress increases, working hours skyrocketed, and consuming experiences such as tourism traveling has downturned.

For example, related to Airbnb, people are moving their houses from the short-term rental to the long-term rental market (Guardian, 2020; Time, 2020) — probably local people have taken a breath of tourists walking in the street pretending to "living like a local". However, the problem is not the virus itself, as we see every day in the news. The real problem is the complex system beyond that has been built based on the argument of economic growth to improve everybody's welfare. It might be time to rethink the role of the so-called uncertainty. I like the phrase when some people in the EPA program called "decision making under deep uncertainty". This is more a philosophical phrase rather than a technical question.

- **About**: *Faster consumption.* The academic David Harvey is an open Marxist thinker (Harvey, n.d.). He explains through the Marxist theory that capitalism is a system that needs to be revisited. Interestingly, he mentioned that the Internet could represent new forms of social revolution and expression —freedom. Everybody can feel to have a voice inside the inmense network by having access to the vast information produced. However, the evolution of capitalism is reaching a new point in the development of digital technologies. The consumerism has found the optimality since the interconnection allows a more efficient way of market clearing. Nonetheless, the economic principles of capitalism promote economic growth, and a rise in demand is expected. At this point is when the data becomes valuable, becoming a valuable asset to understand not only new segments in the market but also to shape our form of consumption —surveillance capitalism.

During the EPA program, I wrote an essay related to the meaning of power. Interestingly, I found that power can be described as "the amount of resistance on the part of B which can be potentially overcome by A" (Emerson, 1962; Foucault, 1982). In that sense, without noticing, we have been subjected to the new forms of capitalism imposed by the big tech industry that now is part of the dominant complex economic system. Our level of being opposed and critic is influenced by the time we spend in the network. In the words of David Harvey, capitalism is speeding up contemporary consumerism (Harvey, n.d.; Harvey, 1990), which in part is the result of the political shift to a neoliberal economic and political model imposed during the 1980s. Therefore, there is not a simple coincidence that the success of data-driven companies depends only on innovation, it goes beyond the structural ideas behind the consumption based on foundations of capitalism. In that sense, Airbnb grew because we created the consumption of experiences as a valuable component of the GDP growth, the neoliberal policies that promotes the commodification of basic needs and allowed that the social aspects of Internet becomes tradable.

- **About**: *Policy Analyst Role.* The social aspects of technological development played an important part in understanding this challenging topic. Even though everything looks more simple in the end, to understand gentrification required to read from fields that were not easy to digest. However, learning that this type of problems are wicked and complex systems are functioning beyond helped me understand less intuitive relationships. The most challenging part was to reduce the problem to simple questions that capture the essential parts of my work. Besides,

my main goal was to get involved with the problems resulting from the consequences of policy side-effects.

Then to operationalize the methodology required not only the statistical background but also to apply the critical mindset learned in the EPA program. In that sense, I also applied the strategies learned to understand the research-oriented way of thinking of my supervisors. At this point, I realize that listening and asking the right questions helped me understand how to address my own research path. From my statistics background to being a non-native English speaker, this dissertation is a valuable piece of work for me and my first real role as a policy analyst.

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BIBLIOGRAPHY

Addie, J.-P. D. (2017). "Rent Gap". In: *International Encyclopedia of Geography: People, the Earth, Environment and Technology*, pp. 1–2. DOI: 10.1002/9781118786352. wbieg0724.

Airbnb (2019). *Airbnb proposes new tourism tax model for Amsterdam*. URL: https://news.airbnb.com/airbnb-proposes-new-tourism-tax-model-for-amsterdam/.

Alizadeh, T., Farid, R., and Sarkar, S. (2018). "Towards Understanding the Socio-Economic Patterns of Sharing Economy in Australia: An Investigation of Airbnb Listings in Sydney and Melbourne Metropolitan Regions". In: *Urban Policy and Research* 36.4, pp. 445–463. ISSN: 14767244. DOI: 10.1080/08111146.2018.1460269.

Atkinson, R. (2000). "Measuring Gentrication and Displacement in Greater London". In: *Urban Studies* 37.1, pp. 149–165.

— (2004). *The evidence on the impact of gentrification: New lessons for the urban renaissance*. Vol. 4. 1, pp. 107–131. ISBN: 1461671042000. DOI: 10.1080/1461671042000215479.

Batty, M. (2018). *Inventing Future Cities*. Cambridge, MA: MIT Press, p. 304. ISBN: ISBN: 9780262038959.

Briney, A. (2019). *An Overview of Urban Geography*. URL: https://www.thoughtco.com/overview-of-urban-geography-1435803.

Business Insider (2019). *The history of Airbnb, from air mattresses to $31 billion company - Business Insider*. URL: https://www.businessinsider.com/how-airbnb-was-founded-a-visual-history-2016-2?international=true&r=US&IR=T.

Buuren, S. van and Groothuis-Oudshoorn, K. (2011). "mice: Multivariate imputation by chained equations in R". In: *Journal of Statistical Software* 45.3, pp. 1–67. ISSN: 15487660. DOI: 10.18637/jss.v045.i03.

Caufield, J. (1989). "No Title". In: *The Canadian Review of Sociology and Anthropology* 26.4.

Chapple, K. (2017). "Income Inequality and Urban Displacement". In: *New Labor Forum* 26.1, pp. 84–93. ISSN: 1095-7960. DOI: 10.1177/1095796016682018.

Cohen, M. and Pettit, K. L. (2019). *GUIDE TO MEASURING NEIGHBORHOOD CHANGE TO UNDERSTAND AND PREVENT DISPLACEMENT*. Washington.

Cuppen, E., Klievink, B., and Doorn, N. (2019). "Governing crowd-based innovations: an interdisciplinary research agenda". In: *Journal of Responsible Innovation* 6.2, pp. 232–239. ISSN: 23299037. DOI: 10.1080/23299460.2019.1586511.

Easton, S., Lees, L., Hubbard, P., and Tate, N. (2020). "Measuring and mapping displacement: The problem of quantification in the battle against gentrification". In: *Urban Studies* 57.2, pp. 286–306. ISSN: 1360063X. DOI: 10.1177/0042098019851953.

Emerson, R. M. (1962). "Power-Dependence Relations". In: *American Sociological Review* 27.1, pp. 31–41.

Forrest, R. and Williams, P. (1984). "Commodification and housing: emerging issues and contradictions." In: *Environment & Planning A* 16.9, pp. 1163–1180. ISSN: 0308-518X. DOI: 10.1068/a161163.

Foucault, M. (1982). "The Subject and Power". In: *The University of Chicago Press* 8.4, pp. 777–795.

Friedman, T. L. (2005). *The world is flat : a brief history of the twenty-first century*. Farrar, Straus and Giroux, p. 488. ISBN: 9780374292881.

Gant, A. C. (2016). "Holiday rentals: The new gentrification battlefront". In: *Sociological Research Online* 21.3, pp. 1–9. ISSN: 13607804. DOI: 10.5153/sro.4071.

Gemeente Amsterdam (n.d.[a]). *Follow the policy - Municipality of Amsterdam*. URL: https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/.

— (n.d.[b]). *Home - Data en informatie - Amsterdam*. URL: https://data.amsterdam.nl/.

Gray, D. W. and Wyly, E. K. (2020). "Gentrification". In: *International Encyclopedia of Human Geography*. Vol. 4. Elsevier, pp. 335–341. ISBN: 9780081022955. DOI: 10.1016/B978-0-08-102295-5.10881-9.

Gray, L. H. (2017). *Airbnb & Hotel Performance: An analysis of proprietary data in 13 global markets*. Tech. rep. STR. DOI: 10.1515/zava.1906.19.2.272.

Guardian, T. (2020). *How the Covid-19 crisis locked Airbnb out of its own homes*. URL: https://www.theguardian.com/technology/2020/apr/04/how-the-covid-19-crisis-locked-airbnb-out-of-its-own-homes.

Gurran, N. (2018). "Global Home-Sharing, Local Communities and the Airbnb Debate: A Planning Research Agenda". In: *Planning Theory and Practice* 19.2, pp. 298–304. ISSN: 1470000X. DOI: 10.1080/14649357.2017.1383731.

Gurran, N. and Phibbs, P. (2017). "When Tourists Move In: How Should Urban Planners Respond to Airbnb?" In: *Journal of the American Planning Association* 83.1, pp. 80–92. ISSN: 01944363. DOI: 10.1080/01944363.2016.1249011.

Hackworth, J. and Smith, N. (Nov. 2001). "The changing state of gentrification". In: *Tijdschrift voor economische en sociale geografie* 92.4, pp. 464–477. ISSN: 0040-747X. DOI: 10.1111/1467-9663.00172.

Harvey, D. (n.d.). *Podcast: David Harvey's Anti-Capitalist Chronicles - Reading Marx's Capital with David Harvey*. URL: http://davidharvey.org/2018/11/new-podcast-david-harveys-anti-capitalist-chronicles/.

— (1990). *The condition of postmodernity : an enquiry into the origins of cultural change*. Blackwell, p. 378. ISBN: 9780631162940.

Het Parool (2015a). *Airbnb levert Amsterdam 5,5 miljoen aan toeristenbelasting op*. URL: https://www.parool.nl/nieuws/airbnb-levert-amsterdam-5-5-miljoen-aan-toeristenbelasting-op~b685a0e2/.

— (2015b). *Gemeente Amsterdam verlengt samenwerking met Airbnb*. URL: https://www.parool.nl/nieuws/gemeente-amsterdam-verlengt-samenwerking-met-airbnb~b8497ea0/.

Hochstenbach, C. (2015). "Stakeholder Representations of Gentrification in Amsterdam and Berlin: A Marginal Process?" In: *Housing Studies* 30.6, pp. 817–838. ISSN: 14661810. DOI: 10.1080/02673037.2014.979770.

Hochstenbach, C. and Gent, W. P. van (2015). "An anatomy of gentrification processes: variegating causes of neighbourhood change". In: *Environment and Planning A* 47.7, pp. 1480–1501. ISSN: 14723409. DOI: 10.1177/0308518X15595771.

Hochstenbach, C. and Musterd, S. (2018). "Gentrification and the suburbanization of poverty: changing urban geographies through boom and bust periods". In: *Urban Geography* 39.1, pp. 26–53. ISSN: 02723638. DOI: 10.1080/02723638.2016.1276718.

Hochstenbach, C., Musterd, S., and Teernstra, A. (2015). "Gentrification in Amsterdam: Assessing the Importance of Context". In: *Population, Space and Place* 21.8, pp. 754–770. ISSN: 15448452. DOI: 10.1002/psp.1854.

Ioannides, D., Röslmaier, M., and Zee, E. van der (2019). "Airbnb as an instigator of 'tourism bubble' expansion in Utrecht's Lombok neighbourhood". In: *Tourism Geographies* 21.5, pp. 822–840. ISSN: 14701340. DOI: 10.1080/14616688.2018.1454505.

Khan, L. M. (2016). "Amazon's Antitrust Paradox Amazon's Antitrust Paradox". In: *Yale Law Journal* 126.3, pp. 710–805.

Kloosterman, R. (2010). "From Amsterdamned to I Amsterdam: The Amsterdam Economy and Its Impact on the Labor Market Position of Migrants, 1980–2010". In: *New York and Amsterdam*. Ed. by N. Foner, J. Rath, J. W. Duyvendak, and R. van Reekum. New York: NYU Press, pp. 107–131.

Kramer, M. B. C. (2019). *Regulating peer-to-peer sharing economy platforms in institutional voids*. Tech. rep. Master Thesis- TU Delft.

Lees, L., Bang, H., and López-Morales, E. (2016). *Planetary Gentrification*. Cambridge, UK.

Lees, L., Slater, T., and Wyly, E. (2008). *Gentrification*. London, New York: Routledge, p. 310. ISBN: 978-0-415-95037-4. URL: www.tnyIorandfrancis.com.

— (2010). *The Gentrification Reader*. Ed. by L. Lees, T. Slater, and E. Wyly. London: Routledge.

Ley, D. (1986). "Alternative Explanations for Inner-City Gentrification : A Canadian Assessment". In: *Annals of the Association of American Geographers* 76.4, pp. 521–535.

Madden, D. J. and Marcuse, P. (2016). *In Defense of Housing: The Politics of Crisis*. London, New York: Verso. ISBN: ISBN-13: 978-1-78478-356-3.

Maginn, P. J., Burton, P., and Legacy, C. (2018). "Disruptive Urbanism? Implications of the 'Sharing Economy' for Cities, Regions, and Urban Policy". In: *Urban Policy and Research* 36.4, pp. 393–398. ISSN: 14767244. DOI: 10.1080/08111146.2018.1555909.

Marcuse, P. (1986). "Abandonment, Gentrification, and Displacement". In: *The Gentrification Reader*. Ed. by L. Lees, T. Slater, and E. Wyly. First. London: Routledge. Chap. 26, pp. 333–347.

9

Meerow, S., Newell, J. P., and Stults, M. (2016). "Defining urban resilience: A review". In: *Landscape and Urban Planning* 147, pp. 38–49. ISSN: 01692046. DOI: 10.1016/j.landurbplan.2015.11.011.

Musterd, S. (2014). "Public Housing for Whom? Experiences in an Era of Mature Neo-Liberalism: The Netherlands and Amsterdam". In: *Housing Studies* 29.4, pp. 467–484. ISSN: 14661810. DOI: 10.1080/02673037.2013.873393.

Musterd, S., Hochstenbach, C., and Boterman, W. (2020). "Ripples of structural economic transformation: The changing social geographies of Dutch metropolitan regions". In: *Applied Geography* 116.xxxx, p. 102151. ISSN: 01436228. DOI: 10.1016/j.apgeog.2020.102151.

Musterd, S. and Ostendorf, W. (2003). "Understanding Segregation in the Metropolitan Area of Amsterdam". In: *Amsterdam Human Capital*. Ed. by S. Musterd and W. Salet. First. Amsterdam: Amsterdam University Press. Chap. 3.5, pp. 181–197. ISBN: 90 5356 595 7.

Nieuwland, S. (2017). "Help , Airbnb is taking over the City ! A study on the impacts of Airbnb on cities and regulatory approaches ." In: p. 65. URL: http://theses.ubn.ru.nl/bitstream/handle/123456789/5434/Final%20VersionThesis%20S.Nieuwland.pdf?sequence=1.

Nieuwland, S. and Melik, R. van (2018). "Regulating Airbnb: how cities deal with perceived negative externalities of short-term rentals". In: *Current Issues in Tourism* 0.0, pp. 1–15. ISSN: 13683500. DOI: 10.1080/13683500.2018.1504899.

NOS (2017). *De explosieve groei van Airbnb in Amsterdam is voorbij*. URL: https://nos.nl/artikel/2195345-de-explosieve-groei-van-airbnb-in-amsterdam-is-voorbij.html.

Opportunity, I. o. M. (2016). *Are Minneapolis and St . Paul Gentrifying ?* Tech. rep. Minneapolis: University of Minnesota Law School, p. 50.

Peacock, S. and Galster, G. (1986). "Urban Gentrification: Evaluating Alternative Indicators". In: *Social Indicators Research* 18, pp. 321–337.

Raman, S. (2014). "Gentrification". In: *Encyclopedia of Quality of Life and Well-Being Research*. Dordrecht: Springer Netherlands, pp. 2509–2512. DOI: 10.1007/978-94-007-0753-5{_}1157.

Ritchie, H. (2018). *How urban is the world? - Our World in Data*. URL: https://ourworldindata.org/how-urban-is-the-world.

Rouwendal, J., Keus, A., and Dekkers, J. (2018). "Gentrification through the sale of rental housing? Evidence from Amsterdam". In: *Journal of Housing Economics* 42.January 2017, pp. 30–43. ISSN: 10960791. DOI: 10.1016/j.jhe.2018.07.002.

Schumpeter, J. (1911). *The Theory of Economic Development, Harvard Economic Studies*. Ed. by R. Opie. Harvard Economic Studies, p. 255. ISBN: 9780674879904.

Sheppard, S. and Udell, A. (2016). "Do Airbnb properties affect house prices?" In: *Williams College Department of Economics Working Papers* 3, pp. 1–45. DOI: 10.1111/j.1708-8208.2009.00227.x.

Slater, T. (2009). "Missing marcuse: On gentrification and displacement". In: *City* 13.2-3, pp. 292–311. ISSN: 13604813. DOI: 10.1080/13604810902982250.

9

Smith, N. (1987). "Gentrification and the Rent Gap". In: *Annals of the Association of American Geographers* 77.3, pp. 462–465. ISSN: 00045608, 14678306. URL: http://www.jstor.org/stable/2563279.

— (2012). "New Globalism, New Urbanism: Gentrification as Global Urban Strategy". In: *Spaces of Neoliberalism: Urban Restructuring in North America and Western Europe*, pp. 80–103. DOI: 10.1002/9781444397499.ch4.

— (1997). *The new urban frontier: Gentrification and the revanchist city*. Vol. 21. 3. Routledge, p. 247. ISBN: 0203975642. DOI: 10.1177/030913259702100327.

Statista.com (2018). • *Airbnb: number of listings in major cities worldwide 2018 | Statista*. URL: https://www.statista.com/statistics/752498/airbnb-number-of-listings-in-major-cities-worldwide/.

Stevens Curl, J. (2006). *Sixteen Principles of Urbanism - Oxford Reference*. 3rd ed. ISBN: 9780198606789. URL: https://www.oxfordreference.com/view/10.1093/acref/9780198606789.001.0001/acref-9780198606789-e-4291?rskey=vFNapN&result=5041.

Stiglitz, J. (2014). *The Future of Globalization*. The Hague.

The Economist (2013). *Peer-to-peer rental - The rise of the sharing economy | Leaders | The Economist*. URL: https://www.economist.com/leaders/2013/03/09/the-rise-of-the-sharing-economy.

Time (2020). *How Coronavirus Could Affect Housing Policies in Europe*. URL: https://time.com/5839393/europe-housing-coronavirus-airbnb-prices/.

Van der Bijl, V. (2016). "The effect of Airbnb on house prices in Amsterdam". PhD thesis. University of Amsterdam (UvA), p. 59.

Van Gent, W. and Boterman, W. (2019). "Gentrification Of The Changing State". In: *Tijdschrift voor Economische en Sociale Geografie* 110.1, pp. 35–46. ISSN: 14679663. DOI: 10.1111/tesg.12331.

Vith, S., Oberg, A., Höllerer, M. A., and Meyer, R. E. (2019). "Envisioning the 'Sharing City': Governance Strategies for the Sharing Economy". In: *Journal of Business Ethics* 159.4, pp. 1023–1046. ISSN: 15730697. DOI: 10.1007/s10551-019-04242-4.

Wachsmuth, D., Kerrigan, D., Chaney, D., and Shillolo, A. (2017). "Short-term cities: Airbnb's impact on Canadian housing markets". In: *Urban Politics and Governance research group School of Urban Planning McGill University* 2017, pp. 1–48.

Wachsmuth, D. and Weisler, A. (2018). "Airbnb and the rent gap: Gentrification through the sharing economy". In: *Environment and Planning A* 50.6, pp. 1147–1170. ISSN: 14723409. DOI: 10.1177/0308518X18778038.

Wegmann, J. and Jiao, J. (2017). "Taming Airbnb: Toward guiding principles for local regulation of urban vacation rentals based on empirical results from five US cities". In: *Land Use Policy* 69.October, pp. 494–501. ISSN: 02648377. DOI: 10.1016/j.landusepol.2017.09.025.

Yrigoy, I. (2019). "Rent gap reloaded: Airbnb and the shift from residential to touristic rental housing in the Palma Old Quarter in Mallorca, Spain". In: *Urban Studies* 56.13, pp. 2709–2726. ISSN: 1360063X. DOI: 10.1177/0042098018803261.

Zuboff, S. (2019a). "Surveillance Capitalism and the Challenge of Collective Action". In: *New Labor Forum* 28.1, pp. 10–29. ISSN: 15572978. DOI: 10.1177/1095796018819461.

9

Zuboff, S. (2019b). *The Age of Surveillance Capitalism: The Fight For A Human Future.*
　　First. New york: Public Affairs, p. 717. ISBN: 9788578110796. DOI: `10.1017/CBO9781107415324.004`.

A

APPENDIX

A.1. VARIABLE DESCRIPTION

Label	Description	Type	Field
HSingle_PaFa	Single-parent family	Household Composition	Perc.
HSingle_Pe	Single-person	Household Composition	Perc.
HMar_WOCh	Married without children	Household Composition	Perc.
HMar_WCh	Married with children	Household Composition	Perc.
HUnMar_WOCh	Unmarried without children	Household Composition	Perc.
HUnMar_Ch	Unmarried with children	Household Composition	Perc.
HOther	Other	Household Composition	Perc.
Pop18_22	People registered in Amsterdam aged 18 to 22	Age Cohorts	Perc.
Pop23_39	People registered aged 23 to 39	Age Cohorts	Perc.
Pop40_64	People registered aged 40 to 64	Age Cohorts	Perc.
Pop65Plus	People registered aged 65 or more	Age Cohorts	Perc.
Dutch	Dutch.Population born in the Netherlands with both parents also born in the Netherlands(no migration background)	Ethnicity	Perc.
NonWest	Non-Western.Number of people registered in Amsterdam born in Morocco, Turkey, Surinam, the (former*) Dutch Antilles or other African, Latin-American, and Asian countries, or with at least one parent born in Morocco, Turkey, Surinam, the (former*) Dutch Antilles or other African, Latin-American, and Asian countries (Indonesia and Japan excluded). [1]	Ethnicity	Perc.
			Continued on next page

[1]The mother's country of birth determines the migration background, unless the mother was born in the Netherlands. In that case the father's country of birth determines the migration background.

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Label	Description	Type	Field
West	Western. Percentage of the population born in Europe, North-America , Oceania, Indonesia or Japan, or with at least one parent born in Europe, North-America , Oceania, Indonesia or Japan (Turkey and the Netherlands excluded) [2][1]	Ethnicity	Perc.
Pop_Arr	Number of people that moved to Amsterdam from another municipality in the Netherlands or abroad.	Migration	Num.
Pop_Dep	Number of people that moved from Amsterdam to another municipality in the Netherlands or abroad.	Migration	Num.
Pop_Arr_AMS	Number of people that moved to the particular area from another area in Amsterdam.	Migration	Num.
Pop_Dep_AMS	Number of people that moved from the particular area to another area in Amsterdam.	Migration	Num.
Pop_Mig_Ar	Number of people that moved within the area.	Migration	Num.
Dur_Res	The duration of residence: the average number of years between registration on the current address and the key date.	Migration	Num.
popKm2	Population per Km2	Population	Perc.
New_Urb	Percentage of the population classified as 'new urbanites': people with a Dutch or western migration background (Eastern Europe excluded), aged 18 to 54, who moved to Amsterdam aged 18 and over.	Migration	Perc.
EDU_Low	Percentage of the population aged 15 to 74 with a low level of education (maximum level: preparatory vocational education (VMBO)).	Education	Perc.
EDU_Medium	Percentage of people aged 15 to 74 with a mid-level of education (general to higher secondary education (MBO, HAVO, VWO)).	Education	Perc.
EDU_High	Percentage of people aged 15 to 74 with a high level of education (Higher Vocational Education (HBO) or university).	Education	Perc.
Income	Mean disposable income per household [3]	Socio-economic/Household haracteristics	Num.
Prop_Corp	Percentage of the housing stock registered as property of a housing corporation.	Type of tenure	Perc.
Prop_Priv	Percentage of addresses not registered as property of the occupant or as property of a housing corporation.	Type of tenure	Perc.
Prop_Owner	Percentage of addresses registered as property of the occupant.	Type of tenure	Perc.
LivSp0_40	Percentage of the housing stock with a living space from 0 to 40 m2	Housing characteristics	Perc.
LivSp40_60	Percentage of the housing stock with a living space from 40 to 60 m2	Housing characteristics	Perc.

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[3]The disposable income is defined as the gross income minus current transfers paid (like alimony payments to an ex-partner), income insurance premiums, health insurance premiums and tax on income and wealth. Gross income is the sum of income from labour, income from self-employment, income from property, payments from the government and other receipts (like alimony payments by an ex-partner).

Table A.0 – continued from previous page

Label	Description	Type	Field
LivSp60_80	Percentage of the housing stock with a living space from 60 to 80 m2	Housing characteristics	Perc.
LivSp80_100	Percentage of the housing stock with a living space from 80 to 100 m2	Housing characteristics	Perc.
LivSp100Plus	Percentage of the housing stock with a living space over 10 m2	Housing characteristics	Perc.
OccuHome	The average number of occupants per home in the area	Housing characteristics	Num.
HousStock	Total number of homes [4]	Housing Stock	Num.
WOZ	WOZ: Average house value [x 1 000 euro]	Property Valuation	Num.
HomeSale	Percentage of homes for sale.	Homes Sales	Perc.
OldFr2000	Percentage number of homes that are included in the Housing Register in or after the year 2000	Building Characteristics	Perc.
OldUp2000	Percentage number of homes included in the Housing Register before the year 2000	Building Characteristics	Perc.

A.2. MISSING VALUES IMPUTATION
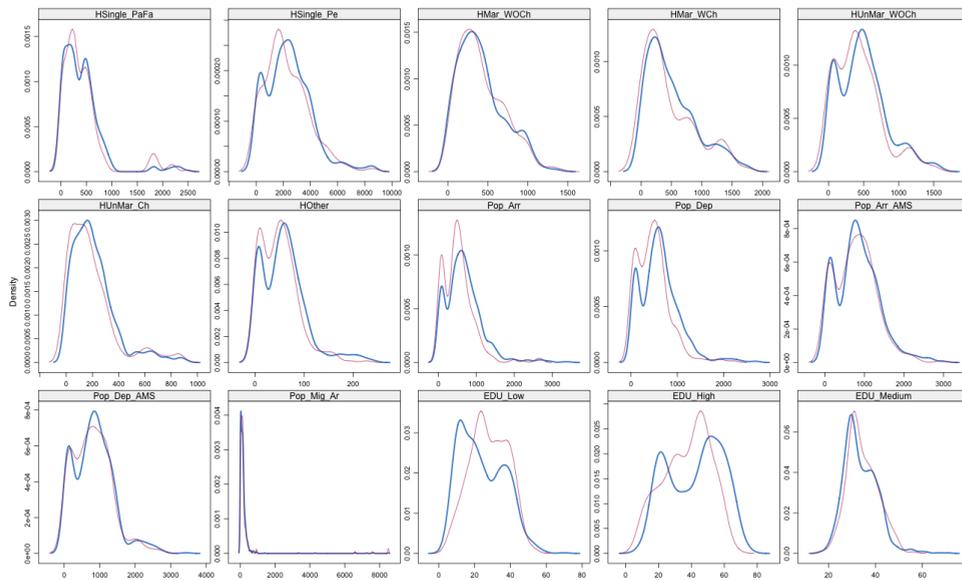
Figure A.1: Density comparison using multiple estimations procedure - Household Characteristics

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[4]A house is intended for habitation building that, from a construction engineering point of view, is permanently intended for permanent residence by a private household. Rounded to five.
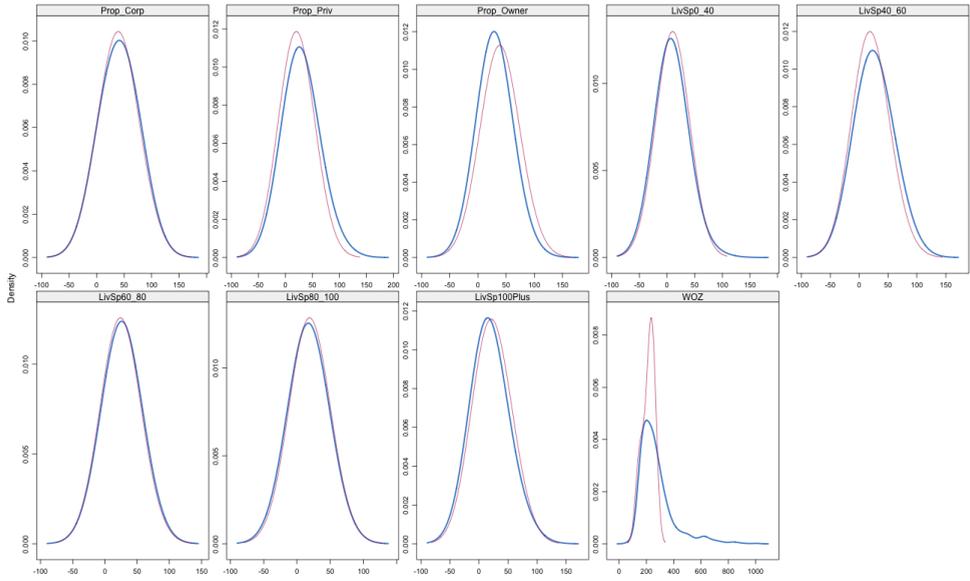
Figure A.2: Density comparison using multiple estimations procedure - Housing Dynamics

A.3. STATISTICS PER QUINTILES FOR EACH INDICATOR

Housing Mobility	Low	Medium-Low	Medium	Medium-High	High
HSingle_PaFa	11.6%	11.3%	8.3%	6.4%	4.6%
HSingle_Pe	39.2%	48.2%	53.6%	61.2%	62.6%
HMar_WOCh	17.1%	11.1%	10.2%	7.6%	7.2%
HMar_WCh	18.1%	15.2%	10.7%	7%	5.6%
HUnMar_WOCh	6.5%	8%	11.2%	12.1%	14.7%
HUnMar_Ch	6.6%	4.9%	4.7%	4.1%	3.5%
HOther	0.8%	1.2%	1.4%	1.5%	1.9%
Pop18_22	7.6%	8.5%	8%	9%	10.4%
Pop23_39	25.8%	35.8%	37%	44.4%	49.2%
Pop40_64	47.4%	40.1%	39.8%	35.3%	31.9%
Pop65Plus	19.1%	15.6%	15.2%	11.3%	8.5%
Dutch	61.9%	42.6%	55.5%	56.1%	59.2%
NonWest	26.4%	43.1%	25.3%	22.8%	17.5%
West	11.7%	14.3%	19.2%	21.1%	23.3%
Pop_Arr	328.13	757.84	732.38	690.65	691.23
Pop_Dep	364.03	701.73	688.36	613.41	569.41
Pop_Arr_AMS	514.3	1053.82	946.04	885.18	727.62
Pop_Dep_AMS	454.9	994.24	956.54	914.5	819.77
Pop_Mig_Ar	215.54	316.09	159.44	287.57	131.84
Dur_Res	11.13	7.65	8.63	7.44	6.55
popKm2	4664.9	6993.82	10258.94	13195.75	12169.89
New_Urb	16.5%	19.4%	33.1%	40.3%	49.4%
EDU_Low	34.1%	34.5%	22.9%	20.8%	14%
EDU_Medium	38.6%	36.7%	31.4%	30.9%	31.6%
EDU_High	27.3%	28.9%	45.7%	48.4%	54.5%

Table A.1: Average per class on Housing Mobility Indicator

A

Foreign Vibrant	Low	Medium-Low	Medium	Medium-High	High
HSingle_PaFa	8.25%	6.26%	6.64%	9.72%	11.09%
HSingle_Pe	45.22%	56.64%	58.76%	53.28%	51.06%
HMar_WOCh	16.5%	10.61%	8.09%	9.05%	9.03%
HMar_WCh	13.12%	9.3%	7.82%	12.22%	14.16%
HUnMar_WOCh	9.44%	11.55%	12.51%	9.92%	9.24%
HUnMar_Ch	6.17%	4.19%	4.54%	4.79%	4.08%
HOther	1.3%	1.45%	1.64%	1.03%	1.34%
Pop18_22	6.25%	10.39%	9.47%	7.98%	9.38%
Pop23_39	30.28%	37.96%	44.31%	39.68%	39.89%
Pop40_64	45.56%	38.09%	34.51%	39.3%	37.21%
Pop65Plus	17.9%	13.56%	11.71%	13.04%	13.52%
Dutch	68.24%	61.82%	57.37%	50.55%	38.05%
NonWest	13.47%	16.42%	22.02%	33.53%	48.78%
West	18.29%	21.76%	20.61%	15.92%	13.17%
Pop_Arr	163.93	590.21	657.06	750.88	1032.8
Pop_Dep	159.56	510.91	606.13	692.89	961.88
Pop_Arr_AMS	214.58	675.92	804	992.33	1426.59
Pop_Dep_AMS	207.68	699.74	830.58	951.32	1437.75
Pop_Mig_Ar	168.68	154.84	262.31	255	259.96
Dur_Res	10.33	7.84	7.66	7.63	7.97
popKm2	4577.13	8509.13	11413.04	10513.68	12211.98
New_Urb	30.52%	39.75%	40.77%	28.3%	19.78%
EDU_Low	24.22%	16.97%	20.84%	28.03%	35.64%
EDU_Medium	33.83%	33.67%	31.87%	34.04%	35.73%
EDU_High	41.93%	49.35%	47.39%	37.88%	28.62%

Table A.2: Average per class on Foreign Vibrant Indicator

Housing Marketization	Low	Medium-Low	Medium	Medium-High	High
Prop_Corp	64.65%	58.3%	37.52%	30.45%	13.6%
Prop_Priv	16.56%	19.03%	32.74%	35.94%	41.22%
Prop_Owner	18.78%	22.67%	29.75%	33.61%	45.17%
LivSp0_40	6.16%	13.74%	9.58%	9.69%	5.11%
LivSp40_60	48.77%	28.35%	32.84%	13.62%	6.74%
LivSp60_80	30.2%	30.16%	26.46%	29.62%	14.16%
LivSp80_100	9.79%	16.94%	16.95%	24.05%	20.54%
LivSp100Plus	4.62%	8.94%	12.35%	19.24%	48.74%
OccuHome	2.00	2.00	2.00	2.00	3.00
HousStock	4731.34	6205.68	5008.83	3347.89	2504.50
WOZ	212.85	216.30	243.38	275.08	412.60
HomeSale	18.23%	23.47%	28.26%	35.17%	44.18%
OldFr2000	4.08%	16.11%	13.26%	20.32%	21.52%
OldUp2000	95.93%	83.89%	86.74%	79.68%	78.48%

Table A.3: Average per class on Housing Marketization

A

Housing Acquisition Interest	Low	Medium-Low	Medium	Medium-High	High
Prop_Corp	42.01%	53.83%	52.6%	38.92%	17.35%
Prop_Priv	37.19%	23.08%	18.88%	29.7%	36.53%
Prop_Owner	20.8%	23.08%	28.52%	31.38%	46.12%
LivSp0_40	18.68%	9.61%	7.82%	4.08%	3.6%
LivSp40_60	11.17%	29.14%	32.45%	33.3%	25.28%
LivSp60_80	20.43%	28.63%	28.91%	27.36%	25.08%
LivSp80_100	20.92%	17.86%	15.05%	17.53%	16.64%
LivSp100Plus	24.91%	12.32%	13.61%	16.43%	26.65%
OccuHome	2.46	1.88	1.98	1.97	1.99
HousStock	3497.04	5755.22	4650.59	4893.42	3056.73
WOZ	219.48	235.75	238.13	263.1	404.12
HomeSale	24.02%	23.18%	26.16%	30.42%	45.28%
OldFr2000	47.8%	11.24%	6.5%	5.16%	3.59%
OldUp2000	52.2%	88.77%	93.5%	94.84%	96.41%

Table A.4: Average per class on Housing Acquisition Interest

A

Variables	Residential Mobility (Factor1)	Foreign Vibrant (Factor2)
HSingle_PaFa	-0.26	0.18
HSingle_Pe	0.28	0.06
HMar_WOCh	-0.25	-0.22
HMar_WCh	-0.27	0.02
HUnMar_WOCh	0.28	-0.03
HUnMar_Ch	-0.16	-0.10
HOther	0.20	-0.01
Pop18_22	0.07	0.07
Pop23_39	0.28	0.13
Pop40_64	-0.22	-0.12
Pop65Plus	-0.20	-0.10
Dutch	0.02	-0.35
NonWest	-0.11	0.35
West	0.25	-0.15
Pop_Arr	0.08	0.33
Pop_Dep	0.04	0.34
Pop_Arr_AMS	0.03	0.35
Pop_Dep_AMS	0.06	0.34
Pop_Mig_Ar	-0.03	0.08
New_Urb	0.31	-0.14
Dur_Res	-0.21	-0.15
popKm2	0.13	0.12
EDU_Low	-0.25	0.19
EDU_Medium	-0.18	0.07
EDU_High	0.26	-0.17

Table A.5: Weights PCA - Household Characteristics

A.4. Variable Indicator Weights and square cosines

A

Variables	Housing Marketization (Factor1)	Housing Acquisition Interest (Factor 2)
Prop_Corp	-0.37	-0.13
Prop_Priv	0.18	-0.04
Prop_Owner	0.35	0.26
LivSp0_40	-0.05	-0.41
LivSp40_60	-0.32	0.20
LivSp60_80	-0.23	0.19
LivSp80_100	0.16	-0.03
LivSp100Plus	0.43	-0.03
OccuHome	0.18	-0.11
HousStock	-0.19	0.09
WOZ	0.31	0.21
HomeSale	0.37	0.20
OldFr2000	0.12	-0.53
OldUp2000	-0.12	0.53

Table A.6: Weights PCA - Housing Dynamics

Variable	Residential Mobility (Factor1)	Foreign Vibrant (Factor2)
HSingle_PaFa	0.57	0.18
HSingle_Pe	0.68	0.02
HMar_WOCh	0.53	0.28
HMar_WCh	0.61	0.00
HUnMar_WOCh	0.67	0.00
HUnMar_Ch	0.23	0.06
HOther	0.34	0.00
Pop18_22	0.04	0.03
Pop23_39	0.66	0.09
Pop40_64	0.43	0.08
Pop65Plus	0.34	0.05
Dutch	0.00	0.70
NonWest	0.11	0.72
West	0.53	0.12
Pop_Arr	0.06	0.63
Pop_Dep	0.02	0.65
Pop_Arr_AMS	0.01	0.71
Pop_Dep_AMS	0.03	0.67
Pop_Mig_Ar	0.01	0.04
Dur_Res	0.37	0.13
popKm2	0.16	0.08
New_Urb	0.82	0.12
EDU_Low	0.56	0.20
EDU_Medium	0.27	0.03
EDU_High	0.58	0.16

Table A.7: Cosine square for columns representation

A

	Housing Marketization	Housing Acquisition Interest
Prop_Corp	0.60	0.05
Prop_Priv	0.14	0.01
Prop_Owner	0.54	0.20
LivSp0_40	0.01	0.49
LivSp40_60	0.45	0.12
LivSp60_80	0.23	0.11
LivSp80_100	0.12	0.00
LivSp100Plus	0.81	0.00
OccuHome	0.14	0.04
HousStock	0.16	0.02
WOZ	0.41	0.13
HomeSale	0.60	0.12
OldFr2000	0.07	0.81
OldUp2000	0.07	0.81

Table A.8: Cosine square for columns representation - Household Dynamics

A.5. COMPARISON GENTRIFIED NEIGHBORHOODS WITH INDICATORS
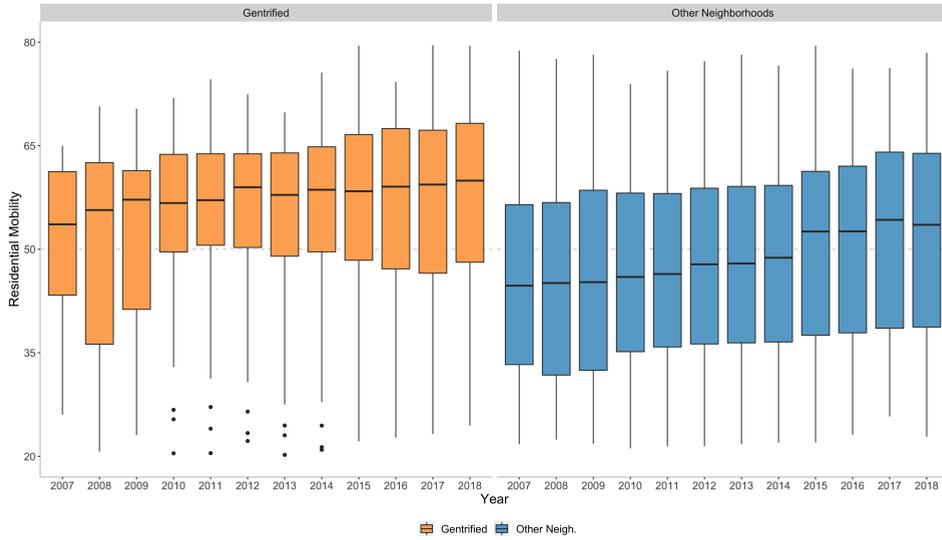
Figure A.3: Boxplot - Distribution Residential Mobility indicator on income gentrified neighborhoods
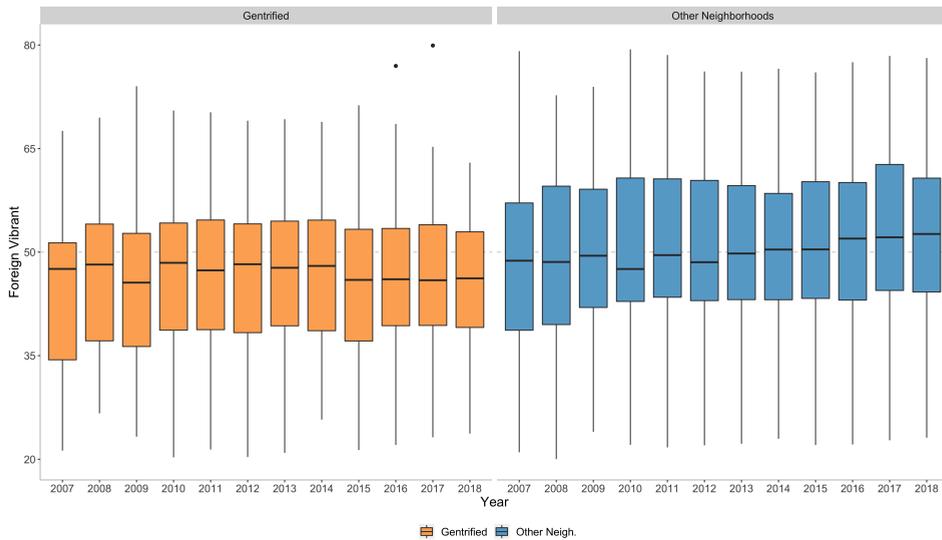
Figure A.4: Boxplot - Distribution Foreign Vibrant Indicator on income gentrified neighborhoods
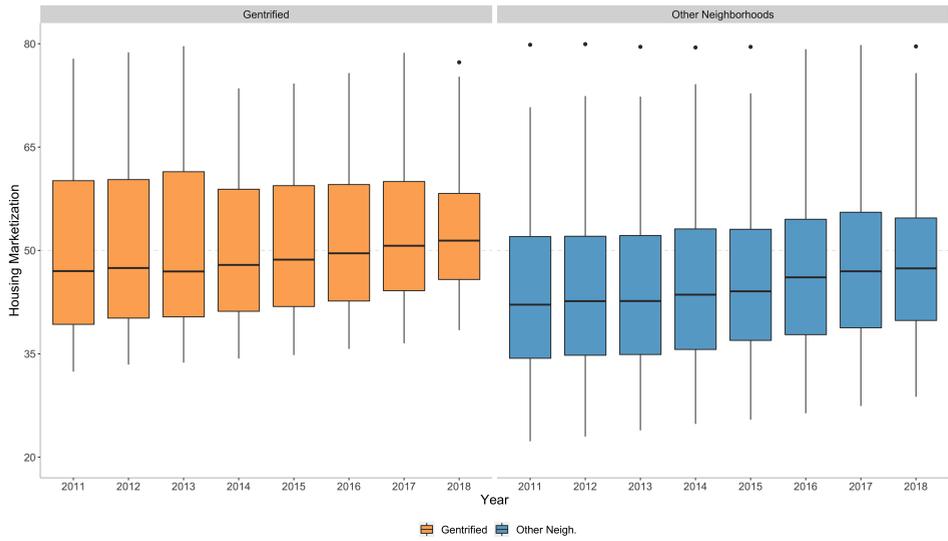
Figure A.5: Boxplot - Distribution Housing Marketization on income gentrified neighborhoods
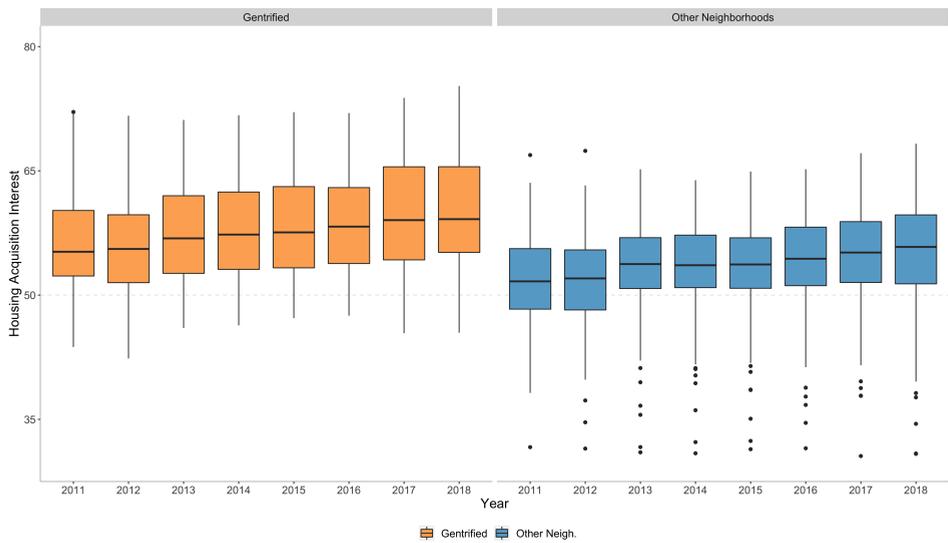
Figure A.6: Boxplot - Distribution Housing Acquisition Interest on income gentrified neighborhoods

A.6. DISTRIBUTION OF LISTINGS BY INDICATORS
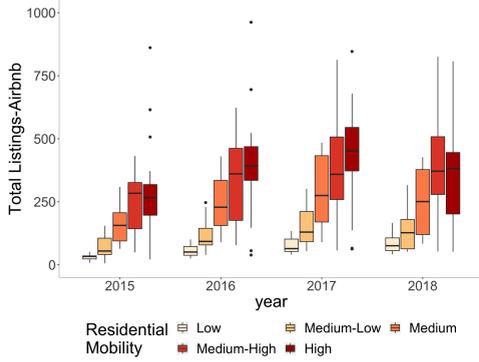
Figure A.7: Distribution Total Listings on Residential Mobility categories
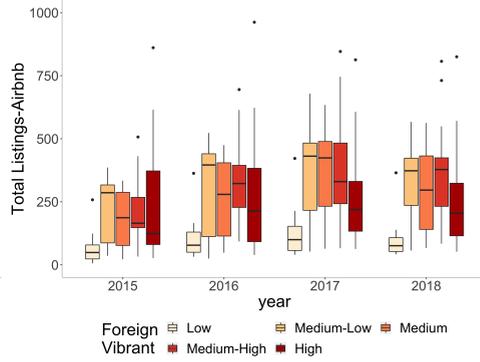
Figure A.8: Distribution Total Listings on Foreign Vibrant categories
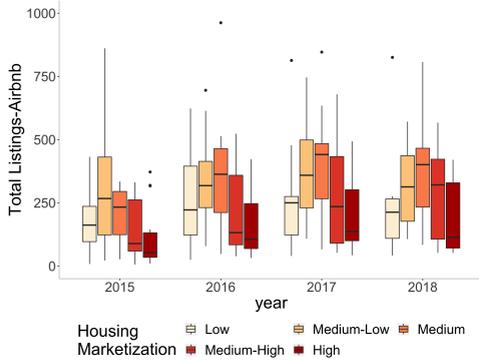
Figure A.9: Distribution Total Listings on Housing Marketization categories
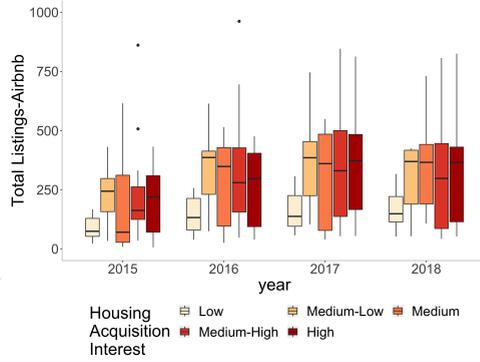
Figure A.10: Distribution Total Listings on Housing Acquisition Interest categories

A.7. RESULTS FOR THE LOG-LINEAR REGRESSION MODEL

A.7.1. ESTIMATIONS

A.7.2. BOX-COX TRANSFORMATION TEST

Indicator	Category	Estimation	Increment	Std. Error	t value	Pr(>|t|)	Sig.
	Reference(Low)	10.53	37410.25	0.24	43.82	< 2e-16	***
Residential Mobility	Medium-Low	0.2	21.7%	0.2	0.96	0.3362	
	Medium	0.89	144.5%	0.21	4.25	3.49E-05	***
	Medium-High	1.39	300.5%	0.2	6.85	1.26E-10	***
	High	1.68	435%	0.22	7.51	3.06E-12	***
Foreign Vibrant	Medium-Low	0.8	122.1%	0.17	4.78	3.68E-06	***
	Medium	0.98	165.3%	0.18	5.32	3.20E-07	***
	Medium-High	1.23	241.6%	0.18	6.79	1.78E-10	***
	High	1.42	313.8%	0.2	7.21	1.69E-11	***
Housing Marketization	Medium-Low	0.18	19.4%	0.14	1.26	0.2097	
	Medium	0.28	32.8%	0.17	1.72	0.0875	.
	Medium-High	0.09	9.7%	0.16	0.57	0.5722	
	High	0.85	134.2%	0.19	4.45	1.55E-05	***
Housing Acquisition Interest	Medium-Low	1.26	251.1%	0.17	7.19	1.86E-11	***
	Medium	0.94	155.8%	0.17	5.59	8.60E-08	***
	Medium-High	0.86	137%	0.16	5.38	2.39E-07	***
	High	0.74	110%	0.16	4.59	8.54E-06	***
Year	2016	0.58	78.4%	0.12	4.75	4.25E-06	***
	2017	0.83	129%	0.12	6.75	2.17E-10	***
	2018	0.69	98.6%	0.12	5.56	1.01E-07	***

Table A.9: Results log-linear model for Gentrified Neighborhoods. Increment is interpreted as percentages of increments given the reference category. Significant (Sig.). codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Indicator	Category	Estimation	Increment	Std. Error	t value	Pr(>|t|)	Sig.
	Reference(Low)	11.51	100157.58	0.36	32.43	< 2e-16	***
Residential Mobility	Medium-Low	1.87	547.90%	0.31	6.05	0	***
	Medium	1.18	223.90%	0.14	8.56	0	***
	Medium-High	1.82	519.30%	0.17	10.82	< 2e-16	***
	High	1.74	468.00%	0.14	12.15	< 2e-16	***
Foreign Vibrant	Medium-Low	0.41	50.70%	0.13	3.21	0	**
	Medium	0.21	23.20%	0.2	1.05	0.3	
	Medium-High	0.32	38.30%	0.2	1.66	0.1	
	High	-0.23	-20.50%	0.21	-1.08	0.28	
Housing Marketization	Medium-Low	-0.45	-36.30%	0.23	-1.95	0.05	.
	Medium	-0.75	-53.00%	0.25	-3.04	0	**
	Medium-High	-1.07	-65.60%	0.27	-3.89	0	***
	High	-0.94	-60.90%	0.25	-3.7	0	***
Housing Acquisition Interest	Medium-Low	1.66	424.10%	0.25	6.66	0	***
	Medium	1.07	190.70%	0.23	4.69	0	***
	Medium-High	1.41	308.80%	0.2	7.2	0	***
	High	1.44	324.10%	0.2	7.17	0	***
Year	2016	0.61	83.60%	0.11	5.7	0	***
	2017	0.87	139.00%	0.11	8.07	0	***
	2018	0.89	143.80%	0.11	8.03	0	***

Table A.10: Results log-linear model for Gentrified Neighborhoods. Increment is interpreted as percentages of increments given the reference category. Significant (Sig.). codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Indicator	Category	Estimation	Increment	Std. Error	t value	Pr(>|t|)	Sig.
	Reference (Low)	10.58	39160.52	0.2	52.85	< 2e-16	***
Residential Mobility	Medium-Low	0.53	69.95%	0.15	3.62	0	***
	Medium	1.19	229.98%	0.13	9.35	< 2e-16	***
	Medium-High	1.63	410.76%	0.14	12.07	< 2e-16	***
	High	1.73	462.32%	0.14	12.7	< 2e-16	***
Foreign Vibrant	Medium-Low	0.68	97.83%	0.12	5.66	0	***
	Medium	0.64	89.2%	0.13	4.79	0	***
	Medium-High	0.97	163.87%	0.13	7.44	0	***
	High	0.94	156.18%	0.15	6.45	0	***
Housing Marketization	Medium-Low	0.19	21%	0.12	1.61	0.11	
	Medium	0.2	22.42%	0.13	1.56	0.12	
	Medium-High	-0.06	-5.38%	0.13	-0.42	0.68	
	High	0.48	61.54%	0.14	3.35	0	***
Housing Acquisition Interest	Medium-Low	1.24	245.22%	0.14	8.93	< 2e-16	***
	Medium	0.95	159.86%	0.13	7.26	0	***
	Medium-High	0.95	159.26%	0.12	7.87	0	***
	High	0.98	167.14%	0.12	8.01	0	***
Year	2016	0.55	73.66%	0.1	5.8	0	***
	2017	0.81	125.23%	0.1	8.45	0	***
	2018	0.69	99.94%	0.1	7.18	0	***

Table A.11: Results log-linear model for Gentrified Neighborhoods. Increment is interpreted as percentages of increments given the reference category. Significant (Sig.). codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
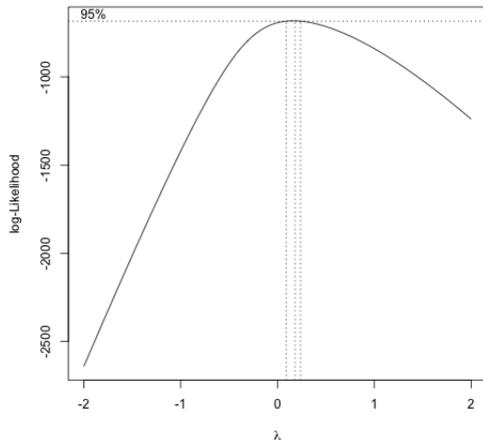
Figure A.11: Box-Cox test for Amsterdam model. Logarithmic transformation is proposed for the revenue variable
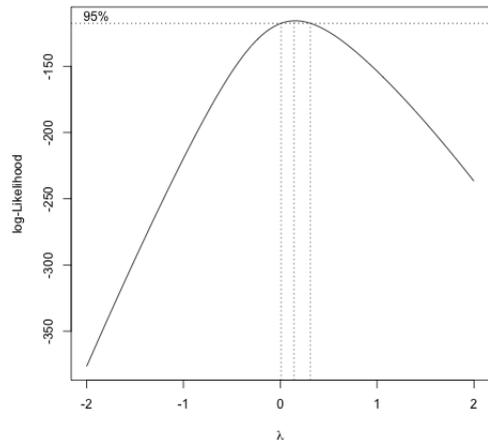
Figure A.12: Box-Cox test for gentrified neighborhoods model. Logarithmic transformation is proposed for the revenue variable
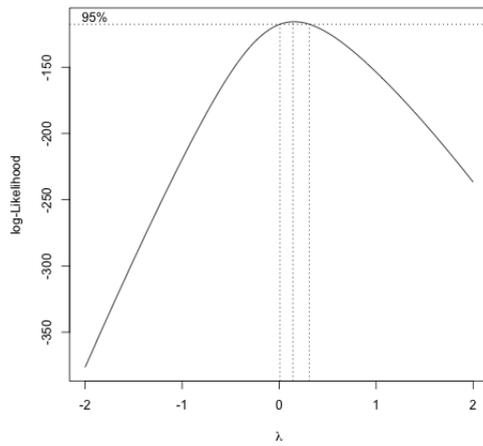
Figure A.13: Box-Cox test for Other neighborhoods model. Logarithmic transformation is proposed for the revenue variable