UNIVERSITAT DE BARCELONA

Causes and Consequences of the Housing Affordability Crisis

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To my family, that helped me never to lose my south.

Acknowledgments

Overall, my Ph.D. experience has been incredibly satisfying. During this time, I have been accompanied by many who made this experience much better. To them, I want to dedicate the following lines.

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Contents

1 Introduction

Throughout history, cities have been a driving force of human development. Cities have historically been hubs for producing goods and services and have become nodes for communications and transport. They have also pushed social, political, and economic transformation, have concentrated political power, and emerged as cultural spaces (Beall and Fox, 2009). Currently, cities are the main engines of national economies, accounting for more than 80% of global gross domestic product and outpacing national averages rate growths. Despite occupying only 2% of the world's surface, cities host more than 50% of the population. Additionally, the global population living in urban areas is expected to reach 65% in 2050, which implies an increase of 2.5 billion people (United Nations, 2018). While new technological developments may put into question some of the advantages of living in a city, their importance for us is such that we will likely remain, as Glaeser (2011) stated, an *"urban species"*.

Housing is one of the main challenges faced by cities. Housing is critical to households as it is the single largest asset in their portfolio (Causa et al., 2019). For that, its dynamics can have macroeconomic consequences on the national economy. Housing prices drive aggregate spending in developed economies (Andersen and Leth-Petersen, 2021). Housing is behind at least a quarter of the recessions in the developed world since the 1960s, and recessions related to housing prices have deep and long-lasting effects on the economy (The Economist, 2020). Housing also plays a vital role in the increasing inequality levels in developed countries, as pointed by Piketty (2018). All of these factors have lead housing to become a major topic of research within economics (Duranton et al., 2015). In particular, to provide affordable housing for a growing urban population will prove to be one of the principal challenges faced by cities in the near future[1]. As stated in a recent contribution to *VoxEU*, cities worldwide currently suffer from increasing housing costs and prices (Causa and Woloszko, 2020). The UN-Habitat has established that only 13% of the cities with over 100,000 inhabitants provide affordable housing

[1]Housing affordability broadly refers to the relationship between housing costs and household income (Bieri, 2014). While measured in several ways, agencies as the UN-Habitat (UN-Habitat, 2018) and the Housing and Urban Development in the US (HUD, 2017) consider housing as affordable if housing costs do not exceed 30% of the household's income.

(Angel et al., 2012). The extent of such a scenario has lead to the term "housing affordability crisis," as mentioned in *The Atlantic* (Lowrey, 2020).

Housing affordability problems are no longer restrained to large metropolitan areas or low-income households. It has become more frequent for households to save their yearly income several times to afford a down payment and for renters to dedicate large amounts of their income to paying rent (UN-Habitat, 2020). In the OECD countries, house prices have increased three times faster than the household median income and overall inflation during the last two decades (OECD, 2019a). In the US, the share of overburden rental households is on all-time high levels, with over 50% of households dedicating more than 30% of their income to housing (Housing Studies, 2020). In Europe, approximately one in ten families spend more than 40% of their income on housing costs, a problem much aggravated in cities (Eurostat, 2020). In the OECD countries, housing affordability is a top concern for the general population, particularly for younger people (OECD, 2019b).

As Duranton and Puga (2020) point out, the benefits of urban areas have been well documented in the literature. Either arising from productivity gains (as reviewed by Ahlfeldt and Pietrostefani (2019)), reduced travel distances (Duranton and Turner, 2018), increased innovation (Moretti, 2019), reduced pollution (Glaeser and Kahn, 2010), or the consumption of amenities (Diamond, 2016; Couture and Handbury, 2020). However, urban density also brings costs, which have often been understudied. In particular, higher density causes an increase in housing costs. For example, papers as Combes et al. (2019) and Duranton and Puga (2019), both determine a positive elasticity between housing prices, rents, and urban population.

The literature has focused on the causes driving housing affordability with special attention to the role of housing supply, e.g., Glaeser and Gyourko (2003); Glaeser et al. (2005); Hilber and Robert-Nicoud (2013); Turner et al. (2014); Gyourko and Molloy (2015); Hilber and Vermeulen (2016); Brueckner et al. (2017); Glaeser and Gyourko (2018); Molloy et al. (2020); Anenberg and Kung (2020); Gyourko et al. (2021). However, as pointed by Galster and Ok Lee (2021a), the literature has also worked on other potential mechanisms driving housing affordability. The work by Chen et al. (2004); Matlack and Vigdor (2008); Zhang et al. (2016); Dong (2018), point towards the role of income inequality, with wealthier residents pricing out large masses of poorer individuals, in particular in large metropolitan areas. Related to this, Gyourko et al. (2013) also stress that the migration of high-income households towards large metropolitan areas can drive housing prices up. Also, Anenberg and Kung (2020) show that the role of amenities can be more important when determining affordability than housing supply. The influence of credit constraints and interest rates on housing prices has been documented by Favara and Imbs (2015) and Favilukis et al. (2017). The agglomeration forces present in urban areas have also been targeted as potential sources for increasing housing prices (Rosenthal and Strange, 2004; Behrens et al., 2014; Chen et al., 2019). Finally, other studies have focused on the relevance of increasing construction costs on housing affordability (Quigley and Raphael, 2004; Yates, 2016).

The affordability crisis implies extensive costs for society, as housing affordability has severe impacts both at the household and at the macroeconomic level (Galster and Ok Lee, 2021b). Households suffering from affordability problems can have their access to food, healthcare, or educational needs severely compromised (Wetzstein, 2017). At an aggregate level, the lack of affordable housing can have significant and negative effects on economic growth, as Herkenhoff et al. (2018) and Hsieh and Moretti (2019) proved for the US case and Helble et al. (2021) showed for urban areas in Asia. Additionally, housing affordability can affect growth by misallocation of labor and capital (Brueckner and Sridhar, 2012; Hsieh and Moretti, 2019; Parkhomenko, 2020). The pandemic will likely aggravate existing affordability problems, particularly for young and urban population (Moody's, 2020). Therefore, a scientific understanding of the causes and consequences of unaffordable housing is paramount to project sustainable urban areas in the future.

This Ph.D. dissertation contributes by shedding new light on three topics that significantly impact housing in urban areas, using fine-grained data. Chapter 2 studies the effect that new home-sharing platforms such as Airbnb have on housing prices and rents. Chapter 3 deals with the consequences of labor market conditions on housing access and affordability for young people. The final chapter deals with the effect that flood events have on housing supply and its location. This dissertation also contributes in terms of public policy. Chapter 2 shows that Airbnb activity reduces long-term rental supply. Our results have been discussed in the EU parliament in the context of considering the need for public policy intervention on short-term rental platforms (Cox and Haar, 2020). Chapter 3 shows that housing aid policies can have significant impacts on welfare, especially for young people. However, results also show that this policy's welfare gains can be captured by other than the targeted groups, a feature in the public arena in France. Finally, Chapter 4 shows that signaling areas as potentially dangerous without strong enforcement is not enough to deter agents from locating near these spaces. This points toward the potential redesign of public policies in the EU strategy to mitigate climate change risks.

Home-sharing platforms raise substantial concerns regarding housing affordability. Following Koster et al. (2018), platforms such as Airbnb could potentially affect housing affordability through three channels. First, by promoting a more efficient use in space for dwellings that are not used to their total capacity. This efficiency gain could cause an increase in housing demand, then increasing housing prices, as also pointed out by Barron et al. (2021). For example, empty apartments during holiday periods are efficiency losses that can be reduced through short-term rentals. Second, by diverting rental supply, form the long-term residential market towards short-term rental. If the supply of units in the long-term market is reduced, it could increase housing prices and rents. Finally, Airbnb could cause negative externalities for residents in terms of noise or uncivil behavior and cause displacement of long-term residents.

Barcelona constitutes an interesting case study for several reasons. First, Airbnb is one of the top touristic destinations in Europe and worldwide, with over 12 million tourists visiting the city in 2019 (MasterCard, 2019; OTB, 2020). Second, Airbnb accounts for 70% of the market share in the home-sharing market.[2] Third, Airbnb penetration in Barcelona is high, with Barcelona being Airbnb's 6th top destination worldwide.[3]

In Chapter 2, titled *"Do short-term rental platforms affect housing markets? Evidence from Airbnb in Barcelona"*[4], we assess the impact of Airbnb on housing rents and prices in the city of Barcelona. Examining very detailed data on rents and both transaction and posted prices, we use several econometric approaches that exploit the exact timing and geography of Airbnb activity in the city. To study the effect of Airbnb listings on residential housing markets, we combine publicly available web-scraped data on Airbnb listings in Barcelona with high-quality data on housing rents and real estate prices. We have access to i) individual-level data on the universe of transactions of second-hand apartments sold in the 2009-2017 period and ii) all posted advertisements for rentals and sales active each December in 2007-2017 period, from a major real estate website (*Idealista*). We aggregate the information at the geographical level of small neighborhoods, which leaves us with a panel dataset of 221 small geographical areas with an average population of about 7,000 inhabitants.

Our results suggest that Airbnb has increased both rents and prices. Our preferred specification shows that 54 more active listings in a small neighborhood (about the average level in 2016) increase rents by 1.9%, while transaction and posted prices increase by 4.6% and 3.7%, respectively. However, our estimates imply that local impacts can be substantial in the city's most touristic parts. Our results indicate that an increase of 200 listings (the average number of listings in the top decile of the Airbnb activity distribution in 2016) increase rents by 7% and transaction and posted prices by 17% and 14%, respectively. We also show that Airbnb listings

[2] According to the DataHippo Project `https://datahippo.org/es/`.

[3] 'You'll never guess which city has the most Airbnb listings.' Forbes. J Bishop 2017.

[4] This research is coauthored with Miquel-Àngel García-López, Jordi Jofre-Monseny, and Mariona Segú. It has been published in the Journal of Urban Economics, vol. 119, September 2020.

reduce the number of resident households in the neighborhood.

Chapter 2 contributes to the literature in several ways. First, we focus on a city where the difference in returns between Airbnb and long-term rentals is significant, resulting in high levels of Airbnb activity. Second, we provide direct evidence on the supply mechanism by showing that Airbnb reduces the number of households living in the neighborhood. Third, this is the first study to carefully estimate the effects of Airbnb in the context of a large European city[5]. This is relevant given the underlying differences between European and US cities. For instance, European cities might have less excess capacity, where guest houses or basement apartments are virtually nonexistent.

The affordability crisis particularly affects the young population. They are spending more on housing than any previous generation while experiencing a lower quality of life (Judge and Tomlinson (2018); Inchauste et al. (2018)). At the same time, young people are struggling to leave the parental home. In 2020, more than 50% of the young US population (aged between 18 and 29 years old) were living with their parents, the highest level since the great depression (Fry et al., 2020). This value is 20 percentage points higher than the 1980 average. In Europe, 69% of those aged between 16 and 29 lived with their parents in 2019 (Eurostat, data for EU-19). For several countries, this implies the highest value since the 1980 s (Schwanitz and Mulder, 2015).

A potential explanation for the younger population's affordability problems lies in the conditions faced when entering the labor market. For young Europeans, initial labor market conditions have recently been harsh. The unemployment rate among those aged between 15 and 24 years old in the European Union was 22% for the 2008-2017 period, five percentage points higher than for the 1998-2007 period (OECD, data for EU-19). A lower income can mean an inability to afford to rent or buy and consequently the need to stay in the parental home. For those who do leave, this may translate into worse affordability. However, bad initial labor market conditions affect entire cohorts rather than just single individuals, so the interaction between the labor and housing markets could be significant. Specifically, if prices and rents are flexible and adjust fully to new income levels, housing tenure should not change. However, if housing markets are rigid, prices and rents fall to a lesser extent than income. This forces young people to live with their parents, thereby worsening their welfare even further.

In Chapter 3, titled *"Mom, Dad: I'm staying. Initial labor market conditions, housing markets, and welfare"*, I study how initial labor market conditions can have

[5]Although not the main aim in Almagro and Domínguez-Iino (2020), the authors use a shift-share instrumental variables approach that indicates that Airbnb activity increased rents in Amsterdam.

long-term effects on housing tenure and affordability. For that, I exploit the unemployment rate at the time of college graduation as an exogenous income shock to study housing outcomes, comparing different cohorts of college graduates across several European countries[6]. Additionally, I develop an overlapping generations (OLG) model to link income shocks to young agents with housing tenure changes at the aggregate level. I introduce an outside option for landlords that allows for potential rigidity into the rental market.

For this research, I use micro-data from two major European datasets: the European Union Statistics on Income and Living Conditions (EU-SILC) and the European Community Household Panel (ECHP). Both surveys provide cross-sectional information on various factors such as income, labor, and housing conditions, at both the individual and household level. These data allow studying the effect of labor market entry in bad times for cohorts from 1960 until 2019 for 33 EU countries and over 10 million individuals.

This empirical approach provides three key findings. First, the results confirm the negative and scarring effects of entering the labor market under bad economic conditions on housing tenure and affordability. Notably, a one percentage point increase in the unemployment rate at the time of graduation leads to a 1.5 percentage point rise in the probability of living with parents one year after graduation. Effects are persistent over time and are still present ten years after graduation. The accumulated effect after ten years is 12.5 percentage points. Second, the results show that one year after, a one percentage point increase in the unemployment rate at the time of graduation decreases the probability of renting by 1.02 percentage points and of ownership by 0.45 percentage points. Third, worse initial labor market conditions translate into worse affordability ratios for owners and renters. This worsening in affordability is due to lower household income and stable rents or prices.

The OLG model shows that in a scenario where rental markets are rigid, the share of young agents living with their parents will increase, as some can no longer afford to rent. For young renters, affordability will get worse as their incomes decrease, but rents do not. This scenario also leads to significant welfare losses for young agents, as they allocate more in their least preferred housing tenure option and their affordability ratios are worse than before. Additionally, this model is also helpful to provide policy insights. I show that housing aid policies can help recover welfare losses for young agents by enabling them to afford to rent.

[6]The vast majority of college graduates enter the labor market and become economically active immediately after graduation. For that, they constitute the best subjects for studying the effects of initial labor market conditions. Additionally, by working at the country level, concerns regarding the migration of graduates to other labor markets with better conditions are mitigated, as migration between EU countries is very low (Dijkstra and Gakova, 2008).

The contribution of Chapter 3 is three-fold. First, it expands on the literature on the persistent effects of initial labor market conditions by proving that existing conditions at the time of graduation can have negative and scarring effects on housing tenure and affordability. Additionally, studying housing outcomes adds an entirely new perspective to the welfare impacts of initial labor market conditions. The results indicate that the consequences of bad initial labor market conditions may be more extensive than previous literature suggested, as Kahn (2010); Oreopoulos et al. (2012); Schwandt and von Wachter (2019); von Wachter (2020). Second, it extends the framework of the OLG models for housing markets. Building on the work by Ortalo-Magné and Rady (2004, 2006); Carozzi (2020), I show that these models can analyze housing allocation and are also a helpful tool for welfare and policy analysis. Third, it contributes to policy design towards housing markets. I show that housing aid policies can absorb a shock that originates in the labor market. However, if markets are flexible enough, a policy of this kind will lead to welfare gains for landlords and welfare losses for the targeted population. These results highlight the importance of identifying the correct scenario for applying these policies to ensure that welfare gains benefit the targeted population.

Climate change poses a specially dangerous threat to housing in urban areas. As pointed by the UN, cities are particularly vulnerable to floods and sea-level rise (Rolnik, 2009). Floods can overwhelm existing drainage capacities and further weaken existing infrastructure. Additionally, sea-level rise can disproportionately affect coastal cities, which account for 10% of the global population. Affordability problems also reinforce risks from climate change; a lower disposable income after meeting housings costs can imply no resources for evacuation when a disaster occurs, a feature documented for the US (Housing Studies, 2020). In most cases, the human costs associated with flood events in urban areas are derived from the lack of adequate protection and the location of poor neighborhoods (Satterthwaite, 2007). Floods can also deepen existing inequalities. For example, poorer communities and public housing locate disproportionately in areas more exposed to floods in the US (Reuters, 2021). The location of new housing concerning potential flood risk becomes highly relevant for cities in the future, and public policy can play a crucial role in mitigating losses.

For that, Chapter 4, titled *"Business as usual? The dynamics of land development around flood spaces"*[7], studies the dynamics of new development when there is a flood event. We use development changes in surface, distance to flood zones, and elevation compared to before a flood to capture the new construction response. We make this analysis both at the municipal level and at different fringes outside the

[7] This research is co-authored with Pierre Magontier.

floodplain. We are primarily interested in the spaces right outside flood zones as these spaces are historically identified as areas at risk. Our empirical strategy relies on the assumption that conditional on municipality and year fixed effects, the timing and the extent of a flood is as good as random. This unanticipated shock allows a difference-in-differences analysis around the appearance of a flood event for each endangered municipality.

The primary dataset includes the universe of buildings in Spain as provided by the Land Register Administration — that is, approximately 12 million georeferenced units[8]. We combine this information with the complete dataset of digitized floodplains maps for Spain to identify buildings' distance to flood zones. Additionally, we extract detailed terrain elevation data from satellite images. Finally, we gather nearly 778 historical flood records identified at the municipal level between 1978 and 2010. We complete our analysis with socio-economic covariates gathered at the municipality level.

Results suggest no significant differences in the level of new development in the municipality following a flood. Additionally, new development distance to water or terrain elevation is not affected. However, in cities with low development levels before the flood, a flood leads to a construction boom. This chapter also studies the implementation of a European-level policy to identify areas with a high potential for flood events. This study shows that signaling a zone as potentially risky can increase development near that zone if no further actions are taken.

Overall, this chapter contributes to several strands of the new climate-economy literature[9]. To our knowledge, only a few papers specifically study the impact of natural disasters on urban development, e.g., Hornbeck and Naidu (2014); Elliott et al. (2015); Gallagher and Hartley (2017); Deryugina et al. (2018); Kocornik-Mina et al. (2020). We first contribute to this literature by collecting and using an extensive historical database of flood events in Spain. Consequently, our results do not build on specifically selected billion-dollar or deadly disasters, thus mitigating potential issues related to the external validity. Second, combined with the universe of buildings provided by the Land Register Administration, it means that we cannot only study the immediate impact of floods but also see how this later evolves through time. Finally, this chapter contributes to the broader discussion of optimal policies to mitigate urban development exposure to natural disasters as in (Kahn and Walsh, 2015; Kocornik-Mina et al., 2020). This is important as more frequent and more intense extreme climate events are expected in the near future. Our results show that signaling areas as potentially high-risk do not deter development from happening near such areas.

[8]Excluding the Basque Country and Navarre, who have an independent land register.

[9]For an extensive literature review, see Dell et al. (2014).

Finally, Chapter 5 provides concluding remarks. It reviews the main results of the previous chapters. Additionally, it addresses the main lessons drawn from this research in terms of policy design and housing.

2 Do short-term rental platforms affect housing markets? Evidence from Airbnb in Barcelona[1]

2.1 Introduction

Tourism has grown enormously in recent decades: between 1990 and 2017, the worldwide number of international tourist arrivals increased from about 400 million to 1,300 million (WTO, 2018). This pattern is particularly apparent in urban tourism; the number of visitors to the 162 most popular cities in the world has increased on average 6.5% each year between 2009 and 2018 (MasterCard, 2019). Home-sharing peer-to-peer platforms such as Airbnb have recently entered the market, partly accommodating the increased demand for tourism in cities. As a consequence, they have contributed to increasing the overlap between tourism and housing markets by allowing owners of residential properties to enter the hospitality sector.

Proponents of home-sharing platforms argue that short-term rentals provide residents with an additional source of income while decentralizing tourism within cities. From an economic point of view, home-sharing platforms can be seen as an efficiency improvement in markets where goods are not fully used (Barron et al., 2021). For example, empty apartments during holiday periods are efficiency losses that can be reduced through short-term rentals. However, if home-sharing platforms are used by owners to permanently shift from long-term to short-term rentals for tourists, the supply of units in the long-term market is reduced, increasing housing prices and rents. Critics of home-sharing platforms emphasize that short-term rental units in residential areas might constitute a negative externality for residents in terms of noise or uncivil behavior and cause displacement of long-term residents.[2] Complaints about touristification effects and nuisances have resulted in local policy im-

[1]This chapter is coauthored with Miquel-Àngel García-López, Jordi Jofre-Monseny, and Mariona Segú. It has been published on the Journal of Urban Economics, vol. 119, September 2020.

[2]Similarly, the hotel industry views home-sharing platforms as a threat to fair competition. Zervas et al. (2017) empirically studies the effect of Airbnb on hotel revenues.

plementation that limits the expansion of platforms such as Airbnb. Such policy responses include permit requirements (Barcelona, Berlin, Paris, San Francisco, and Los Angeles), limiting the rental period (Amsterdam, New York, Paris, and San Francisco), paying a rental tax (Amsterdam and San Francisco), or outlawing short-term rentals under some conditions (Berlin and New York). Despite all these local policy responses, we still have limited evidence on the effect of home-sharing platforms on housing markets.

In this paper, we analyze the effects of the arrival and expansion of Airbnb in Barcelona. Barcelona is ideal to study the effects of Airbnb on local housing markets for several reasons. First, Barcelona has experienced rapid tourism growth. The number of passengers in the city's airport increased from 20 to 47 million between 2000 and 2017. It is the 7th most visited destination city in Europe, measured by overnight visitors, and the 17th worldwide (MasterCard, 2019). Second, Airbnb accounts for the majority of short-term rental activity in the city, far ahead of its competitors.[3] Third, Airbnb penetration in Barcelona is high, with Barcelona being Airbnb's 6th top destination worldwide.[4]

Table 2.1 compares the number of Airbnb listings in Barcelona, New York, Los Angeles and Paris in 2015. Despite substantial legal uncertainties regarding the use of home-sharing platforms in Barcelona, about 2.06% of all housing units are listed on Airbnb.[5] This figure is higher than in New York (1.31%) and Los Angeles (0.86%), and slightly smaller than Paris (2.56%). However, if we measure Airbnb listings relative to the number of rented units, the percentage for Barcelona rises to 6.84%, a figure significantly higher than the other cities.[6] This high penetration of Airbnb in Barcelona is likely to be explained by the (large) difference between the returns of short-term and long-term rentals. At the bottom of Table 2.1, we provide estimates of the difference in revenue between Airbnb and long-term rentals. In 2015, the average long-term rental price in Barcelona was €11 per night (€735 per month), while the average Airbnb price (short-term rental) was €71 per night. An Airbnb listing yields the monthly income of a long-term rental in just 10 days of

[3]For Barcelona, Airbnb's market share is around 70% according to the DataHippo Project (`https://datahippo.org/es/`) which collects data from several home-sharing platforms since 2017. We do not use this data-set because it does not cover the period of study.

[4]'You'll never guess which city has the most Airbnb listings'. Forbes. J Bishop 2017.

[5]Barcelona's regulation of short-term rental platforms has not substantially changed during recent years. A city law passed in 2007 (Housing Rights Act 18/2007) states that tourist apartments that are neither primary nor secondary residences are required to have a business activity permit. When Airbnb first arrived in Barcelona around 2009, the short-term rentals of entire apartments without a permit were illegal. Nevertheless, enforcement of the law was very low until 2016, when the number of inspections substantially increased.

[6]Compared to traditional tourist accommodation, the number of active listings was equal to 32% of the total number of beds in hotels in the city in 2017.

occupancy.

Table 2.1: Airbnb activity in 2015 in selected cities

	Barcelona	New York	Los Angeles	Paris
Airbnb Listings	16,951	45,260	30,000	35,000
as % of total units	2.06	1.31	0.86	2.56
as % of rented units	6.84	1.92	1.56	4.97
Average Airbnb price/day (€)	71	131	114	81
Long-term rent/day (€)	11	59	75	37
Days/month for same revenue	10	14	20	14

Notes: Data on Barcelona comes from Cadastral Records and INCASOL, data on New York and Los Angeles comes from US Census Bureau, Zillow Rent Index and *airdna*, and data for Paris comes from INSEE and OLAP. All Airbnb data have been obtained through InsideAirbnb.

To guide the empirical analysis and to clarify the underlying mechanisms of the Airbnb effect on residential housing markets, we develop a stylized model where owners can decide to rent long-term to residents or short-term to tourists. The model predicts that Airbnb will increase housing prices and rents, with the effect on rents being larger than for prices. In terms of testable implications regarding mechanisms, the model predicts that Airbnb reduces the long-term supply of residential housing units.

To study the effect of Airbnb listings on residential housing markets, we combine publicly available web-scraped data on Airbnb listings in Barcelona with high-quality data on housing rents and real estate prices. We have access to i) individual-level data on the universe of transactions of second-hand apartments sold in the 2009-2017 period and ii) all posted ads for rentals and sales from a major real estate website (Idealista) that were active each December in the 2007-2017 period. We aggregate the information at the geographical level of small neighborhoods, which leaves us with a panel dataset of 221 small geographical areas that have an average population of about 7,000 inhabitants.

Throughout the empirical analysis, our dependent variable is the average residual resulting from a hedonic regression in which the log of housing rents or real estate prices are regressed on time dummies and unit characteristics. In all regressions, we control for neighborhood and time fixed effects. Since Airbnb has grown the most in central parts of the city, our main identification concern is that neighborhoods that experienced higher Airbnb penetration might be simultaneously experiencing processes of urban revival.[7] Aside from controlling for time-varying neighborhood socioeconomic characteristics that are associated with gentrification processes, we

[7]For the US, processes of urban revival have been described and studied by Baum-Snow and

adopt several strategies to account for the potential unobserved confounding effects of urban revival.

First, we estimate panel fixed effects specifications that allow neighborhoods to have different time trends. We run i) specifications that include interaction terms between baseline neighborhood characteristics (including the distance to the city centre) and a time trend (either linear or quadratic), ii) specifications that include interaction terms between these same neighborhood characteristics and (the log of) aggregate regional GDP, iii) specifications that fit neighborhood-specific time trends (either linear or quadratic), and iv) specifications on detrended data, where the outcome is measured as the deviation from its pre-2013 extended linear trend.

Second, we apply an IV strategy, where the instrument is the interaction between i) a measure of proximity to the city's tourist amenities at the neighborhood level and ii) a Google Trends measure that tracks changes in Airbnb activity over time. The proximity to tourist amenities predicts Airbnb listing locations, while searches for Airbnb in Google predict when these listings are posted. We indirectly verify the exclusion restriction by showing that proximity to tourist amenities does not predict rent and price growth in the pre-Airbnb period (i.e., before 2013).

Third, we also estimate event study regressions. Specifically, we estimate interaction terms between year dummies and a continuous measure of Airbnb activity in 2016. This approach allows us to directly check if housing markets in neighborhoods that experienced a high Airbnb penetration after 2012 were evolving similarly prior to the expansion of Airbnb as compared to the rest of the city.

Finally, we study rent and price dynamics around one specific location, *Sagrada Familia*, one of the main tourist attractions in the city. While Airbnb activity is high around *Sagrada Familia*, it is outside the city centre. The results for *Sagrada Familia* are less prone to be confounded by urban revival dynamics affecting the most central parts of the city.

All the empirical approaches yield results that are qualitatively and quantitatively similar, and are consistent with the predictions of our model. Airbnb has increased both rents and prices. Our preferred specification results suggest that 54 more active listings in a small neighborhood (about the average level in 2016) increase rents by 1.9%, while transaction and posted prices increase by 4.6% and 3.7%, respectively. However, our estimates imply that local impacts can be substantial in the most touristic parts of the city. Our results imply that an increase of 200 listings (the average number of listings in the top decile of the Airbnb activity distribution in 2016) increase rents by 7% and transaction and posted prices by 17% and

Hartley (2020); Couture and Handbury (2020), while Behrens et al. (2018) focus on the changes in local businesses associated with gentrification processes. González-Pampillón et al. (2019) provide some evidence of gentrification in the city center of Barcelona.

14%, respectively. We also show that Airbnb listings reduce the number of resident households in the neighborhood.

Despite Airbnb being a recent phenomenon, there are already some research papers that estimate the effect of Airbnb on housing markets. Barron et al. (2021) and Koster et al. (2018) are the two papers that are the most similar to our study. Barron et al. (2021) look at the impact of Airbnb on rents and house prices for all cities in the US.[8] Their main strategy consists of using a 'shift-share' instrument, where the time variation comes from Google Trends of 'Airbnb' searches, while the cross-sectional variation is a neighborhood 'touristiness' index based on the location of restaurants. They find that a 1% increase in Airbnb listings increases rents by 0.018% and housing prices by 0.026%. Koster et al. (2018) study the effects of Airbnb bans implemented by several, but not all, local governments in the Los Angeles area. Exploiting changes in prices at the administrative border, they find that banning Airbnb decreases prices by about 5%.

Compared to Koster et al. (2018), our paper focuses on a different channel through which Airbnb affects housing markets. In Koster et al. (2018) the use a spatial RD design, which compares changes in prices across municipality borders following Airbnb bans. This neatly identifies the price increase of a property due to the possibility of using Airbnb. However, properties located across a border might be part of the same housing market, and, their spatial RD estimates do not capture changes in rents and prices that are caused by supply reductions. As Koster et al. (2018) point out, rents should be smooth at the border. The supply channel is of great interest from a policy perspective, as rent increases caused by Airbnb are among the main complaints made by critics of short-term rental platforms.

Calder-Wang (2020) and Almagro and Domínguez-Iino (2020) adopt structural approaches to estimate the effects of Airbnb on the welfare of heterogeneous residents. Calder-Wang (2020) develops a model where absentee landlords can choose to rent either short-term (to tourists) or long-term (to residents) and where residents can also host by temporarily renting their home. In the model, estimated with data from New York, Airbnb affects residents' welfare trough two different channels. A rent channel, that comes from rent increases, following the reduction of long-term supply, and a host channel, since residents are allowed to collect income by renting their homes. Her results show that renters' net welfare effect is negative since the rent channel dominates the host channel. She finds that rent increases are widespread across the city, even in neighbourhoods with low Airbnb activity, due to spillover effects. In terms of distributional effects, rent increases are particularly

[8] An earlier contribution is Sheppard and Udell (2016) that focuses on New York City. Their results suggest that doubling Airbnb in a 300-meter circle around a property translates to an increase in its value by 6% to 9%.

high for high-income, highly-educated people whose preferences are more aligned with tourists. Moreover, host gains are concentrated in a small fraction of residents with low hosting costs. Almagro and Domínguez-Iino (2020) set up a dynamic spatial equilibrium model of residential choice and estimate it with data from Amsterdam. The model features multiple endogenous amenities that include the congestion effects of tourism as well as services provided by monopolistically competitive firms. The authors emphasize that endogenizing neighborhood amenity formation is key to understand the nature and welfare consequences of spatial sorting. Unlike the structural approach of these two studies, our focus produces reduced-form estimates that are shown to be robust to multiple identification threats.

We contribute to the literature in several ways. First, we focus on a city where the difference in returns between Airbnb and long-term rentals is large, resulting in high levels of Airbnb activity. Second, we provide estimates from four different identification strategies that yield qualitatively and quantitatively similar results that cross-validate each other. This is particularly true for rental prices, where all our estimates indicate that the average impact of Airbnb on rents is between 1% and 3%. Third, we have access to multiple high-quality micro-level data sets to track granular changes in housing rents, and posted and transaction prices. These micro-level data sets allow us to measure changes in rents and housing prices net of composition changes in rented or sold units, which is not possible when working with neighborhood average rents or prices. Fourth, we provide direct evidence on the supply mechanism by showing that Airbnb actually reduces the number of households living in the neighborhood. Fifth, this is the first study to carefully estimate the effects of Airbnb in the context of a large European city[9]. This is relevant given the underlying differences between European and US cities. For instance, European cities might have less excess capacity, where guest houses or basement apartments (below a main house) are virtually nonexistent. For the case of Barcelona, our analysis below shows that only a small proportion of housing units active on Airbnb are primary residences. Despite these differences, the results that we find are remarkably close to those found in Barron et al. (2021).

The paper is organized as follows. In Section 2.2, we develop the stylized model that studies the effects of short-term rentals on residential housing markets. Section 2.3 describes the Airbnb, rents and housing prices data and describes the most relevant variables. A description of our empirical strategies is provided in Section 2.4. The main results are presented and discussed in Section 2.5, while Section 2.6 contains the instrumental variables and event study results. Finally, some concluding

[9] Although not the main aim in Almagro and Domínguez-Iino (2020), the authors use a shift-share instrumental variables approach that indicates that Airbnb activity increased rents in Amsterdam.

remarks are provided in Section 2.7.

2.2 Theoretical framework

In this section we develop a theoretical framework to understand how short-term rentals to tourists can affect the residential market for long-term rentals. The model also guides our empirical analysis in terms of model specification, threats to identification, estimation strategies and interpretation of the results.

Model set-up — There are two neighborhoods: a central neighborhood c with fixed size C, and a suburban neighborhood s, with a housing supply curve which is not completely inelastic. All units in the city are owned by absentee owners. In the centre, owners can rent their units to residents (on a long-term basis) or to tourists (on a short-term basis).[10] In contrast, the suburban neighborhood s only hosts residents. The masses of residents and tourists have been normalized to one and each individual consumes one unit of housing.

Owner choices — Owners in neighborhood c can rent their apartments through a long-term rental to a resident and obtain an annual market rent Q^c or, alternatively, rent short-term to tourists and obtain an annual rent of T. Each owner j, who owns one unit, faces a cost b_j to rent short-term to tourists, which reflects the legal uncertainties or the costs of running an Airbnb business. The term b_j is heterogeneous across owners since they can differ in their risk aversion towards legal uncertainties or their access to legal services. If $T - b_j > Q^c$, the owner rents short-term to tourists, while if $T - b_j \leq Q^c$, the owner rents long-term to a resident. The cost b_j allows T to exceed Q^c in equilibrium, which is a salient feature of the data for the case of Barcelona. In equilibrium, there is a marginal owner who is indifferent between renting to residents or to tourists, $T - b_j^* = Q^c$, which implies that owners with $b_j < b_j^*$ rent short-term, while those with $b_j \geq b_j^*$ rent long-term. Hence, b_j^* is the share of units in neighborhood c that are rented on a short-term basis.

Resident and tourist choices — The utility that resident i obtains in neighborhood c is $U_{ir}^c = A_r - Q^c - \alpha F_b(b_j^*) + e_{ir}$, where A_r reflects the residents' valuation of amenities of neighborhood c, Q^c is the rental price, while $\alpha F_b(b_j^*)$ is a term reflecting the negative externality that tourism can impose on residents due to noise or un-

[10]Note that the model leaves out resident homeowners as it focuses on the competition for housing between tourists and renters.

civil behavior.[11,12] Finally, e_{ir} is an idiosyncratic term reflecting the relative preference of resident i to live in neighborhood c as opposed to neighborhood s. The utility level that resident i would obtain in neighborhood s is $U^s_{ir} = -Q^s$, where we normalize to zero the value of amenities in neighborhood s. The willingness to pay of the marginal resident to live in neighborhood c is $Q^c(e^*_{ir}) = A_r - \alpha F_b(b^*_j) + e^*_{ir} + Q^s$, with everyone with $e_{ir} > e^*_{ir}$ living in the centre and everyone with $e_{ir} \leq e^*_{ir}$ living in the suburbs.

The utility that tourist i obtains if staying in a short-term rental in neighborhood c is $U^c_{it} = A_t - T + e_{it}$, where A_t reflects the tourists' valuation of amenities in neighborhood c, and e_{it} is an idiosyncratic term reflecting the preference of tourist i to stay in a short-term rental in neighborhood c. As in Almagro and Domínguez-Iino (2020), residents and tourists might value amenities differently. Tourists have a fixed reservation utility level $U^0_t = 0$, which could reflect the possibility to stay at a hotel or visit another city. The willingness to pay of the marginal tourist to stay in a short-term rental in neighborhood c is $T(e^*_{it}) = A_t + e^*_{it}$, with only those tourists with $e_{it} > e^*_{it}$ staying in a short-term rental unit in the centre.

The equilibrium units in short-term rentals — Without loss of generality, we assume that b_j, e_{ir} and e_{it} are $U \sim (0,1)$, which simplifies the market clearing conditions in neighborhood c. $1 - e^*_{ir}$ and $1 - e^*_{it}$ are the shares of residents and tourists who stay in the central neighbourhood c. We write $Cb^*_j = 1 - e^*_{it}$ which ensures that demand for short-term rentals equals its supply, while market clearing for long-term rentals implies $C(1 - b^*_j) = 1 - e^*_{ir}$. In neighborhood s, the long-term rental price is assumed to be an increasing function of its population. Specifically, we posit that $Q^s = \gamma\, e^*_{ir}$, with $\gamma > 0$. Combining the market clearing conditions, the willingness to pay of the marginal resident and tourist, $Q^c(e^*_{ir})$ and $T(e^*_{it})$, and the definition of the marginal owner, $T - b^*_j = Q^c$, we obtain the share of owners that rent short-term to tourists in neighborhood c:

$$b^*_j = \frac{(A_t - A_r) + C - \gamma(1 - C)}{2C + (1 - \alpha) + \gamma(C)} \tag{2.1}$$

[11] Tourism as a negative externality is in line with the local population's perception of tourism as a negative phenomena in Barcelona. This is documented by an opinion poll made by local authorities since 2011, which surveys citizen perception of Barcelona's most important problems. In this poll, tourism was mentioned, on average, as the city's fourth largest problem during the entire period, reaching the top ranking in 2017.

[12] Almagro and Domínguez-Iino (2020) posit that tourism affects residents through a direct negative effect and indirectly by changing the availability of non-tradable goods and services such as child care facilities.

Equation 2.1 indicates that the main driver of the penetration of Airbnb in a central neighborhood is the tourists' valuation of amenities relative to the resident's valuation ($A_t - A_r$).[13]

Rental prices — The equilibrium price of long-term rentals can be obtained by inserting the market clearing conditions $C(1-b_j^*) = 1 - e_{ir}^*$ and $Q^s = \gamma\, e_{ir}^*$ in the residents' willingness to pay function:

$$Q_c = (1-C)(1+\gamma) + A_r + (C + \gamma C - \alpha)\, b_j^* \tag{2.2}$$

Equation 2.2 indicates that the number of units in the short-term rental market affect long-term rents through three different mechanisms. First, one additional unit in the short-term market reduces the number of long-term residents, which mechanically increases the willingness to pay of the marginal resident as the market clearing condition reveals. Reducing the supply of long-term units increases prices. The second term is a second order general equilibrium effect. An increase in b_j^* displaces residents from neighborhood c to s, increasing rental prices in the suburbs as equation $Q^s = \gamma\, e_{ir}^*$ reveals. Rents can increase in areas with little to no Airbnb listings as emphasized in Calder-Wang (2020). A higher rental price in neighborhood s makes neighborhood c relatively more attractive, further increasing rents in neighborhood c. Finally, a marginal increase in b_j^* means higher negative externalities, which contribute to lower long-term rents. Provided that these externalties are not too large, the overall effect of Airbnb on rents will be positive.

Housing prices — To relate rents and housing prices, we follow the approach of Barron et al. (2021). The market is assumed to be in a steady state, and the price of a housing unit (P^c) is given by the present value of discounted cash flows to the landlord:

$$P^c = \sum_{t=1}^{\infty} \delta^t \left[(1-b_j^*)Q^c + \int_0^{b_j^*} (T - b_j)\, db_j \right] = \frac{1}{1-\delta} \left[Q^c + (T - Q^c) b_j^* - \frac{(b_j^*)^2}{2} \right] \tag{2.3}$$

Assuming δ as the discount factor, the cash flow in each period reflects the fact that $1-b_j^*$ units are rented long-term at price Q^c, and b_j^* units are rented in the short-term market at rate T paying the cost b_j. Equation 2.3 indicates that the effects of Airbnb on housing prices (P^c) will be larger than those on rents (Q^c), as part of the stock available for rent obtains a return of $T - b_j$ that is higher than Q^c.

[13] For $0 \le b_j^* \le 1$, it has to be the case that $\gamma(1-C) - C \le (A_t - A_n) \le C + 1 - \alpha + \gamma$.

Implications for the empirical analysis — Equations 2.2 and 2.3 motivate our empirical analysis consisting of relating changes in housing rents or prices with changes in Airbnb activity at the neighborhood level. From the theoretical framework developed here, we draw five implications for the empirical analysis.

First, the model predicts that Airbnb activity increases rents and prices, with the effect on prices being larger in absolute value.

Second, inspecting equations 2.1 to 2.3 reveal the main identification threat faced in the empirical analysis. The effect of Airbnb activity on residential housing markets will be biased if neighborhoods where Airbnb penetration is high are simultaneously experiencing changes in the residents' willingness to pay. It could be that neighborhoods where A_t is high are becoming increasingly popular among residents. Central neighborhoods where Airbnb activity is higher are going through gentrification processes. We will extensively address these concerns in the empirical analysis.

Third, besides the increase in rents (and prices), the model indicates that Airbnb reduces the supply of units in the long-term rental market. As a consequence, the model predicts that Airbnb displaces residents. To test the model's main mechanism we will also estimate the effect of Airbnb activity on the number of resident households.

Fourth, as we have seen above, equation 2.1 predicts that the penetration of Airbnb is (partly) determined by the presence of neighborhood amenities that are more important to tourists than they are to residents. In Section 2.4.2 we document that, the proximity to relevant tourist attractions is a strong predictor of Airbnb activity at the neighborhood level. This observation motivates the instrumental variables strategy developed in Section 2.4.2.

Fifth, our empirical analysis essentially estimates the effect of Airbnb by comparing changes in rents (or prices) between neighborhoods with high versus low Airbnb activity. Subtracting Q^s from equation 2.2 yields:

$$Q^c - Q^s = (1 - C) + A_r + (C - \alpha)\, b_j^* \tag{2.4}$$

Equation 2.4 reveals that rent comparisons between neighborhoods with different levels of Airbnb penetration provides a lower bound of the total effect of Airbnb. Differences in rents (or prices) net-out the second-order general equilibrium effects that increase rents and prices throughout the city.

2.3 Data and variables

Neighborhood definition — Our geographical unit of analysis is the Basic Statistical Area (BSA). BSAs are built and used by the Barcelona City Hall for statistical purposes. There are a total of 233 BSAs with an average of 7,122 inhabitants, but due to data restrictions we keep 221 BSAs in our sample. We believe that BSAs are the appropriate neighborhood definition, as they are designed to contain population with similar socio-economic characteristics and their size is sufficient to generate meaningful measures of housing rents and prices for neighborhoods over time.

Airbnb — To measure Airbnb activity, we use information extracted directly from the Airbnb website. InsideAirbnb is a dataset collected at different points in time by Murray Cox, an independent Internet user who has made it publicly available. For Barcelona, it contains 21 data points between April 2015 and February 2018.[14] Each listing has information on the host ID, geographical coordinates, room characteristics, date the host registered, and date of each guest review. Even though Airbnb is not the only home-sharing platform active in the city, we consider that its listings are a good proxy for the short-term rental market. Its market share is by far the highest among its competitors and most short-term rentals are advertised through more than one platform simultaneously, implying that adding listings from a second platform would cause significant double counting.

For our purposes, it is crucial to identify a listing's active period. Even though the information started being scraped in early 2015, by exploiting the date of each review, we are able to reconstruct the listing's activity prior to 2015 (as well as in between the rest of the data points). This strategy is supported by the fact that, according to Airbnb, 72% of guests leave a review.[15] We follow Zervas et al. (2017) and consider that a listing is active in a given quarter if it has received at least one review during that quarter.[16]

The potential consequences of Airbnb might be very different if the platform is used to rent out excess capacity (home-sharing), or if units are rented short-term through Airbnb all year long. We label listings that correspond to this second cat-

[14] Details about the website can be accessed through `http://insideairbnb.com/about.html`.

[15] Although some guests do not leave a review, there are no reasons to believe that the percentage of guests that leave a review changes non-randomly across space or time.

[16] An alternative approach would be to use the entry date and assume that listings never exit, which is the preferred method in Barron et al. (2021). In the case of Barcelona, we consider that this approach is problematic. First, approximately 25% of all listings do not have any reviews at all. Second, the entry date indicates the time when the host registered. If the host has multiple listings (which is the case for the majority of listings in Barcelona), it is not possible to know the entry date of each listing.

egory as 'commercial'. Listings in Airbnb are *entire apartments*, *private rooms* or *shared rooms*. We consider multi-hosted properties (host has more than one listing) and single-hosted *entire apartments* with a minimum of 5 reviews per quarter to be commercial. This definition is clearly conservative, as many entire properties are rented as separate *private rooms*.[17] Despite this, more than 75% of all listings in every single year in our sample correspond to this commercial category. Although some genuine home-sharing exists on the platform, Airbnb in Barcelona is mostly a commercial activity.

Rents and prices — We use two sources of data to obtain information on rents and prices at a fine spatial level. In particular, we have two measures for prices (transaction prices and posted prices) and one measure for rents (posted rents). For transaction prices, we use data from the Catalan Tax Authority from transaction tax records, which includes the price, exact location, date of transaction, size of the housing unit, year of construction, and a variable reflecting the quality of the dwelling. We have the universe of transactions that occurred in Barcelona during the period 2009-2017.[18] We label this dataset ITP (*Impuesto sobre Transmisiones Patrimoniales*) or transaction prices.

For posted rents and prices, we use information from the online real estate portal Idealista. With more than one million ads and an average of 17 million weekly views, Idealista is by far the most important Spanish real estate portal. Idealista provided us with all ads that were active for the city of Barcelona in December of every year for the period 2007-2017[19][20]. The data include the exact location, the posted rent or price and the size of the unit, among other characteristics[21].

Having two measures of prices is useful because both transaction and posted prices have advantages and disadvantages. Posted prices might differ from final prices since bargaining is a regular part of the process. Official transaction prices should, in principle, measure prices more precisely. However, in practice, the transaction (ITP) data have two limitations. First, there might be a non-negligible time

[17]This practice increased after July 2016. Short-term rentals of *entire apartments* without a permit is illegal, but enforcement was very low before July 2016. It is less clear if renting a *private room* is also against the law, and in practice, enforcement with respect to *private rooms* has been low throughout the period we study.

[18]We keep only those sales transactions with a declared value of less than 10,000,000 euros.

[19]We have dropped the following data: sales ads with posted prices below 10,000 euros and those of less than 20 square meters, and we drop all ads with monthly rents below 100 euros or above 30,000 euros.

[20]Idealista's monthly aggregate data for Barcelona show little seasonality, indicating that using December data should not be a limitation in our context.

[21]Other characteristics that are available and that we use are number of floors, number of rooms, presence of air-conditioning, lift and boxroom, and whether it is a studio, penthouse, or duplex.

lapse between the date at which parties agree on a price and the date when the ITP tax is paid. Second, there is some fraud in the ITP tax that consists of under-reporting the ITP price and the tax base. For rents, we cannot compare posted to actual rents. However, Chapelle and Eymeoud (2018) show, in the French context, that bargaining is less of an issue for rents and that online posted prices are a good measure of actual rents.

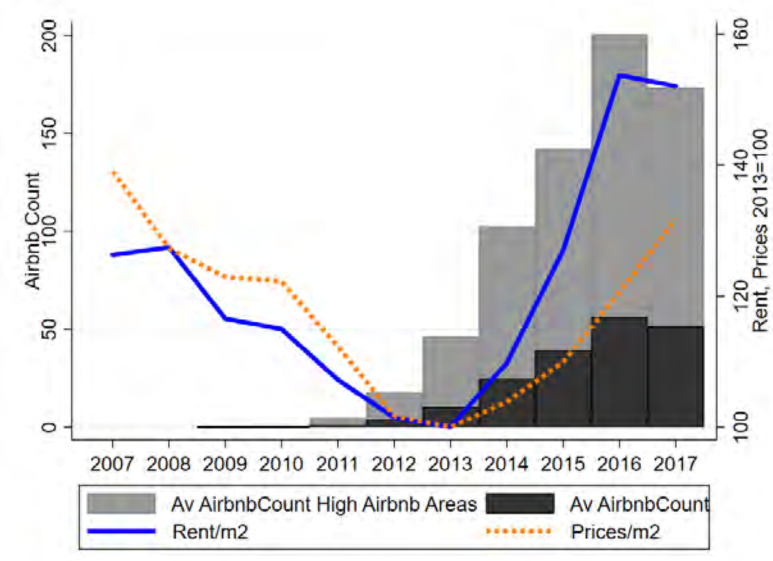
Descriptive statistics — In Figure 2.1, we plot the evolution over time of Airbnb activity, together with that of rents and prices. Airbnb experienced a very rapid increase from its first entrance in 2009 up to 2016, when the growth stopped because of City Hall's increased efforts to reduce tourist apartments operating without a license. In 2016, the average BSA had 54 listings, while *High Airbnb Areas* (those BSAs in the top decile) had an average of 200 active listings. In these areas of the city, approximately 5% of all housing units are listed on Airbnb. The substantial variation in Airbnb activity across neighborhoods is further explored in Figure 2.2, which shows the distribution of Airbnb listings across BSAs for the last quarter of 2016. Airbnb activity is higher around the city center and, to some extent, along portions of the beach line or around the *Sagrada Familia*. Airbnb activity is low in many other parts of the city.

The evolution of housing rents and prices in the period we study is turbulent. Following the financial crisis and the burst of the Spanish housing bubble, rents and prices fell until 2013, when they started recovering as the economy started to grow. While prices reached pre-crisis levels towards the end of the period, rents surpassed pre-crisis levels around 2015 and kept rising. During this period, housing affordability was one of the main concerns among residents.[22] The recovery of rents and prices coincides in time with the return of economic growth and the expansion of Airbnb. We address the endogeneity concerns related to this coincidence in the empirical section.

We complement the data on rents, prices and Airbnb listings with a comprehensive set of socioeconomic BSA characteristics including population, age distribution, relative income index, average household size, unemployment level and the percentage of foreign population. In Table 2.2, we report descriptive statistics. We present the BSA means for the years 2012 and 2016 for two different samples: all BSAs and *High Airbnb Areas* (BSAs in the top decile of the Airbnb listings distribution in 2016).

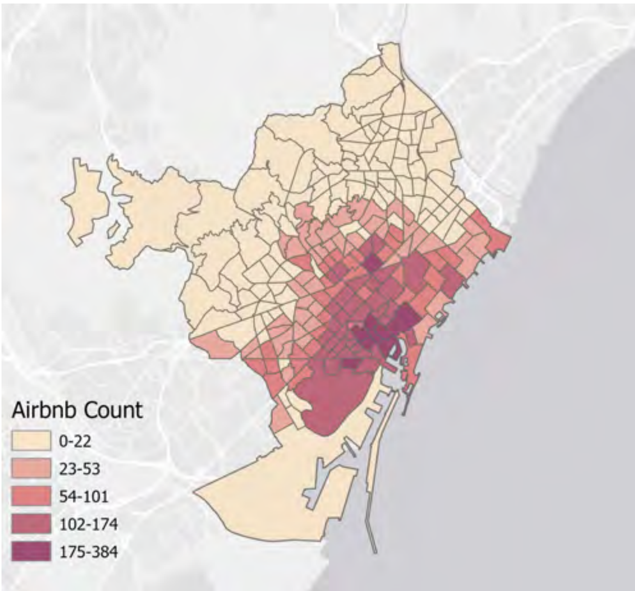
[22] See *'El acceso a la vivienda, el principal problema de los barceloneses'* Macedo, G., October 2010.

Figure 2.1: Airbnb listings, rents and prices: 2007-2017



Notes: This graph plots the evolution over time of the BSA averages in Airbnb listings, rents and posted prices (per square meter) for the period 2007-2017. Rents and prices are normalized to their 2013 value. The dark gray bars represent the average Airbnb listings for all BSA, while the light gray bars depict the average listings for *High Airbnb Areas* (BSAs in the top decile of the Airbnb listings distribution in 2016).

Figure 2.2: Airbnb activity across BSAs in 2016



Notes: This graph plots the number of active Airbnb listings in the fourth quarter of 2016 at the BSA level.

Table 2.2: Descriptive statistics: Variables' means across BSAs for 2012 and 2016.

	2012		2016	
	All BSAs	High Airbnb Areas	All BSAs	High Airbnb Areas
Airbnb Count	2.79	13.35	47.84	178.58
Rent (€/m^2)	11.83	12.93	16.39	20.19
Posted Price (€/m^2)	3250	3338	3753	4282
Transaction Price (€/m^2)	2269	2356	2619	3027
Population	6978	7750	6973	7514
Population Density	0.03	0.04	0.03	0.04
Mean Age	43.36	42.10	43.69	42.08
% of Foreign Population	0.18	0.32	0.17	0.33
Household Size	2.47	2.41	2.48	2.41
Unemployment Rate	10.48	10.81	7.80	7.83
Income Index	98.37	96.48	102.78	104.58

Notes: Columns 1 and 3 report the mean for all BSAs in 2012 and 2016. Columns 2 and 4 report the means of *High Airbnb Areas* (BSAs in the top decile of the Airbnb activity. distribution in 2016).

2.4 Empirical strategies

2.4.1 Baseline specification

Our main analysis consists of estimating the following fixed effects specification (and variants of it):

$$log(Y_{n,t}) = \beta Airbnb\,Count_{n,t} + \gamma X_{n,t} + \tau_t + \mu_n + \varepsilon_{n,t} \tag{2.5}$$

where $Y_{n,t}$ is our measure of housing rents or prices at the BSA level, the number of active listings at time t in BSA n is given by $Airbnb\,Count_{n,t}$, τ_t are time fixed effects, and μ_n are BSA fixed effects that account for time-invariant neighborhood characteristics. Our dependent variable $log(Y_{n,t})$ is the average residual at the BSA-time period level of a (micro-level) regression in which log rents (or log housing prices) are regressed on time dummies and unit characteristics.[23] This controls for price changes across neighborhoods that could be explained by changes in the composition of units rented or sold across BSAs and over time. For example, it allows us to control for BSAs that might have a growing proportion of high-end apartments being sold or rented over time. Throughout the regression analyses, we weight BSA-time cells by the relevant number of ads or sales. Standard errors are clustered at the BSA level to account for serial correlation within panel units (Bertrand et al., 2004).

Our main concern regarding identification is that neighborhoods with the most Airbnb activity growth during our period of study might be experiencing processes of sociodemographic change, which might have a direct impact on housing rents and prices. Airbnb has grown the most in central parts of the city that have also been experiencing processes of urban revival in the last two decades. We adopt several strategies to control for the potential confounding effects of gentrification.

First, we introduce in equation 2.5 a set of time-varying controls at the BSA level ($X_{n,t}$); average age, log of population density, average household size, unemployment rate, relative income, and percentage of foreign residents. Since this equation includes BSA fixed effects, this allows us to control for yearly changes in variables associated with processes of gentrification. In some specifications, we allow for neighborhoods with different characteristics to have different time trends (linear or quadratic). We do so by introducing, as additional regressors, interaction terms be-

[23] We construct a panel on the BSA-year (data from Idealista) and BSA-quarter (transaction prices). Unit characteristics in the Idealista database are size, number of floors, number of rooms, air-conditioning, lift and boxroom, and whether it is a studio, penthouse, or duplex. In the ITP database, dwelling characteristics are size, year of construction, and a variable reflecting the quality of the dwelling (with scale 1 to 8).

tween the time trend and the control variables measured in 2012, i.e., $X_{n,2012} \times t$ in the linear case or $X_{n,2012} \times t$ and $X_{n,2012} \times t^2$ in the quadratic case. In this specification, we also include the interaction term between the time trend and the distance to the city center.[24] This would allow, for instance, more central neighborhoods to have a steeper time trend.

Second, in a more data demanding approach, we include BSA-specific time trends (linear or quadratic). Specifically, we add $\rho_n \times t$ interaction terms for the linear case and $\rho_n \times t + \psi_n \times t^2$ for the quadratic case. This is a very flexible specification since it allows each BSA to have its own time trajectory in housing rents and prices. Here, the variations that we exploit are deviations from each BSA's own specific linear (or quadradic) time trend.

If Airbnb affects not only *levels* but also *trends* of these variables, including BSA-specific time trends would not be appropriate since it would capture both the effect of Airbnb and BSA-specific time trends (Wolfers, 2006). We resort to a detrending procedure previously applied in the taxation (Kleven et al., 2014) and minimum wage (Monras, 2015) literatures and estimate linear time trends using data prior to 2013 only (i.e. the pre-Airbnb period). We estimate the following two equations at a neighborhood-time level:

$$log(Y_{n,t}) = \mu_n + \tau_t + \rho_n \times t + \varepsilon_{n,t}, \text{ for } t \leq 2012 \tag{2.6}$$

$$\widetilde{log(Y_{n,t})} = \beta Airbnb\ count_{n,t} + \gamma X_{n,t} + \tau_t + \varepsilon_{n,t}, \text{ for all } t \tag{2.7}$$

The first equation estimates the outcome based on BSA dummies, time dummies, and BSA specific linear time trends for the years up to 2012. Based on these OLS coefficients, we predict $log(Y_{n,t})$ for the entire sample years and compute the residuals, $\widetilde{log(Y_{n,t})}$. In the second stage (equation 2.7), we regress these detrended residuals against Airbnb listings, time dummies and the time-varying controls ($X_{n,t}$).

2.4.2 Instrumental variables fixed effects models

As an alternative approach to tackle the endogeneity of Airbnb location, we also estimate equation 2.5 through a Two-Stage Least Squares regression. Our theoretical model indicates that short-term rentals locate in areas where tourist amenities are high. Following this prediction, we use a shift-share variable as an instrument that combines i) cross-sectional variation across BSAs in tourist amenities and ii) aggregate time variation in Airbnb activity.

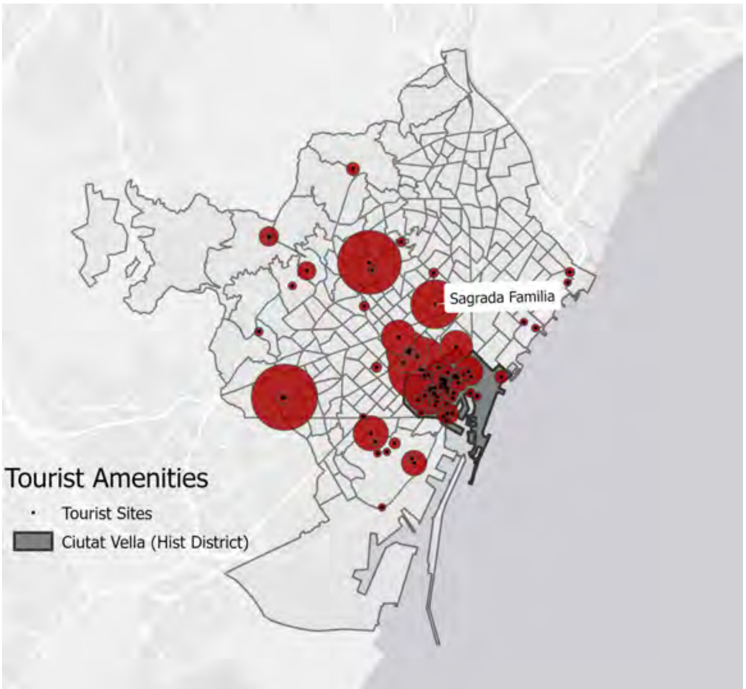
[24]Distance to the city center is measured as the distance from Plaça Catalunya (the main city square) to the centroid of each BSA.

For the cross-sectional 'share' component of the instrument, we build an index that measures proximity to tourist amenities. Our instrument aims to capture the set of amenities that tourists enjoy while not being of particular interest to residents. We use TripAdvisor to produce a complete list of the city's tourist amenities.[25] We geolocate these amenities and collect the number of Google reviews of each attraction. We use the number of reviews to weight the relative importance of each site.[26] Our measure of tourist amenities is built as follows:

$$TouristAmenities_n = \sum_k \frac{1}{dist_{n,k}} \times Reviews_k \tag{2.8}$$

where k indicates the amenity, $dist_{n,k}$ is the distance in meters between the centroid of each BSA n and amenity k, and $Reviews_k$ is the number of Google reviews. Figure 2.3 shows the location of these amenities, where the size of each circle is proportional to the number of reviews.

Figure 2.3: Location of tourist amenities

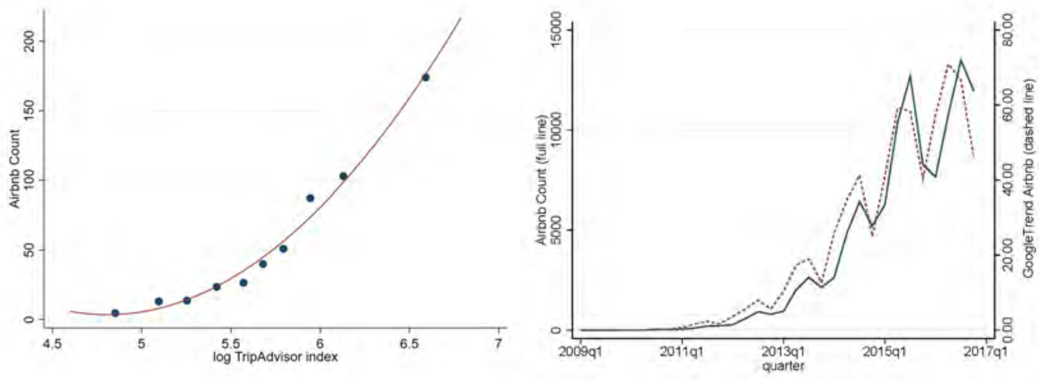


Notes: Location of tourist amenities across the city, the size of the circles is proportional to the number of reviews. The darker area shows the city's historical district.

[25]TripAdvisor is a website that offers tourism-related content. According to the site, it currently has over 390 million monthly unique visitors. We exclude the more endogenous and less historical amenities such as areas known for restaurants, bars or clubs.

[26]Although TripAdvisor also provides reviews, Google has more.

Figure 2.4: Airbnb activity, tourist amenities and Google Trends searches.



(a) Airbnb activity and tourist amenities **(b)** Airbnb activity and Google Trends searches

Notes: Graph (a) shows BSAs' Airbnb listings as a function of the tourist amenities index (bins are deciles of the tourist amenities distribution). Graph (b) shows the time profile of Airbnb listings (solid line, left axis) and Google Trends searches for 'Airbnb Barcelona' (dashed line, right axis).

As the 'share' component of the instrument, the tourist amenities index should predict where Airbnb listings will appear. Panel a) in Figure 2.4 plots this relationship by binning the data for deciles of the tourist index distribution. The graph clearly shows that BSAs that are closer to tourist amenities tend to show the highest number of Airbnb listings. This relationship can be rationalized by the model of Section 2.2. Tourist amenities (A_t) increase the tourists willingness to pay which increases both Airbnb prices (T) and Airbnb activity (b_j^*). In Figure A1 in the Appendix, we show that neighborhoods with high levels of Airbnb activity have more expensive Airbnb listings.

Turning to the 'shift' component of the instrument, we follow Barron et al. (2021) and use worldwide searches in Google for the term 'Airbnb Barcelona'. This variable is measured at a monthly level and is normalized to 100 for the month with the highest number of searches. Panel b) of Figure 2.4 shows that the number of Google Trends searches for 'Airbnb Barcelona' tracks the time variation in Airbnb activity very well.

The rationale behind the instrument works as follows. The proximity to tourist amenities predicts where Airbnb listings locate, while searches in Google Trends for the term 'Airbnb Barcelona' predict when listings appear. Figure 2.4 provides suggestive evidence of the relevance of the instrument. We also test for this in the first stage regressions.

As for the exclusion restriction, recent research on shift-share instruments indicates that the main identification threats are related to the 'share' component of the instrument (Goldsmith-Pinkham et al., 2020). Since our specifications contain a BSA fixed effect, instrument validity hinges on the assumption that the cross-sectional 'share' component, proximity to tourist amenities, is only correlated with *changes* in housing rents and prices through Airbnb listings. For example, our instrument would be invalid if residents' valuation of proximity to tourist amenities (or any other BSA characteristic that correlates with it) changes over the study period for a reason other than the presence of tourism. If the instrument is valid, proximity to tourist amenities should not explain changes in housing rents and prices prior to the arrival of Airbnb. We address this issue at length below.

2.4.3 Event study plots

We conduct an event study exercise, using the following regressions:

$$log(Y_{n,t}) = \sum_{t \neq 2012} \delta_t \times AirbnbCount_{n,2016} + \gamma X_{n,t} + \mu_n + \tau_t + \varepsilon_{n,t} \tag{2.9}$$

where $AirbnbCount_{n,2016}$ is the number of listings in BSA n in 2016. Like in previous regressions, we include time and BSA fixed effects and time-varying characteristics ($X_{n,t}$). We estimate $AirbnbCount_{n,2016}$ × year interactions, leaving 2012 as the base year. This approach allows us to estimate the yearly effect of having one additional listing in 2016. Again, we choose 2012 as the last pre-Airbnb year as, starting in 2013, Airbnb's activity became more significant. This exercise allows us to check if, prior to the arrival of Airbnb, areas that will experience higher Airbnb activity display similar trends in housing rents and prices compared to other neighborhoods.

2.4.4 Evidence from *Sagrada Familia*

In our last empirical strategy, we will focus on *Sagrada Familia*, one of the main tourist amenities in the city. It is one of the three major tourist amenities not found in the city centre as shown in Figure 2.3. The other two non-central hotspots are Camp Nou (north-west of city centre) and Parc Güell (north-west of *Sagrada Familia*). Figure 2.2 shows that only the area around *Sagrada Familia* has a high level of Airbnb activity, possibly because Camp Nou and Parc Güell are too far from the city centre. Unlike the most central parts of the city, the area around *Sagrada Familia* is an upper-middle class residential neighborhood. In 2000, this area was ranked 14 out of 38 broad neighborhoods by relative family income[27]. Its position in this ranking was 13 in 2008, indicating that this area was not experiencing gentrification

[27] Before 2008, income is only available for 38 broad neighborhoods.

in the pre-Airbnb period[28]. *Sagrada Familia* provides us a setting to study the effects of short-term rentals where concerns regarding the confounding effects of urban revival are diluted.

First, we estimate equation 2.5 by Two-Stage Least Squares where the instrument is the interaction term between the inverse distance to *Sagrada Familia* ($1/distSF_n$) and our measure of Google Trends searches. In this case, proximity to this particular attraction predicts the location of Airbnb listings, while, as before, Google Trends predicts the timing of Airbnb arrival and expansion. We argue that this is an exogenous instrument since it is unlikely that residents' preferences to locate close to *Sagrada Familia* had change during the period 2007-2017 for a reason other than tourism.

Second, we also replicate our event study design but focus on the proximity to *Sagrada Familia* as a predictor of Airbnb activity. We estimate $1/distSF_n \times$ year interactions, while controlling for the usual neighborhood characteristics and fixed effects.

$$log(Y_{n,t}) = \sum_{t \neq 2012} \delta_t \times \frac{1}{distSF_n} + \gamma X_{n,t} + \mu_n + \tau_t + \varepsilon_{n,t} \tag{2.10}$$

This strategy is useful to determine whether BSAs at different distances (measured in kilometers) to *Sagrada Familia* experience similar trends in rents and prices before and after the arrival of Airbnb.

2.5 Main results

2.5.1 Graphical evidence

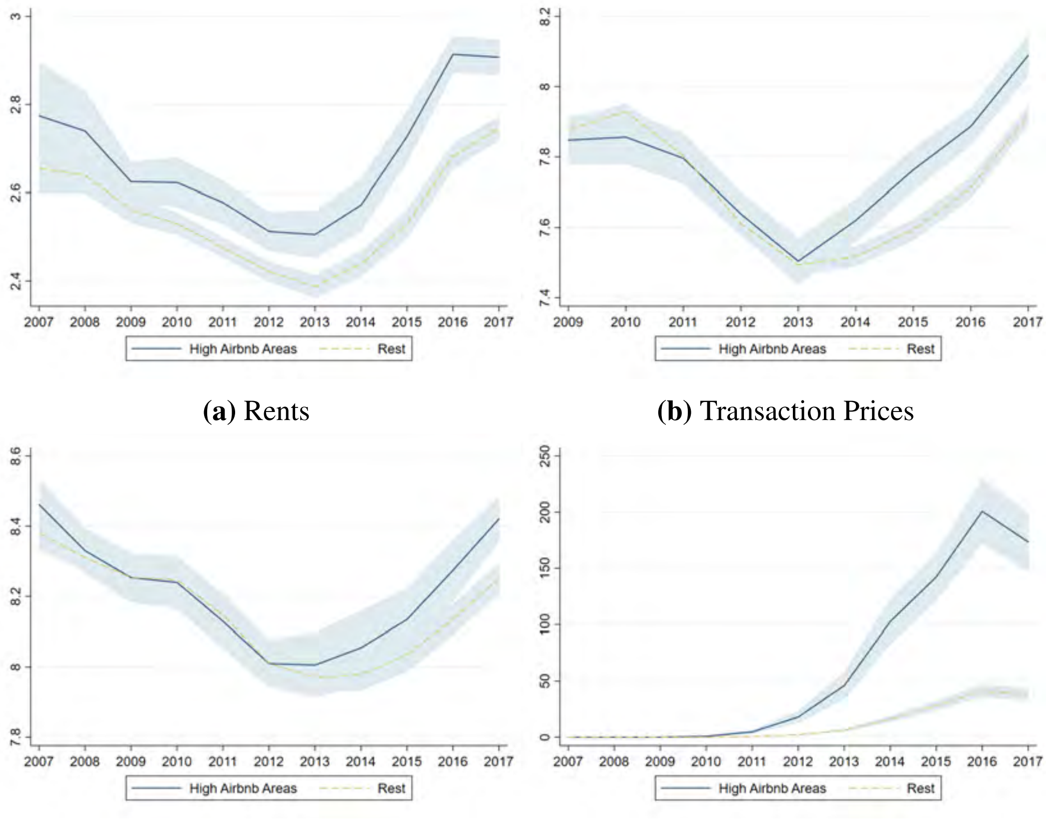
Before proceeding to the regression results, in Figure 2.5, we show graphical evidence of the effect of Airbnb on housing markets. We plot raw average (log) prices and rents series over time for *High Airbnb Areas* (BSAs in the top decile of Airbnb listings distribution in 2016) versus the rest. In Panel (a) we graph rents, while in Panels (b) and (c), we show corresponding graphs for transaction prices and posted prices, respectively. For completeness, in Panel (d), we plot our measure of Airbnb activity.

The levels of both rents and prices tend to be higher in BSAs with more Airbnb activity. While the series for the period before 2012 appear fairly parallel, the gaps

[28]Similarly, the share of population between 20 and 34 years, which is another indicator associated with gentrification, has also remained stable over the same period in the Sagrada Familia area. It was equivalent to 26% in 2000 and to 27% in 2008.

in rents and prices seem to widen, with the expansion of Airbnb in 2013 and onwards, especially for rents and transaction prices, where the divergence is more noticeable. In the first three figures, the difference between the two groups is statistically significant at the end of the period, while this is not the case for the first years. Finally, in Panel (d), we report the evolution of the count of Airbnb listings by group. While the number of listings increased drastically for the *High Airbnb Areas*, the increase was very modest for the other BSAs, reflecting the fact that Airbnb is highly concentrated in particular areas of the city.

Figure 2.5: Evolution of rents and prices for *High Airbnb Area* vs. the rest



(a) Rents **(b)** Transaction Prices

(c) Posted Prices **(d)** Airbnb Count

Notes: Rents, Transaction and Posted prices are expressed in logs. Graphs plot raw averages and the appropriate confidence intervals. *High Airbnb Area* are BSAs in the top decile of the Airbnb listings distribution in 2016.

These graphs are suggestive evidence that neighborhoods with higher Airbnb penetration also experienced higher rents and price growth with the arrival and expansion of Airbnb. Since these series might be affected by other confounding factors that could be biasing the results, we move to our main empirical strategies described in Section 2.4.

2.5.2 Baseline results

In Table 2.3, we report our baseline results for the impact of Airbnb on rents (Panel A) and prices (Panels B and C). As explained above, throughout the table, the dependent variable is the average BSA-time period residual of a micro regression in which log rents (or log prices) are regressed on housing characteristics and time dummies.

In column 1, we regress the outcome of interest against the number of Airbnb listings while controlling only for time and BSA fixed effects. Then, in column 2, we add BSA time-varying controls. Coefficients are positive and significant for both rents and prices, which implies that an increase in the number of listings translates into an increase in rents and prices. The effects on prices are larger than on rents, especially for transaction prices. The presence of contemporaneous controls has no large impact on the estimates for rents, while it slightly decreases coefficients for prices, although not in a statistically significant way. Nevertheless, we keep the socioeconomic controls in subsequent specifications for the sake of completeness.

In column 3 (4), we include socioeconomic-specific linear (or quadratic) time trends by introducing interaction terms between a linear (or quadratic) time trend and the control variables measured in 2012 as detailed in Section 2.4. The coefficients for prices are somewhat reduced, while they remain fairly constant for rents. Then, we report the results of specifications that fit BSA-specific time trends. Column 5 shows the results for linear trends and the results for quadratic trends are presented in column 6. These allow for both observable and unobservable characteristics to impact neighborhood trends. The inclusion of linear time trends increases the coefficient for rents (though not significantly) and reduces the coefficients for prices, especially for posted prices where the coefficient becomes non-significant. As for regressions with quadratic trends, they do not substantially change the coefficients of rents and transaction prices but it further decreases the coefficient for posted prices. Nevertheless, by introducing quadratic trends we might be overfitting the model as a vast majority of the BSA quadratic trend coefficients are non-significant. For posted prices, where results are more sensitive to the inclusion of quadratic trends, the F-test of their joint significance is only 1.60.

Table 2.3: Impact of Airbnb on rents and prices - Baseline Specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A	Rents								
Airbnb Count (x100)	0.036***	0.035***	0.037***	0.036***	0.058***	0.051***	0.034*	0.038***	0.053***
	(0.008)	(0.009)	(0.009)	(0.009)	(0.020)	(0.024)	(0.018)	(0.008)	(0.010)
N	2.123	2.123	2.123	2.123	2.123	2.123	2.123	2.123	1.920
Panel B	Transaction Prices								
Airbnb Count (x100)	0.110***	0.085***	0.039**	0.040**	0.052***	0.062**	0.082***	0.063***	0.084***
	(0.019)	(0.016)	(0.017)	(0.018)	(0.020)	(0.025)	(0.025)	(0.017)	(0.022)
N	7.901	7.901	7.901	7.901	7.901	7.901	7.901	7.901	7.228
Panel C	Posted Prices								
Airbnb Count (x100)	0.081***	0.068***	0.032***	0.026***	0.022	0.005	0.084***	0.045***	0.075***
	(0.010)	(0.009)	(0.010)	(0.010)	(0.019)	(0.023)	(0.21)	(0.010)	(0.012)
N	2.229	2.229	2.229	2.229	2.229	2.229	2.229	2.229	2.024
Time FE	X	X	X	X	X	X	X	X	X
BSA FE	X	X	X	X	X	X	X	X	X
Controls	-	X	X	X	X	X	X	X	X
Trends	-	-	$X_{n,2012}$ (L)	$X_{n,2012}$ (Q)	BSA (L)	BSA (Q)	-	-	-
Detrendend BSA	-	-	-	-	-	-	X	-	-
$X_{n,2012} \times$ GDP	-	-	-	-	-	-	-	X	-
No Hist Dist	-	-	-	-	-	-	-	-	X

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the BSA level. Each column represents a different specification. Panel A reports the results for rents, while Panels B and C report the corresponding estimates for transaction and posted prices. Outcomes are average residuals at the BSA-time period level, as explained in the main text. Regressions weighted with the total number of ads (for rents and posted prices) and of transactions (for prices). The analysis takes place at the BSA-year level for rents and posted prices and BSA-quarter for transaction prices. Controls are: average age, log of population density, average household size, unemployment rate, average relative income, and percentage of foreign residents. Trends can be either characteristic-specific ($X_{n,2012}$) or BSA-specific (BSA) and either linear (L) or quadratic (Q). Characteristic specific trends also include a distance to city center trend.

As mentioned before, one caveat of this approach is that if Airbnb impacts rent and price trends rather than levels, the BSA fixed effects will absorb part of the Airbnb effect on the outcomes. In column 7, we repeat the analysis after detrending the data following the procedure described in Section 2.4. In a first step, the pre-Airbnb data are used to estimate BSA-specific time trends, which are then used to detrend all data points. Here, the coefficient for rents slightly decreases and gets closer to the specifications reported in columns 1 and 2. For prices, they both increase with respect to columns 3 to 6, and their magnitude becomes more similar to each other. While these estimates provide yet another robustness test of the results, we acknowledge that the pre-Airbnb period is admittedly short to reliably estimate the pre-trends needed to detrend the post-Airbnb data.

The arrival and expansion of Airbnb coincides with the period of economic recovery that started in 2013. One concern is that economic growth might have impacted rents and prices differently across the city. In column 8, we add an interaction term between each control variable in 2012 (including the distance to the city centre) with the log of regional GDP. This allows us to control for areas reacting differently to economic growth. Our coefficients are still positive, strongly significant and of a similar magnitude after this inclusion. Finally, in a last sensitivity test, we also show that our findings are not driven by neighborhoods in the historical city center (*Ciutat Vella*), characterised by very high levels of Airbnb activity. The results reported in column 9 show that coefficients are still significant and of a similar magnitude after BSAs in the more central parts of the city are excluded.

To interpret the economic size of the estimated effects, we focus on the results in column 2. At face value, our estimates imply that an increase in 100 Airbnb listings in a given neighbourhood translates to increases of 3.5% in rents, 8.5% in transaction prices and 6.8% in posted prices. Given that the average increase in Airbnb activity in the period 2012-2016 is of 54 listings, our estimates imply an average increases of 1.89% in rents, 4.59% in transaction prices and 3.67% in posted prices.

The large degree of heterogeneity in Airbnb activity across BSAs implies that Airbnb has not affected all neighborhoods equally. In Figure A2 in the Appendix we illustrate these heterogeneous impacts by plotting the result of multiplying the coefficients obtained in column 2 by the Airbnb activity of each BSA in 2016. While the implied effects are very close to zero for the less central BSAs, our estimates imply some local impacts that are substantial. For the *High Airbnb Areas*, Airbnb has increased rents, transaction prices and posted prices by an average of 7%, 17% and 14%, respectively.

Across the different specifications, the results indicate that higher Airbnb penetration leads to increases in both rents and prices, with the effects on prices being larger than on rents. These results are an empirical test of the predictions of our theoretical model of Section 2.2. The results suggest that the net effect of Airbnb activity positively affects rents and prices, which implies that the possible negative externalities associated with Airbnb do not offset its inflationary effects. Since housing units that are on Airbnb yield, on average, a higher return than those units that are rented to residents, the housing price increase due to Airbnb exceeds that of long-term rents.

The results of specifications with BSA-specific linear time trends in column 5 are close to those reported in column 2, which corresponds to a more parsimonious specification with BSA and time fixed effects and time-varying control variables. Overall, we consider the estimates in column 2 as our baseline results for two reasons. First, the time period before the expansion of Airbnb (i.e., ≤ 2012) might be too short to obtain robust estimates of BSA-specific time trends. Second, and most importantly, the event study exercises shown below indicate that the parallel trends assumption holds before 2013, suggesting that specifications that fit neighborhood specific time trends are unnecessary.

Finally, we perform a formal test *à la Oster* to assess the robustness of the results to omitted variable bias. The method, developed by Oster (2019) and inspired by Altonji et al. (2005), analyzes how the inclusion of controls changes the coefficient of interest and the R-squared of the main regression. If including controls increases the predictive capacity of the model while not affecting the coefficient of interest, it is less likely that including unobservables would bias the results. One way to assess this potential bias is to compute the relative importance of unobservables to observables (δ) that would be consistent with a coefficient of interest equal to zero ($\beta = 0$). This is equivalent to asking how important the unobservables would need to be relative to the observables to eliminate the estimated effect.

For our baseline specification (column 2 in Table 2.3), the δ that matches $\beta = 0$ amounts to 6.77 for rents, 1.41 for transaction prices and 39.7 for posted prices.[29] It means that the importance of unobservables would have to be 6.8, 1.4 and 39.7 times higher than that of the observables for the coefficients to be null. These high values occur because controls have a very large explanatory power while their inclusion has a small influence on our Airbnb coefficients. This exercise indicates that concerns about omitted variables bias are limited since the values of δ are larger than one. This also suggests that gentrification is unlikely to explain the bulk of our effects.

[29] We compare a constrained specification (with time dummies only) with an unconstrained specification which also includes BSA fixed effects and all the time varying controls at the BSA level ($X_{n,t}$). As proposed by Oster (2019), we set $R^2_{max} = 1.3 \times R^2$.

2.5.3 Alternative Airbnb measures

In this subsection, we show that the results are robust to alternative measures of Airbnb activity. So far, our measure of Airbnb activity reflected contemporaneous activity. Each BSA-time cell is matched to the number of Airbnb listings that received a review in that particular quarter. In column 2 of Table A1 in the Appendix, we consider a specification in which Airbnb activity is measured over a longer time window. Each BSA-time cell is matched to a moving average (MA) measure of Airbnb activity that averages contemporaneous activity with that of the previous three quarters (AbnbCount MA). The purpose of this measure is to take into account Airbnb seasonality.

Although the BSAs are relatively similar in size, we compute a measure of Airbnb density by dividing the number of listings over the total number of housing units (column 3). Finally, in column 4, we take the log of the number of Airbnb listings to reproduce the log-log specification used by Barron et al. (2021). The last row of Table A1 provides the average of each of the alternative measures of Airbnb activity to ease comparability across estimates.

Overall, our findings are robust to using alternative measures of Airbnb activity. Despite the underlying differences between the two studies, our results (reported in column 4) are similar in magnitude to Barron et al. (2021) for the US. They find that a 1% increase in Airbnb listings increases housing rents and prices by 0.018% and 0.026%, respectively. Our estimates are a bit lower for rents (0.0098), while Barron et al. (2021)'s estimate for housing prices is in between our estimates for posted prices (0.017) and transaction prices (0.031).

2.5.4 Mechanisms

As explained in the theoretical model of Section 2.2, the impact of Airbnb on rents comes from the reduction of long-term rental supply caused by owner choice to shift to short-term rentals. To provide direct evidence of this mechanism, we would ideally look at the number of units rented to residents. Since this data is not available, we examine instead the number of households, which includes both owner-occupiers and tenant households.[30] We also assess the impact on population and household size, where the latter is computed as the ratio between population and the number of households. We argue that, while a gentrification process might reduce population and household size of the gentrifying neighborhood, as new incoming households are richer and have a lower average household size, it should

[30] Alternatively, we could look at the number of signed rental agreements from official records. However, this information is not provided at the BSA level but at the district level and only starts in 2013.

not reduce the number of households in the neighborhood. Gentrifying processes revitalise neighbourhoods by attracting more households.

Table 2.4: Impact of Airbnb on the number of households, household size and population

	(1)	(2)	(3)	(4)
Panel A	Outcome: log(Number of Households)			
Airbnb Count (x100)	-0.014***	-0.024***	-0.010*	-0.007**
	(0.005)	(0.006)	(0.006)	(0.004)
Panel B	Outcome: log(Household Size)			
Airbnb Count (x100)	-0.002	-0.018***	-0.009*	0.004
	(0.004)	(0.005)	(0.005)	(0.005)
Panel C	Outcome: log(Population)			
Airbnb Count (x100)	-0.016*	-0.043***	-0.020**	0.002
	(0.009)	(0.009)	(0.008)	(0.004)
N	2056	2056	2056	2056
Time FE	X	X	X	X
BSA FE	X	X	X	X
Controls	-	X	X	X
Time Trends	-	-	$X_{n,2012}$ (L)	BSA (L)

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the BSA level. Each cell represents a different regression with the log the number of households (panel A), the log of household size (panel B) and the log of population (panel C). The analysis takes place at the BSA-year level for the period 2009-2017. Controls are average age, unemployment rate, average relative income, and percentage of foreign residents. Linear trends can be either characteristic-specific ($X_{n,2012}$ (L)) or BSA-specific (BSA (L)). Characteristic specific trends also include a distance to city center trend.

In Table 2.4, we report the results of running specifications 1, 2, 3 and 5 of Table 2.3 on the three different outcomes. The results of Panel A indicate that Airbnb listings have a negative and strongly significant effect on the number of households across all four specifications. If we focus on column 2, the estimates imply that 100 Airbnb listings decrease the number of households by 2.4%.

On the contrary, Panels B and C show Airbnb's negative effect on household size and population on three of the four specifications. We can decompose the effect of Airbnb on population into the number of households plus the effect on household size.[31]. Then, we can compute how much of the reduction in population is due to

[31]The fact that $pop_n = households_n \times (pop_n/households_n)$, combined with outcomes measured in logs allows for this decomposition.

a reduction in the number of households or due to a lower average household size. In columns 1 to 3, the contribution of the number of households to the reduction in population is of 88%, 56% and 50%, respectively. In column 4, Airbnb only has a significant effect on the number of households, suggesting again that Airbnb displaces residents.

Overall, these results strongly support the hypothesis that the channel behind the impact of Airbnb on housing prices is a supply reduction of long-term rentals. The results also lend credibility to the hypothesis that the increases in housing rents and prices that we estimate are caused by Airbnb activity and not by ongoing gentrification processes.

2.6 Results for alternative empirical strategies

2.6.1 Instrumental variables results

In Table 2.5, we report first and second-stage results of the instrumental variables approach described in Section 2.4.2. Columns 2 and 4 report the second-stage results for rents, transaction prices and posted prices, respectively. The specification corresponds to equation 2.5, where Airbnb activity is instrumented with the interaction between the cross-sectional tourist amenities index (equation 2.8) and the Google Trend searches. In columns 1 and 2, we control for BSA and time fixed effects as well as the usual control variables; in columns 3 and 4, we also include the interaction term between the control variables in 2012 (including distance to the city center) and the regional GDP level.[32]

Columns 1 and 3 report the first-stage coefficients. To test the relevance of the instrument we provide the F-test of excluded instruments which is well above 10, the standard rule of thumb accepted by practitioners (Angrist and Pischke, 2008). The instrument is not weak and predicts well when and where Airbnb listings appear. Moving to the second-stage results, the coefficients remain positive and statistically significant at the 1% significance level. In terms of magnitude, coefficients in column 2 are remarkably similar to their OLS counterparts of column 2 in Table 2.3, although admittedly the estimated coefficient for transaction prices is larger (although not in a statistically significant sense). As for column 4, the inclusion of interaction terms with GDP increases the coefficient of rents while it decreases the coefficients of prices, just like in Table 2.3. One concern regarding instrument validity might be that a large fraction of tourist amenities are located at the city center. The fact that our results remain stable with the inclusion of distance to the

[32] These specifications correspond to columns 2 and 8 of Table 2.3.

city center times GDP provides evidence that our IV estimates are not biased by a shift in preferences for the city center among residents during the recovery period.

Table 2.5: Impact of Airbnb on rents and prices: IV regressions

	First Stage	Second Stage	First Stage	Second Stage
	(1)	(2)	(3)	(4)
Panel A	Rents			
Airbnb Count (x100)		0.022**		0.033***
		(0.011)		(0.010)
TouristAmenities	0.005***		0.005***	
×GoogleTrends	(0.000)		(0.001)	
N	2.123	2.123	2.123	2.123
F-stat. excl. inst.	192.2		70.2	
Panel B	Transaction Prices			
Airbnb Count (x100)		0.123***		0.104***
		(0.020)		(0.023)
TouristAmenities	0.004***		0.003***	
×GoogleTrends	(0.000)		(0.000)	
N	7.228	7.228	7.228	7.228
F-stat. excl. inst.	217.8		61.3	
Panel C	Posted Prices			
Airbnb Count (x100)		0.074***		0.047***
		(0.014)		(0.013)
TouristAmenities	0.005***		0.005***	
×GoogleTrends	(0.000)		(0.001)	
N	2.229	2.229	2.229	2.229
F-stat. excl. inst.	159.0		70.5	
Time FE	X	X	X	X
BSA FE	X	X	X	X
Controls	X	X	X	X
$X_{n,2012}\times$ GDP	-	-	X	X

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the BSA level. Panel A reports the results for rents, while Panels B and C report the corresponding estimates for transaction and posted prices. Outcomes are average residuals at the BSA-time period level, as explained in the main text. Regressions weighted with the total number of ads (for rents and posted prices) and of transactions (for prices). The analysis takes place at the BSA-year level for rents and posted prices and BSA-quarter for transaction prices. Controls are: average age, log of population density, average household size, unemployment rate, average relative income, and percentage of foreign residents. $X_{n,2012}\times$ GDP also includes distance to city center times GDP.

According to Goldsmith-Pinkham et al. (2020), when discussing the exogeneity of a shift-share instrument, attention should be paid to the 'share' component of the instrument. In our case, the main concern is that BSAs that are close to tourist amenities could be experiencing different trends in housing rents and/or prices for reasons unrelated to Airbnb.

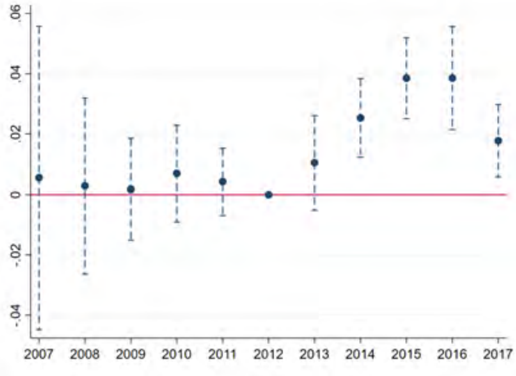
To provide some evidence of the exogeneity of our instrument, we run event study regressions (as in equation 2.9) where we interact year dummies with an indicator variable for BSAs in the top decile of the tourist index distribution. This exercise attempts to verify whether BSAs that are closer to relevant tourist amenities were experiencing a different trend in rents and prices before the arrival of Airbnb. Panel (a) of Figure A3 in the Appendix shows that, before 2013, pretrends in rents were not statistically different between the two groups. In 2014, coinciding with the expansion of Airbnb, the difference becomes significant. The results are similar in Panels (b) and (c), hence lending credibility to the exogeneity hypothesis of our instrument. The results of the IV strategy provide a solid robustness test of the validity of our instrumental variables results. The fact that coefficients remain fairly similar and equally significant helps diminishing potential endogeneity concerns.

2.6.2 Event study regression results

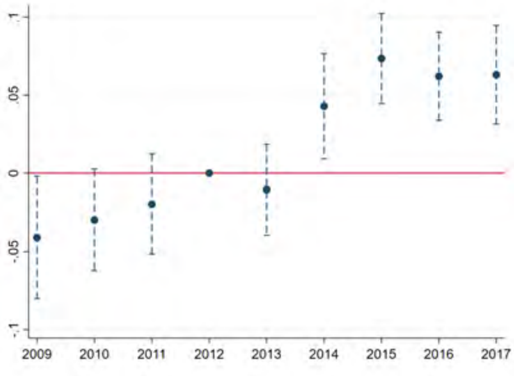
In this subsection, we report the results of the event study regressions (equation 2.9 in Section 2.4.3). Figure 2.6 plots the coefficients of the interaction terms between Airbnb activity in 2016 and the year dummies for rents (a), transaction prices (b) and posted prices (c), where the coefficients in 2012 have been normalized to zero.

The interaction terms between 2016 Airbnb activity (times 100) and year dummies are statistically insignificant before 2013, while they are positive and significant starting in 2014. This indicates that, at the beginning of the period, when the number of Airbnb listings was low, rents and prices were not evolving differently in the BSAs that after 2013 had high Airbnb activity. In contrast, between 2014 and 2017, when Airbnb's presence became important, neighborhoods where Airbnb activity was concentrated started to experience higher rents and price growth. In a robustness test that is reported in Figure A4 in the Appendix, we show that the results are robust to using a binary measure of Airbnb activity in 2016, where BSAs are classified into *High Airbnb Areas* and other areas.

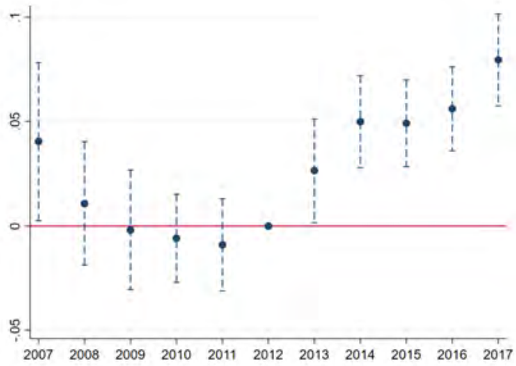
Figure 2.6: Event study graph for rents and prices



(a) Rents



(b) Transaction Prices



(c) Posted Prices

Notes: Outcome variables Rents, Transaction and Posted prices are expressed in logs. Event study regressions following Equation 2.9, in which we interact year dummies with the level of Airbnb activity for 2016.

The coefficients in Figure 2.6 can be interpreted as follows: an increase from zero to 100 listings in 2016 increases rents by 3.8%, transaction prices by 6.2% and posted prices by 5.6% in that year. These magnitudes are broadly in line with our baseline estimates of Table 2.3.

2.6.3 *Sagrada Familia* results

Finally, in this sub-section we report the *Sagrada Familia* results. Table 2.6 displays the first and second-stage results of estimating equation 2.5 using the interaction between proximity to *Sagrada Familia* and the Google Trend searches as an instrument.

Columns 1, 3 and 5 report the first stage where our instrument is positively and significantly associated with Airbnb activity, which suggests that the instrument is relevant. The F-statistics of excluded instruments are high, which reinforces our claim. Columns 2, 4 and 6 report the second-stage results where the coefficients are positive, statistically significant and of a relatively higher magnitude than in our previous regressions, although not in a statistically significant way. Once again, the results of this exercise point in the same direction, indicating that Airbnb activity had an impact on both rents and prices in Barcelona.

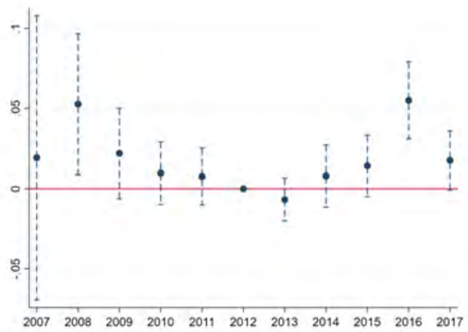
Table 2.6: Impact of Airbnb on rents and prices: IV estimates *Sagrada Familia*

	Rents		Transaction Prices		Posted Prices	
	(1)	(2)	(3)	(4)	(5)	(6)
	Airbnb	Ln(Rent)	Airbnb	Ln(Prices)	Airbnb	Ln(Prices)
Airbnb		0.095**		0.120**		0.101**
Count (x100)		(0.038)		(0.052)		(0.044)
Inv Dist SF	0.733***		0.452***		0.686***	
$\times$ GoogleTrends	(0.197)		(0.112)		(0.193)	
N	2.138	2.138	7.916	7.916	2.247	2.247
Time FE	X	X	X	X	X	X
BSA FE	X	X	X	X	X	X
Controls	X	X	X	X	X	X
F-stat of exc. inst.	13.8		16.3		12.5	

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the BSA level. Each column represents a different specification. Panel A reports the results for rents, while Panels B and C report the corresponding estimates for transaction and posted prices. Outcomes are average residuals at the BSA-time period level, as explained in the main text. Regressions weighted with the total number of ads (for rents and posted prices) and of transactions (for prices). The analysis takes place at the BSA-year level for rents and posted prices and BSA-quarter for transaction prices. Controls are: average age, log of population density, average household size, unemployment rate, average relative income, and percentage of foreign residents.

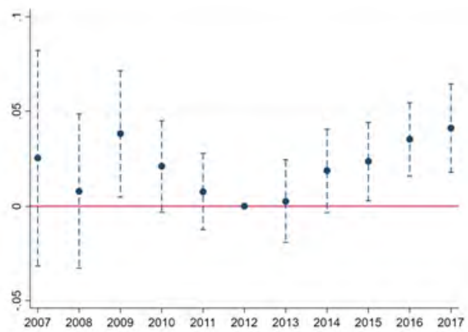
Finally, Figure 2.7 depicts the results of running an event study regression using proximity to *Sagrada Familia* as a predictor of Airbnb activity. While the results are less conclusive in this exercise, we can nevertheless observe a similar trend than in the previous event study where coefficients become positive and significant in 2015. This is true especially for rents and for posted prices. Yet again, this last strategy suggest that Airbnb had an inflationary effect on housing markets.

Figure 2.7: Event study graph for rents and prices using inverse distance to *Sagrada Familia*



(a) Rents

(b) Transaction Prices



(c) Posted Prices

Notes: Outcome variables Rents, Transaction and Posted prices are expressed in logs. Event study regressions following Equation 2.10, in which we interact year dummies with the inverse distance to *Sagrada Familia*.

2.7 Concluding remarks

The rapid expansion of urban tourism and short-term rentals have recently garnered much interest in public opinion and among policy-makers, especially in large tourist cities. Concerns about the potential negative consequences of these phenomena have led local administrations to apply a wide range of regulatory measures.

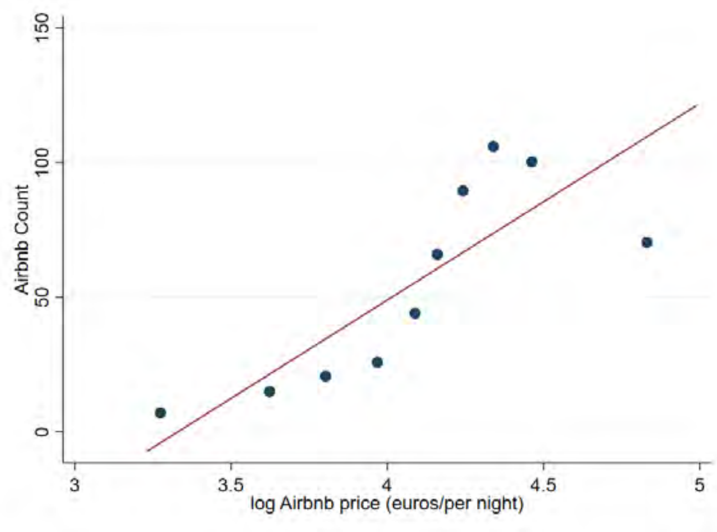
To study how Airbnb affects the city's housing markets, we examine high-quality microdata on both rents and prices and combine these data with information on the location of Airbnb activity within the city. We apply several regression-based approaches that exploit the timing and geography of the entry of Airbnb in the city to estimate the effects of this platform on the city's housing markets. The results show that Airbnb activity in Barcelona has led to an increase both in rents and housing prices, with larger effects for prices than for rents. Our preferred results indicate that, for a neighborhood with the average Airbnb activity in the city, rents have increased by 1.9%, while transaction prices have increased by 4.6% and posted prices by 3.7%.

Although the effects on rents are not small, they cannot explain the bulk of the high aggregate increases in rents that the city has experienced between 2012 and 2016. In the most touristic parts of the city, the effects of Airbnb are substantial. In neighborhoods in the top decile of the Airbnb activity distribution, rents are estimated to have increased by as much as 7%, while increases in transaction and posted prices are as high as 17% and 14%, respectively.

Short-term rental platforms such as Airbnb might worsen the housing affordability problem in cities such as Barcelona, where tourism is popular and the difference in profitability between renting long-term to residents or short-term to tourists is high. Our findings can contribute to a more informed debate about the consequences of Airbnb and the desirability and design of policies that aim to limit the size of the short-term rental market.

2.8 Appendix

Figure A1: Airbnb Activity and Airbnb Prices



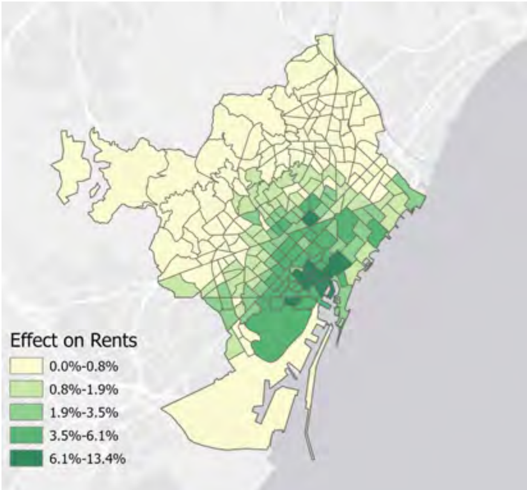
Notes: The graphs shows deciles of BSAs with respect to their mean Airbnb Count for the fourth quarter of 2016 ordered in the y axis. For each decile the mean log Airbnb nightly price for those active listings is shown in the x axis.

Table A1: Impact of Airbnb on rents and prices: Robustness checks

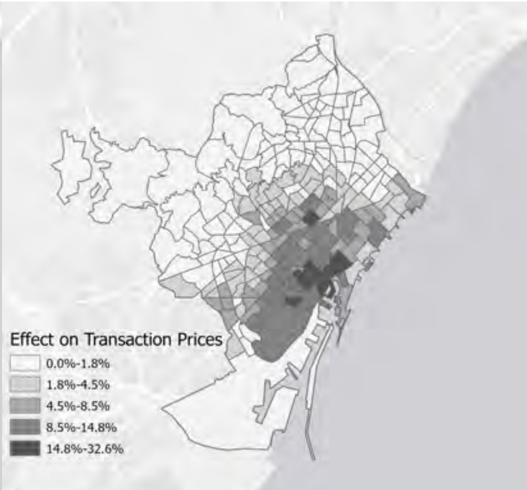
	Baseline* (1)	AbnbCount MA* (2)	AbnbDens (3)	log AbnbCount (4)
Panel A	Rents			
Airbnb	0.035***	0.029***	0.0068	0.0098***
	(0.009)	(0.008)	(0.005)	(0.003)
N	2.123	2.123	2.123	2.123
Panel B	Transaction Prices			
Airbnb	0.085***	0.086***	0.030***	0.031***
	(0.016)	(0.021)	(0.005)	(0.006)
N	7.916	7.916	7.916	7.916
Panel C	Posted Prices			
Airbnb	0.068***	0.070***	0.019***	0.017***
	(0.009)	(0.010)	(0.004)	(0.004)
N	2.229	2.229	2.229	2.229
Time FE	X	X	X	X
BSA FE	X	X	X	X
Controls	X	X	X	X
Mean 4Q2016	56	49	1.57%	1.76

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the BSA level. Panel A reports the results for rents, while Panels B and C report the corresponding estimates for transaction and posted prices. * In the case of Baseline and AbnbCount MA, the coefficients are multiplied by 100. Outcomes are average residuals at the BSA-time period level. Regressions are weighted with the total number of ads (for rents and posted prices) or transactions (for prices). The analysis takes place at the BSA-year level for rents and posted prices and BSA-quarter level for prices. Controls are average age, the log of population density, average household size, unemployment rate, average income, and percentage of foreign residents.

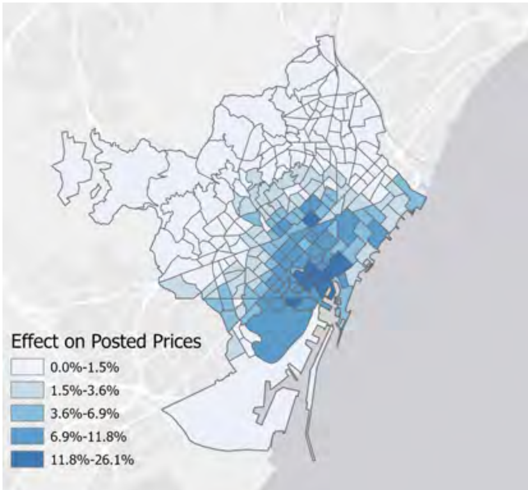
Figure A2: Implied effects of Airbnb across BSAs



(a) Impact on Rents



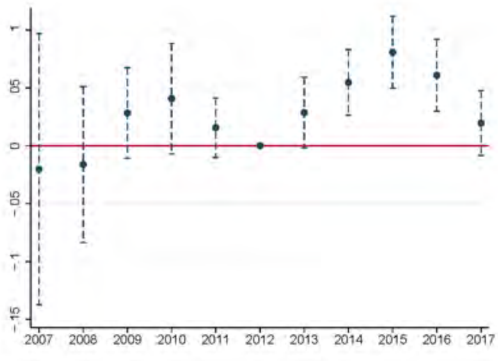
(b) Impact on Transaction Prices



(c) Impact on Posted Prices

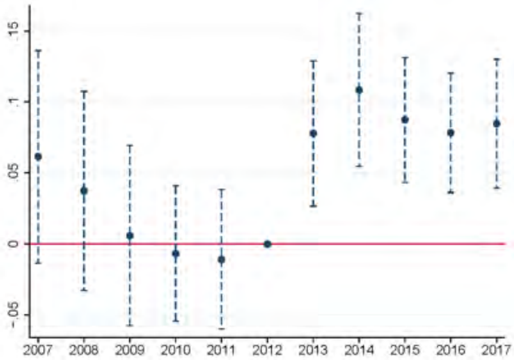
Notes: These maps plot the implied impacts of Airbnb on rents and on transaction (posted) prices. For this we take the results reported in column 2 of Table 2.3, and multiply it by Airbnb activity in each BSA at 2016.

Figure A3: Instrument pretrend analysis.



(a) Rents

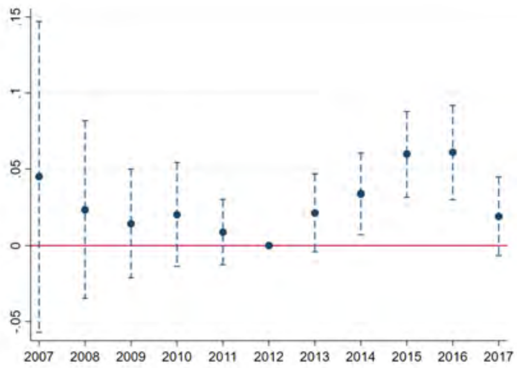
(b) Transaction Prices



(c) Posted Prices

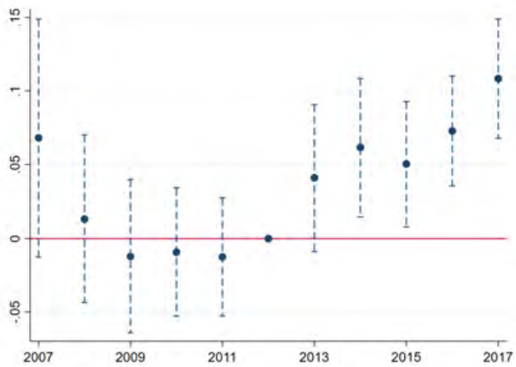
Notes: Outcome variables Rents, Transaction and Posted prices are expressed in logs. Event study regressions where we interact year dummies with an indicator variable for BSAs in the top decile of the tourist index distribution.

Figure A4: Event study graph for rents and prices (top decile)



(a) ln(Rents)

(b) ln(Prices)



(c) ln(Posted Prices)

Notes: This graph plots coefficient estimates (and confidence intervals) as in equation 2.9 but the continuous measure of Airbnb activity has been replaced by a dummy variable for the top decile. Regressions are weighted with total number of ads (for rents) and of transactions (for prices). Each point represents the difference in rents or prices between BSAs above the 90th percentile of Airbnb listings in 2016 compared to all other BSAs.

3 Mom, Dad: I'm staying. Initial labor market conditions, housing markets, and welfare

3.1 Introduction

Around the world, young people are struggling to leave the parental home. In 2020, more than 50% of the young US population (aged between 18 and 29 years old) were living with their parents, the highest level since the great depression (Fry et al., 2020). This value is 20 percentage points higher than the 1980 average. In Europe, 69% of those aged between 16 and 29 lived with their parents in 2019 (Eurostat, data for EU-19). For several countries, this implies the highest value since the 1980s (Schwanitz and Mulder, 2015). Additionally, young people face major affordability challenges;[1] young people around the world are spending more on housing than any previous generation, while experiencing a lower quality of life (Judge and Tomlinson, 2018). Previous evidence suggests that these phenomena could be harming their welfare. Specifically, living with your parents as an adult is associated with a negative social stigma (Parker, 2012), worse adult child-parent relationships (Lang, 2015; Tosi, 2020), delayed family formation (Parker, 2012), and a overall reduction in satisfaction with personal well-being (Capic et al., 2016). Additionally, financial stress, such as that deriving from bad affordability, can lead to poorer physical and mental health outcomes (French and McKillop, 2017; Vásquez-Vera et al., 2017), and lower overall well-being (Netemeyer et al., 2018).

A potential explanation for these phenomena lies in the conditions faced by individuals when first entering the labor market. For young Europeans, initial labor market conditions have recently been tough; the unemployment rate among those aged between 15 and 24 years old in the EU was 22% for the 2008-2017 period, five percentage points higher than for the 1998-2007 period (OECD, data for EU-19).

[1] Housing affordability broadly refers to the relationship between housing costs and household income (Bieri, 2014). While measured in several ways, agencies as the UN-Habitat (UN-Habitat, 2018) and the Housing and Urban Development in the US (HUD, 2017), consider housing as affordable if housing costs do not exceed 30% of the household's income.

A lower income can mean an inability to afford to rent or buy and consequently the need to stay in the parental home. For those who do leave, this may translate into worse affordability. However, bad initial labor market conditions affect entire cohorts rather than just single individuals, so the interaction between the labor and housing markets could be substantial. Specifically, if prices and rents are flexible and adjust fully to new income levels, housing tenure should not change. However, if housing markets are rigid, then prices and rents fall to a lesser extent than income. This forces young people to live with their parents, thereby worsening their welfare even further.

In this paper, I study how initial labor market conditions can have long-term effects on housing tenure and affordability. The ideal experiment to determine the long-term effects of initial labor market conditions would randomly expose identical graduates to different initial employment conditions (von Wachter, 2020). The best approach to this experiment has consisted of comparing graduates who entered different labor markets with different unemployment rates. This strategy has been used extensively in the labor literature (Kahn, 2010; Oreopoulos et al., 2012; Schwandt and von Wachter, 2019). In this research, I exploit the unemployment rate at the time of college graduation as an exogenous income shock to study housing outcomes. I do so by comparing different cohorts of college graduates across different European countries. As the vast majority of college graduates enter the labor market and become economically active immediately after graduation, they constitute the best subjects for studying the effects of initial labor market conditions. Additionally, by working at the country level, concerns regarding the migration of graduates to other labor markets with better conditions are mitigated, as migration between EU countries is very low (Dijkstra and Gakova, 2008). The empirical specification follows a cell-based model, in which outcomes are aggregated at the country, year of graduation, and calendar year, and outcomes are regressed against the unemployment rate at the country and year of graduation.

For this research, I use micro-data from two major European datasets: the European Union Statistics on Income and Living Conditions (EU-SILC) and the European Community Household Panel (ECHP). Both surveys provide cross-sectional information on various factors such as income, labor, and housing conditions, both at the individual and household level. The ECHP originally covered Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, the Netherlands, Austria, Portugal, Sweden, and the United Kingdom, for the period between 1994 and 2001. After it was discontinued in 2001, the survey was replaced by the EU-SILC, which addressed virtually the same factors. Furthermore, the EU-SILC sample progressively included other European nations, reaching up to 33 countries by 2018 and over 10 million individuals. Using these data makes it possible to study the effect of labor market entry in bad times for cohorts from 1960 until 2018. This research is the first to do so for the entire European Union and such an extended period, mainly due to using cross-sectional data.

This empirical approach provides three key findings. First, the results confirm the negative, scarring effects of entering the labor market under bad economic conditions on housing tenure and affordability. Notably, a 1 pp increase in the unemployment rate at the time of graduation leads to a 1.5 pp increase in the probability of living with parents one year after graduation, which is equal to an increase of 2.9% with respect to the mean. Effects are persistent over time and are still present ten years after graduation, with the accumulated effect after ten years being 12.5 pp. Second, the results show that, one year after, a 1 pp increase in the unemployment rate at the time of graduation decreases the probability of renting by -1.02 pp (-4.9% with respect to the mean) and the probability of ownership by -0.45 pp (-2.0% with respect to the mean). Third, worse initial labor market conditions translate into worse affordability ratios for homeowners and renters. This worsening in affordability is due to lower household income and stable rents or prices.

However, in this setting, it is imperative to analyze how housing markets can absorb or amplify the initial labor market shock. To understand this, I develop an overlapping generations (OLG) model in which agents live for three periods and have three different housing tenure choices (living with parents, renting, and owning). Agents accumulate housing and non-housing wealth and consume a numeraire good. In my model, agents prefer ownership over renting and renting over living with parents. Additionally, as younger agents are poorer than older agents, they will be outbid in the housing market, and only young agents will be forced to live with their parents. As for the rental market, I allow only older agents to become landlords, making the rental supply endogenous. Also, I introduce an outside option for the rental market, and landlords will choose the outside option if the rent they obtain from young agents is too low. The existence of outside options in the rental market has been documented in several ways; for example, as the conversion of residential units to short-term tourism accommodation (Garcia-López et al., 2020), as conversion to office units (Beauregard, 2005), or leaving the unit empty (Segú, 2020). The outside option will work as a floor price for rents, thereby introducing rigidity into the rental market.

I use the model to explore what would happen if there is a permanent and negative income shock only to young agents. In particular, I study two different scenarios. In the first scenario, the outside option is not binding so rental markets are flexible ($\Delta\%income = \Delta\%rents$). In this case, an income shock affecting young agents will not change the share of young agents living with their parents, as rents fully adjust to their new income. However, as housing prices depend on the income of both young and old agents, they will not fall as much as the income of young agents, thus reducing the share of young homeowners. Affordability for young renters will not worsen as rents fall in the same proportion as their income. In the second scenario, with the rental outside option binding, rental markets are rigid ($\Delta\%income > \Delta\%rents$). In this case, the model predicts that the share of young agents living with their parents will increase, as some can no longer afford to rent. As in the previous case, prices are not fully responsive to changes in the income of young agents, so the share of young homeowners decreases. For young renters, affordability will get worse as their incomes decrease, but rents do not. In both scenarios, young agents' welfare decreases, but this is more pronounced when rental markets are rigid. The share of agents in their least preferred housing tenure option increases and affordability is worse than on flexible markets.

Additionally, this model is also helpful to provide policy insights. In this regard, the numerical solution of the model provides some guidance into housing policies when there is a negative income shock to young individuals. To achieve this, I use housing allowances in France as a case study. The French case is relevant, as almost one in three French households receive a housing allowance, one of the highest rates in the OECD. Additionally, representing 0.72% of national GDP, these allowances account for a large part of government spending, i.e., the fourth largest expenditure in the OECD (OECD, 2018). On average, households receive 30% of their housing expenditure, with 90% living in rental units (Hananel and Richet-Mastain, 2019). In the model, I translate this policy into one in which 30% of poorest agents receive housing aid equivalent to 30% of the rental market price. The results indicate that this type of policy effectively alleviates the welfare impact of negative income shocks in rigid rental markets. Such policies can help recover part of the lost welfare due to a labor market shock, as it helps young agents access rental units and improve their affordability ratio. However, this policy creates the opposite results when applied in flexible rental market scenarios. In this case, it does not allow for rents and prices to adjust, creating prices and rents inflation, a phenomenon detected on the French housing aid system (Bozio et al., 2017). Additionally, welfare gains are captured by landlords, who are mainly concentrated on older cohorts.

The contribution of this paper is three-fold. First, it expands on the literature on the persistent effects of initial labor market conditions by proving that existing conditions at the time of graduation can have negative and scarring effects on housing tenure and affordability. So far literature has focused on labor market outcomes, such as individual earnings (Raaum and Røed, 2006; Kahn, 2010; Genda et al., 2010; Oreopoulos et al., 2012; Kawaguchi and Murao, 2014; Brunner and Kuhn, 2014; Liu et al., 2016; Cockx and Ghirelli, 2016; Fernández-Kranz and Rodríguez-Planas, 2018). More recently, other variables outside the labor market have been studied, such as health status (Currie and Schwandt, 2014; Maclean and Hill, 2015), mortality (Schwandt and von Wachter, 2020), and family formation (Currie and Schwandt, 2014). This research builds on Schwandt and von Wachter (2019), who extend the existing methodology into large cross-sectional databases and study the effects of initial labor market conditions on career and socioeconomic outcomes such as poverty incidence and health insurance. In this paper, I further extend the analysis to housing outcomes, adding an entirely new perspective to the welfare impacts of initial labor market conditions. My results suggest that the consequences of bad initial labor market conditions may have been larger than what previous literature suggested.

Second, I extend the framework of the OLG models with housing markets. I show that these models can be used for analyzing housing allocation and are a helpful tool for welfare and policy analysis. In Ortalo-Magné and Rady (2004) the authors use an OLG model to introduce the idea of a housing ladder, in which agents move according to their age and income, from less preferred housing options to more valued ones. In the study by Ortalo-Magné and Rady (2006), the authors use an OLG model to show how the ability of young agents to afford down payment on a starter home can affect the entire housing allocation in the economy. Additionally, the authors show a positive correlation between the income of young individuals and housing prices in the economy. In a more recent work, Carozzi (2020) develops an OLG model with no uncertainty and housing quality to relate changes in the composition of housing sales to credit constraint shocks. In his model, younger poorer agents are outbid from ownership by wealthier households. Still, all the previous models assume perfect elasticity for prices and rents, which may constrain the analysis and may be unrealistic. I contribute to this strand of literature by developing an OLG model to study housing allocation, affordability, and welfare. Additionally, I introduce an outside rental option, a feature present in several rental markets. By doing so, I show that the rental market can either absorb or amplify the welfare impact of initial labor market conditions, depending on its rigidity. Additionally, this is the first paper to use these models to perform policy analysis.

Third, this paper contributes to policy design towards housing markets. I show that housing aid policies can absorb part of the shock that comes from the labor market. However, if markets can adjust to income shocks, then applying a policy of this kind will lead to worse results for the targeted population and welfare gains concentrating on landlords. This analysis highlights the importance of identifying the correct scenario for applying these policies to ensure that welfare gains benefit the targeted population.

The paper is organized as follows: Section 3.2 focuses on describing the data used while providing some descriptive statistics and outlining the empirical strategy; Section 3.4 presents the results of the main specification and some heterogeneous analysis; Section 3.5 provides the OLG model from which a set of propositions is derived, and the welfare and policy analysis is done; and, finally, Section 3.6 presents some concluding remarks.

3.2 Data

For this research, I use the micro-data from two major European datasets: the European Union Statistics on Income and Living Conditions (EU-SILC) and the European Community Household Panel (ECHP). The EU-SILC is designed and overseen by Eurostat and is compulsory for all EU member states. Although each state carries out the survey, Eurostat defines a common framework to ensure a harmonized set of variables. Data collection for these surveys is based on a nationally representative sample of the population residing in private households within the country, irrespective of language, nationality and, legal residence status.

These surveys cover all private households, and all persons over the age of 16 within the household are potential respondents[2]. Both surveys provide cross-sectional information on various aspects such as income, labor, and housing conditions, at both the household and the individual level. Additionally, they also provide longitudinal data so that changes can be measured over four years. In contrast to other surveys, the ECHP and the EU-SILC contain precise information on graduation year and the educational level attained. This allows going beyond the years in which the surveys were being carried out.

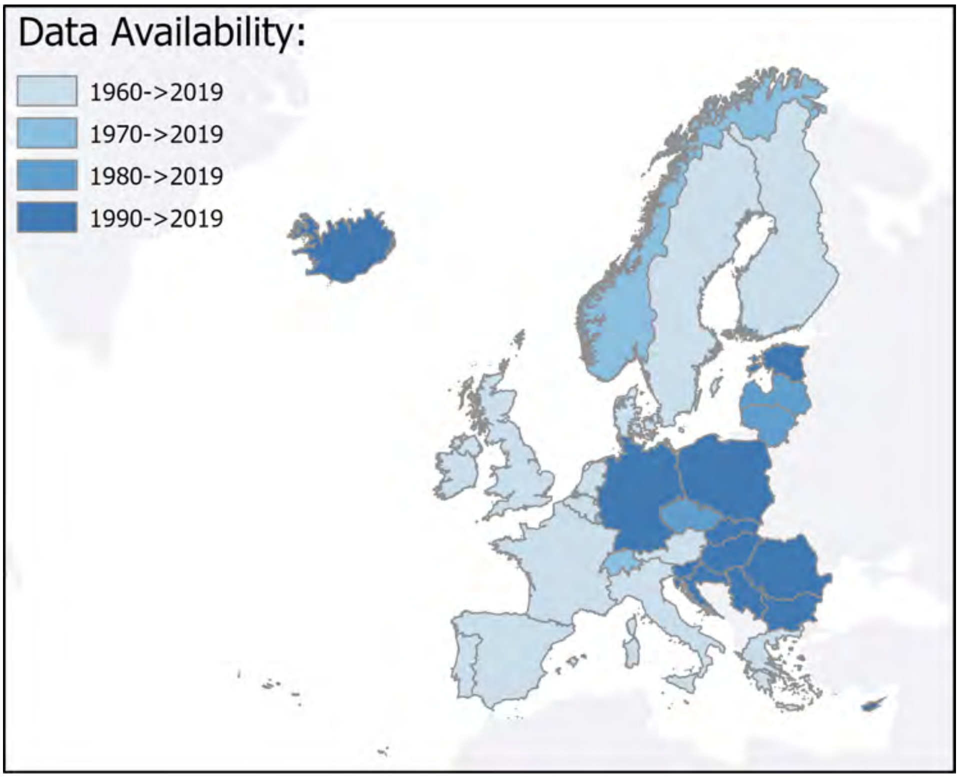
The ECHP originally covered Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, the Netherlands, Austria, Portugal, Sweden, and the United Kingdom, from 1994 to 2001. After the survey was discontinued in 2001, it was replaced by the EU-SILC, which covered virtually the same aspects. The EU-SILC gradually incorporated other European nations, and by 2019 the sample included 33 countries. A table showing data availability in detail is presented in Annex A.

National-level unemployment is obtained from the European Central Bank (ECB) or national statistics institutes. Unemployment rate data is available from 1960. This is the primary data source used to measure labor market conditions at the time of graduation. Additional data on unemployment is obtained from the International Labor Organization (ILO), which provides a standardized measure of unemployment for countries in the sample starting from 1990.

[2] A more detailed account of the methodology used for EU-SILC can be found in Eurostat (2018) and for ECHP in Eurostat (1996).

Overall, combining data availability from the ECHP, the EU-SILC, and the national unemployment rates allows to study the effect of initial labor market conditions for cohorts that graduated as early as 1960, covering over 10 million individual observations. The countries and their data availability are depicted in Figure 3.1.

Figure 3.1: Data availability



Notes: Data availability across European countries. As the ECHP finished in 2001 and the EU-SILC only started in 2004, no data are available for 2002 or 2003.

3.3 Empirical strategy

The ideal experiment to study the effect of initial labor market conditions on housing outcomes would be to randomly expose newly graduates to different initial conditions. This would result in the following regression:

$$Housing_{i,t} = \alpha + \beta_e initial_{i0} + \gamma_e + \varepsilon_{i,t} \tag{3.1}$$

$Housing_{i,t}$ is the housing outcome of interest at a given time t, i.e., whether the individual is living in the parental home, is an owner, or is renting, or its affordability ratio. $initial_{i0}$ refers to the initial labor market conditions faced by individual i at time 0. Potential years of experience are denoted by e, which is computed as the number of years since graduation; therefore, γ_e is potential experience fixed effects. With these fixed effects, β_e captures the potential experience specific deviation from the typical experience profile caused by different initial labor market conditions.

The standard application of Equation 3.1 has been to compare newly graduates across different labor markets with different unemployment rates, as in Schwandt and von Wachter (2019) and Oreopoulos et al. (2012). For this analysis I work with a cell-based model in which I collapse the outcome of interest at the country (c), cohort of graduation (g), and calendar year (t). This analysis does not rely on the use of individual-level controls and so it matches the level of variation of the variable of interest, which is the cohort-country-year level. The baseline specification is as follows:

$$Y_{c,g,t} = \alpha + \beta_e u_{g,c} + \gamma_e + \delta_c + \eta_g + \theta_t + \varepsilon_{c,g,t} \tag{3.2}$$

Where $u_{g,c}$ refers to the unemployment rate of the given country c in a graduation year g, this is the main variable of interest[3]. e refers to potential years of labor market experience[4]. Given the presence of experience, country, cohort, and time fixed effects, and given that there is no control for the current unemployment rate, then β_e captures the effect of an increase in the unemployment rate at the time of graduation, considering the subsequent regular evolution of the national labor market (Schwandt and von Wachter, 2019)[5]. Errors are clustered at the cohort-country level to account for group-specific correlation. Cells are weighted by their corresponding cell size to represent population-level estimates.

In line with the reasoning proposed by von Wachter (2020), consider the example in which $Y_{c,g,t}$ is the share of cohort g from country c that is living in the parental home, then γ_e should capture the regular decrease in the share of the cohort living with their parents with years of experience. Then β_e captures the deviation in the share of individuals living with their parents from the regular experience profile at each experience year. When considered together, the coeficcient β_e should capture the change in experience profile caused by the initial unemployment rate. Additionally, given the year and country dummies, the variation in each country's unemployment rate consists of changes over time (relative to its own mean, captured by the country-specific coefficient δ_c) that differ from the EU economic cycle (captured by year specific coefficient η_g). These country-specific cyclical changes in the unemployment rate identify the shifts in the experience profiles caused by

[3]Country refers to the country of current residence.

[4]Potential experience is calculated as calendar year minus graduation year.

[5]For this specification, I present individual coefficients for each of the first ten years after graduation, but I create a dummy variable for those potential years equal or greater than 11. This last coefficient should indicate the long-term effect of the initial unemployment rate.

bad initial conditions.

The data used for this paper offers an advantage over the previous literature, given that it allows an individual's exact year of graduation to be identified. This helps avoid the use of proxy measures for the year of graduation (such as the Mincerian approach), which increase the probability of measurement errors in highly heterogeneous contexts such as Europe's different educational systems across countries and time[6]. Additionally, working with cross-sectional data provides an opportunity to cover a larger sample than that allowed by traditional longitudinal surveys. This makes it possible to study the long-term effects of initial labor market conditions for cohorts starting as early as 1960 up to 2018.

Potential threats to identification — This strategy has two major potential threats. The first refers to endogenous graduation timing. Individuals can potentially shift their graduation according to the labor market conditions at the time of their intended graduation. If this were the case, the estimates would be biased to zero. As shown in Figure A2 of the Annex, a higher unemployment rate at graduation time increases the probability of being a full-time student for recent low and medium graduates. This indicates that elementary and high school graduates facing harsh economic conditions when graduating are more likely to stay in the education system. However, a higher unemployment rate does not increase the probability that college graduates will continue to study. Therefore, despite an individual's concerns about the state of the economy at the time of graduation, completing higher education translates into entering the labor market. This threat to identification has been faced by previous studies (Kahn, 2010), and following their strategy I restrict the sample study to college graduates.

The second potential threat arises from endogenous migration. If individuals choose to move to avoid the economic conditions in their place of residence when graduating, by assigning their current place of residence as their graduation location, individuals would probably be assigned better economic conditions than those they would have faced. This would lead to an attenuation bias in the results. Endogenous moving has been documented for the US, for example by Wozniak (2010), whereby individuals facing harsh labor market conditions at the time of their graduation in their home state decide to move to another state. However, as shown by Dijkstra and Gakova (2008), while around 2% of the working population moves from one state to another every year in the US, in the EU-27, only 0.14% of the working-age population changed residence to another EU country. Therefore, as

[6]The Mincerian year of graduation is often calculated as the sum of the year of birth, plus six, plus the years of reported education.

cross-national border mobility in the EU is generally low, endogenous migration does not pose a threat to this study.

Sample restrictions — Given the above-mentioned potential identification concerns, this analysis focuses only on the native population with higher education[7]. Thus, to identify a graduation year and country, I exclude all individuals who were not born in the same country as they were interviewed. Additionally, I exclude those who graduated in the same year as the interview to avoid measurement errors, given that several variables are measured with respect to the year before the interview.

Descriptive statistics — Table 3.1 shows summary statistics of the sample for the main variables of interest. I separate the variables into two groups: those relating to housing outcomes and those relating to the labor market. For housing tenure, I consider the living arrangement as a set of three options. These are: (1) living with at least one parent, (2) being an owner without any parent present in the household, and (3) being a renter without any parent present[8]. Finally, I also include a measure of affordability to indicate the effort required by a household to meet its housing costs. Affordability is traditionally computed as the ratio between housing costs (either down payment or rent) and household income. Regarding labor market outcomes, I show the employment rate, different measures for earnings at both a personal and household level, the number of hours worked in a week, and a temporary employment indicator.

Table 3.1 shows that living with parents is much more common among recent graduates than in the general population. Similarly, newly graduates are less likely to be homeowners or renters. In the labor market, newly graduates have lower incomes and a higher rate of temporary employment, despite having higher employment levels than the general population.

[7]Given that educational systems can vary significantly between European countries, I segmented the different possible educational levels into three broad categories. First, the lowest possible educational achievement: primary education and first stage secondary education. Second, higher education, including undergraduate studies. Third, all other possible educational achievements, which consisted mainly of second-stage secondary education, and all other professional and technical education. From now on, when referring to college graduates, I will refer to the second group.

[8]In the rest of the paper, *owner* refers to living in owned dwelling by one member of the household, without any parent being present. Similarly, *renter* refers to living in a dwelling that is being rented by the households but without any parent present. Finally, *with parents* refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. Other living arrangements such as living rent-free represent less than 5% of the total population.

Table 3.1: Descriptive Statistics for Graduation Cohorts Across Europe

Housing tenure	Full Sample	By Gender: Male	By Gender: Female	One year after grad.
With parents	0.07	0.07	0.07	0.52
Owner	0.77	0.77	0.77	0.23
Renter	0.12	0.12	0.13	0.21
Affordability	0.17	0.16	0.18	0.20
Labor market outcomes				
Employed	0.54	0.56	0.51	0.64
Personal monthly gross income €	1,806	2,148	1,451	1,411
Personal annual net income €	11,714	12,124	9,283	6,633
Household annual net income €	37,842	39,349	36,318	34,744
Average weekly hours worked	21.1	23.4	18.7	24.9
Temporary employment	0.06	0.05	0.07	0.24

Notes: Owner refers to living in owned dwelling by one member of the household, without any parent being present. Similarly, renter refers to living in a dwelling that is being rented by the households but without any parent present. Finally, with parents refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. Affordability is calculated as total housing expenses over the household's annual net income. All values are converted to euros and then deflated to the harmonic price index (HPI, which the ECB calculates) with the base year of 2018. Personal annual net income and household annual net income are measured with respect to the year before the interview, while personal monthly gross income is measured as current income. Temporary employment represents the share of the cohort working under a temporary contract.

3.4 Results

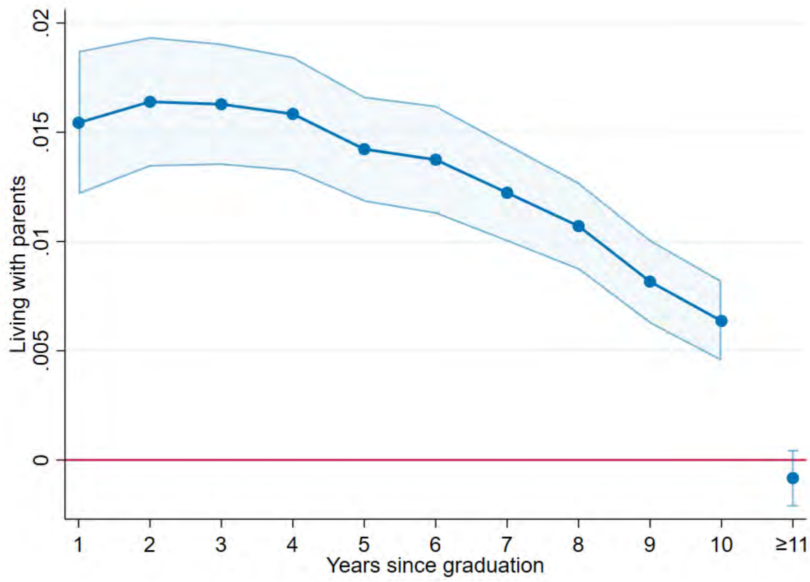
3.4.1 Housing market outcomes

One of the main objectives of this study is to determine whether bad initial economic conditions can have long-term effects on housing tenure and affordability. For this study, I will focus on whether individuals live in the parental home (labeled as *with parents*), live in an owned unit with no parent present (labeled as *owner*), or live with no parents in a rental unit (labeled as *renter*)[9]. Figure 3.2 shows the β_e coefficients from Equation 3.2. These coefficients capture the shift of the share of individuals living with their parents from the typical in the potential experience

[9] *With parents* is defined as an individual living with at least one person who can be identified as his or her biological, step, adoptive or foster parent, or guardian. *Owner* refers to a person living in a dwelling owned by one member of the household, without any parent being present. Similarly, *renter* refers to living in a dwelling that is being rented by the households but without any parent present. Households could potentially live in rent-free accommodation, provided by either family or the state. This is not a common situation, especially among young people.

year profile due to an increase in the unemployment rate at the time of graduation, given the regular subsequent evolution of the labor market[10].

Figure 3.2: Effect of a one-point increase in the unemployment rate at graduation time on living with parents.



Notes: Effect of a one point increase in the unemployment rate on the probability of living with parents. "With parents" refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. The mean one year after graduation is 52%. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

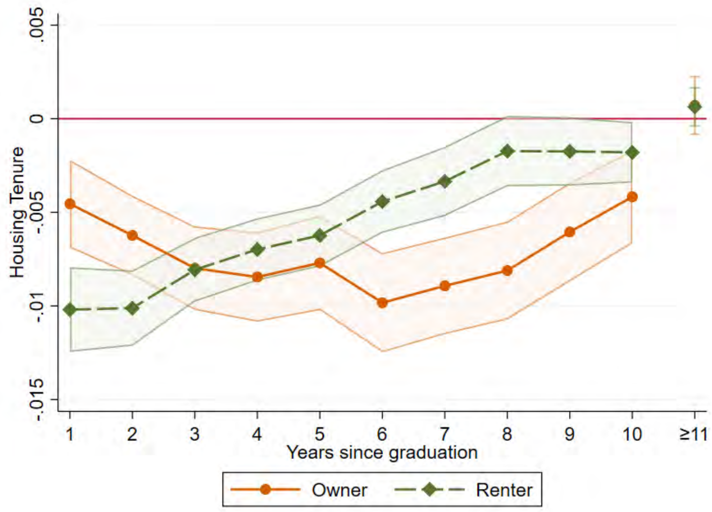
The results indicate that a 1 pp increase at the time of graduation increases the probability of staying in the parental home by 1.5 pp one year after graduation, or when compared to the mean in Table 3.1, an increase of 2.9%. The effect is stronger on the years immediately after graduation; however, it is highly persistent and is still significant even ten years after graduation. The accumulated effect after ten years of a 1 pp increase in the unemployment rate is 12.5 pp. Overall, graduating at a bad time leads to a significant increase in the probability of living with the parents.

Bad economic conditions when graduating reduce the probability of leaving the parental home and becoming a renter, as shown in Figure 3.3a. A 1 pp increase in the unemployment rate at the time of graduation decreases the probability of renting by 1.02 pp (or 4.9% when compared to the mean) one year after graduation. This effect follows a similar pattern to that of living with parents, with the largest coefficients being immediately after graduation. Nevertheless, bad initial labor market

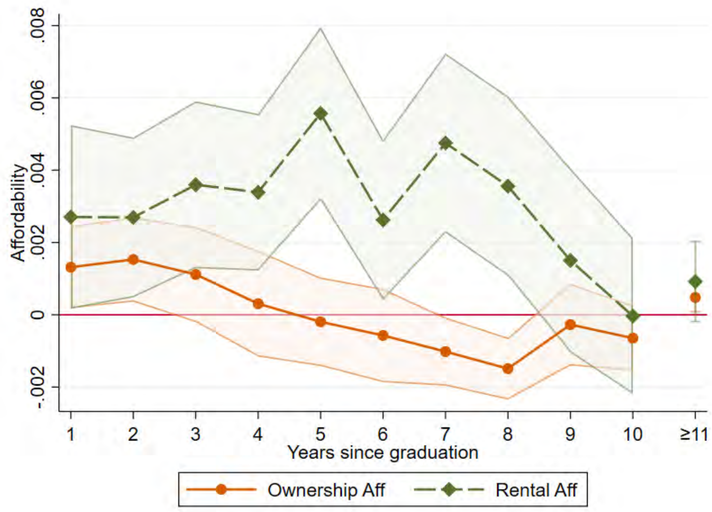
[10] As results are based on the cell model from Equation 3.2, the coefficients can be interpreted as the share of the cohort living with their parents, but also as the probability that the individual will live in the parental home.

conditions do not affect the probability of being a renter beyond eight years from graduation.

Figure 3.3: Effect of a one-point increase in the unemployment rate at graduation time on housing tenure and affordability.



(a) Tenure status



(b) Affordability for owners and renters

Notes: Sub-figure a) depicts the effect of a 1 pp increase in the unemployment rate at the time of graduation on the probability of being an owner and renter. "Owner" refers to living in a dwelling owned by one household member, without any parent being present. Similarly, "renter" refers to living in a dwelling that is being rented by the household but without any parent present. The mean one year after graduation is 21% for "renter" and 23% for "owner". Sub-figure b) depicts the effect of a 1 pp increase in the unemployment rate at the time of graduation on housing affordability for owners and renters. Affordability is calculated as the yearly housing costs over the household's yearly income. Results are based on Equation 3.2.

A 1 pp increase in the unemployment rate leads to a lower probability of ownership in the year after graduation, with the effect being equal to 0.45 pp (a -2.0% decrease with respect to the mean in Table 3.1), as shown in Figure 3.3a. Again, effects are significant ten years after graduation. However, in this case, coefficients are smaller in the first years and become larger in absolute magnitude with each passing year from graduation. This could be explained by the fact that most newly graduates do not opt to buy a home immediately after graduation. Most graduates buy a home some years after graduation after they have been able to save enough. The effect on ownership is interesting because it points to a different long-term dynamic than previous literature that focused on labor market outcomes. The results suggest that focusing solely on the years immediately after graduation could lead to underestimating the actual impact of initial labor market conditions.

The magnitude of the effect on living in the parental home is equal to the sum of the coefficients of renting and ownership. This indicates that the empirical strategy correctly captures the tenure options of young individuals. The results are depicted in Figure 3.3a, and the values of the coefficients are presented in Table A1 of the Annex.

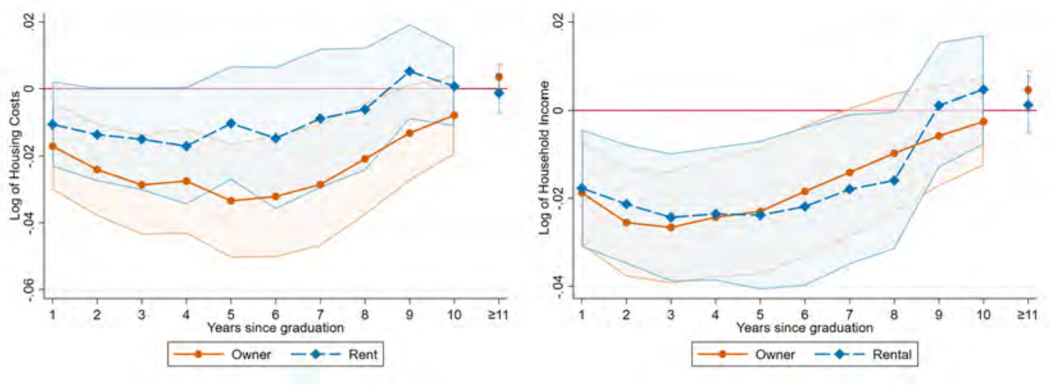
Affordability is commonly computed as the coefficient between yearly housing costs and yearly household income[11]. Therefore, higher levels of this ratio indicate a larger effort by the household to meet its housing living expenses. The results in Figure 3.3b show that an increase in the unemployment rate at the time of graduation increases affordability ratios for all individuals, regardless of their tenure status. The effect is a 0.27 pp increase, one year after graduation, in the affordability ratio for renters (a 1.0% increase compared to the mean). Over ten years, this implies a 3.3 pp increase in the affordability ratio. Concerning affordability for those who own their unit, the effect implies a 0.13 pp increase, one year after graduation, (a 0.6% increase compared to the mean). Over ten years, the accumulated effect is 0.15 pp.

As mentioned above, affordability is calculated as a ratio. Therefore the variation could arise from either the rent (or mortgage) paid or the household income. For example, if households' income falls, but rental costs and prices fall in the same proportion, the affordability ratio should remain constant. On the other hand, if the households' income falls but rental costs and prices are somewhat rigid and decrease less than income, it could lead to worse (i.e., higher) affordability ratios. This latter hypothesis seems to be confirmed in Figure 3.4. The results show that, while housing costs remain unaffected, there is a negative and significant effect

[11]The housing costs measure includes the rent or mortgage paid and other living costs, such as building insurance, regular maintenance and repairs, utilities (for rental units), and other services and charges. While including these other factors could introduce undesired sources of variation, in any case, rent or mortgage payments constitute the majority of housing costs.

on household income for both owners and renters. These results are in line with those previously reported and indicate that worse affordability arises mainly from a reduction in household income rather than an increase in housing costs, in particular rents.

Figure 3.4: Effect of a one-point increase in the unemployment rate at graduation time on housing costs and household income.



(a) Log of housing costs **(b)** Log of household income

Overall, poor economic conditions at graduation time seem to affect young people's housing outcomes significantly. If I consider one standard deviation in the unemployment rate in the sample, i.e., an increase of 4.4 pp, then the increase in the share of young graduates living with their parents one year after graduation, associated with such deviation, is 6.75 pp. Additionally, such a deviation could imply worse affordability ratios for both renters and owners. The magnitude of such effects suggests that a typical recession in the labor market has the potential to affect the housing market through the tenure decision of young people.

Heterogeneity analysis

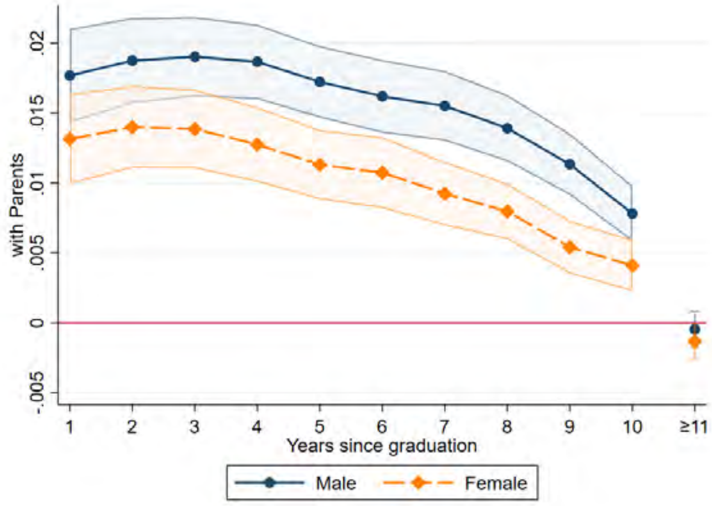
Given the different characteristics presented by the sample, it is important to analyze the results across different dimensions. This provides further evidence on how initial labor conditions can affect individuals. For visualization purposes, I will focus only on the probability of individuals living with their parents[12].

[12]For these results, the equation used is the following:

$$Y_{c,g,t} = \alpha + \beta_e u_{g,c} X + X + \gamma_e + \delta_c + \eta_g + \theta_t + \varepsilon_{c,g,t} \tag{3.3}$$

Where the only difference with respect to Equation 3.2, it includes the variable X, which is a dummy variable that takes a value equal to one if the cell corresponds to the group of interest and zero otherwise.

Figure 3.5: Effect of a one-point increase in the unemployment rate at graduation time on living with parents by gender



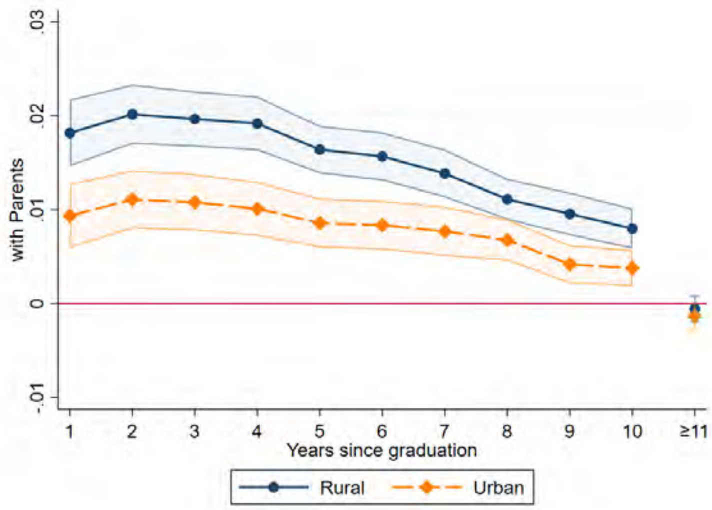
Notes: Effect of a one-point increase in the unemployment rate on the probability of living with parents, understood as living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.3. Data from ECHP and EU-SILC.

First, as shown in Figure 3.5, the results differ with gender. The impacts on living with parents are higher for males and also more persistent in time. For men, a 1 pp in the unemployment rate at the time of graduation translates into a 1.77 pp increase in the probability of living with parents one year after graduation. For women, the effect is 1.30 pp. While for men, the effect with respect to the mean represents a 3.29% increase, this figure is 2.66% for women. The lower labor force participation rate in women could explain this difference in the effect. While 64% of males are working within the first year after graduation, only 62% of newly graduated women work in the first year after graduation. Since this is a shock in the labor market, female individuals that were not planning to enter the labor market may not be affected by the shock.

As the housing opportunities faced by young people vary when they live in a city or rural environment, it is also important to shed light on the heterogeneous results in this dimension[13].

[13]This analysis restricts the sample only to countries and years for which data on urban density are available due to data availability. This excludes all countries before 2005, the Netherlands throughout the entire sample, and Germany and France for 2016, 2017, and 2018.

Figure 3.6: Effect of a one-point increase in the unemployment rate at graduation time on living with parents by urban density



Notes: Effect of a one point increase in the unemployment rate on the probability of living with parents, understood as living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.3. Data from ECHP and EU-SILC.

An increase in the unemployment rate causes a larger increase in the probability of living with parents in rural compared to urban ones. While the effect is 1.85 pp in rural areas, the figure is 0.90 pp in urban areas one year after graduation. The effect, when compared to the mean, is 3.2% and 1.92%, respectively. We know that rental markets differ significantly between urban and rural areas; therefore, a potential explanation is that rental markets play a role in how income shocks affect housing tenure.

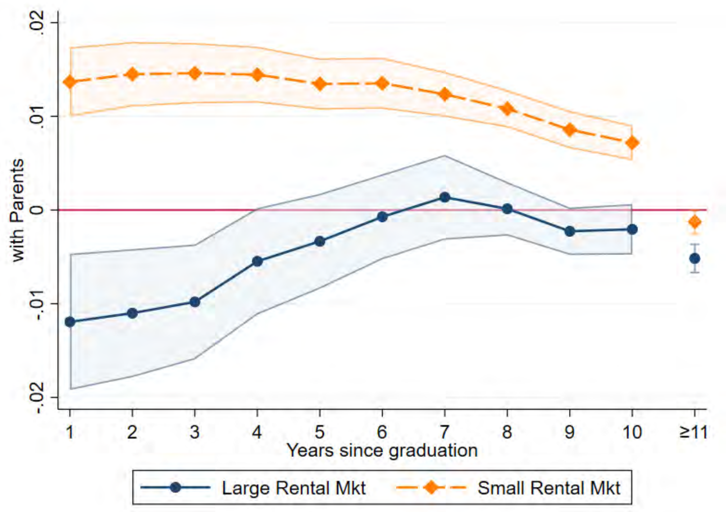
To analyze whether the size of the rental market plays a role in the results; I split the sample into countries with "large" versus "small" rental markets. I label a country as having "large rental market" if the share of households living in rental units is larger than the EU-27 mean for 2017 (which is equal to 30%), and countries with "small rental market" are those below the median[14]. The results show that the effects for countries with large rental markets are negative, while countries with smaller rental markets drive most of the results.

Rental markets could play a major role in how the shock ends up affecting housing tenure decisions. A potential mechanism is that if the rental market is occupied primarily by young people, then a large market with the ability to adjust to demand shocks should be better at absorbing shocks such as those experienced by newly

[14]The countries with large rental markets are: Austria, Denmark, France, Germany, Ireland, Netherlands, Sweden, Switzerland, and the United Kingdom.

graduates. This point will be discussed at length in Section 3.5.

Figure 3.7: Effect of a one-point increase in the unemployment rate at graduation time on living with parents by size of rental market.



Notes: Effect of a one point increase in the unemployment rate on the probability of living with parents, understood as living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

Robustness

In this section, I test whether the results previously presented are robust to different specifications and measures. First, I test whether using an alternative measure for the national unemployment rate causes any change to the results. As unemployment rates can be calculated based on different criteria across countries, I use estimates for national unemployment rates by the International Labour Organization (ILO), which provides data for all countries in the sample starting from 1991. The ILO unemployment rate should provide a more harmonic measure of unemployment across countries than that of the ECB or national statistics institutes, with the caveat the date only goes back as far as 1991. Figure A8 in Annex E replicates the main results using the ILO unemployment rate, along with the baseline results. Results show that coefficients obtained using the ILO unemployment rate are not significantly different from locally calculated unemployment rates.

Second, a problem could arise from binning the long-term effect from 11 or more years of potential experience into a single coefficient. Potentially, by binning coefficients, some dynamics that take place in the medium to long-term could be lost. Figure A9 in Annex E replicates the main results for the main specification using different thresholds for the long-term effects, with individual coefficients up to 20 years after graduation. The results show that the effect persists over time, with each new coefficient being closer to zero than the one before. This suggests that the effect does indeed tend to fade over time.

Third, I also test for different model specifications. I control for country-year fixed effects. The graphs are depicted in Figure A10 in Annex E. The results show no statistically significant difference between the baseline equation and that with year-country fixed effects added.

While this research focuses on college graduates only, Section F of the Annex presents the results for all educational levels. This approach shows some significant differences. For individuals with only primary school completed, worse economic conditions when finishing their studies lead to an increase in the probability of renting and a decrease in that of becoming an owner and living with parents. A potential explanation may be that these households are more vulnerable and cannot afford to have a household member studying when economic conditions are bad. This would push primary graduates to move from their parental household looking for new job opportunities. For those high school graduates, an increase in the unemployment rate when graduating leads to a lower probability of becoming an owner or renter and increasing the probability of living with parents. Coefficients for secondary graduates are closer to those of college graduates. While not being strictly comparable due to potential endogeneity discussed in Section 3.3, results suggest that college graduates are more affected by bad economic conditions when graduating than secondary graduates. This could be a consequence of college graduates unable to avoid the shock by continuing to study for several years, a possibility available to high school graduates.

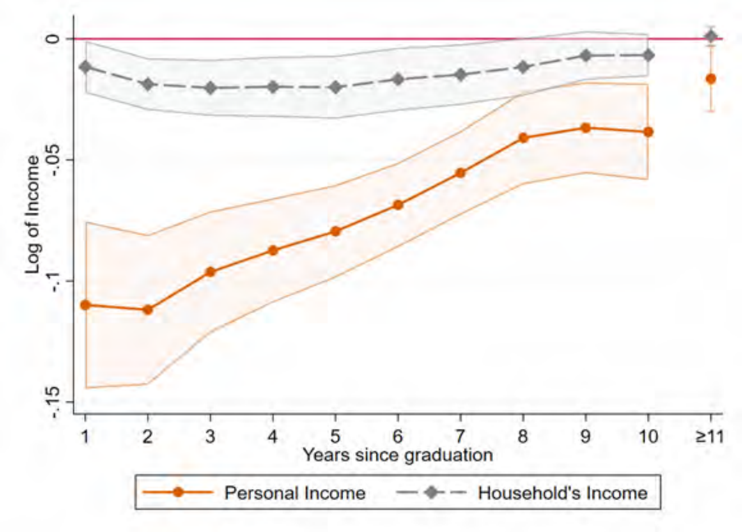
3.4.2 Additional outcomes

Labor market outcomes

Using graduation time as exogenous, I study the effect of the initial labor market conditions at graduation time on labor market outcomes later in life. Figure 3.8 shows the coefficients of β_e for each experience year. As shown on Figure 3.8, an increase in the unemployment rate at the time of graduation negatively impacts personal and household earnings.

The results indicate that a rise in unemployment at the time of graduation leads to lower personal earnings; specifically, a 1 pp increase in the unemployment rate at graduation time leads to an 11% decrease in personal earnings in the first year after graduating. While this effect fades over time, it is still present ten years after graduation. The results indicate that the accumulative effect of a 1 pp increase in the unemployment rate at graduation on earnings after ten years is about 38% of average annual earnings. It is important to note that, as the surveys capture all individuals, the effect captures those that enter the labor market, those who did not, and those with longer spells of unemployment.

Figure 3.8: Effect of a one-point increase in the unemployment rate at graduation time on annual earnings and household income.



Notes: Effect of a one-point increase in the unemployment rate on the log annual personal earnings, and net household income, both measured in the previous year. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

Compared to previous studies, the estimates are somewhat larger. The most similar study (given that it uses several cohorts) is Schwandt and von Wachter (2019), who found that a 1 pp increase in the unemployment rate leads to a loss of 3.8% in earnings during the first three years after graduation. However, these estimates are increased once they control for endogenous graduation timing. For Oreopoulos et al. (2012) the effect of a 3 pp increase in the unemployment rate leads to a 6% loss in earning during the first year after graduation. However, Kahn (2010) found that a 1 pp increase in the regional unemployment rate leads to a 9.2% loss in annual earnings. Despite this, it is important to state that the context of these studies differs significantly from this research. These papers focused on North America, and in the case of Oreopoulos et al. (2012) and Kahn (2010) on male college graduates only. Additionally, this paper deals with the world crisis in 2008, which could have had a larger effect than previous recessions.

The data allows me to study the causes behind this drop in personal income. The results show that an increase in the unemployment rate at the time of graduation leads to a lower probability of being employed in the years following graduation.

A 1 pp increase in the unemployment rate at the time of graduation leads to a 1.2 pp decrease in the probability of being employed in the first year after graduation. Concerning those working, they have a higher probability of being employed under a temporary contract rather than a permanent one. A 1 pp increase in the unemployment rate at graduation time leads to a 0.9 pp increase in the probability of being employed under a temporary contract in the first year, which implies an increase of 3.7% when compared to the mean. Additionally, for those working at the time of the interview, being exposed to a higher unemployment rate leads to lower labor intensity, with individuals working fewer hours per week. In this case, a 1 pp increase in the unemployment rate leads to a 4.5% decrease in the average number of hours worked per week.

In terms of the impact on household income, the magnitude of the effect is much smaller than on personal income, with a decrease of 0.9% in the first year after graduation for every 1 pp increase in the unemployment rate at the time of graduation. This difference between the personal and household effect can be partially explained by the results presented in the previous section. This attenuation could potentially occur because household income also captures parental income if the individuals have not moved. If individuals choose to stay in the parental home, and parents are not affected to the same extent as newly graduates by an increase in the unemployment rate, then the household income will have a smaller effect than the effect on personal income. In this case, the results are similar in magnitude to those of Schwandt and von Wachter (2019), with a 1.0% reduction in the household income one year after graduation for each 1 pp increase in the unemployment rate the previous year. Table A2 in the Annex presents the results in detail and shows the coefficients for different potential experience years.

Mediation analysis

The results so far have shown that bad initial labor market conditions lead to a higher probability of living in the parental home and to a lower personal income. However, it is important to establish whether a lower personal income or another simultaneous effect derived from poor initial conditions drives the effect on living in the parental home. To answer this question, I perform a mediation analysis.

Mediation analysis is often used to determine the mechanisms behind the relationship between a treatment and its outcome. The idea is to identify an "indirect effect" that operates through a mediator variable and a "direct effect" that takes account of the other mechanisms. If the effect of the treatment variable works entirely through the mediator, it is called full mediation. Mediation analysis has been used extensively across the social sciences. In economics, some recent examples can be found in Huber (2015), whose authors used this method of analysis to study the mechanisms behind the decrease in the gender wage gap in the US. A key point in mediation analysis is to ensure that the indirect effect is statistically significant. A valid strategy is to use bootstrapping, as pointed out by Memon et al. (2018).

An application to this study would help clarify the mechanisms by which the unemployment level at the time of graduation affects housing outcomes. In this case, the mediation variable is the individual's income[15]. The results shown in Figure A7 in the Annex suggest that, in the first few years after graduation, the income effect explains almost the totality of the effect on the probability of living with parents. In the first few years after graduation, the direct effect (that of the unemployment rate) is not statistically different from zero. We can also see this in the total and indirect effect coefficients, which are not significantly different.

Overall, these results suggest that bad initial labor market conditions affect housing tenure mainly through an income channel in the first years after graduation. So young people remain in the parental home because they cannot afford to rent on their own or a down payment to become homeowners.

Other outcomes: Housing aid, family formation, and health status

There are ways in which a younger household can decide to cope with the shock and still leave the parental home. A potential strategy is to rely on external economic aid to meet housing costs. This aid can come from the parents or the government through special housing aid. I now explore these two possibilities.

I study whether young households that leave the parental home after graduating in worse economic conditions receive larger amounts of money from another household. The results indicate that a higher unemployment rate at the time of graduation leads to an increase in the amount received from another household when not living in the parental home. For those living in the parental home, the effect is the opposite. This suggests that while some individuals still decide to leave the parental home, they can do so by receiving regular money from the parental household. In particular, a 1 pp increase in the unemployment rate at the time of graduation increases the

[15] In the context of this research this translates into Equation 3.4.

$$\begin{aligned} Parents_{c,g,t} &= \alpha + \beta_e u_{g,c} + \kappa_e inc_{g,c} + \gamma_e + \delta_c + \eta_g + \theta_t + \varepsilon_{c,g,t} \\ inc_{c,g,t} &= \mu + \pi_e u_{g,c} + \rho_e + \sigma_c + \tau_g + \upsilon_t + \varepsilon_{c,g,t} \end{aligned} \tag{3.4}$$

Following the benchmark approach proposed by Sobel (1982), the indirect effect of income on individuals staying with parents is equal to the product of κ_e and π_e. The direct effect of unemployment at the time of graduation on living with one's parents is given by the coefficient β_e. Figure A7 shows the coefficients of applying Equation 3.4 to the data set.

amount received from another household by 3.5%. This effect is statistically significant up to seven years after graduation. For households that leave the parental home, an increase in the unemployment rate also increases the amount of housing allowance received from the government. The effect is a 0.6% increase in the amount received in housing allowances from the government, although this effect is not statistically significant. The results are shown in Figure A6 in the Annex.

These results concerning housing aid are broadly in line with the duration of the effects of the unemployment rate at the time of graduation on the probability of renting and being an owner, with the effect on renting becoming statistically insignificant eight years after graduation and the effect on being an owner reaching its lowest negative value six years after graduation. This suggests that parental households assist their adult children with housing costs until their peers living with parents leave the parental home.

So far, the literature has focused on the effects of initial labor market conditions on several career outcomes. However, the results presented here have shown that graduating at a bad time can lead to worse housing tenure and affordability outcomes. These results show that the welfare impacts of initial labor market conditions can be underestimated if one considers only labor market outcomes. In this subsection, I provide some results in other areas that corroborate the idea of greater welfare impacts.

Initial unemployment conditions can impact other outcomes correlated with housing tenure and can affect individual welfare. A clear example of this is family formation. The results in Figure A4 in the Annex show that worse economic conditions at graduation time lead to a lower probability of being in a relationship. This is true when considering formal marital relationships and consensual unions, and cohabitation with a partner. Overall, individuals are less likely to form part of a couple (whether formal or not) when the unemployment rate is higher at the time of graduation. A potential consequence of not being in a relationship is delayed parenthood. The results indicate that a higher unemployment rate at the time of graduation reduces the probability of being a parent. These results concerning family formation are significant even ten years after graduation. While the coefficient indicates that a 1 pp increase in the unemployment rate at the time of graduation decreases the probability of becoming a parent by approximately 0.9 pp one year after graduation, the effect is 5.5% when compared to the mean. These results are broadly in line with previous literature that found a negative relationship between the unemployment rate at the time of graduation and childbearing and marriage. Detailed results are presented in Figure A4 and Table A3 in the Annex.

As initial unemployment conditions can impact important outcomes such as income, housing tenure, and family formation, it is possible that they also affect an individual's health. Overall, initial unemployment conditions do not seem to have a significant impact on an individual's health. Concretely, an increase in the unemployment rate at the time of graduation does not affect the probability that individuals will declare their health status as being "bad" or "very bad." Moreover, the unemployment rate at the time of graduation does not significantly affect the probability of suffering from chronic illness, being limited in one's daily activity due to their health, or having unmet medical examination needs in the last year. Detailed results are presented in Figure A5 and Table A4 in the Annex. These results are in line with previous literature as in the case of Cutler et al. (2015), who found that graduating during periods of high unemployment in Europe does not significantly affect health outcomes for individuals with at least ten years of education. Concerning previous studies on the US, Schwandt and von Wachter (2019) found that college graduates do not experience a reduction in health insurance coverage due to graduating during a bad period.

3.5 An OLG model for housing tenure and affordability

In this section, I present a stylized version of a deterministic overlapping generations (OLG) model. I focus on the impact of a negative income shock on young agents' housing consumption and affordability, showing the pivotal role that an outside rental option can have on the outcome. A fully developed solution of the model can be found on Section G in the Annex.

3.5.1 Set up

Agents are born with no wealth but are heterogeneous in their income and live for three periods. Let $e_a(i)$ be the endowment at age $a \in (1,2,3)$ of type $i \in [0,1]$, such that $e_a(i) \to \mathbb{R}^+$ is continuous and increasing, and $e_1(i) = \psi e_2(i)$ where $\psi \in (0,1)$. In this case, I will assume a uniform distribution of agents' income.

Agents receive utility from the consumption of a numeraire good and their housing tenure choices. Agents prefer ownership over renting and renting over living with parents[16]. There is a utility discount β and an interest rate r, and I assume

[16] More formally, let U_{c_t,h_t} be the household's utility, which can be expressed as $U_{c_t,h_t} = c_t + u_h(\tau_t)$ where c_t is the consumption of the numeraire good, and $u_h(\tau_t)$ the residential choice at time t. Agents living with their parents receive zero utility from housing, while agents living in an owned unit receive the maximum utility v_o. Agents in rental units receive uv_o utility from housing, and as $u < 1$, then the utility from renting is lower than being an owner.

that $\beta(1+r) \geq 1$. These assumptions will imply that agents consume no housing in period three as in Carozzi (2020) so the maximum housing demand is equal to 2.

Agents can choose between three tenure options: live with their parents, rent, and own. The housing stock for ownership is fixed at S^o, and $S^o < 2$, so not all agents can rent or own a unit, and therefore some are forced to live with parents[17].

The supply of rental units comes from landlord agents, who own more than one unit and live in one while renting out the other. I introduce an outside option for rental units, which works as a price floor in the rental market. This feature has been documented in several ways: as the possibility of renting out to tourists (Garcia-López et al., 2020), a reserve value of leaving the accommodation empty (Segú, 2020), or converting housing into offices (Beauregard, 2005). Landlords decide to rent to younger households as long as they can afford to pay at least the outside rental option; otherwise, they opt for the outside option.

Prices are depicted as p_t, which are prices for housing at time t, and R_t is the rent paid in advance at time t. To own a unit, individuals can borrow an amount γp_t, as long as they have the initial down payment $(1-\gamma)p_t$. I impose a restriction whereby a household can only have one mortgage at a time. Additionally, I assume $r < min[\gamma, 1-\gamma]$ so that households can always pay their debt in the steady state and there is no default.[18]

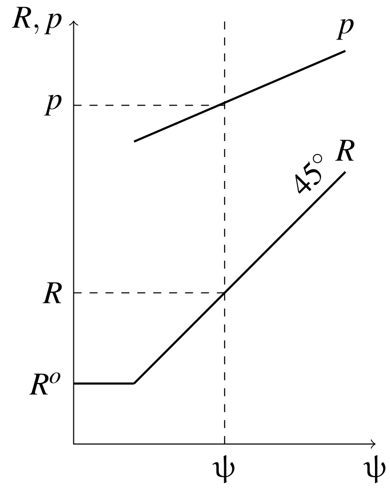
In the long term, both rental and ownership markets must be in equilibrium. In the rental market, the supply of rental units from landlords must be equal to the sum of the units demanded from older agents, young agents, and, (if applicable) the outside option. Similarly, the fixed supply of owned units (S^o), must be equal to the sum of the demand for owned units from older agents, young agents, and the supply of rental units.

In the steady state, it is possible to determine some boundaries for housing prices and rents. For rents, it is possible to show that $R = e_1(2-S^o)$, which implies that rent is determined solely by young agents' income. For prices, it is possible to establish a lower bound: $p \geq e_1(2-S^o)(1-\gamma)^{-1}$. In this case, housing prices are related both to young and old agents income. This points that while rents are fully linked to young agent's income, ownership prices are not. A diagram of how these boundaries work with respect to young agents' income is depicted in Figure 3.9.

[17]Setting ψ low enough is enough to ensure that only young agents live with their parents.

[18]Additionally, there is no guarantee of $rp = R$ in equilibrium as there are no deep-pocketed investors.

Figure 3.9: Rents, prices and young agents' income in the steady state



Notes: This figure depicts the steady state prices and rents for different levels of young agents' income (ψ). While rents are on the 45 degree line, prices have a lower slope, thus indicating that changes in ψ lead to proportional changes in rents but not in prices. When ψ is low enough, rent in steady state is equal to the outside option value.

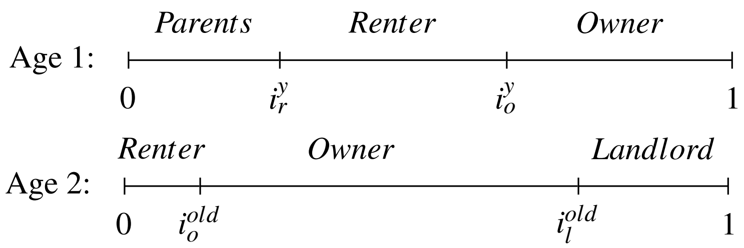
3.5.2 Allocation and affordability

I define thresholds in the type distribution of agents that determine the distribution of households across units. For young agents, the relevant thresholds are i_r^y and i_o^y, which indicate the thresholds young agents can afford to rent and own. For old agents the relevant thresholds are i_r^{old} and i_l^{old}. These indicate the points at which old agents can afford to own and become landlords (i.e., own a unit and rent out the other). Therefore, for young households, we can identify the share of agents living with their parents as i_r^y, the share of agents in rental units as $i_o^y - i_r^y$, and the share of agents in owned units as $1 - i_o^y$. The position of these thresholds depends entirely on the model parameters.

Agents pay different amounts for each housing tenure choice. In particular, they pay zero when living with parents, R when renting, and $p(1-\gamma)$ when they own their homes. These housing costs define their affordability ratio for young agents as φ^h where $h \in [p, r, o]$ for those living with parents, renting, and homeowners, respectively. As housing costs remain constant within the tenure options, agents differ in their affordability ratio according to their income.

The marginal renter is the individual who can barely afford to rent, spending all of her income on rent, thus having an affordability ratio equal to one. As income increases, the affordability ratio decreases, up to the wealthiest renter, who pays the same price for the rental unit as the marginal renter but has the highest income. The

Figure 3.10: Steady state allocations



Notes: This figure depicts the steady state allocations for young and old individuals, arranged by income. For higher income levels agents locate in their more preferred housing tenure choice, such as ownership. Only young agents face the possibility of living with their parents.

wealthiest renter has the lowest affordability ratio, as the price paid for the housing unit takes up the least amount of income. The average affordability ratio for rental agents is the average of the affordability ratios between the marginal renter and the wealthiest renter. It is also possible to define the average affordability for renters as the average between the affordability of the marginal and the wealthiest renter. This provides an index measure to reveal how affordability changes between housing tenure groups. Analogously, the same can be said for young owners.

3.5.3 Effect of a negative income shock on housing allocation and affordability

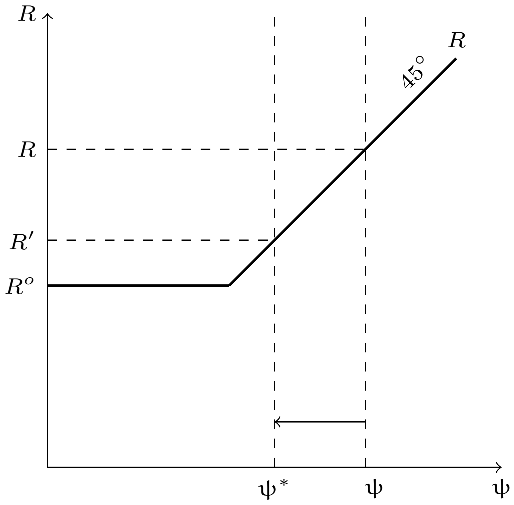
This section analyzes the impact of a negative income shock on young individuals, depicted as a permanent decrease in ψ. I focus on two scenarios: one in which the rental market has downward flexibility, which means that the outside rental option plays no role, and the other with downward flexibility in the rental markets, which implies that the outside option functions as a price floor.

Case 1: Flexible rental markets

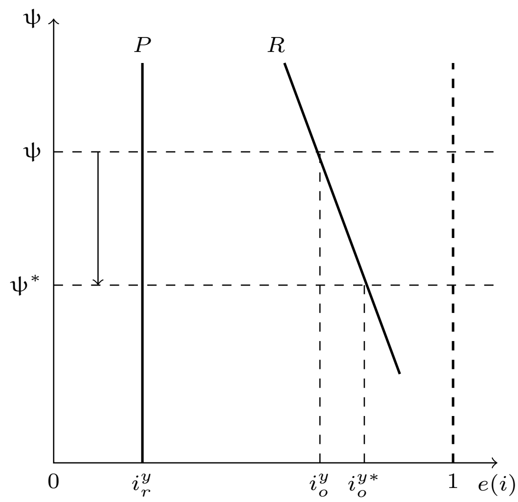
If the rental markets are flexible, then a decrease in the income of young agents should cause a proportional decrease in rents. This is because as young agents are the only marginal renters, the rent level will follow the marginal renters' income to keep housing markets in equilibrium. This dynamic is depicted in Figure 3.11a.

Figure 3.11b shows the steady state housing allocations for young households for different levels of ψ. When ψ decreases, young agents are poorer than older agents. This means that they will settle for the least preferred housing options, as older, wealthier households outbid them. Since rents adjust perfectly to the new young agent's income, in this case, the share of young agents living with their parents, depicted by i_r^y, will remain the same. However, as prices do not adjust fully to the new income of young agents, some of them will no longer be able to afford to become an owner. In this case, there will be a group of agents that were owners with the previous allocation but are now renters, thus making the total share of young agents living in rental units increase (this is depicted by the shift from i_o^y to i_o^{y*}). In this way, the number of housing units consumed by agents in equilibrium remains the same.

Figure 3.11: Effect of a negative income shock on rents and housing allocation in a flexible rental market.



(a) Effect on rents



(b) Effect on housing allocation

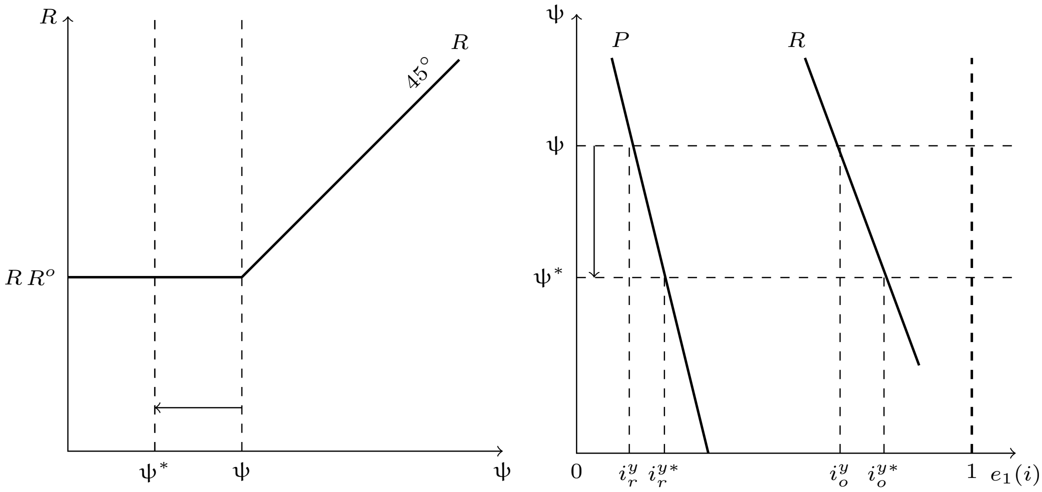
Notes: The figure on the left shows the effect on equilibrium rent for a negative shock in income for young households (depicted by ψ). In this case the shock is translated into a proportional drop in rents, thus making equilibrium rents flexible. The figure on the right shows the effect on housing allocation for young households. As rents are flexible the share of young people living with their parents does not change. As prices do not fully adjust, there are fewer young homeowners.

The shock will affect young renters' average affordability. While the marginal renter (i.e., between living with parents and renting) will still spend all of her income on rent, the new wealthiest renter will spend less on housing costs. This is because the wealthiest renter is now an agent who otherwise would have been an owner. Even though the income of this agent falls, the price paid for housing consumption shifted from an owned unit to a rental one. Paying for an owned unit is always more expensive than paying for a rental one, thereby making its affordability ratio drop. In this way, the average affordability ratio for renters also drops.

Case 2: Rigid rental markets

If rental markets are rigid, meaning that the outside option works as a price floor in the rental market, then a drop in income for young individuals will not cause a proportional fall in rental prices. It could even be the case that rental markets are fully rigid, meaning that rents will not respond to a drop in young agents' income. This case is depicted in Figure 3.12a.

Figure 3.12: Effect of a negative income shock on rents and housing allocation in a rigid rental market.



(a) Effect on rents **(b)** Effect on housing allocation

Notes: The figure on the left shows the effect on equilibrium rent for a negative shock in income for young households (depicted by ψ). In this case the initial equilibrium rent is already equal to the outside option rent, making the equilibrium rent to be fully rigid. The figure on the right shows the effect on housing allocation for young households. As rents are rigid the share of young people living with their parents increases. As prices do not fully adjust, there are fewer young homeowners.

As a direct consequence of this rigidity in the rental market, the share of agents living with their parents is no longer fixed. This dynamic is presented in Figure 3.12b. When faced with a negative income shock, a group of agents living in rental units will see their incomes drop, but their housing costs (in this case, rental costs) remain unchanged, thus making renting unaffordable. Therefore, a negative income shock leads to a steady state with more agents living with their parents, with a shift from i_r^y to i_r^{y*}. Housing markets remain in equilibrium as landlords receive R^o from the outside option, which keeps the rental option attractive for them. As in the previous case, prices do not fully capitalize the shock in young agents' income, meaning that some will no longer afford to own and will opt to rent.

Again, the shock will affect young renters' average affordability, but in the opposite direction to the previous case, leading to worse (i.e., higher) average affordability for young renters. The marginal renter will spend all of her income on rent. However, it is possible to prove that the wealthiest renter will see a reduction in her income larger than the drop in the amount spent on housing (as rents are now more rigid than prices), thereby increasing its affordability ratio. As marginal renter's affordability remains the same, but the wealthiest renter's affordability increases, the average affordability for renters will increase.

Overall, the results presented in Section 3.4 seem to be in line with the second scenario discussed here. A negative income shock, such as that caused by bad initial labor market conditions, leads to a higher share of individuals living with their parents and higher affordability ratios for renters and owners. This would suggest that rental markets have downward rigidity and that renting to young people is not as attractive as other rental options for landlords.

3.5.4 Welfare

The model can be numerically solved to provide some insight into several questions. A fully developed version of the model, along with its calibration and numerical solution, is shown in Section G of the Annex. The first task is to study the welfare impacts of the above-mentioned income shock on agents. To that end, I develop a measure of welfare at the cohort level that takes account of both the utility derived from housing allocation and the utility derived from low affordability ratios[19].

Using the calibration shown in detail in Section G of the Annex, it is possible to show that housing welfare in young agents decreases when there is a negative income shock. In line with the predictions shown in the previous section, welfare decreases more for young agents when rental markets are rigid. In particular, an income loss of 33% for young agents will imply an 11% decrease in welfare in flexible rental markets while a 39% when the rental market is rigid.

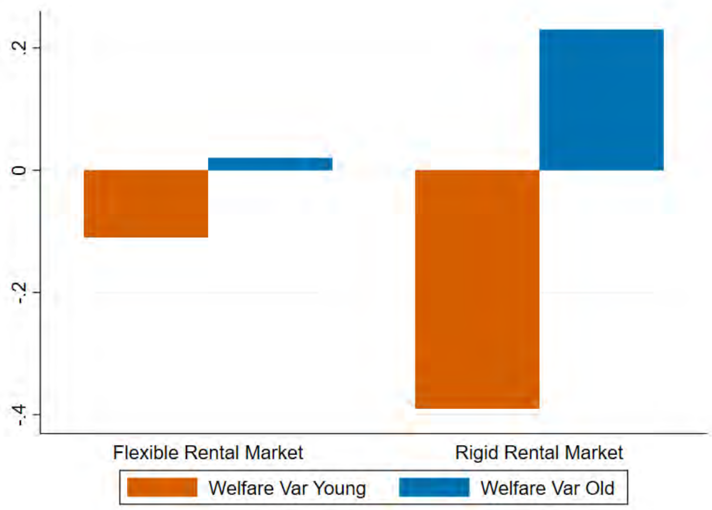
[19]The utility function solved by agents is a long-term one, and it does not take into account housing affordability. However, evidence suggests that high affordability ratios can affect individual welfare. Therefore, using the utility function as a welfare measure can lead to underestimating the short-term effect of changes in housing tenure and affordability on welfare. For that, I develop an index that both reflects agents' decision-making in the model and captures the negative impact of having a high affordability ratio. In particular, I compute welfare as the sum of the individuals' welfare with age a as the following:

$$W_a = \sum_i \frac{u_{h,i}}{\mu * v_o} * 0.75 - \varphi_i * 0.25$$

Where W_a represents welfare for cohort age a. $u_{h,i}$ is the housing utility as defined in the model derived from the housing option normalized to the rental utility, and φ_i represents the affordability ratio for individual i. The index has values of between zero and two.

Young agents' larger welfare loss on rigid rental market scenarios is because more young households are pushed to live with their parents (and therefore receive no utility), and owners and renters have higher affordability ratios. Welfare losses in flexible rental markets are minimized, as housing allocation shifts less towards the least preferred options, and affordability ratios are not greatly affected. For older households, welfare is almost not affected when a shock occurs in a flexible rental market scenario. However, when the rental markets are rigid and a negative income shock to young agents occurs, older agents' welfare will increase significantly. This is because older agents can outbid younger agents in the housing market since they are now wealthier in relative terms. These results are depicted in Figure 3.13.

Figure 3.13: Effect of a negative income shock on welfare agents, in flexible and rigid rental market.



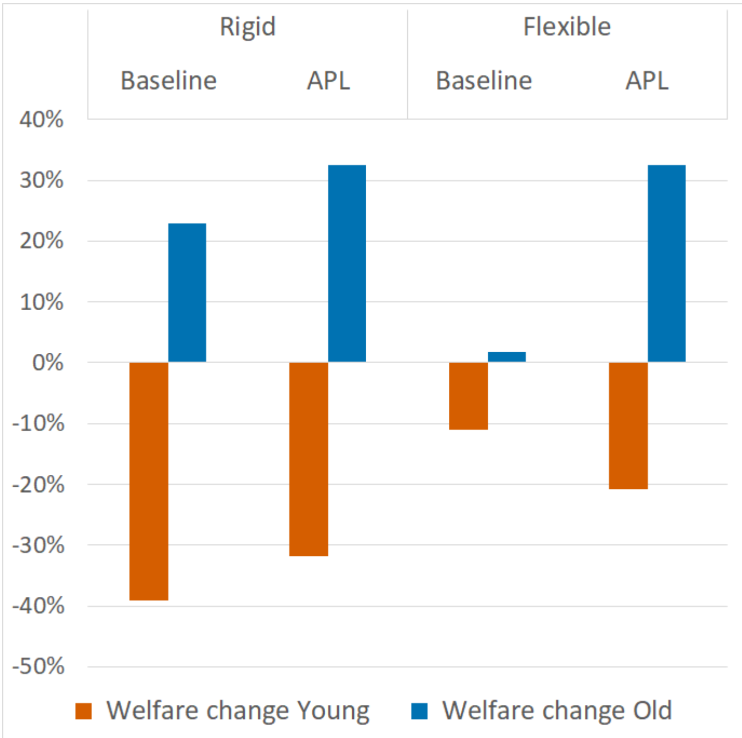
Notes: The figure illustrates welfare losses derived from a 33% sudden drop in young agents' income. Results are shown for flexible and rigid rental markets. Parameters are based on the calibration in Section G.

3.5.5 Policy analysis

The model's numerical solution also allows conducting policy analysis. Consider the case of housing aid in France. This is an interesting case, as almost one in every three French households receive a housing allowance, one of the highest rates in the OECD. Additionally, these allowances account for a large part of government spending, given that it accounted for 0.72% of national GDP, the fourth-highest expenditure in the OECD (OECD, 2018). On average, households receive 30% of their housing expenditure, with 90% living in rental units (Hananel and Richet-Mastain, 2019). In the model, I translate this policy into one in which 30% of the poorest agents received housing aid equivalent to 30% of the rental market price and refer to it as APL *(Aide Personnalisée au Logement)*, the name of France's largest housing aid program.

The results shown in Figure 3.14 indicate that these policies effectively alleviate the welfare impact of a negative income shock in rigid rental markets. In particular, when young agents suffer a 33% income loss, the welfare loss in rigid rental markets is 39%. After implementing an APL policy, welfare losses are reduced by 7 pp. As young agents have lower incomes than older agents, they will benefit from this policy, diminishing the welfare impact of a negative income shock. The mechanism through which this policy operates is by increasing young agents' income and making it competitive with the outside rental option. This decreases the number of agents who would otherwise be living with their parents. Additionally, it improves the affordability of renters since it increases their income.

Figure 3.14: Welfare effects in a rigid rental market when an APL-style policy is applied.



Notes: The figure illustrates welfare losses derived from a 33% sudden drop in young agents' income, when applying no policy (baseline) and when applying an APL-style of policy. Results are shown for flexible and rigid rental markets. Parameters are based on the calibration on Section G.

However, when implementing this policy in a flexible market scenario, the policy causes a drop in young agents' welfare. The policy distorts prices and rents adaptation to the new steady state, introducing rigidity in the housing and rental market. Now, some agents suffer both an income loss and stable rental costs, pushing them closer to a situation of rigid rental markets. This rigidity also worsens affordability ratios for some young agents. Welfare for older agents improves as they profit from the rigidity in rents and are relatively wealthier than young individuals. Overall, applying a housing aid policy in a flexible rental market scenario makes young agents worse off.

This analysis shows that policies aimed at the housing market can help recover part of the lost welfare due to a labor market shock. It helps young agents access ownership and rental units and lowers the share of young agents living with their parents. However, for the policy to improve young agents' welfare, it must be implemented in the right scenario.

3.6 Concluding remarks

This research estimates the long-term effects of an increase in the unemployment rate at graduation time on housing tenure and affordability. I exploit the unemployment rate at the time of college graduation as an exogenous income shock to the individual, for a large sample of college graduates since 1960 across Europe. This strategy has been explored extensively for career outcomes, but so far, not for housing tenure and affordability. These two outcomes are essential, as they are key determinants of an individual's welfare.

The results show that a 1 pp increase in the unemployment rate at the time of graduation leads to a 1.50 pp increase in the probability of living with parents. Additionally, it lowers the probability of ownership by 1.02 pp and renting by 0.45 pp. Worse conditions when graduating also worsen affordability ratios for owners and renters, with the effect caused by lower incomes and unchanging housing costs. All of these effects are persistent over time. This shock also leads to long-lasting effects on personal earnings, with a magnitude larger than previously reported in the literature. Bad initial labor market conditions significantly affect family formation, with individuals less likely to be in a relationship and become parents.

I develop an overlapping generations (OLG) model to link income shocks to younger cohorts to housing tenure and affordability changes. This model provides several predictions. Mainly, that rigidity on the rental market is largely responsible for whether the labor market's welfare shock is absorbed or amplified by the housing market. This rigidity will result from an outside option for landlords, a feature widely documented in the literature. In particular, if rental markets are rigid, an income shock to young agents will create a shift away from renting and ownership in favor of the parental home. Additionally, this shock worsens affordability for both renters and owners, as their income drops while housing costs do not. This scenario leads to significant welfare losses for young cohorts, while older agents become relatively wealthier and are better off.

Finally, I address whether these shifts in housing tenure affect agents' welfare and what policies can be used to mitigate the shock. To answer this question, I numerically solve the model and find that a rigid rental market leads to more acute welfare losses than flexible rental markets. Additionally, I find that housing aid policies such as the *Aide Personnalisée au Logement* (APL) in France can help mitigate the shock by enabling young agents to afford to rent. However, these policies only improve young agents' welfare when implemented in rigid rental markets, pointing towards the importance of identifying the correct conditions for applying these policies.

3.7 Appendix

A Data availability in detail

Figure A1: Data Availability

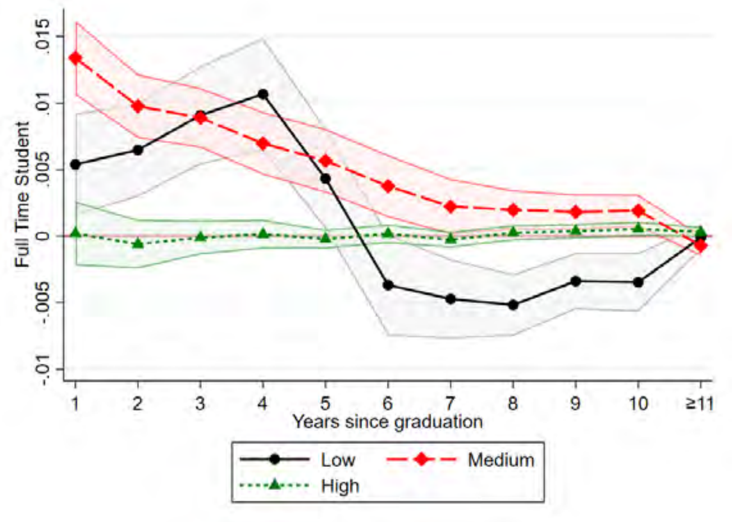
Year	ECHP								EU-SILC														
	1994	1995	1996	1997	1998	1999	2000	2001	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BG	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X
CH	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X
CY	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CZ	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DE	X	X	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DK	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EE	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ES	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FI	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FR	X	X	X	X	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X
HU	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
IE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
IS	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-
IT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LT	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LU	X	X	X	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LV	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MT	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	-
NL	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NO	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X
PL	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RO	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X
RS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
SE	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SI	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SK	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	-
UK	X	X	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	-

B Potential endogeneity

The specification in Equation 3.2 treats the entering in the labor market, determined by the time of graduation, as exogenous. However, as pointed out by Schwandt and von Wachter (2019), individuals may decide to extend their education to avoid unfavorable labor market conditions. Also, individuals may choose to finish their education sooner to take advantage of a favorable labor market. This potential endogeneity would attenuate the results towards zero.

The following graph shows the probability of being a student given the unemployment rate at the graduation time of the last educational level attained. For those who graduated from primary school, bad conditions when entering the labor market lead to an increase in the probability of becoming a student. This effect is significant 4 to 5 years after graduation, which would point towards these individuals entering secondary school, and then going back to the labor market. For secondary level graduates, bad initial labor market conditions lead to a higher probability of being a student, either in other secondary studies or college. In this case, the effect is more persistent in time. Finally, the results suggest that bad initial labor market conditions do not push those that already attained a college degree into continuing studying.

Figure A2: Effect of a one-point increase in the unemployment rate at graduation time on being a student.



Notes: Effect of a one point increase in the probability of being a full time student. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

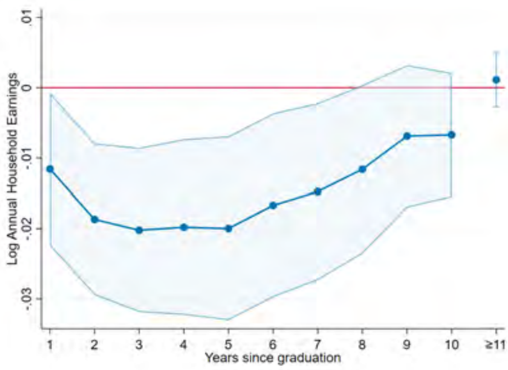
C Detailed results

Table A1: Effect of a one-point increase in the unemployment rate at graduation time on housing tenure

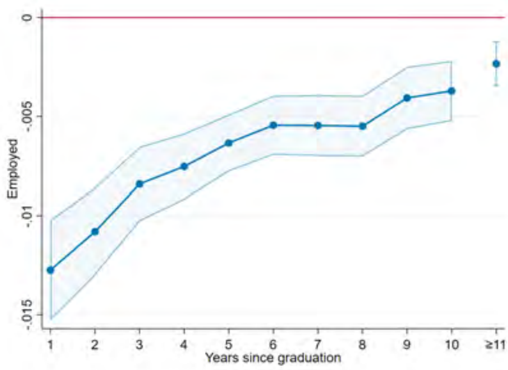
Potential Experience Years	With Parents	Owner	Renter
1	0.015***	-0.005***	-0.010***
	(0.002)	(0.001)	(0.001)
2	0.016***	-0.006***	-0.010***
	(0.002)	(0.001)	(0.001)
3	0.016***	-0.008***	-0.008***
	(0.002)	(0.001)	(0.001)
4	0.015***	-0.008***	-0.007***
	(0.001)	(0.001)	(0.001)
5	0.014***	-0.008***	-0.006***
	(0.001)	(0.001)	(0.001)
6	0.013***	-0.010***	-0.004***
	(0.001)	(0.001)	(0.001)
7	0.012***	-0.009***	-0.003***
	(0.001)	(0.001)	(0.001)
8	0.010***	-0.008***	-0.002*
	(0.001)	(0.001)	(0.001)
9	0.008***	-0.006***	-0.002*
	(0.001)	(0.001)	(0.001)
10	0.006***	-0.004***	-0.002**
	(0.001)	(0.001)	(0.001)
11	-0.002***	0.001	0.001
	(0.001)	(0.001)	(0.001)
Constant	0.085***	0.736***	0.149***
	(0.004)	(0.005)	(0.003)
Observations	18,157	18,157	18,157

Notes: This table shows the coefficients from Figure 3.2 and Figure 3.3a. Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the cohort-region level. *Owner* refers to living in owned dwelling by one member of the household, without any parent being present. Similarly, *renter* refers to living in a dwelling that is being rented by the households but without any parent present. Finally, *with parents* refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

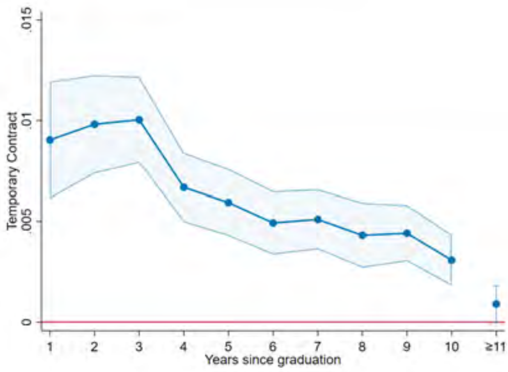
Figure A3: Effect of a one-point increase in the unemployment rate at graduation time on net household income, unemployment months, temporary employment and weekly hours worked.



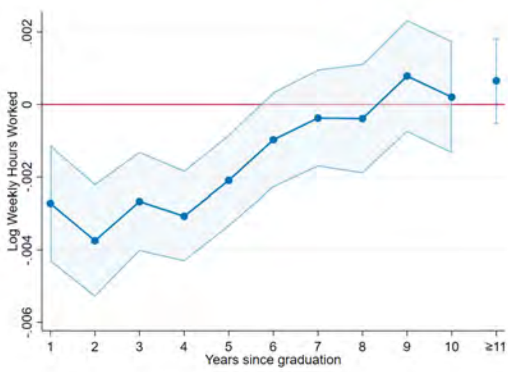
(a) Net household income



(b) Employed



(c) Temporary employment



(d) Log weekly hours worked

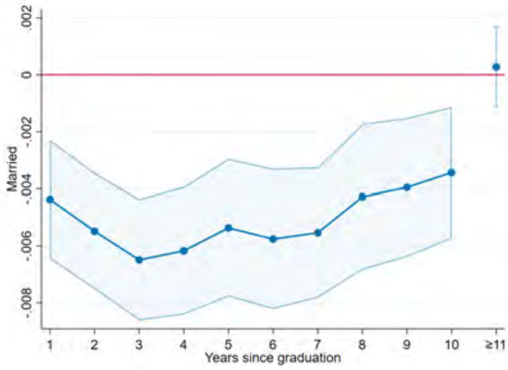
Notes: Effect of a one point increase in the unemployment rate on various labor market outcomes. Unemployment months refers to the number of months during last year that the individual classified herself as "unemployed", temporary employment refers to the type of contract in which the individual is in, which can be fixed or temporary. Weekly hours worked refers to the average number of hours worked by week, if the individual is not working then the number is equal to zero. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

Table A2: Effect of a one-point increase in the unemployment rate at graduation time on labor market outcomes

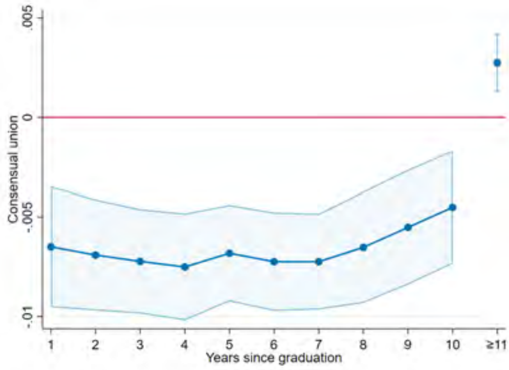
Potential Experience Years	Log Personal Earnings	Log Households Earnings	Employed	Temporary Employment
1	-0.107***	-0.009	-0.012***	0.009***
	(0.018)	(0.006)	(0.001)	(0.002)
2	-0.112***	-0.016***	-0.010***	0.010***
	(0.016)	(0.006)	(0.001)	(0.001)
3	-0.099***	-0.018***	-0.008***	0.010***
	(0.013)	(0.006)	(0.001)	(0.001)
4	-0.090***	-0.018***	-0.007***	0.007***
	(0.012)	(0.007)	(0.001)	(0.001)
5	-0.084***	-0.018**	-0.007***	0.006***
	(0.011)	(0.007)	(0.001)	(0.001)
6	-0.075***	-0.014*	-0.005***	0.005***
	(0.010)	(0.008)	(0.001)	(0.001)
7	-0.059***	-0.012	-0.006***	0.005***
	(0.010)	(0.007)	(0.001)	(0.001)
8	-0.046***	-0.008	-0.005***	0.004***
	(0.010)	(0.007)	(0.001)	(0.001)
9	-0.040***	-0.003	-0.004***	0.004***
	(0.010)	(0.006)	(0.001)	(0.001)
10	-0.040***	-0.001	-0.004***	0.003***
	(0.011)	(0.005)	(0.001)	(0.001)
11	-0.023***	0.004*	-0.003***	0.001
	(0.007)	(0.002)	(0.001)	(0.000)
Constant	7.073***	10.130***	0.757***	0.041***
	(0.045)	(0.013)	(0.004)	(0.004)
Observations	13,554	18,092	18,157	17,288

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the cohort-country level. Temporary employment refers to the type of contract in which the individual is in, which can be fixed or temporary. Employment refers to whether the individual is employed or not. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

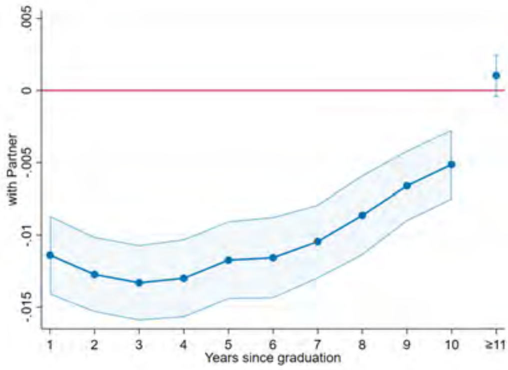
Figure A4: Effect of a one-point increase in the unemployment rate at graduation time on family formation outcomes



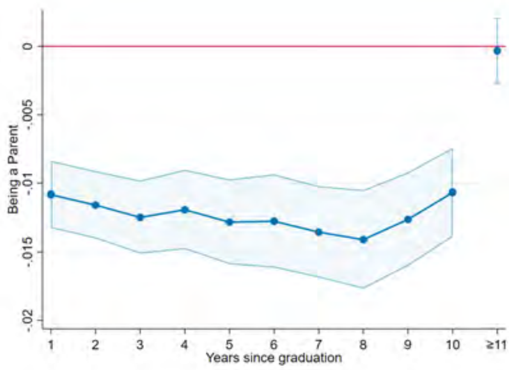
(a) Married



(b) Consensual union



(c) Living with partner



(d) Being a parent

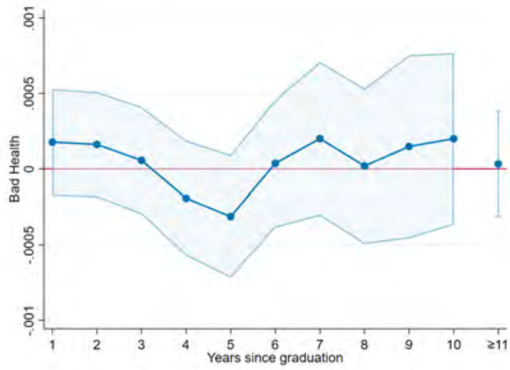
Notes: Effect of a one point increase in the unemployment rate at the time of graduation on family formation outcomes. Married refers to whether the individual is married on a legal basis or not. Consensual union refers to whether the individual is living a consensual union, with or without legal basis. Living with Partner refers to whether there is a cohabitation status with their partner for the ECHP, or whether the individual's partner is a part of the household for EU-SILC. Being a Parent refers to whether the individual can be identified as "own" / step / adopted / foster parent or guardian of another member of the household. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

Table A3: Effect of a one-point increase in the unemployment rate at graduation time on family formation outcomes

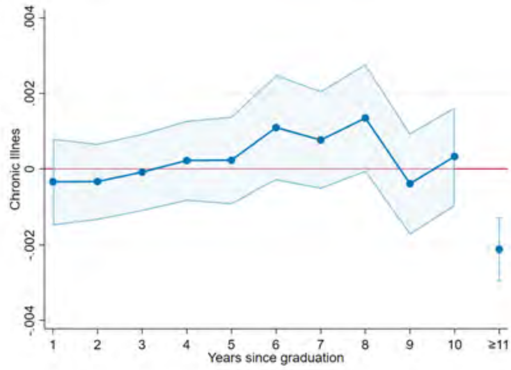
Potential Experience Years	Consensual Union	Married	Being a Parent	Cohabitation
1	-0.007***	-0.004***	-0.009***	-0.011***
	(0.002)	(0.001)	(0.001)	(0.001)
3	-0.007***	-0.006***	-0.011***	-0.013***
	(0.001)	(0.001)	(0.001)	(0.001)
5	-0.006***	-0.005***	-0.011***	-0.011***
	(0.001)	(0.001)	(0.002)	(0.001)
7	-0.007***	-0.005***	-0.012***	-0.010***
	(0.001)	(0.001)	(0.002)	(0.001)
10	-0.005***	-0.004***	-0.009***	-0.006***
	(0.002)	(0.001)	(0.002)	(0.001)
11	0.004***	0.001	0.001	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	17,232	17,549	17,549	17,545

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the cohort-region level. Effect of a one point increase in the unemployment rate on Family Formation outcomes. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

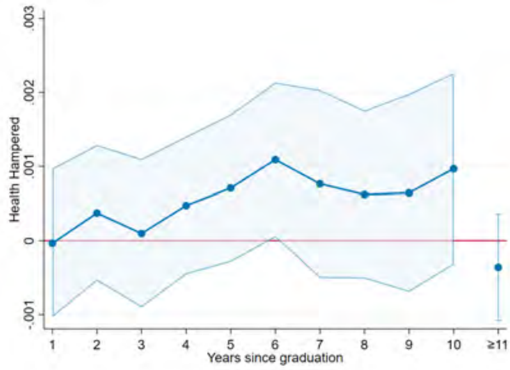
Figure A5: Effect of a one-point increase in the unemployment rate at graduation time on health outcomes



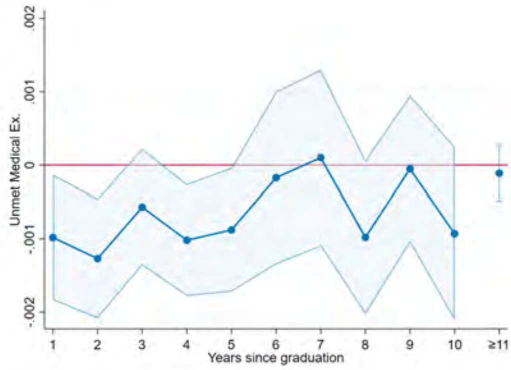
(a) Poor health status



(b) Chronic illness



(c) Limitation due to health



(d) Unmet medical examination

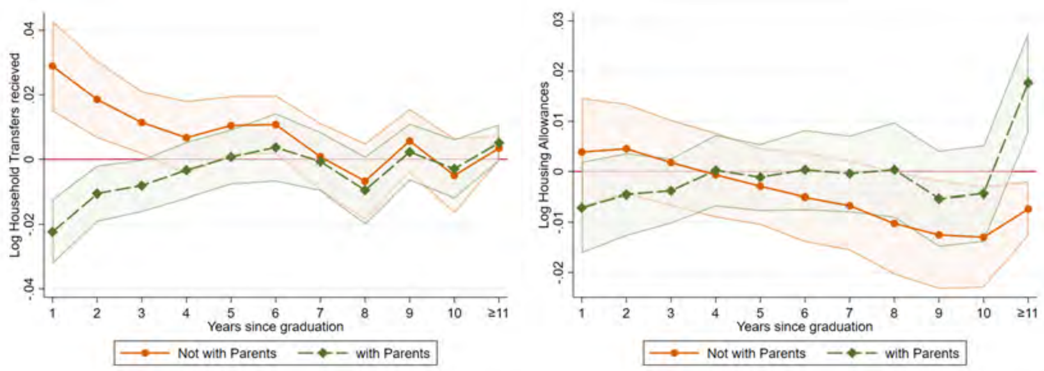
Notes: Effect of a one point increase in the unemployment rate at the time of graduation on various health outcomes. Poor health status refers to whether the person self perceives her health status as "Bad" or "Very Bad". Chronic illness refers to whether the individuals declares having any chronic illness. Limitation due to health refers to if the person declares having any sort of limitation in their daily activity due to their health. Unmet medical examination refers to whether the person declares not being able to meet a needed medical examination in the last year. Results are based on Equation 3.2. Data from ECHP and EU-SILC, except for unmet medical examination which is only available for the EU-SILC.

Table A4: Effect of a one-point increase in the unemployment rate at graduation time on health outcomes

Potential Experience Years	Poor Health Status	Chronic Illness	Health Hampered	Unmet Medical Examinations
1	0.000	-0.001	-0.000	-0.001**
	(0.000)	(0.001)	(0.001)	(0.000)
3	-0.000	-0.000	0.000	-0.001
	(0.000)	(0.001)	(0.001)	(0.000)
5	-0.001**	-0.000	0.001	-0.001*
	(0.000)	(0.001)	(0.001)	(0.000)
7	0.000	0.001	0.001	-0.000
	(0.000)	(0.001)	(0.001)	(0.001)
10	0.000	-0.000	0.001	-0.001**
	(0.000)	(0.001)	(0.001)	(0.001)
11	-0.000	-0.002***	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	17,529	17,188	17,529	14,338

Notes: Significance is indicated by * p<0.1, ** p<0.05, and *** p<0.01. Standard errors, in parentheses, are clustered at the cohort-region level. Effect of a one point increase in the unemployment rate on Family Formation outcomes. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

Figure A6: Effect of a one-point increase in the unemployment rate at graduation time on household's sources of income.

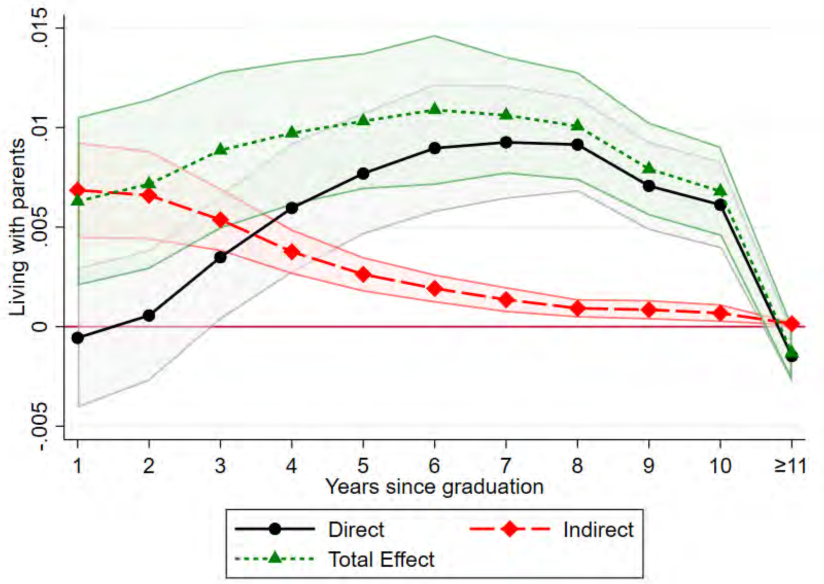


(a) Transfers from another household **(b)** Governmental housing allowances

Notes: Effect of a one point increase in the unemployment rate on sources of income for the households. Results are based on Equation 3.2. Data from EU-SILC.

D Mediation

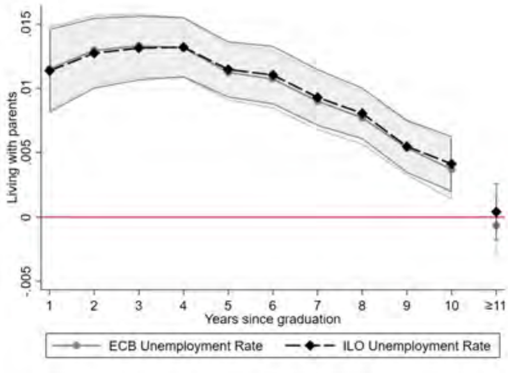
Figure A7: Mediation of personal income on living with parents



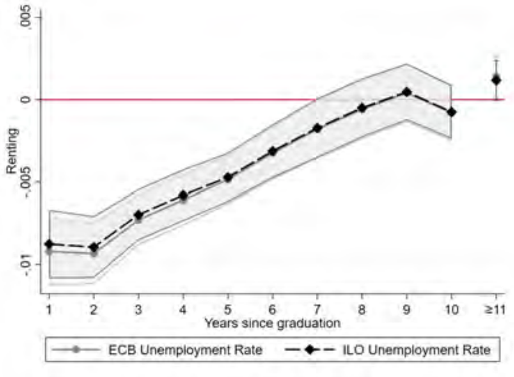
Notes: Effect of a one point increase in the unemployment rate on living with parents using a as a mediator personal income. Standard errors are bootstrapped. Data from ECHP and EU-SILC.

E Robustness

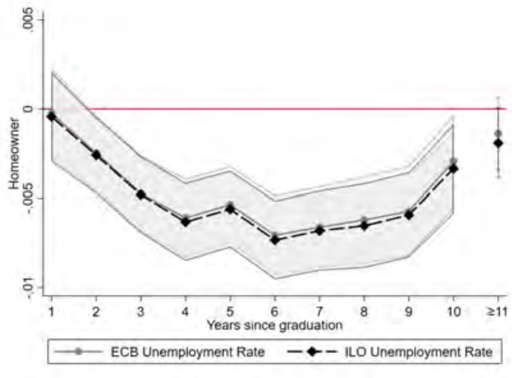
Figure A8: Effect of a one-point increase in the unemployment rate at graduation time on housing tenure using ECB and ILO Unemplyment Rates.



(a) Living with Parents



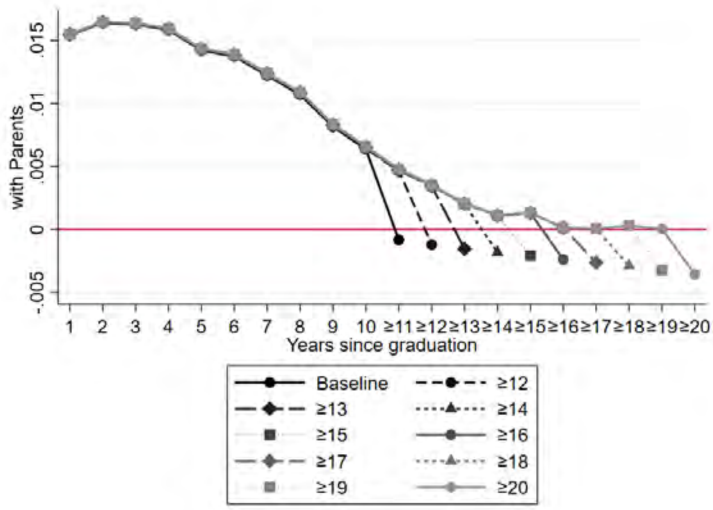
(b) Renter



(c) Owner

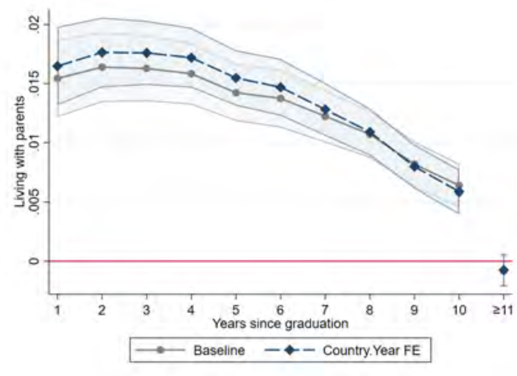
Notes: Effect of a one point increase in the unemployment rate at the time of graduation on tenure status. *Owner* refers to living in owned dwelling by one member of the household, without any parent being present. Similarly, *renter* refers to living in a dwelling that is being rented by the households but without any parent present. Finally, *with parents* refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

Figure A9: Effect of a one-point increase in the unemployment rate at graduation time on living with parents, using different observation windows.

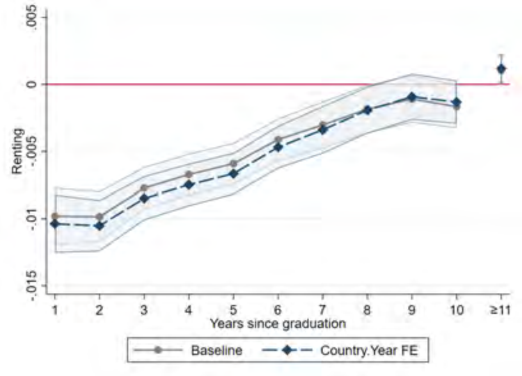


Notes: Effect of a one point increase in the unemployment rate on probability of living with parents. *With parents* refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

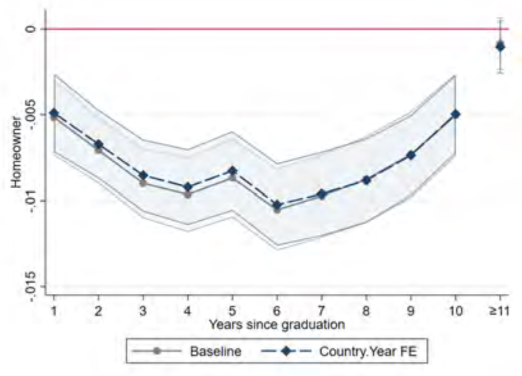
Figure A10: Effect of a one-point increase in the unemployment rate at graduation time on tenure status using Baseline Specification and adding Country-year Fixed effects.



(a) Living with Parents



(b) Renter

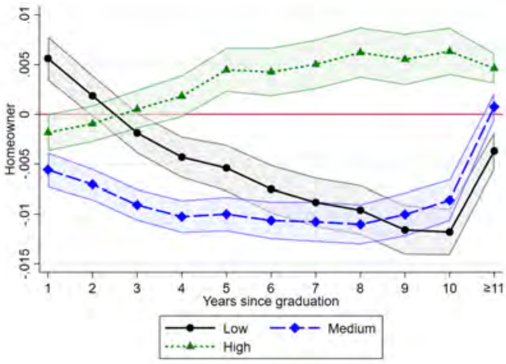


(c) Owner

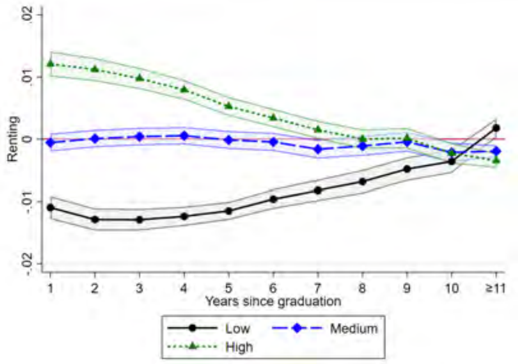
Notes: Effect of a one point increase in the unemployment rate at the time of graduation on tenure status. *Owner* refers to living in owned dwelling by one member of the household, without any parent being present. Similarly, *renter* refers to living in a dwelling that is being rented by the households but without any parent present. Finally, *with parents* refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

F Results using all educational levels

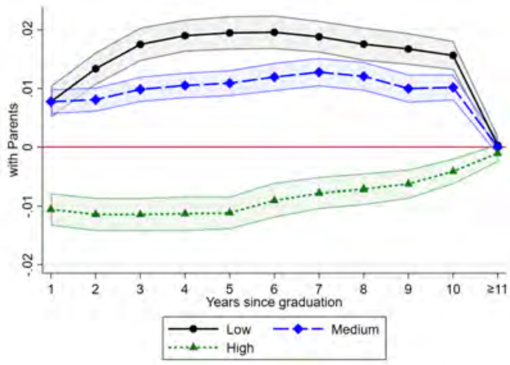
Figure A11: Effect of a one-point increase in the unemployment rate at graduation time on housing tenure by educational level



(a) Owner



(b) Renter



(c) Parents

Notes: Effect of a one point increase in the unemployment rate at the time of graduation on tenure status. *Owner* refers to living in owned dwelling by one member of the household, without any parent being present. Similarly, *renter* refers to living in a dwelling that is being rented by the households but without any parent present. Finally, *with parents* refers to living in a dwelling where at least one parent is present, irrespective of the tenure status. Results are based on Equation 3.2. Data from ECHP and EU-SILC.

G An OLG model for housing tenure and affordability

In this section, I develop a theoretical framework to study the effects of an income shock in younger generations on housing markets. This model builds on the work by Carozzi (2020) and Ortalo-Magné and Rady (2006), where authors develop a tractable model with income and housing heterogeneity with no uncertainty. In the study by Ortalo-Magné and Rady (2006), the authors use an OLG model to show how the ability of young agents to afford down payment on a starter home can affect the entire housing allocation in the economy. Additionally, the authors show a positive correlation between the income of young individuals and housing prices in the economy. In a more recent study, Carozzi (2020) develops an OLG model with no uncertainty and housing quality to relate changes in the composition of housing sales to credit constraint shocks. In his model, younger poorer agents are outbid from ownership by wealthier households.

In this research, I extend the framework of the OLG models with housing markets. I develop an OLG model to study housing allocation, affordability, and welfare. Additionally, I introduce an outside rental option, a feature present in several rental markets. By doing so, I show that the rental market can either absorb or amplify the welfare impact of initial labor market conditions, depending on its rigidity. I show that in steady states with lower income for young households and a flexible rental market, a lower share of them are homeowners, and more live in rental units. This is because the older, wealthier agents price out these young households, and then marginal buyers are then forced to rent. Additionally, I show that in steady state with lower income for young households and a rigid rental market, a larger fraction of them will live with their parents. These predictions are tested in Section G.

This section develops an OLG model with no uncertainty, where agents live for three periods with heterogeneity in income but not on housing quality. The total mass of agents is equal to one in each age.

Incomes — Agents are born with no wealth but are heterogeneous in their income.

Let $e_a(i)$ be the endowment at age $a \in (1,2)$ of type $i \in [0,1]$ such that $e_a(i) \to \mathbb{R}^+$ is continuous and increasing. For notation purposes we can also write $e(i) = e_1(i)(1+r)+e_2(i)$.

Assumption 1: $e_1(i)$ can be written as $e_1(i) = \psi e_2(i)$ where $\psi \in (0,1)$.

Housing stock — Agents can either: live with their parents, rent, own, or become landlords (owning more than one unit, living in one, and renting the other one). The housing stock for ownership is fixed so $S^o = S^o$. Prices are expressed as p_t, which are prices for housing at time t, and R_t is the rent paid in advance at time t.

An important assumption is that $S^o < 2$ so not all agents can rent or own a unit; therefore, some are forced to live with parents.

Borrowing constraints — They enter the model via down payment requirements. Let γ be the loan-to-value ratio for a house. Then γp_t is the amount borrowed for housing at t, and $(1-\gamma)p_t$ is the down payment.

We impose a restriction in which a household can only have one mortgage at a time. Additionally, we assume $r < min[\gamma, 1-\gamma]$ so that households can always pay their debt in the steady state. This implies that there is no default in the steady state.

Affordability — Agents will pay different sums for each housing tenure choice. They will pay 0 when living with parents, R when renting, and $p(1-\gamma)$ when being homeowners.

Agents dedicate different shares of their income to meet their housing costs. we define this ratio for young agents as φ^{yh} where $h \in [p, r, o]$ for those living with parents, renting, and being homeowners, respectively.

The φ_i^{yh} for individual i will be equal to $\begin{cases} 0 & \text{if living with parents.} \\ \frac{R}{e_1(i)} & \text{if living in a rental unit.} \\ \frac{p(1-\gamma)}{e_1(i)} & \text{if living in an owned unit.} \end{cases}$

Preferences — Preferences are defined over a housing and a numeraire good. Let U_{c_t,h_t} be the household's utility, that can be expressed as $U_{c_t,h_t} = c_t + u_h(\tau_t)$ where c_t is the consumption of the numeraire good, and $u_h(\tau_t)$ residential choice in t. Housing tenure decision can be expressed as: $\tau_t = (\tau_{r,t}, \tau_{o,t})'$.

The utility derived from this decision is $u_h(\tau_t) = \begin{cases} 0 & \text{if living with parents.} \\ uv_o & \text{if living in a rental unit.} \\ v_o & \text{if living in an owned unit.} \end{cases}$

As $u < 1$, the utility from renting is lower than that of being an owner. Finally, there is a time utility discount: β, and an interest rate r; and we assume that $\beta(1+r) \geq 1$.

Supply of rental units — The supply of rental units comes from landlords agents, who own more than one unit: live in one, and rent the other one. Let $\lambda_t(i,a)$ denote the number of units rented by agents of age a, type i at time t. There is no guarantee of $rp = R$ in equilibrium as there are no deep-pocketed investors.

There is an outside option for rental, which can be understood as renting to tourists or a reservation value of leaving the accommodation empty. Landlords will decide to rent to young households as long as the rent that they perceive from them (R^y) is larger than the rent from the outside option (R^o). Then the market rent (R) will be: $R = max[R^y, R^o]$.

Timing and decisions — The timing of the decisions for households is the following: First, they derive utility, then they receive the endowment, then they pay and receive any interest, then they trade on the housing market, and finally, they derive utility from consumption.

Every period agents decide: whether to buy (or not) a housing unit, to become landlords, where to reside next, and how much to consume or save. More specifically, they choose $c_t, h_{t+1}, \tau_{t+1}, \lambda_{t+1}$. But as only households with more than one unit are landlords, then λ_{t+1} is given by h_{t+1}. So, $\lambda_{t+1}(i,a) = \sum h_{t+1}(i,a) - 1$ if $h_{t+1} > 0$ and 0 otherwise. Additionally, as all consumption happens in the last period and the first unit is always owner occupied, then with h_{t+1} and τ_{t+1} all decisions are characterized.

State variables — Let:

- $b(i,a)$ be the non-housing net wealth s.t. $i,a \to \mathbb{R}$.
- $h(i,a)$ be the housing wealth s.t. $i,a \to \tau_t$.
- $V^a(b,h)$ agents value function at age a.

$\implies V^a(b,h) = max_{(\tau',h)} c + u_h(\tau) + \beta V^{a+1}(b,h)$

Policy functions are $\tau'(i,x,a)$ and $h'(i,x,a)$ which map the type, age, and state of the economy, to the optimal decision. The law of motion for individual non-housing wealth is:

$b' = (1+r)(e_a(i)(1-1[\tau'=0]) + b - c - P(h'-h) + R(\lambda - \tau_r))$

Long-Term equilibrium — Regarding the housing market we can identify the following features:

- $\mathbb{P}_t = n(R_t, p_t)$ set of prices and rents.
- $b_t(i,a)$: gross savings.
- $h_t(i,a)$: housing allocations in age/type space:$[0,1] \times [1,2]$.
- $\tau_t(i,a)$: housing decisions.

$\implies$ Housing market clearing:

- $D_1^R(\mathbb{P}_t) + D_2^R(\mathbb{P}_t) + D_{out}^R(\mathbb{P}_t) 1\{R^y < R^o\} = S^R(\mathbb{P}_t)$
  Demand for rental (from age one and two) and the demand from outside option for rental (if binding) is equal to supply of rental.

- $S^R(\mathbb{P}_t) + D_1^O(\mathbb{P}_t) + D_2^O(\mathbb{P}_t) = S^o$
  Demand for ownership (from age one and two) plus supply of rentals must be equal to supply of owner housing.

Where $S^R(\mathbb{P}_t)$ is supply of rented units, $D_a^h(\mathbb{P}_t)$ is the demand of h tenure by agent of age a buying or renting in t. It is clear here that supply of owners is exogenous and fixed, while the supply of rental is endogenous.

Parameters conditions for a stable steady state — To ensure that credit constraints are binding for all agents (which implies that incentives for ownership are always present) and that the steady state equilibrium has a lifetime transition following a housing ladder (where old potential buyers outbid young ones), then the following conditions must apply:

1. $v_o > e(1)r/(1-\gamma)$: owner occupation is always worth the user cost of housing.
2. $uv_o > R$: renting is always worth the rental price.
3. $e_1(2-S^o) > e_1(1)r/(1-\gamma)$: becoming a landlord of a unit is profitable.

Now in order to make the steady state with a housing ladder structure we impose that:

4. $e_2(0) > e_1(2-S^o)$: Only young agents are priced out.
5. $e_1(1) < p(2-\gamma) - R$: Only old agents become landlords.
6. $e(1) > p(1-\gamma) + p(1+r) - R$: Some agents are able to own more than one unit
7. $e_2(1) < p(1-\gamma) + 2p - R$: Landlords cannot rent out two properties.

Steady state — In the steady state it is possible to state that the following price bonds exists:

- $R = e_1(2-S^o)$
- $P \geq e_1(2-S^o)(1-\gamma)^{-1}$

The intuition behind this is the following. If the market equilibrium rent was higher than $e_1(2-S^o)$, there would be a larger share than $2-S^o$ living in the parental home. If it was lower than $e_1(2-S^o)$, a larger share than $2-S^o$ would afford to rent. In any case, the rental market would not be in equilibrium.

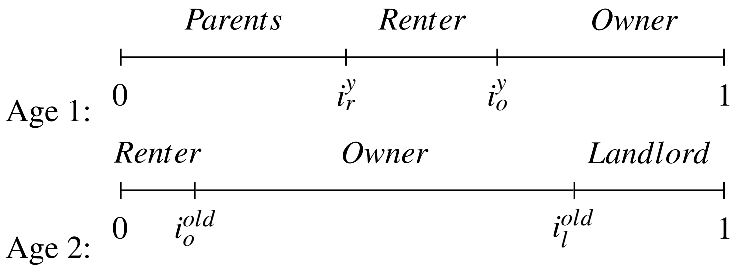
As for prices, if they were lower than $e_1(2-S^o)(1-\gamma)^{-1}$, then a mass larger than $2-S^o$ individuals would be able to own, and markets would not clear. A detailed proof is provided in Section H.

Allocations — We define thresholds in the type distribution of agents that determine the distribution of households across units:

- i_r^y, i_o^y: thresholds for which beyond these thresholds, young agents can afford to rent or own.
- i_r^{old}, i_l^{old}: thresholds for which beyond these thresholds, old agents can afford to own and to be landlords (own a unit and rent the other).

The value for each of the thresholds are derived in Section H, and they can be denoted in the following way:

Figure A12: Allocations for Steady State



The position of these thresholds depends entirely on the model parameters. However, it is possible, by using the assumptions and the price ordering such that $R(1-\gamma)^{-1} < P$, to prove that the steady state allocations will be similar to those shown by Figure A12, with the following relationships between thresholds:

- $i_r^y < i_o^y < 1 < i_l^y$
- $i_h^{old} < i_h^y \ \forall \ h = [R, O]$
- $i_r^{old} < 0 < i_o^{old} < i_l^{old}$
- $i_o^y < i_l^{old} < 1$

The proofs for this thresholds inequalities are shown in Section H. Then the housing market equilibrium conditions are[20]:

- $3 - i_o^{old} - i_o^y - i_l^{old} = S^o$.
  Which can be read as following: the demand from old households to own $(1-i_o^{old})$, plus the demand from young households to own $(1-i_o^y)$, plus the

[20] We can also use these thresholds to depict the demands for different types of housing: $D_1^R = i_o^y - i_r^y$; $D_2^R = i_o^{old}$; $S^R = 1 - i_l^{old}$; $D_1^O = 1 - i_o^y$; $D_2^O = 1 - i_o^{old}$.

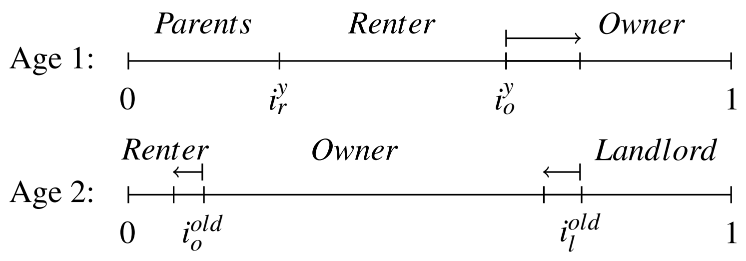
demand from landlords to own their owner-occupied unit ($1-i_l^{old}$), must be equal to the total supply of owner housing (S^o).

- $i_o^{old} + i_o^y - i_r^y = 1 - i_l^{old}$.
  Which can be read as following: the demand from old households to rent (i_o^{old}), plus the demand from young households to rent ($i_o^y - i_r^y$), must be equal to the total supply of rental housing ($1-i_l^{old}$).

Effect of a negative income shock on housing allocation and affordability This section analyzes the impact of a negative income shock on young individuals, depicted as a permanent decrease in ψ. I focus on two scenarios: one in which the rental market has downward flexibility, which means that the outside rental option plays no role, and the other with downward flexibility in the rental markets, which implies that the outside option functions as a price floor.

Proposition Case 1: Flexible rental markets — A lower ψ leads to a steady state in which fewer young households are *Owners*, more young households are *Renters*, and fewer old households are *Renters*. As for housing costs, rents fully capitalize the shock while prices only do so partially. This leads to worse (higher) average affordability for young *Owners*. The new steady state is shown in Figure A13.

Figure A13: Short term changes in allocations for a lower ψ. Proposition Case 1



Notes: This picture depicts the changes in the steady state caused by a drop in ψ, and the rental market is flexible (the outside option is non-binding). With lower incomes, young marginal owners households are forced to rent, while as rents adjust fully to the new income, the share living with parents remains the same.

Formal proof: See appendix H.

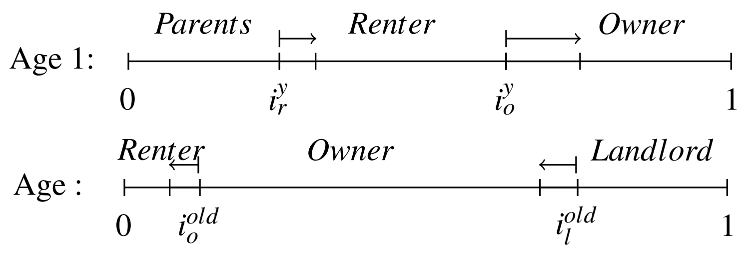
The intuition behind this new steady state is as follows. Rents adjust fully to the new income, as the young agents' income solely determines them; therefore, they fall in the same proportion as ψ. Prices, in contrast, do not absorb the shock fully as they also depend on the income of old agents. With rents adjusting to the new income, the marginal renter does not change, and neither does the share living with their parents. As prices fall less than the young agents' income, the previous marginal owner can no longer afford ownership, and now fewer young agents will be homeowners.

As for older agents, fewer of them live in rental units as they see rents fall, but their income is not affected by the shock. Therefore, there is an increase in the share of older agents living in owned units. The number of landlords will increase or decrease depending on whether the drop in demand from rental units from older agents is larger than the increase in demand for rental units from younger agents. The share of landlords adjusts so that the rental market is in equilibrium.

As for affordability, young renters see both rents and income fall in the same proportion, so the affordability ratio should not be affected. However, the new steady state implies more young individuals in rental units. These new renters are agents that would otherwise be homeowners had their income not fall. Therefore they are "wealthier" than the rest of the rental population. Their housing costs shifted from paying a down payment to a rental unit, a decrease that is larger than their reduction in income. Hence, these "wealthier" agents will have a lower affordability ratio, causing the average affordability for renters to fall.

Proposition Case 2: Rigid rental markets — A lower ψ leads to a steady state in which fewer young households are *Owners* and more households live with *Parents*, while fewer old households being *Renters*. This leads to higher average affordability for young *Owners*, and potentially also for *Renters*. Prices will partially capitalize the income shock, and rents will capitalize the shock depending on how binding the outside option is.

Figure A14: Short term changes in allocations for a lower ψ. Proposition Case 2



Notes: This picture depicts the changes in the steady state caused by a drop in ψ when the rental market is rigid (the outside option is binding). With lower incomes, young marginal owners are forced to rent. Additionally, as rents do not adjust, a larger share of young agents are forced to live with their parents.

Additionally, in the particular case when the outside option is fully binding (e.g., rents do not capitalize at all), the average affordability for young *Renters* will be higher than for young *Owners*. Also, it is possible to show that the share of *Landlords* increases. These shifts in the steady state are shown in Figure A14.

Formal proof: See appendix H.

The outside option now determines rents, so they will fall in proportion to how binding the outside option is. Prices will partially capitalize the shock, not falling as much as incomes. The marginal renter will now be determined by that individual whose income is equal to the outside option. As the outside option rent is higher than the market equilibrium rent, there will be more individuals living with their parents. Again, as prices drop less than the young agents' income, the previous marginal owner can no longer afford prices, and now fewer young agents will live with their parents.

As for older agents, fewer of them live in rental units as they see rents fall, but their income remains unchanged. This increases the share of older agents living in owned units. The share of agents becoming landlords will increase or decrease depending on whether the drop in demand of rental units from older agents is larger than the increase in the demand of rental units from younger agents. Those units previously rented by young agents are now rented to the outside option. The share of landlords adjusts so that the rental market is in equilibrium.

As for affordability ratios, young renters experience a drop in their income but not a proportional fall in rents. If the relative reduction in rents is lower than the relative reduction in prices, then the average affordability for renters will go up. As for owners, agents have a decrease in income but a smaller decrease in prices, which will push average affordability up.

When the outside option rent is equal to the initial steady state rent, then rents do not capitalize at all. The average affordability ratio for renters will increase, and it will be higher than that of homeowners. This is because prices adjust (although not entirely), while rents do not. There will also be more landlords as prices fall (which makes it cheaper to buy a unit) and rents remain the same, making it more attractive to become a landlord. The rental market is in equilibrium as there is also more demand for rental units coming from young agents.

Calibration — To study the transition period between steady states, I use a numerical analysis of the response of the features of the model that are of interest, namely, allocations for young individuals and affordability outcomes. The code is set to solve a recursive equilibrium as noted in appendix H.

In each period, N individuals are born in each cohort. Income and parameters satisfy conditions presented in the parameter conditions section, which leads to a steady state such as Figure A12. The shock of interest is an unexpected reduction in ψ in period 0. Prices and rents adjust as to ensure equilibrium in ownership and rental markets across the entire transition.

The set of parameters are provided in Table A5, and they follow closely those in Carozzi (2020). Housing stock S^o is equal to 1600, which implies that 400 individuals (40% of the young population) will be living with their parents. Income distributions are uniform in all periods. The initial value of ψ is 0.3, which means that old agents' income is three times as much as those of the younger individuals. This is broadly in line with data and ensures that older agents outbid young ones even with high levels of γ. I show the case of ψ dropping up to 0.2. Table A5 depicts all the values for the parameters in the transition analysis. I will study two types of scenarios following the propositions mentioned in the previous section. One in which the rental market is flexible and one in which rental market is fully rigid.

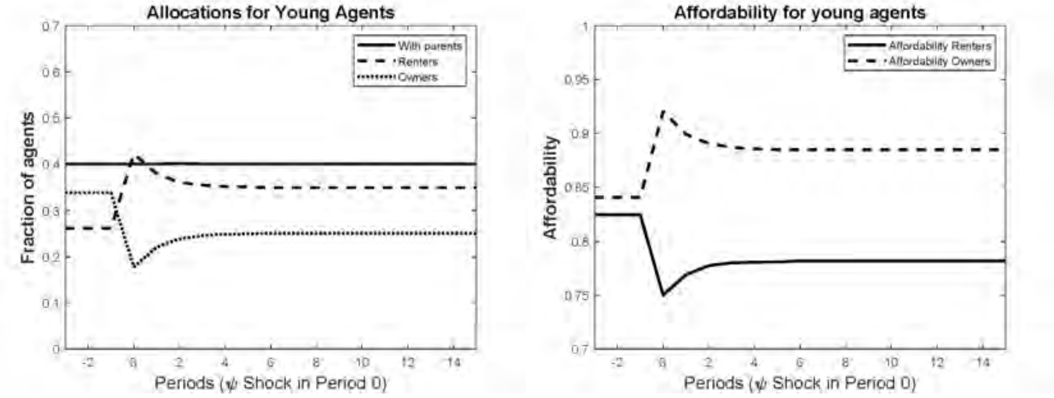
Table A5: Transition analysis: parameters values

Parameters	Value
Income Period 2,3	U(3,20)
ψ_i	0.3
ψ_f	0.2
v	400
μ	0.5
S^o	1600
r	0.01
γ	0.7

The transition towards a steady state with a lower ψ with a flexible rental market is depicted in Figure A15. The left graph shows the allocations for young individuals, and the right one depicts the affordability ratios for young individuals. In line with the model's predictions, the number of young agents living with their parents remains unchanged, while there is a trade-off between ownership and renting. The final state is reached within four periods in which markets are always in equilibrium. In the periods immediately after the shock, there is a spike in the share of renters (and a low point in ownership) as prices tend to adjust more slowly than individuals' incomes.

The graph on the right depicts the evolution of the affordability ratios. After reaching the new steady state, rental households have lower affordability ratios. As for owners, the average affordability ratio goes up as prices decrease less than young agents' income.

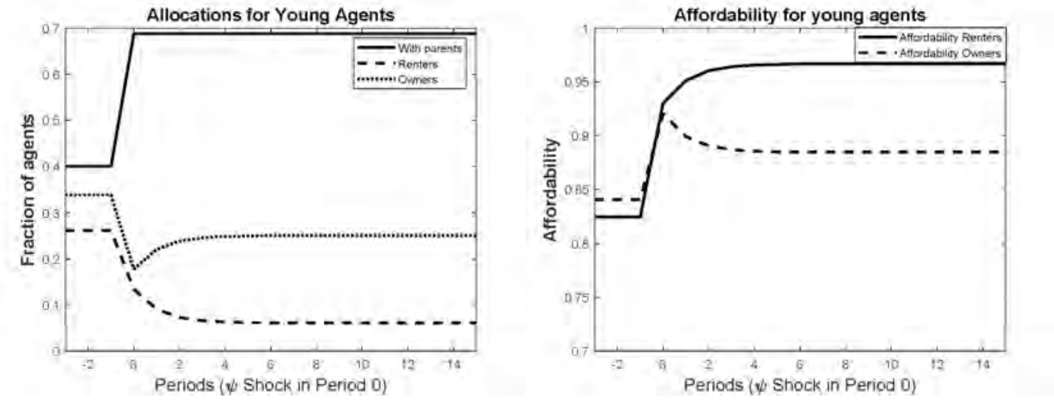
Figure A15: Transitions after an income shock on young individuals, with flexible rental markets.



(a) Young agents allocations **(b)** Young agents affordability

Notes: The left panel depicts the transition for the allocation of young individuals, while the right panel shows the transition for the average affordability ratio.

Figure A16: Transitions after an income shock on young individuals, with rigid rental markets.



(a) Young agents allocations **(b)** Young agents affordability

Notes: The left panel depicts the transition for the allocation of young individuals, while the right panel shows the transition for the average affordability ratio.

The transitions for the case in which rental markets are fully rigid are shown in Figure A16. The left graph shows the allocations for young individuals, while the right one shows the transition for the affordability ratios. In line with the model's predictions, the number of young agents living with their parents increases, while there is a decrease in the number of young agents living in rental units and owned units. The increase in the share of young individuals living with parents is linked to how binding the outside option is. The more inflexible the rents are, the more younger agents will be forced to live with their parents. The final equilibrium is reached within two periods for agents living with parents. However, it takes up to four periods for homeowners and renters as markets need to be in equilibrium.

As for the average affordability, it is possible to see that the ratio increases for renters and owners and, in line with the predictions, is larger for renters. The transition reaches its final steady state allocations and affordability in four periods. In period zero, the share of renters peaks (as the share of owners reaches its minimum) because prices do not adjust immediately (as to maintain equilibrium in the markets), making ownership unaffordable for a greater share of young agents.

These results, and more particularly those in which rental markets are rigid, are similar to those found in the empirical section of the paper.

H Theoretical framework proofs

In this sections I provide the different proofs and derivations required for the model. This sections is organized as follows:

1. Price Bonds and Rental Market
2. Thresholds
3. Proof Proposition Case 1
4. Proof Proposition Case 2
5. Recursive equilibrium form
6. Indirect utilities in the Steady State

Price bonds —

- $R = e_1(2 - S^o)$.
  Proof (by contradiction):
  - Assume that $R < e_1(2 - S^o)$, and considering that $uv_o > e(2 - S^o)$, then households that are not able to become homeowners would rent, so a mass larger that $2 - S^o$ would afford to rent in age 1 and 2. Which would create an excess demand, so $R \geq e_1(2 - S^o)$.

    Now assume that $R > e_1(2 - S^o)$ then a mass larger than $2 - S^o$ of young households would be homeless by the end of each period. So rental markets would not clear, then $R \leq e_1(2 - S^o)$.

    Then $R = e_1(2 - S^o)$.

Additionally:

- $P \geq e_1(2 - S^o)(1-\gamma)^{-1}$
  Proof (by contradiction):
  - Assume $P < e_1(2 - S^o)(1-\gamma)^{-1}$, which is equal to $P(1-\gamma) < e_1(2 - S^o)$. This implies that the mass of agents of age 1 that can buy a unit is $m_o^1 > 1-(2-S^o)$, but as older agents outbuy younger agents ($e_2(0) > e_1(2-S^o)$), then $m_o^2 = 1$. This implies that $m_o = m_o^1 + m_o^2 > S^o - 1 + 1 = S^o$. So more can afford to own than the actual supply. Then, it must be the case that $P \geq e_1(2-S^o)(1-\gamma)^{-1}$.

Rental markets exist as long as the following conditions are met. First, that there are incentives to rent, that is, $R > rp$. Second, at least some agents can own when young and then buy another unit when old, which is ensured by condition 6. Third, that the rental equilibrium price is $R = e_1(2-S^o)$. Fourth, that becoming a landlord is profitable, which condition 3 guarantees.

Thresholds — We can define the thresholds in the following way:

The thresholds for young agents are:

- $i_r^y = e_1^{-1}(R)$
- $i_o^y = e_1^{-1}(p(1-\gamma))$
- $i_l^y = e_1^{-1}(p(1-\gamma)+p-R)$

The thresholds for old agents are:

- $i_r^{old} = e^{-1}(R)$
- $i_o^{old} = e^{-1}(p(1-\gamma))$
- $i_l^{old} = e^{-1}(p(1-\gamma)+(1+r)p-R)$

As mentioned earlier, we can prove that the allocation can be depicted as in Figure A12, by showing that:

- $i_r^y < i_o^y < 1 < i_l^y$
- $i_r^{old} < 0 < i_o^{old} < i_l^{old}$
- $i_h^{old} < i_h^y \; \forall \; h = [R, O]$
- $i_o^y < i_l^{old} < 1$

Proof: $i_r^y < i_o^y < 1 < i_L^y$
The first inequality, $i_r^y < i_o^y$, follows from the price ordering $R < (1-\gamma)p$. Additionally, $i_o^y < i_l^y$ is true as $e_a(i)$ is increasing and continuous in i. Finally, $1 < i_l^y$ is ensured by condition 5.

Proof: $i_r^{old} < 0 < i_o^{old} < i_l^{old}$
The first inequality, $i_r^{old} < 0$, is ensured by the price bond $R = e_1(2-S^o)$ and condition 4. This means that old agents can always afford to rent.

Using that $e_a(i)$ is increasing and continuous in i, we know that $e(i)$ will also be increasing and continuous in i. Taken together with the price ordering $R < (1-\gamma)p$, it implies that $i_r^{old} < i_o^{old} < i_l^{old}$.

Proof: $i_h^{old} < i_h^y \; \forall \; h = [R, O]$
To prove that $i_r^{old} < i_r^y$, we use the previous proof that shows $i_r^{old} < 0$. Additionally, we know that $i_r^y > 0$, as otherwise there will be no agents living with their parents (which is ensured by $S^o < 2$). Therefore $i_r^{old} < i_r^y$.

For $i_o^{old} < i_o^y$, we use that the fact we allow marginal old owners to live with their parents when young. This allows us to rewrite i_o^{old} as $i_o^{old} = e_2^{-1}(p(1-\gamma))$. Additionally, as $e_1(i) < e_2(i) \; \forall \; i$, then $e_2^{-1}(i) < e_1^{-1}(i)$. This means that $e_2^{-1}(p(1-\gamma)) < e_1^{-1}(p(1-\gamma))$, proving that $i_o^{old} < i_o^y$.

Proof: $i_o^y < i_l^{old} < 1$
The statement $i_l^{old} < 1$ follows from the existence of rental markets, proven in determining the price bonds.

The inequality $i_o^y < i_l^o$ is the only that ensures that housing markets work. If $i_o^y > i_l^o$ it means that either marginal landlords were renting when young or that landlords are renting more than one property at the same time. The latter is ruled out by condition 7.

If landlords were renting when young this would mean that $i_l^{old} = e^{-1}(R(1+r) + p + p(1-\gamma) - R)$. However, as we know that $i_o^y = e_1^{-1}(p(1-\gamma))$, then $i_o^y > i_l^o$ which implies that $R(1+r) + p + p(1-\gamma) - R < p(1-\gamma)$, which can not hold. Therefore $i_o^y < i_l^o$, which means that landlords were owners when young.

Proof Proposition Case 1: Flexible rental markets — The case with a non-binding outside option can be characterized as $R_f > R^o$, with R_f being the equilibrium rent after the income shock. That is, the rent in the new steady state is still larger than the outside option rent.

As a general tool for the proofs, first let us define $g_a(x) = \dfrac{\partial e_a^{-1}(x)}{\partial x}$ and $g(x) = \dfrac{\partial e^{-1}(x)}{\partial x}$, with both functions being positive. Additionally as $e_1(i) = \psi e_2(i)$ we can write $e_1^{-1}(i) = e_2^{-1}(\dfrac{1}{\psi} i)$.

A. To prove the changes in housing tenure we need to derive the thresholds for housing allocation:

1. First the thresholds determining the agents living with parents i_r^y,

$$\frac{\partial i_r^y}{\partial \psi} = \frac{\partial e_1^{-1}(R)}{\partial \psi} = \frac{\partial e_2^{-1}(\frac{1}{\psi} R)}{\partial \psi}$$

Which gives:

$$\frac{\partial e_1^{-1}(R)}{\partial \psi} = g_2\left(\frac{1}{\psi}R\right)\left[\frac{-R}{\psi^2} + \frac{\partial R}{\partial \psi}\right]$$

As in equilibrium and with the outside option non binding $R = e_1(2 - S^o) = \psi e_2(2 - S^o)$, then:

$$\frac{\partial e_1^{-1}(R)}{\partial \psi} = g_2\left(\frac{1}{\psi}R\right)\left[\frac{-\psi e_2(2 - S^o)}{\psi^2} + \frac{e_2(2 - S^o)}{\psi}\right]$$

Which means that $\frac{\partial i_r^y}{\partial \psi} = 0$. Then, there are the same share of young individuals living with their parents.

2. The second threshold determines the share of old agents living as homeowners i_o^{old}:

$$\frac{\partial i_o^{old}}{\partial \psi} = \frac{\partial e^{-1}(p(1-\gamma))}{\partial \psi}$$

Which gives:

$$\frac{\partial i_o^{old}}{\partial \psi} = g(p(1-\gamma))\left[\frac{\partial p}{\partial \psi}(1-\gamma)\right]$$

As we know that $g(.)$ is always positive, and assuming that $\frac{\partial p}{\partial \psi} > 0$, then: $\frac{\partial i_o^{old}}{\partial \psi} > 0$. This implies that there are fewer old agents living in rental units.

3. The third threshold determines the share of young agents living as homeowners i_o^y. Given the threshold's value:

$$\frac{\partial i_o^y}{\partial \psi} = \frac{\partial e_1^{-1}(p(1-\gamma))}{\partial \psi}$$

It can be rewritten as:

$$\frac{\partial e_2^{-1}(\frac{1}{\psi}p(1-\gamma))}{\partial \psi} = g_2\left(\frac{1}{\psi}p(1-\gamma)\right)\left[\frac{-p}{\psi^2} + \frac{\partial p}{\partial \psi}\frac{1}{\psi}\right](1-\gamma)$$

In order to prove that $\frac{\partial p}{\partial \psi} < \frac{p}{\psi}$ we will proceed by contradiction, and show that any other option does not allow for market equilibrium. For that, assume $\frac{\partial p}{\partial \psi} \geq \frac{p}{\psi}$, which implies that $\frac{\partial i_o^y}{\partial \psi} \geq 0$. Additionally:

$$\frac{\partial i_l^{old}}{\partial \psi} = \frac{\partial e^{-1}(p(1-\gamma)+(1+r)p-R)}{\partial \psi}$$

Which gives:

$$\frac{\partial i_l^{old}}{\partial \psi} = g(p(1-\gamma)+(1+r)p-R)\left[\frac{\partial p}{\partial \psi}(1-\gamma)+\frac{\partial p}{\partial \psi}(1-r)-\frac{\partial R}{\partial \psi}\right]$$

As $\frac{\partial p}{\partial \psi} \geq \frac{p}{\psi}$ then:

$$\left[\frac{\partial p}{\partial \psi}(1-\gamma)+\frac{\partial p}{\partial \psi}(1-r)-\frac{\partial R}{\partial \psi}\right] \geq \left[\frac{p}{\psi}(1-\gamma)+\frac{p}{\psi}(1-r)-\frac{\partial R}{\partial \psi}\right]$$

As we know that $P \geq \psi e_2(2-S^o)(1-\gamma)^{-1}$ and that $R = \psi e_2(2-S^o)$, then:

$$\left[\frac{p}{\psi}(1-\gamma)+\frac{p}{\psi}(1-r)-\frac{\partial R}{\partial \psi}\right] \geq$$
$$e_2(2-S^o)+e_2(2-S^o)(1+r)(1-\gamma)^{-1}-e_2(2-S^o) > 0$$

Which implies that $\frac{\partial i_l^{old}}{\partial \psi} > 0$.

If we consider that the market equilibrium condition must still apply, we can write $3-i_o^{old}-i_o^y-i_l^{old} = S^o$, which implies $-\frac{\partial i_o^{old}}{\partial \psi}-\frac{\partial i_o^y}{\partial \psi}-\frac{\partial i_l^{old}}{\partial \psi} = 0$

Now if we take these results and add the market clearing conditions:

- $\frac{\partial i_o^{old}}{\partial \psi} > 0$
- $\frac{\partial i_o^y}{\partial \psi} \geq 0$
- $\frac{\partial i_l^{old}}{\partial \psi} > 0$
- $-\frac{\partial i_o^{old}}{\partial \psi}-\frac{\partial i_o^y}{\partial \psi}-\frac{\partial i_l^{old}}{\partial \psi} = 0$

They cannot be simultaneously true, therefore $\frac{\partial p}{\partial \psi} < \frac{p}{\psi}$, which implies that $\frac{\partial i_o^y}{\partial \psi} < 0$. This means fewer young agents in owned units. This leaves the sign of $\frac{\partial i_l^{old}}{\partial \psi}$ undetermined.

4. Finally, we can derive the effect of the rental market equilibrium, $i_o^y + i_o^{old} + i_r^y = 1 - i_l^{old}$, with respect to ψ:

$$\frac{\partial i_o^y + i_o^{old} + i_r^y}{\psi} = \frac{\partial 1 - i_l^{old}}{\partial \psi}$$

As we know that $\frac{\partial i_o^y}{\partial \psi} < 0$, $\frac{\partial i_o^{old}}{\partial \psi} > 0$, and $\frac{\partial i_r^y}{\partial \psi} = 0$, the sign of $\frac{\partial 1 - i_l^{old}}{\partial \psi}$ will depend on which effect dominates, whether the increase in rental demand from young agents or the reduction in rental demand from older agents.

B. The second part of the proposition refers to the affordability ratios. First let us define ψ_i, R_i and p_i as the equilibrium parameter values before the shock, and in the same way ψ_f, R_f and p_f as the equilibrium parameters after the shock. To prove the changes in affordability ratios we need to prove that:

$$\frac{\psi_f}{\psi_i} = \frac{R_f}{R_i} < \frac{P_f}{P_i}$$

These inequalities imply that while rents will change in the same proportion as ψ, prices will change proportionally less than ψ.

The first part implies that the ψ-elasticity of R is equal to one, which can be proved as:

$$\varepsilon_{R,\psi} = \frac{\partial R}{\partial \psi} \times \frac{\psi}{R} = \frac{\partial(\psi e_2(2 - S^o))}{\partial \psi} \times \frac{\psi}{\psi e_2(2 - S^o)} = 1$$

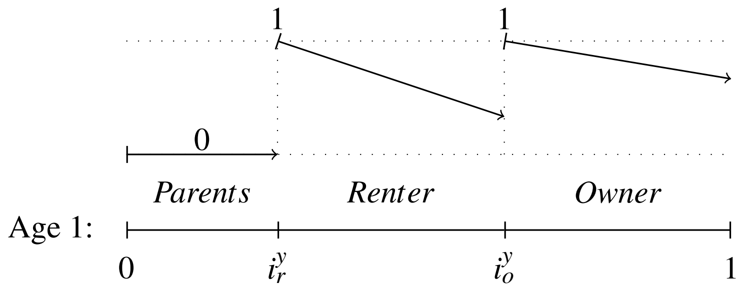
This is in line with previous results, as it implies that rents fully capitalize the shock, and respond one-to-one to changes in ψ.

The second inequality implies that prices do not fully adjust to a shock in ψ. This is equivalent to say that the ψ-elasticity of p is lower than one. Using that $\frac{\partial p}{\partial \psi} < \frac{p}{\psi}$ we get that:

$$\varepsilon_{p,\psi} = \frac{\partial p}{\partial \psi}\frac{\psi}{p} < \frac{p}{\psi}\frac{\psi}{p} = 1$$

The intuition behind this result is that rents fully capitalize the income shock, as they are determined solely by young agents' income. On the contrary, prices do not as they are also determined by older agents' income (which are unaffected by the income shock). Therefore, prices fall less than rents.

The affordability ratios in the steady state for young agents can be illustrated in the following way:



As mentioned before, affordability refers to the ratio between what agents pay for their housing tenure and their income. Now the average affordability for young renters (owners), will be the average between the marginal renter (owner) affordability and the wealthiest renter (owner) affordability.

Define φ_i^{yr} and φ_f^{yr} as the initial and final average affordability of renters, which can be calculated as the average between the marginal renter and the wealthiest renter affordability:[21]

$$\varphi_i^{yr} = \frac{\frac{R_i}{e_{i1}(i_r^y)} + \frac{R_i}{e_{i1}(p_i(1-\gamma))}}{2} = \frac{1}{2} + \frac{R_i}{2p_i(1-\gamma)}$$
$$\varphi_f^{yr} = \frac{1}{2} + \frac{R_f}{2p_f(1-\gamma)}$$

The ratio has two parts. The first one refers to the marginal renter located in i_r^y that will spend all of her income on renting and therefore has an affordability ratio equal to one. The second one is the "wealthiest" renter, which is just below the marginal owner. She will have an income approximately equal to the marginal owner, but will pay only R for housing. The average affordability for renters after the income shock is calculated analogously, but using the final rents and prices. Now it can be proved that:

$$\varphi_i^{yr} > \varphi_f^{yr} \iff \frac{1}{2} + \frac{R_i}{2p_i(1-\gamma)} > \frac{1}{2} + \frac{R_f}{2p_f(1-\gamma)} \iff \frac{p_f}{p_i} > \frac{R_f}{R_i}$$

With the last inequality being proved before.

In a similar way, it is possible to derive the changes in average affordability for

[21]The wealthiest renter will be the agent that can just not afford to own. As the income distribution is continuous we can assume that the income of the wealthiest renter will be approximately equal to that of the marginal owner ($e_1(p(1-\gamma))$).

young homeowners:

$$\varphi_i^{yo} = \frac{\frac{p_i(1-\gamma)}{e_{i1}(i_o^y)} + \frac{p_i(1-\gamma)}{e_{i1}(1)}}{2} = \frac{1}{2} + \frac{p_i(1-\gamma)}{2e_{i1}(1)}$$
$$\varphi_f^{yo} = \frac{1}{2} + \frac{p_f(1-\gamma)}{2e_{f1}(1)}$$

In a similar way to renters, the average affordability is the average between the marginal and the "wealthiest" owner affordability. While the first spends all of her income on the down payment and therefore has an affordability ratio equal to one, the latter has an income equal to $e_1(1)$, which means that has more income disposable income after paying for housing. Now, to prove that affordability ratios increases after the shock, we need to prove that:

$$\varphi_i^{yo} < \varphi_f^{yo} \iff \frac{1}{2} + \frac{p_i(1-\gamma)}{2e_{i1}(1)} < \frac{1}{2} + \frac{p_f(1-\gamma)}{2e_{f1}(1)} \iff \frac{p_f(1-\gamma)}{p_i(1-\gamma)} > \frac{e_{f1}(1)}{e_{i1}(1)}$$

With the last term $\frac{e_{f1}(1)}{e_{i1}(1)}$ being equal to $\frac{\psi_f}{\psi_i}$, which confirms the last inequality as $\frac{p_f}{p_i} > \frac{\psi_f}{\psi_i}$ has already been proved.

Proof Proposition Case 2: Rigid rental markets — The case for a binding outside option can be characterized as one in which $R_f < R^o$. That is, the rent from the final steady state is lower than the outside option rent.

A. The proof of the case when the outside option is binding is very similar to the previous case. In fact the proof for the effect on i_o^y, i_o^{old} and i_l^{old} are the same.

As for the changes in the share of agents living with their parents i_r^y:

$$\frac{\partial i_r^y}{\partial \psi} = \frac{\partial e_1^{-1}(R)}{\partial \psi} = \frac{\partial e_2^{-1}(\frac{1}{\psi}R)}{\partial \psi}$$

Which gives:

$$\frac{\partial e_1^{-1}(R)}{\partial \psi} = g_2\left(\frac{1}{\psi}R\right)\left[\frac{-R}{\psi^2} + \frac{\partial R}{\partial \psi}\right]$$

With the outside option binding $R = R^o$ (with R^o exogenous), then $\dfrac{\partial R^o}{\partial \psi} = 0$ and:

$$\frac{\partial e_1^{-1}(R)}{\partial \psi} = g_2\left(\frac{1}{\psi}R\right)\left[\frac{-R^o}{\psi^2}\right]$$

Which means that $\dfrac{\partial i_r^y}{\partial \psi} < 0$. Then, there are more young individuals living with their parents.

B. Now it is possible to prove that with the outside option binding, in contrast to the case with flexible rental markets, the average affordability for renters can increase. As in the previous scenario, the average affordability for renters before and after the shock is:

$$\varphi_i^{yr} = \frac{1}{2} + \frac{R_i}{2p_i(1-\gamma)}$$
$$\varphi_f^{yr} = \frac{1}{2} + \frac{R^o}{2p_f(1-\gamma)}$$

So therefore:

$$\varphi_i^{yr} < \varphi_f^{yr} \iff \frac{1}{2} + \frac{r_i}{2p_i(1-\gamma)} < \frac{1}{2} + \frac{R^o}{2p_f(1-\gamma)} \iff \frac{R^o}{R_i} > \frac{p_f}{p_i}$$

The average affordability ratio will increase as long as rents absorb less of the shock than prices. In the particular case for $R^o = R_i$ we will have that:

$$\varphi_i^{yr} < \varphi_f^{yr} \iff 1 > \frac{p_f}{p_i}$$

The intuition behind this result is that young renters will have lower income, but as rents do not adjust, it will increase the affordability ratio for those already renting.

Additionally, for the case in which the outside option is fully binding, we can prove that after the shock, the average affordability for renters will be higher than that of owners:

$$\varphi_f^{yr} > \varphi_f^{yo} \iff \frac{1}{2} + \frac{R^o}{2p_f(1-\gamma)} > \frac{1}{2} + \frac{p_f(1-\gamma)}{2e_{f1}(1)} \iff \frac{R^o}{p_f(1-\gamma)} > \frac{p_f(1-\gamma)}{e_{f1}(1)}$$

As we have shown before, even when the outside option is binding, rents and prices must comply with $R < p(1-\gamma)$, which allows us to say that:

$$\frac{R^o}{p_f(1-\gamma)} > \frac{p_f(1-\gamma)}{e_{f1}(1)} > \frac{R^o}{e_{f1}(1)} \iff \frac{e_{f1}(1)}{p_f(1-\gamma)} > 1$$

Whose last part we know to be true as the wealthiest young household must be able to afford a down payment for a unit.

Recursive equilibrium — The recursive equilibrium is composed by: a set of decisions rules for housing purchases, tenure choice and becoming landlord, value functions, price functions mapping the state of the economy to the real line, a set of states of the economy, and a law of motion for the state of the economy. The conditions for a recursive equilibrium are the following:

State variables — The state of the economy at the beginning of the period is given by:

$$x = (h(i,2), h(i,3), b(i,2), b(i,3))$$
$$\text{with } h(i,a) : [0,1] \to N^+ \text{ and } b(i,a) : [0,1] \to R$$

in which $h(i,2)$ and $h(i,3)$ map agents types to their owned units at age 2 and 3. Analogously, $b(i,2)$ and $b(i,3)$ map the non-housing wealth of agents i at age 2 and 3.

Choice variables — In each period, individuals decide for $a = [1,2]$: housing assets $h'(i,x,a)$, non housing assets $b'(i,x,a)$, tenure choice $\tau'(i,x,a)$ and the decision to become a landlord $\gamma'(i,x,a)$.

Constraints — Three constraints fall into agents decisions: budget, credit and housing tenure constraints.

Budget constraints (law of motion of non-housing assets) for $a = 1,2$:

$$\begin{aligned}&b'(i,b,h,h',x,a) = \\ &(1+r)(e_a(i)(1-1\{\tau'(i,a)=0\}) + b(i,a) - c - p(h'(i,x,a) - h(i,a) + \\ &R(\lambda'(i,x,a) - \tau'_R(i,x,a))))\end{aligned}$$

Credit constraints, as to ensure mortgage on one unit only for $a = 1,2$:

$$\Gamma(i,b,h,h',x,a) = \{h' \in N^2 : e_a(i) + b + Ph(i,x,a) \geq \gamma P(x) 1\{h' > 0\}\}$$

Tenure constraints, as to ensure that owner occupation can only be done if being an owner in age $a = 1,2$:

$$\tau'(i,x,a) \in \{0,1\} \text{ if } h'(i,x,a) \geq 1$$
$$\tau'(i,x,a) = 0 \text{ if } h'(i,x,a) = 0$$

Value functions and decisions rules — The policy functions are: f_h for housing assets, f_τ for housing tenure and f_λ for becoming a landlord. Non-housing functions follow the law of motion of wealth previously discussed.

Housing Assets

$$f_h(i,x,1) \text{ solves } v_1(i,x) = \max_{h' \in \Gamma(i,0,0,h',1)} v_2(i, b'(i,0,0,h',1), h', x')$$

$$f_h(i,x,2) \text{ solves } v_2(i,x) = \max_{h' \in \Gamma(i,b,h,h',x,2)} u_h(\tau(i,2) + \beta v_3(i, b'(i,b,h,h',2), h', x')$$

$$f_h(i,x,3) \text{ solves } v_3(i,x) = \max_{h' \in \Gamma(i,b,h,h',x,3)} u_h(\tau(i,3) + b + P(h-h') - b'(i,b,h,h',x')$$

Becoming a Landlord

$$\lambda(i,x,a) = \begin{cases} h'(i,x,a) - \tau'(i,x,a) \text{ if } R(x) \geq 0 \\ 0 \text{ otherwise} \end{cases}$$

Housing tenure

For values of v_o that are large enough:

$$\tau(i,h,a) = \begin{cases} (0,1) \text{ if } h(i,x,a) \geq 1 \\ (1,0) \text{ if } b + e_a(i) > R(x) \ \& \ h(i,x,a) = 0 \end{cases}$$

Housing Market Clearing Conditions

$$\int h'(i,x,2) + h'(i,x,3) \; di = S^o$$
$$\int \lambda'(i,x,2) + \lambda'(i,x,3) \; di = \int \tau_R'(i,x,2) + \tau_R'(i,x,3) \; di$$

Law of Motion

The law of motion is given by:

$$
\begin{aligned}
b(i,2) &= b'(i,0,0,f_h(i,x,1),1) \\
b(i,3) &= b'(i,b(i,2),h(i,2),f_h(i,x,2),1) \\
h(i,2) &= f_h(i,x,1) \\
h(i,3) &= f_h(i,x,2)
\end{aligned}
$$

Indirect utilities in the steady state — Assuming that $\beta(1+r) \geq 1$, we can assume that consumption by agents takes place at age 3. In steady state the prices that they face are the same along their life periods.

The indirect utilities for each path of lifetime tenure choices are:

$$
\begin{aligned}
V^{P,P} &= \beta^2[e_3(i)] \\
V^{P,R} &= \beta^2[e_2(i)(1+r)+e_3(i)-(1+r)R]+\beta^2\mu v_o \\
V^{R,R} &= \beta^2[e(i)(1+r)+e_3(i)-R((1+r)+(1+r)^2)]+\beta^2\mu v_o+\beta\mu v_o \\
V^{R,O} &= \beta^2[e(i)(1+r)+e_3(i)-R(1+r)^2-rp]+\beta^2 v_o+\beta\mu v_o \\
V^{O,O} &= \beta^2[e(i)(1+r)+e_3(i)-(r^2+2r)p]+\beta^2 v_o+\beta v_o \\
V^{O,L} &= \beta^2[e(i)(1+r)+e_3(i)-(r^2+2r)p+(1+r)R]+\beta^2 v_o+\beta v_o
\end{aligned}
$$

In the steady state, housing prices p have to be smaller than $e(1)/(1-\gamma)$, to ensure that at least the richest young agent can afford to buy. Then by using the assumption that $v_o > e(1)r/(1-\gamma)$, we can say that owner occupation is always worth the cost. As rents are pinned by income, then $R = e_1(2-S^o)$, if rental market exists. Then, using assumptions $v_o > e(1)r/(1-\gamma)$ and $uv_o > R$ (previously mentioned), the prices bonds, and the expressions for indirect utilities imply that:

$$
V^{O,L} > V^{O,O} > V^{R,O} > V^{R,R} > V^{P,R} > V^{P,P}
$$

4 Business as usual? The dynamics of land development around flood spaces[1]

4.1 Introduction

Floods are rare events, usually violent, often leading to material losses, injuries, and even deaths. The United Nations considers floods as the most costly natural disaster (United Nations, 2020). In Spain, they have killed more than heat waves and wildfires combined between 1995 and 2015[2]. It is estimated that they cost an average of 800 million euros to the Spanish economy every year and are related to almost half of insurance compensation requests since 1971[3].

Floods occur near water bodies, which are historically valued both for their amenities and intrinsic economic potential. In Spain, the vast majority of building development occurs right outside flood zones. Flood zones are defined as spaces with a probability equal to or higher than one in 500 of being flooded per year. The trade-off between apparent risks and water accessibility has lead individuals to cluster as close as possible to these zones. One building out of ten is located within the first 100-meter fringe outside a flood zone, potentially exposing a large share of development. A simple location decision model predicts that forward-looking individuals would develop less or farther away from these zones after a flood as their expected risks increase.

While the literature has primarily documented migration patterns in the aftermath of natural disasters (Boustan et al., 2012; Hornbeck, 2012; Mueller et al., 2014), it is unclear how natural disasters permanently affect local development activity. For instance, Davis and Weinstein (2002) have highlighted path dependence patterns

[1] This chapter is coauthored with Pierre Magontier.

[2] Spanish Ministry of Interior – Civil Protection and Emergencies http://www.interior.gob.es/web/archivos-y-documentacion/proteccion-civil-y-emergencias.

[3] Spanish Ministry of Ecology – Water Department https://www.miteco.gob.es/es/agua/temas/gestion-de-los-riesgos-de-inundacion/.

when cities are confronted with extensive destruction. Also, Hornbeck and Keniston (2017) documented how the Great Boston Fire led to land value appreciation. Gallagher and Hartley (2017), however, show that after hurricane Katrina, households used their flood insurance to pay back their mortgage and left, rather than rebuilt. Because homes are quickly built but disappear slowly (as shown by Glaeser and Gyourko (2005)), and as the world experiences climate change, understanding how real estate markets react to extreme climate events is of paramount importance.

In this paper, we study the dynamics of land development in Spanish municipalities that experienced a flood. We want to know how new development is affected by a flood, whether it takes place farther away from flood zones or on higher ground, and the duration of these effects over time. Also, we examine how these outcomes vary with housing supply elasticity, which we proxy with past development. Finally, we study the impact of floods on several other economic indicators, including employment and migration patterns.

Our primary dataset includes the universe of buildings in Spain as provided by the Land Register Administration. That is, approximately 12 million georeferenced units[4]. We combine this information with a digitized dataset of all floodplains for Spain. This allows identifying buildings' locations with respect to flood zones. Additionally, we extract detailed terrain elevation data from satellite images. Finally, we gather nearly 778 historical flood records identified at the municipal level between 1978 and 2010. We complete our analysis with socio-economic covariates gathered at the municipality level.

We use an event study framework to investigate the effect of historical floods on these development decisions. For that purpose, we study new development changes in surface, distance to flood zones, and elevation compared to the year before a flood event to capture the development response. We perform this analysis both at the municipal level and considering different fringes outside the floodplain. We are primarily interested in the spaces right outside flood zones. These spaces are historically identified as at-risk, and concentrate a large share of development. Our empirical strategy relies on the assumption that conditional on municipality and year fixed effects, the timing and the extent of a flood is as good as random. The unanticipated shock of a flood allows us to conduct a difference-in-differences analysis around a flood event for each municipality. Our main results indicate that experiencing a flood does not affect new development on average. Development takes place at a similar pace to that before the flood. Additionally, new construction does not change its proximity to water nor its elevation after a flood. When analyzing development's final use, we find that residential buildings are being built at the same

[4]Excluding the Basque Country and Navarre, who have an independent land register.

rate as before the flood. A flood event does not have a significant effect on key economic variables such as unemployment or migration.

We propose that, when a flood hits a community when housing supply is inelastic, prices absorb the demand shock, encouraging developers to overbuild á la Grenadier (1996). However, when a flood hits an expanding community, where housing supply is elastic, quantities absorb the effect while prices remain unchanged.

A heterogeneous analysis by the level of development before the flood shows that there are significant differences. Municipalities having experienced low development levels in the decade before the flood experience a housing boom after the flood. New development increases permanently by 25% compared to the year previous to the event for these cities. This surge in construction is mainly driven by residential and industrial development and is followed by a fall in transaction prices. On the contrary, cities having experienced a development boom before the flood experience a 27% permanent drop in new construction compared to before the flood. Residential development drives this reduction in new construction, but transaction prices remain stable. New construction does not take place farther away from flood zones or on higher ground in both cases. In fact, it increases above pre-treatment levels in the fringes surrounding floodplains after 8 to 10 years in declining cities.

Finally, we show that even in the absence of floods, risk signaling can lead to local housing booms. To do so, we focus on an EU directive mandating EU-member states to identify flood-prone areas, named ARPSIs. In the Spanish case, this directive identified areas that were not previously considered dangerous. Still, it was not accompanied by any regulation designed to restrict future development. We compare areas that were newly declared as potentially dangerous to areas close to water bodies but were not affected by the directive. We show that the flood-prone areas signaled by the policy developed at a higher rate than those that were not flagged. While this latter result can be explained by the developer's fear of future restrictions, it could also be the unintended consequences of a demand shock. It is thus another example of overdevelopment in areas at risk of floods.

Overall, this paper contributes to several strands of the new climate-economy literature, and particularly on how urban development is affected by the consequences of climate change[5]. Many studies have shown the impact of natural disasters on economic activity. Climate-driven variations in income are well-documented (Barrios et al., 2010; Dell et al., 2009, 2012; Hsiang, 2010; Hsiang and Narita, 2012; Lobell et al., 2011; Nordhaus, 2006, 2010). A large share of the literature has argued those earnings windfalls fostered out-migration as an adaptation strategy (Munshi, 2003; Feng et al., 2010, 2012; Boustan et al., 2012; Hornbeck, 2012; Hornbeck and

[5]For an extensive literature review, see Dell et al. (2014).

Naidu, 2014; Desmet et al., 2018; Boustan et al., 2020). Albeit migration responses are not the primary outcome of this paper, it certainly contributes to illustrating the research on settlement choices in the aftermath of a disaster.

To our knowledge, only a few papers specifically study the impact of natural disasters on urban development. In particular, Kocornik-Mina et al. (2020) use nightlight data to study development reallocation in the aftermath of massive floods. They find that new construction does not take place farther away from the flooded areas. Additionally, Elliott et al. (2015) use nightlight data to study the impact of typhoons on economic wealth in coastal China. They show that destructive typhoons have a strong but short-lived effect. A few papers focus on specific cases, such as hurricane Katrina (Gallagher and Hartley, 2017; Deryugina et al., 2018) or other historically destructive events (e.g., Hornbeck and Naidu (2014)). One possible reason for this lack of global evidence on urban development is that natural disasters are low-frequency events with very local consequences. This implies that in the absence of granular data, their impact could be missed (Strobl, 2011; Bouwer, 2011). First, we contribute to this literature by collecting and using an extensive historical database of flood events in Spain. Consequently, our results do not build on specifically selected billion-dollar or deadly disasters. This mitigates potential issues related to external validity. Second, combined with the universe of buildings provided by the Land Register Administration, it means that we can study the impact of the flood several years after the shock. Finally, highly disaggregated administrative data allow us to show the role of housing supply elasticity on development dynamics following the flood.

This work also contributes to the literature on housing supply and development regulations (e.g., Grenadier (1996); Wheaton (1999)). Notably, Glaeser and Gyourko (2005) discuss how the durable nature of real estate investment influences real market reactions to negative demand shocks. Saks (2008) shows that places with an unconstrained housing supply experience more residential construction and smaller increases in house prices when a positive demand shock occurs. Hilber and Vermeulen (2016) show that constrained housing supply has a significant positive impact on the price-earnings elasticity. Closer to the environmental literature, many papers have studied how housing prices respond to increased risk perception of natural disasters (Bernstein et al., 2019; Barrage and Furst, 2019; Singh, 2019; Bosker et al., 2019; Bernstein et al., 2020; Baldauf et al., 2020; Murfin and Spiegel, 2020; Coulomb and Zylberberg, 2021). Here, we contribute by focusing on how natural disasters may have a differentiated impact on new development depending on the characteristics of the housing supply previous to the disaster.

Finally, this paper contributes to the broader discussion of optimal policies to mitigate urban development exposure to natural disasters as in Kahn and Walsh

(2015) and Kocornik-Mina et al. (2020). This is important as more frequent and more intense extreme climate events are expected in the near future. Our results show that signaling areas as potentially high-risk do not deter development from happening near such areas.

The paper is organized as follows: Section 4.2 describes historical floods and development allocation in Spain; Section 4.3 discusses the potential relationship between real estate market cycles and flood; Section 4.4 describes the primary datasets; Section 4.5 outlines the empirical strategy; Section 4.6 presents the results of the main specification and the policy analysis; and, finally, Section 4.7 offers some concluding remarks.

4.2 Flood Zones in Spain

Spatial concentration — Flood zones, or floodplains, are defined based on the historical and geomorphological probabilities of being flooded in a given period. For instance, a 100-year floodplain corresponds to a zone with an average of 1%-chance of being flooded in any given year. It is equivalent to one chance out of four to be flooded over a 25-year mortgage period. By extension, a 500-year floodplain corresponds to a 0.2%-chance of suffering a disaster. These definitions are ad-hoc, and in Spain, the law considers as a flood zone any area located within a 500-year floodplain. Although current legislation varies according to the space definition, most of these areas' frontiers are very close to one another. In more than 90% of the cases, 500-year floodplain borders are only 20 meters away from their 100-year counterparts. The spatial concentration of flood probabilities points to the existence of recognizable terrain patterns.

A common wisdom — Despite this modern definition, it is improbable that individuals were ignorant of flood zones before the law's existence. For more than ten centuries, people located out of floodplain as they learned to recognize these spaces early on in history. The earliest traces of adaptation to flood events date back to the Middle Ages.

While individuals may have considered these disasters a divine outcome, local authorities already began modifying the terrain accordingly, building levees and floodwalls. Ancient fragments of dams named *'turciae'*, made of wood, rocks, and dirt, are mentioned for the first time in a 816 codex – *'De aggeribus juxta Ligerim fadendis'* [6]. Other examples of adaptation to flood risks span across history. In

[6] Which translates to 'On the (*De*) production/construction (*faciendis*) of levees (*aggeribus*) next to (*juxta*) the Loire river (*Ligerim*)'. King Louis I, son of Carolus Magnus, ordered the report.

Figure 4.1: The 1879 Santa Teresa flood along the Segura river

Notes: This map depicts the cartography of the zones affected by the Santa Teresa flood, on October 18th,1879. Extracted from the *'Crónica General de las Inundaciones en Alicante, Murcia y Almería de 14 y 15 de Octubre de 1879*, from Benedicto Mollá (1883, Spanish National Archives).

1150, the French Royal authorities created a corporation of engineers specifically meant to fight flood disasters. In 1160, Henry II of England commanded that local engineers stayed in villages to take care of the levees. In the 17th century, philosophers and mathematicians started to advocate for a higher knowledge of these catastrophes[7].

Although not as detailed as today, the risk was already inferred based on the regular observation of flood events in some areas – in particular agricultural regions. Engineers and statisticians mastered the cyclical prediction of floods, and geographers drew the first official flood maps by the mid-19st century. Figure 4.1 is an early example of such cartographic exercises made in the aftermath of the Santa Teresa Flood, in Spain.

In Spain, the so-called 'Law of Waters' – that administered rivers and lakes in

Knowing it was written in the early 9th century, the local populations likely knew about flood risks way before.

[7]In 1637, French philosopher and mathematician René Descartes wrote: "In place of the speculative philosophy taught in the schools we might find a practical philosophy through which knowing the power and the actions of fire, water, air, the stars, the heavens and all the other bodies in our environment as clearly as we know the various crafts of our artisans, we could (like artisans) put these bodies to use in all the appropriate ways, and thus make ourselves the masters and (as it were) owners of nature. This is desirable [...] for the preservation of health, which is certainly the chief good and the basis for all the other goods in this life."

the country was implemented shortly after, in 1866. During the first half of the 20th century, a series of regional and central government policies organized the use of water resources in the country. However, it was only in 1986 that the central government started to regulate development inside flood spaces while making recommendations for outside flood spaces. The 1986 regulation specified that the central government could implement limitations to the urban growth inside flood areas and that the regional governments could establish additional norms to these decrees. Any developer needed to receive the authorization to build inside a floodplain from the regional water authorities before construction begins. This law has been amended multiple times in the early 21st century to fit the local risks. It was finally entirely modified in 2016. Any new development in flood areas must comply with several specific requirements and benefit from the local government's special authorization and the regional water authorities.

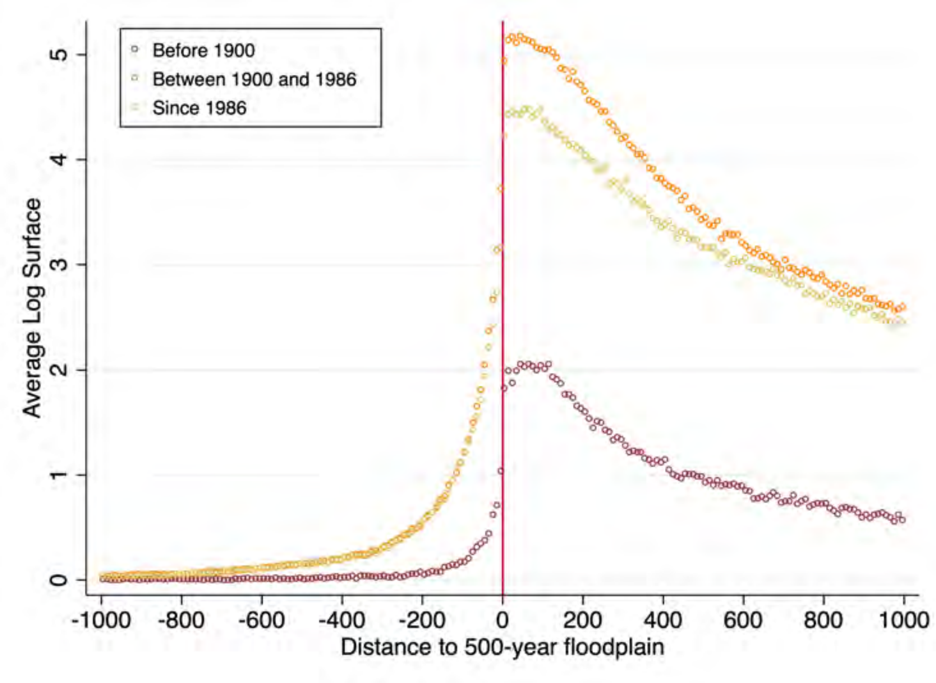
Risks vs. Amenities — Local flood risks appear to have been known for more than ten centuries. Then, it is reasonable to think that the decision to develop inside or outside of the floodplain reveals the heterogeneity of risk preferences towards floods– at least before any legislation took effect. This is to say that more risk-prone individuals may disregard the risk of a flood and decide to build closer to floodplains, while more risk-averse individuals may choose to develop farther away. Figure 4.2 displays the yearly average of the log of surface newly developed around a 500-year floodplain's border for different moments in history.

It is interesting to see similar traits in new development locations, as shown in Figure 4.2. Indeed, it appears that new development concentrates right outside the flood zone border across all the periods studied. In particular, this pattern does not seem to be driven by the introduction of the flood zone regulation. Available land could explain the lack of development far inside the flood zone. Although some new construction does take place inside the floodplain, the frontier characterizes a jump in the density of new development.

Water bodies can explain most of this concentration surrounding floodplain borders. Once we exclude buildings within 1km from a water body – rivers, lakes, or sea, most of the discontinuity vanishes. Figure A1 in the Annex illustrates this phenomenon.

In the absence of water nearby, development outside the floodplain increases with distance from the flood zone border. With water, development outside the floodplain decreases with distance from the flood zone border. A potential explanation could be that risk-averse individuals bunch right outside the floodplain where both the amenity and economic gains net of the perceived risks are maximized. On the contrary, when water bodies are far away, the trade-off between the perceived dangers

Figure 4.2: Development around floodplains' borders



Notes: The outcome is the yearly average log new development (measured in square meters, per year) across municipalities in Spain. On the x-axis is the distance in meters to a floodplain border. Negative values on the x-axis correspond to the inside of a flood zone. The flood zone is defined as a 500-year floodplain, like specified by the Spanish law. Each dot represents the outcome within a 10-meter buffer.

and expected gains vanish. In this case there, is no apparent reason for building close to a hazardous area. In the rest of this paper, we consider flood zones to capture individuals' flood risk perceptions.

We have shown that individuals, motivated by access to water, bunch right outside flood zones because they recognize flood zones as hazardous areas. Now we are interested in learning how new development reacts when a flood occurs. In particular, we want to know whether individuals build less, or farther away, or on higher terrain.

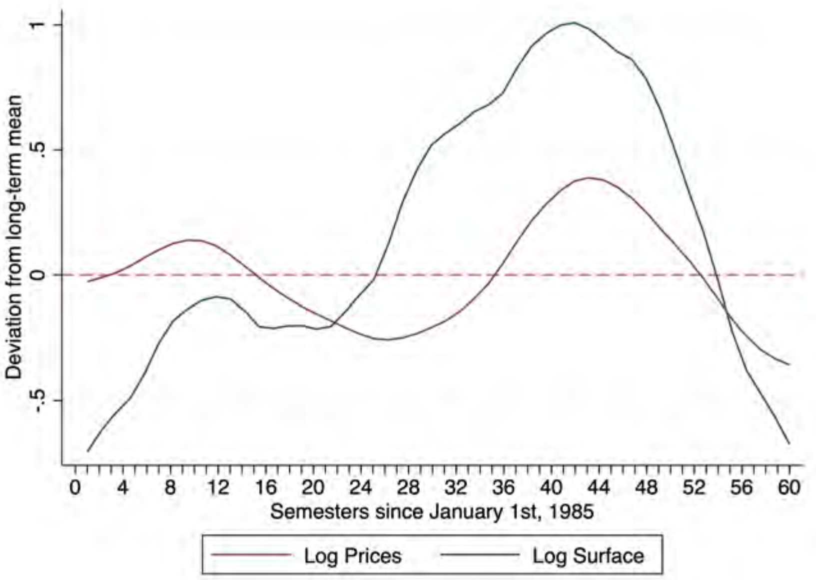
4.3 Real estate markets and floods

This section discusses potential mechanisms on how a flood event can affect new development. In particular, we want to stress the importance of the pre-existing housing supply characteristics when looking at development dynamics after a natural disaster.

Natural disasters can cause housing demand in a particular area to decrease. This demand reduction can be either because the disaster affects local employment or because individuals update their beliefs about the local risk, as shown by Gallagher (2014). If housing demand falls, then real estate markets will likely be affected.

We know that real estate markets behave cyclically. For example, Figure 4.3 illustrates how volumes of new development and average transaction prices' deviated from their 1985-2015 mean using as an example the Spanish city of Málaga. Nevertheless, these cycles vary greatly across cities. One reason for that is that the interaction between demand shocks and housing supply constraints can influence these cyclic patterns. Housing supply constraints can be regulatory or set by the landscape or land scarcity for new development. Generally, new development quantities absorb demand shocks when housing supply is unconstrained. In contrast, prices absorb the demand shock when housing supply is constrained (Wheaton, 1999).

Figure 4.3: Málaga's real estate cycles



Notes: Málaga is a touristic city from the southern Spanish coast. Cycles are derived from our datasets, presented in Section 4.4. A graphical representation of the city is displayed in Figure 4.5. We can see that the city is largely built between the sea and local mountains slopes, therefore reducing the supply of land available for development.

Consider a landowner who, in each period, has to decide whether to develop his parcel. She can either rent it undeveloped and wait to expand later or develop, expecting higher profits. However, if the future is uncertain and an investment (like real estate) is durable and illiquid, then the capacity to proceed to a different investment or not invest at all has economic value (Dixit and Pindyck, 1994; McDonald and Siegel, 1985, 1986). Uncertainty increases this option value.

When a flood hits, rational, forward-looking developers assume the housing demand will fall. In constrained markets, it means that the housing price of new development falls too. If developers believe that the demand shock is short-lived, expanding while prices are low ensures that the lost rent from undeveloped land is minimized. Expanding also increases the total stock of developed land, causing prices to decline even more, and harming competitors' profits. Therefore, if competitors begin to build when the demand erodes, they will shut the developer who does not expand or upgrade out of the market. Thus everyone develops in fear of preemption (Grenadier, 1996), leading to an oversupply of new buildings.

One could oppose that view, arguing that a flood event might have added uncertainty about the very type and amount of real estate to build. This increased uncertainty about future rents increases the option to wait – or delay the option to construct. It has already been shown that increased price volatility delays development (Cunningham, 2006), but an increased developers' competition curbs this negative relation between idiosyncratic risks and the value to wait (Bulan et al., 2009). Furthermore, Cunningham (2007) shows that housing supply constraints reduce the developers' uncertainty about which type of real estate to build to maximize profits, thus having the unintended effect of accelerating development. This latter evidence is important because it could explain why developers might be less likely to enter a preemption game when the housing supply is unconstrained.

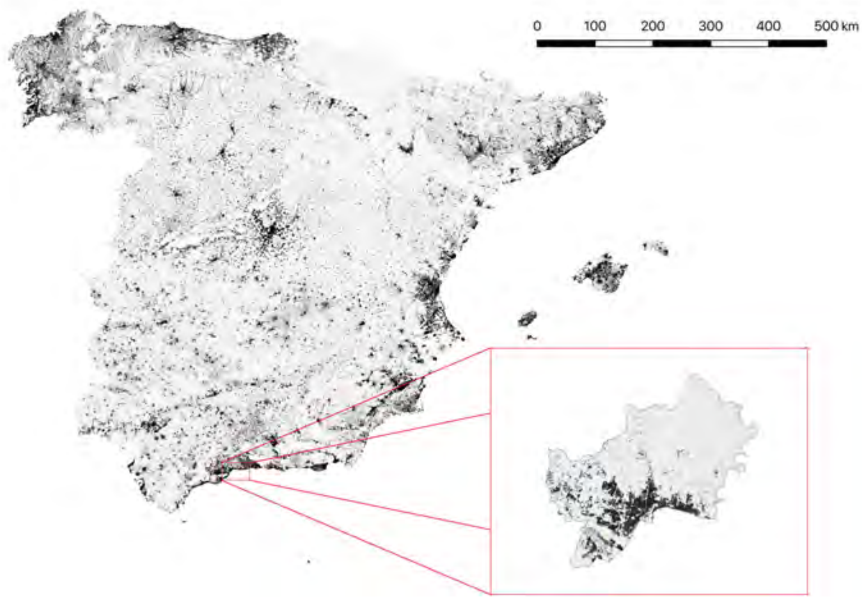
New development quantities will adapt to demand shocks if housing supply is not constrained, and new development prices should remain unaffected. Nevertheless, it is unclear whether new construction would entirely absorb the shock. Glaeser and Gyourko (2005) use weather as an exogenous shock to city attractiveness to argue that adverse shocks are reflected in prices rather than on population decline because of housing durability. This would fit the story of many declining cities with elastic housing supply. However, it is not clear that housing prices in an expanding city with an elastic housing supply would react as sharply as in a declining city. Notably, Genesove and Mayer (2001) argue that sellers are loss-adverse, affecting the transaction prices and volumes of developed housing when demand is down.

Summarizing this theoretical framework, we argue that demand shocks such as those generated by floods can have different consequences for both quantities of new development and transaction prices. In particular, when developers assume the market is eroding, they have incentives to convert undeveloped land in fear of possible preemption. In this case, growth controls and competition can offset the option value to wait and foster development. When demand drops and housing supply is inelastic, the number of new constructions is affected, but new construction prices remain stable. Transaction prices, in general, can drop since development is durable or remain stable if sellers are loss averse.

4.4 Data

The Spanish Land Register — We construct our primary dataset with the Spanish Land Register, which contains information of all buildings developed and currently standing in Spain, except the Basque Country and Navarre[8]. The dataset contains more than 11.7 million georeferenced buildings with their total floor surface, the number of dwellings, and the building's current use.

Figure 4.4: Distribution of buildings in Spain



Notes: In the main picture, each dot corresponds to a building's centroid. The black sprawl describes the density of development in the country. The Basque Country and the Navarre regions are excluded, as they have a different land register. The Canary Islands are excluded from the map for practical overall display. The city represented in the secondary picture is Málaga (Andalucía). A graphical representation of the city is displayed in Figure 4.5.

We measure the base surface of every development. The dataset also provides information on development dates, the last renovation, and the registration date. One limitation of the dataset is that we do not observe destroyed buildings. Later, we perform robustness checks and argue that this is no threat to our estimations. Figure 4.4 displays this information, with a zoom on the city of Málaga, in the region of Andalucía, which we will also use as an example for future visualizations.

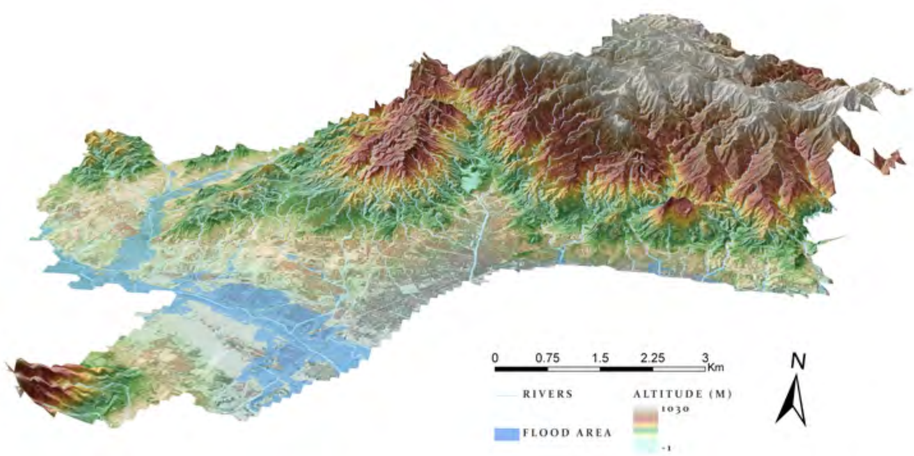
The date of construction tends to concentrate strongly on round numbers during the first half of the 20th century. This is most likely due to measurement error.

[8]These regions have their own land register, which is not accessible.

To avoid this error's potential bias, we restrict our sample to the democratic period 1978-2019. In this case, there is no evidence of clear measurement error in the date of construction, and more covariate data is available.

Floodplains and elevation data — We use the information provided by the Spanish National Institute of Geography for digitized floodplain maps[9]. This information is available for 10, 50, 100, and 500-year flood maps, as well as for water bodies. In what follows, we refer to floodplains, or flood zones, as the 500-year flood maps, which is the official geographic definition used by the national authorities. Finally, we add the digital elevation information derived from the LIDAR 25-meter grid. Figure 4.5 provides a visualization of our final dataset for the city of Málaga.

Figure 4.5: Digital model of the city of Málaga (Andalucía, Spain)

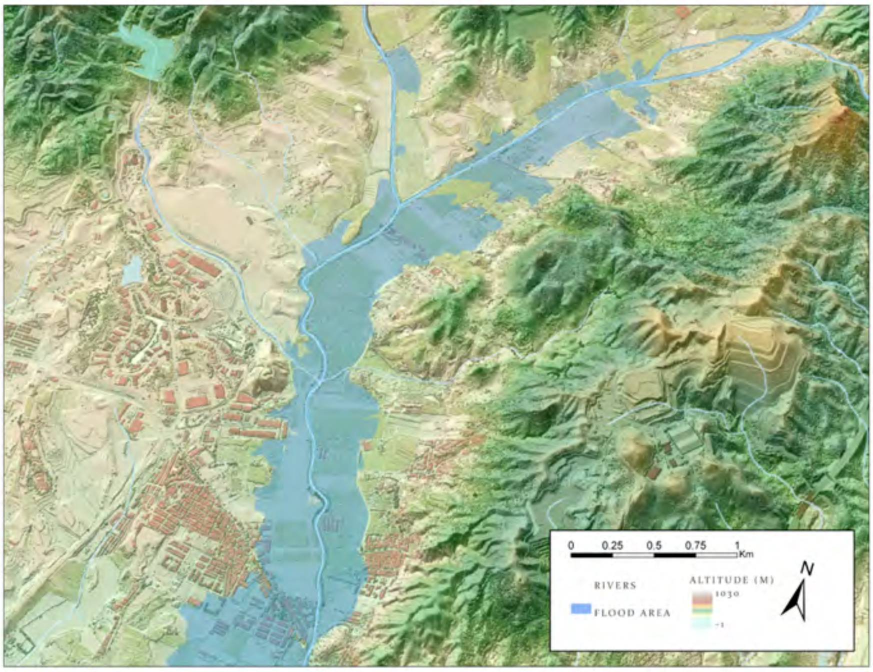


Notes: This is a visual representation of one of the cities of our final raw dataset, it is a digitized representation of the city of Málaga (Andalucía) with exaggerated heights, generated by combining information from (a) the Spanish Land Register for the buildings, (b) the Spanish National Institute of Geography for the floodplains, and (c) LIDAR 25-meter grid for elevation.

These detailed plans allow us to precisely measure each building's base surface, distance to the nearest flood zone and water space, and terrain elevation. For instance, we can see that the neighborhood of Campanillas, at the north-west of Málaga, has a large share of development built along or inside the flood area (see Figure 4.6).

[9]The data for the region of Catalonia must be obtained through the Catalan Minister of Waters website.

Figure 4.6: Digital model of the neighborhood of Campanillas (Andalucía, Spain)



Notes: This is a zoom on the neighborhood of Campanillas, at the northwest of Málaga (see Figure 4.5). Details on development's elevation and distance to the floodplain are visible here.

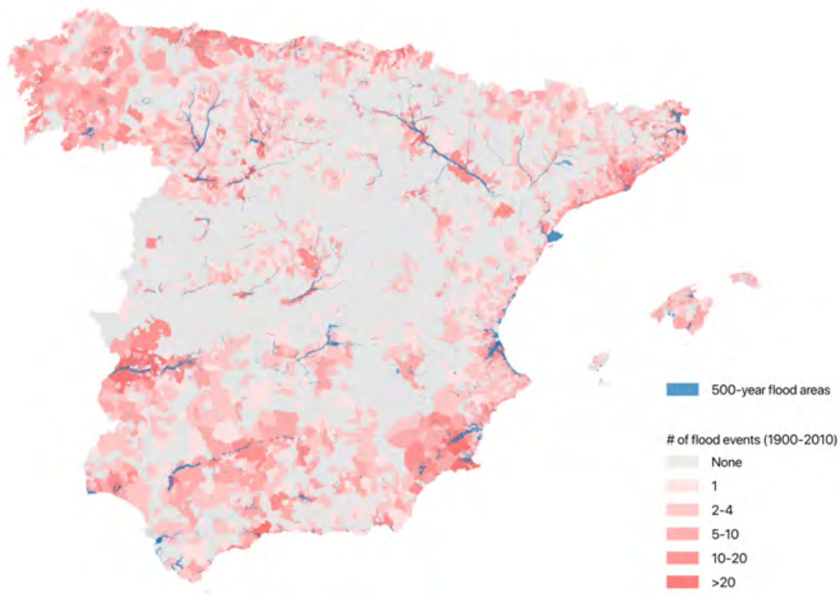
Historical floods — Campanillas (Figure 4.6) has been flooded six times in the last decade[10]. We collect data on historical floods from the National Catalogue of Historical Floods. This allows us to identify more than 5,000 municipalities affected by a total of nearly 1,800 flood events between 1900 and 2010. Figure 4.7 presents the spatial distribution of these disasters.

The main advantage of this dataset is that we can identify local floods spanning over a century. However, the main limitation of this data is that we cannot determine the exact extent of a specific flood within a municipality. Hence, as we cannot have a within-municipality intensive measure of a flood extent, we use an extensive measure of floods. This measure consists of identifying whether a municipality suffered a flood or not in a given year.

Overall, we can see from Figure 4.7 that most floods occurred along coastal areas, near mountain chains, and the most important river basins. Spain's central plateau is historically not as populated as the rest of the country (except for the region of

[10]Recently, Campanillas suffered from the storm Gloria. More than 400 liters per square meter of water caused a major flooding. `https://www.malagahoy.es/malaga/inundaciones-malaga-gloria-campanillas-litros-lluvia_0_1432957293.html`.

Figure 4.7: Distribution of the floods in Spain



Notes: Spatial distribution of flood events in Spain (1900-2010) according to the *National Catalogue of Historical Floods*, and location of the 500-year floodplains. Note that many flood spaces are not visible at this national scale and would require a closer look to be noticeable. For instance, the Malága floodplain (Figures 4.5 and 4.6) is barely visible here.

Madrid). The weather in that zone is arid, with few rivers compared to the rest of the country. These reasons could be both a cause and a consequence of the absence of known flood events there.

Secondary data — To measure the impact of a flood on other economic variables of interest, we complement our primary dataset with data on the labor market, migration, and housing prices.

We use data on the registered unemployment and employment contracts. This allows us to study the effect of floods on the number of unemployed people and the number of people that have signed a labor contract in a given year. The data also allows us to look into economic activity sectors, such as agriculture, industry, construction, and services. This data is available at the National Statistics Institute (INE). It is provided at the municipal level for the period 2006-2019.

Additionally, we use data on migration, which allows us to study population flows after a flood. The data provides information on the inflows and outflows of residents at the municipality level. Additionally, it includes information on gender. This data is computed by the National Statistics Institute (INE). It is provided at the municipality level for the period 1988-2019.

Finally, we also use data on housing prices. For that, we make use of yearly average housing prices in a given municipality. These data are available for 358 municipalities during the period 1985-2015. This is computed by a private firm specializing in housing markets in Spain named TINSA.

Final dataset — Our final dataset is a balanced panel of Spanish municipalities flooded at least once between 1978 and 2010 (except for the Basque Country and Navarre). This represents over 778 flood events, that affected 2,605 municipalities over 32 years, and more than 4.91 million buildings developed. For each municipality and year, it has information on new development's floor surface, the average distance to the nearest flood zone border and a water body, and average terrain's elevation. Distances and elevations have been computed from the centroid of each building. We also calculate alternative distance and elevation measures weighted by the surface developed to measure new development's exposure.

4.5 Empirical strategy

We are interested in capturing the development response in the aftermath of a flood. In particular, we look at new development (measured as new buildings' floor space in square meters)[11], the elevation of new development (measured as the terrain's height in meters), and the distance of new development from water bodies (measured as the distance in meters). We examine these variables at the municipal level. Later, we study what happens inside the floodplain and on fringes right outside flood zones. The empirical strategy follows closely that of Gallagher (2014) and Deryugina (2017). Our main dataset is a balanced panel of Spanish municipalities hit by a flood between 1978 and 2010, as described in Section 4.4, and our main specification is:

$$y_{mt} = \sum_{\tau=-T;\tau\neq-1}^{\tau=T} \beta_\tau Flood_{m\tau} + \alpha_m + \gamma_t + \varepsilon_{mt} \tag{4.1}$$

where y_{mt} is the (log of the) outcome of interest in municipality m at calendar year $t \in T$. Our variable of interest, $Flood_{m\tau}$, is an event time indicator that takes value 1 if a flood hit a municipality m in $t-\tau$. α_m and γ_t denote municipality and year fixed effects, respectively. ε_{mt} is the error term.

[11]Although we lack information about the surface of destroyed buildings, we are still able to measure the base floor space of new buildings, independently from reconstruction, renovations, or updates.

It is important to notice that we are not imposing any particular functional form on the effects of floods in the various outcome variables by using pre-event and post-event dummies. The dummies $Flood_{m\tau}$ capture the average of the outcome variable across all municipalities affected by a flood event τ periods before or after treatment, controlling for nationwide shocks and municipalities invariant characteristics.

The results are relative to the year previous to the flood event, the omitted category in the regression. Given potential biases arising from event study designs, as described by De Chaisemartin and d'Haultfoeuille (2020), we will use the first flood to happen between 1978 and 2010 in our estimation. Therefore, this approach ignores potential floods that happen before or after the period of study and subsequent floods after the first event on a municipality. This should not bias our results, as floods can be considered random conditional on municipality fixed effects. Additionally, following Kocornik-Mina et al. (2020), to avoid potential contamination of the control group, we focus only on those municipalities that experienced a flood in our sample period– this is a total of 2,605 municipalities.

The municipality fixed effects capture time-invariant characteristics of a municipality, such as its geographical patterns. By accounting for year fixed effects, we control for shocks to the Spanish economy and regulation changes issued in a given year that affect all municipalities. Our identifying assumption is that conditional on municipality time-invariant characteristics, particularly its geography, and time trends, the timing of a flood is as good as random. Finally, we allow for unobserved correlation between municipalities within a province by clustering standard errors at that level[12].

Our main specification looks at new development responses ten years before and after a flood event. We bin coefficients for the end periods following Schmidheiny and Siegloch (2020). Formally, these endpoint coefficients are defined as $Flood_{m,T} = \sum_{s=t+10}^{T} Flood_{ms}$ after the flood, and $Flood_{m,-T} = \sum_{s=-T}^{t-10} Flood_{ms}$ before the flood. Note that as we restrict our window to a finite number of lags and leads around our treatment, we explicitly assume that the development response to floods is similar beyond this window.

Following Deryugina (2017), when estimating Equation 4.1 we combine the indicators in two-year bins to increase statistical power. Therefore, the lags are $\tau =$ 1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, and the endpoint coefficient. Analogously, the leads indicating the years before the flood are 3 and 4, 5 and 6, 7 and 8, and the endpoint coefficient. We allow year 0, the year of the flood, to have a specific coefficient as it may have a different response than year 1. Notice that this estimation assumes that the coefficient on the leads 1 and 2 is equal to zero, so

[12]There are a total of 46 provinces (to which we add the autonomous cities of Ceuta and Melilla) in our sample.

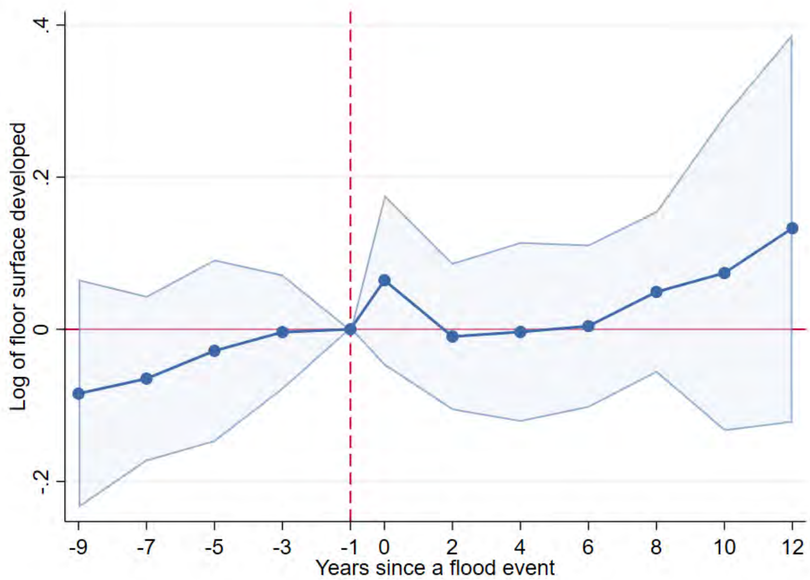
results are interpreted as the relative change to the two years before the flood.

4.6 Results

4.6.1 Main results

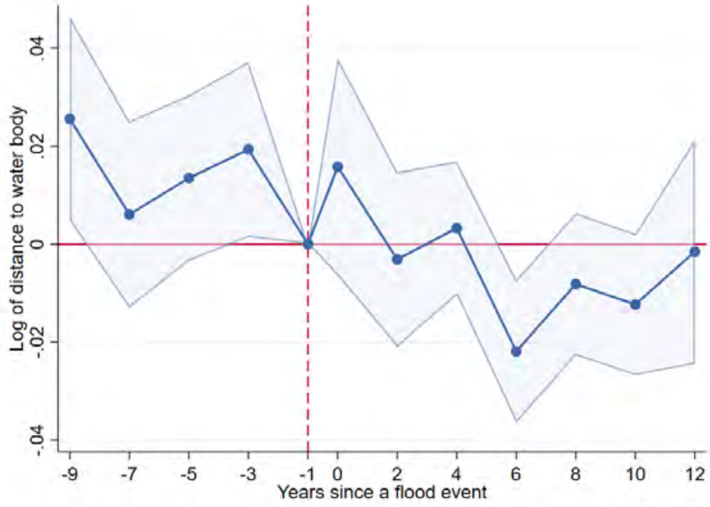
Overall development — Figure 4.8 depicts the results of Equation 4.1 to assess the impact of a flood event on new development. This is measured as the log of the total floor surface built in a given year, showing the coefficients in β_τ in our municipality panel. The x-axis depicts the distance in years to the flood event, with the years indexed with negative numbers being the ones preceding the flood event. Results are normalized to the year previous to the flood so that coefficients can be interpreted as the percentage change in the surface built relative to the year before the flood event. The shaded area represents a 95% confidence interval around the estimated coefficients. There seems to be no significant difference in the new development in the municipality in the years preceding the flood event. This absence of pre-trends largely alleviates potential anticipation effects.

Figure 4.8: Effect of a flood event on new development.

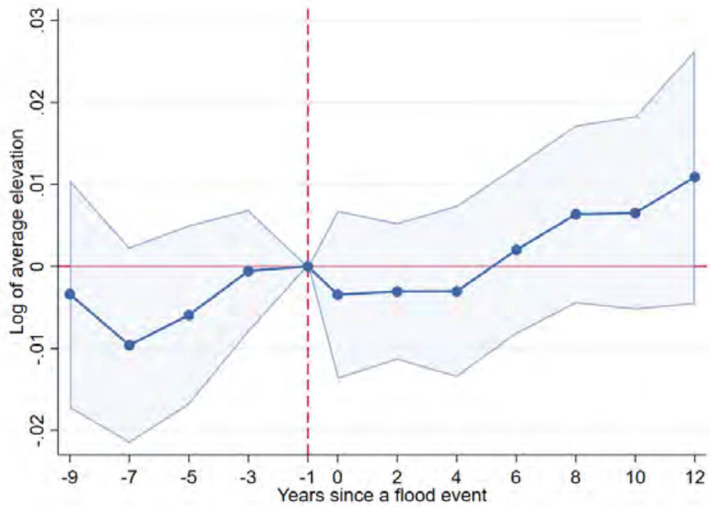


Notes: The vertical axis measures the effect of a flood event on log of the new surface built. Results are based on Equation 4.1. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

Figure 4.9: Effect of a flood event on distance to nearest water body and on elevation.



(a) Effect on distance to water body



(b) Effect on elevation

Notes: These figures plot the impact of a flood on new development's log distance (in meters) to a water body and log terrain elevation. Results are based on Equation 4.1. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

New construction does not locate further away from water after a flood, as shown in Figure 4.9a. Also, the results shown in Figure 4.9b show that new development is not taking place at a different elevation than before. Overall, compared to before the flood, new construction plans do not seem to be affected, not in the level of new construction nor on its location.

Spatial distribution of the effects — Although a flood does not impact the average distance of new development to a water body, it could still have potential effects on the distance to the floodplain border. For that, we perform our analysis on samples restricted to inside the floodplain and to fringes right outside the floodplain limits. In particular, we look at development that occurred (a) inside the floodplain, (b) less than 100 meters, (c) between 100 and 250 meters, and (d) between 250 and 500 meters from a flood zone border.

In particular, we are interested in knowing how development responds to a flood event *inside* the floodplain. We know from Section 4.2 that individuals are unlikely to be completely unaware of the presence of flood zones. Individuals building there are either uninformed or willing to take additional risks. If the agents building inside flood spaces know these risks, we might observe very little change after a flood. Indeed, we find that the impact is non-significant inside floodplains (see Figure A2 in the Annex).

Overall, the patterns do not seem to change dramatically across fringes. We observe no effect in new development irrespective of the distance to the nearest floodplain. Individuals do not seem to be moving new construction further away from the potentially dangerous areas.

However, Figure A2 in the Annex show an increase in new construction in the fringe between 100 and 250 meters from the floodplain on the year of the flood. In this case, development in the fringe increases by more than 20%. This effect is only significant in the year of the flood and dissipates in the following years. Given the short-lived effect, it could point towards a reconstruction mechanism.

Transaction prices — The results show that a flood event does not have a significant impact on transaction prices. Overall, prices are no different after the flood from the year previous to the event. Effects are not statistically significant and are also very small in economic terms. The fact that prices are not affected by a flood event is in line with our baseline results, which indicate that development is not influenced by a flood event. The results are shown in Figure A3 in the Annex.

Final use — We look deeper into the characteristics of new development following a flood event. While not being affected on its level nor with respect to the distance to a water body or elevation, we check if new development is affected differently according to its final use. For this, we use additional data in the land register, which indicates broad categories of use for each building. The potential uses of a building are: residential, agricultural, industrial, office space, retail space, or public building.

Results are shown in Figure A4 in the Annex. As in previous results, flood events seem to have no impact on new development, regardless of the building's final use, which follows patterns similar to the years previous to the flood.

A key result is that residential buildings continue to be built at the same rate as before the flood event. Residential construction is not taking place farther away from water bodies nor on higher ground. Notably, new residential construction continues to take place inside the floodplain, the area with the highest risk of being affected by a new flood.

Floods cause an increase in new construction towards the agricultural sector. In the year of the flood, there is an increase of 20% on the surface used for agriculture. This effect is short-lived and is no longer statistically significant in the year following the flood.

Employment and migration — We check whether floods can impact other economic dimensions besides new construction. We use data on social security records that compute the number of unemployed workers and the number of employment contracts signed in each municipality. This information is also broken down by sectors: agriculture, industry, construction, and services. Additionally, we look into migration patterns after a flood event. For that, we use administrative records that track the migration flows across Spanish municipalities. This dataset provides information on the yearly number of people moving in and out from a given municipality.

Floods do not have an impact on labor market outcomes. The results show that the number of unemployed people in a municipality hit by a flood remains unaltered. When looking by sectors, unemployment is not affected on most of them. However, in the year of the flood, there is an increase of 6% in the number of people unemployed in the construction sector. This effect is short-lived and fades in the years following the flood. The full results are shown in Figure A5 in the Annex.

The results on the number of contracts are in line with the results on unemployment. The overall number of contracts signed in a municipality in a given year is not affected by a flood. Additionally, there is no effect when looking at different economic sectors. The results are shown in Figure A6 in the Annex.

However, the agricultural sector experiences an increase, in the long run, in both the number of unemployed people and in the number of contracts. The high seasonality of the agricultural activity can explain these results. The high seasonality means that there can be simultaneously more people signing contracts and more unemployed people in the same year. Overall, this can indicate a larger share of the population working in this sector. Also, this result is in line with the increase in development used for agriculture shown before.

Floods do not significantly impact the number of people moving into the municipality, with inflow migration numbers similar to those before the flood. A flood event does seem to have a short-lived impact on migration outflow, although it is economically very small. In the year of the flood, there is a 2% increase in the number of people leaving the municipality. The results are shown in Figure A7 in the Annex.

Overall, these results are in line with our baseline specifications, as they show that a flood event does not seem to have a significant impact on development in a city. Also, these results are in line with existing literature that shows that economic activity can be unaffected by natural disasters, as in Kocornik-Mina et al. (2020).

4.6.2 A boost for stalled cities, a bust for booming cities

As suggested by Section 4.3, housing supply elasticity can have important consequences for the development after a flood. In order to test this hypothesis, we apply the following empirical specification:

$$
\begin{aligned}
y_{mt} = \sum_{\tau=-T;\tau\neq-1}^{\tau=T} \beta_\tau Flood_{m\tau} \times Booming_m + \sum_{\tau=-T;\tau\neq-1}^{\tau=T} \beta_\tau Flood_{m\tau} \times Stalled_m + \\
+ \sum_{\tau=-T;\tau\neq-1}^{\tau=T} \beta_\tau Flood_{m\tau} + \alpha_m + \gamma_t + \varepsilon_{mt}
\end{aligned}
\tag{4.2}
$$

The specification is similar to that of Equation 4.1. In this case, it includes an interaction term that indicates a city as a booming city and another indicating whether the city is stalled. We define a municipality as booming if the share of the development on the ten years previous to the flood is on the top quintile of the sample distribution. Analogously, we define a municipality as stalled if the municipality's development on the ten years previous to the flood is in the bottom quintile of the distribution.

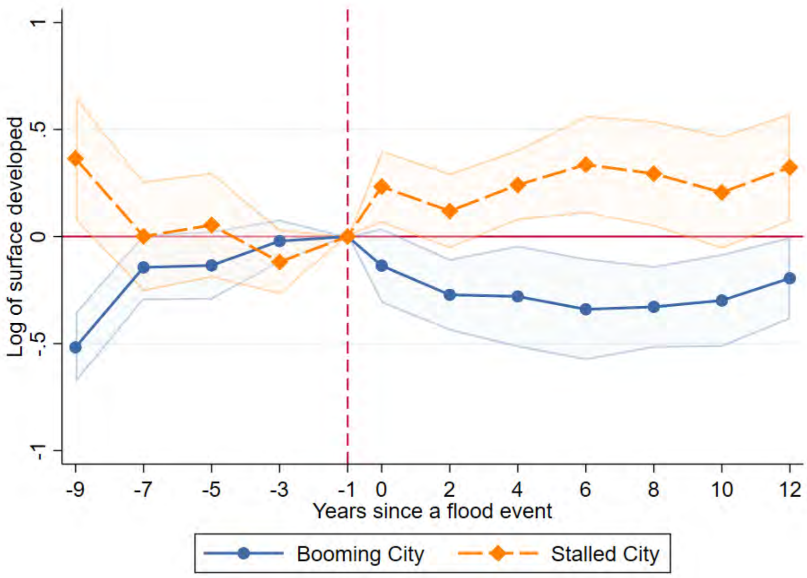
We compare development in cities that during the decade previous to the flood, on average developed 9.6% of their surface (stalled cities), to cities that developed 44% of their surface on average (booming cities). We think that in the absence of an accurate indicator to measure housing supply restrictions, our booming and stalled measure can incorporate certain characteristics of interest. In particular, a significant development in the years preceding the disasters capture lax housing development constraints. Small development figures in the years preceding the disasters likely capture tight housing development constraints[13].

[13]Note that both quintiles do not differ significantly in mean surface developed the year before

Overall development — The results in Figure 4.10 indicate no anticipation effects. The results also imply that a flood event has a substantially different impact depending on the level of development in the years previous to the flood. For booming cities, a flood event implies a reduction in new development. Compared to before the flood, new development permanently decreases by 27%. Additionally, new construction locates closer to a water body, even though the magnitude of the effect is economically small. For these cities, new development does not locate on higher ground than before the flood.

In contrast, stalled cities, those that were not experiencing large amounts of new construction before the flood, have a significant and permanent increase in new development. For these cities, a flood event implies a permanent increase of 25% in new development, compared to the year before the flood. Effects are significant immediately after the flood and remain significant even after ten years of the flood. New construction does not change its proximity to water bodies nor its elevation after a flood for stalled cities.

Figure 4.10: Effect of a flood event on new development, booming and stalled cities.



Notes: The vertical axis measures the effect of a flood event on log of the new floor surface built. A municipality is booming (stalled) if the share of the development on the 10 years previous to the flood is on the top (bottom) 20% of the sample distribution. Results are based on Equation 4.2. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

the flood, so we are not comparing new cities to cities having already exhausted all land in their jurisdiction.

Spatial distribution of the effects — The new development's location is affected both in booming and stalled cities. For stalled cities, the increase in new development occurs mainly in the fringes more than 100 meters away from the floodplain border. This indicates that despite having a significant increase in construction after a flood, new development in stalled cities is not located in the most high-risk areas. New construction in these cities does not increase inside the floodplains nor in the areas that are less than 100 meters from the floodplain border. Figure A9 in the Annex illustrates these results.

Similarly, the reduction in new construction is mainly located on the fringes more than 100 meters away from the floodplain border for booming cities. Notably, new development inside the floodplain is built at the same rate as before the flood. Also, new development is not affected within the first 100 meters from the floodplain border. These results are important as those areas have the highest risk of being hit by a flood.

Transaction prices — Experiencing a flood has a significant effect in new development for stalled cities, reflecting on prices. For these cities, a flood event leads to a permanent and significant reduction in average transaction prices. However, this effect is not immediate and it only becomes significant four years after the flood. The effect reaches its largest magnitude approximately six years after the flood, with prices decreasing over 20%, compared to before the flood. A potential explanation for this result is that the construction boom caused by the flood causes an increase in supply in the housing market, and given construction times, its reflection on prices is delayed.

Additionally, migration flows show that housing demand is unlikely to increase, as there is no increase in the municipality's inflow of people. Therefore, after a few years of increasing housing supply and stable housing demand, prices begin to decrease.

For booming cities, which suffer a drop in construction levels after the flood event, prices are not affected. A potential explanation can be found on the migration patterns of these booming cities after the flood. The following section shows that these cities experience a significant increase in the population outflows after a flood, larger in magnitude than the increase in the population inflow. Therefore, while the housing supply decreases in booming cities, migration flows show that the demand for housing may also be decreasing, thus leaving prices stable. Additionally, as shown in Section 4.3 if sellers are risk averse in a declining market, this risk aversion can lead to stable housing prices. The results are shown in Figure 4.10 in the Annex.

Final use — In terms of final use, the increase in stalled cities' new development is driven mainly by residential and industry-oriented construction. In particular, there is an increase of 25% in the year of the flood on residential development compared to previous levels. Residential buildings have a permanent increase in the development rate after a flood for stalled cities. In contrast, the increase in new industrial development is not immediate, and it peaks six years after the flood, with development being 50% larger than before. For stalled cities, a flood does not increase the space used for agriculture, offices, retail, or public use.

For booming cities, the decrease in new development is driven by residential and retail-oriented development. There is a 25% reduction in new residential development in booming cities following the flood event. New development for retail use is reduced permanently by 48% following a flood. This decrease in new retail-oriented space is also reflected in labor market outcomes. The number of unemployed people related to the services sector increases after a flood, as described in the following section. Booming cities have an increase in agriculture-oriented development in the year of the flood. Booming cities seem to be driving overall results of the increase in agricultural use construction described in the previous section. The results are shown in Figure A10 in the Annex.

Employment and migration — In terms of labor market outcomes, booming cities suffer an increase in the total number of people unemployed, with the effect being driven by the industry, agriculture, and services sectors. This pattern can already be seen in the final use results in Figure A10, which show that booming cities have a significant loss in office-oriented development after a flood. Stalled cities experience no increase in unemployment in any sector. The results suggest that a flood leads to lower industrial unemployment for stalled cities, which is in line with the final use results, that show an increase in industry-oriented development. The results are shown in Figure A11 in the Annex.

The reduction in new construction in booming cities is translated into a lower share of contracts in the construction sector. This drop is stronger in the first years after a flood. The number of contracts on stalled cities suggests an increase in the number of people employed in the construction sector, although the effect is not statistically different from zero. The results are shown in Figure A12 in the Annex.

Migration results also show interesting differences between booming and stalled cities. There is a 20% increase in the number of people moving into the municipality in the long run for booming cities. However, there is also a 25% increase in the number of people moving out from the municipality. In comparison, while the increase in the population inflow happens in the long run, the increase in the population outflow is significant in the years immediately following the flood.

For stalled cities, a flood does not lead to an increase in the population inflow. However, there is an 18% decrease in outflow migration in the long run. These results may help explain the long-term decrease in prices in these cities. A potential explanation is that the housing boom is not effective in attracting new inhabitants. For those living in the city before the flood, selling their property and moving out becomes less attractive given the falling housing prices. The results are shown in Figure A13 in the Annex.

4.6.3 Robustness

Destructive floods — A potential explanation for the baseline results could be that the floods in our dataset account for events that caused little or no damage, therefore not affecting agents' perceptions.

To account for this, we will combine our dataset with that of the Emergency Events Database (EM-DAT), developed by the Centre for Research on the Epidemiology of Disasters (CRED) within the Université Catholique de Louvain (UCLouvain)[14]. This dataset contains the floods that caused more damage, measured either by the number of people affected or by damage costs.

For the case of Spain, this database contains 21 flood episodes that occurred between 1978 and 2010. Combining the approximate date and geographical extension of the flood on the EM-DAT database with our original dataset, it is possible to identify the precise municipalities hit by these floods.

Results in Figure A14 in the Annex show results are not significantly different from our baseline results. Overall, the level of new development is not affected by a destructive flood. Additionally, there is no change in the new development's distance to water bodies or floodplains borders. The new development is also not built on higher ground than before the destructive flood.

Rainfall data — We further check the robustness of our results by using an alternative dataset to measure floods. For this, we use the Terraclimate dataset. This dataset provides monthly data for the period 1958-2019, at a 4km spatial resolution, on several climate-related variables. A full description of the database is provided by Abatzoglou et al. (2018).

We identify a cell as being flooded if it receives in any given month, more than 2 s.d. of the cell's rainfall average. This measure ensures that the cell received enough total rainfall to cause some damage.

[14]This database tracks disaster events worldwide, using various sources, including UN agencies, non-governmental organizations, insurance companies, and research institutes, and press agencies. More detailed information on: `www.emdat.be`.

The empirical specification for this exercise is:

$$y_{gt} = \sum_{\tau=-T;\tau\neq-1}^{\tau=T} \beta_\tau Flood_{g\tau} + \alpha_g + \gamma_t + \varepsilon_{gt} \tag{4.3}$$

where y_{gt} is the (log of the) outcome of interest in cell g at calendar year t. Our variable of interest, $Flood_{g\tau}$, is an event time indicator that takes value 1 if a cell g was hit by a flood in $t-\tau$. Then, α_g and γ_t denote cell and year fixed effects, respectively. ε_{gt} is the error term.

Results are in line with those of the baseline specification and our destructive floods analysis. Results in Figure A15 in the Annex show that there is no significant effect of a flood event on overall development, nor on the location of this new development.

4.6.4 Analysis of a flood-risk mitigation policy

We know that development tends to concentrate largely on areas close to the floodplain border. Potentially, this could be due to different reasons. Individuals may fully comprehend the risk associated with locating inside historical floodplains and thus decide to do so just outside floodplains borders. However, another reason could be that development responds primarily to building restrictions, partially disregarding potential flood risks. To test this hypothesis, we use a recent policy that signaled areas with high flood risk. We study whether the effect of this policy on new development near these areas.

ARPSIs — In 2007 the EU Parliament approved a resolution regarding evaluation and management of flood risks. In this directive, member states were instructed to identify zones with a high risk of a flood. In Spain, this materialized in the ARPSIs (*Áreas de Riesgo Potencial Significativo de Inundación*), or areas with a significant potential risk of flood. Also, it resulted in the creation of flood risk maps, which were made public in 2013. The identification of these areas followed different criteria than those used to determine the existing floodplains. For example, a key difference is that ARPSIs also consider potential risk, while floodplains are mainly determined by historical floods. Therefore, areas that were not considered to have any flood risk before now were signaled as potentially dangerous. An example of this is shown in Figure 4.11, for the city of Zaragoza.

After identifying these areas, the EU-directive established that member states were to develop flood risk management plans for each of the areas before 2015. These plans involved prevention measures (mainly through harsher restrictions on

Figure 4.11: ARPSI and existing floodplain in the city of Zaragoza.

Notes: The image shows an example of how the areas determined as ARPSI in 2012 may differ from the existing floodplain. In this case, a part of the river Huerva that crosses Zaragoza's city is now considered of potential risk, while before it was not.

new development), investment in prevention infrastructure, and alert systems and recovery plans in case of flood events[15].

In Spain, these plans were approved in 2016[16]. However, the implementation of this plan has been slow. No measure from the flood risk management plans was completed by 2019, as established by a European Commission report[17].

To evaluate development activity with respect to ARPSIs, we will study new floor space developed in areas immediately surrounding the ARPSI. For this, we will compare fringes surrounding ARPSIs, before and after they were declared as such. As a control group, we will use fringes surrounding a water body in the same municipalities that were not declared as ARPSIs. Therefore our specification for this part will be:

$$y_{ft} = \sum_{\tau=2000;\tau\neq 2012}^{\tau=2017} \beta_t ARPSI_{f2012} + \alpha_m + \gamma_t + \delta_a + \varepsilon_{mt} \tag{4.4}$$

[15]For more information on this directive: `https://eur-lex.europa.eu/eli/dir/2007/60/oj`.

[16]Except for the Canary Islands, which still does not has a risk management plan for the ARPSIs located with this territory. This led the EU Commission to take Spain to the Court of Justice of the EU for "failure to act on protection against flooding". More information on: `https://ec.europa.eu/commission/presscorner/detail/EN/IP_19_465`.

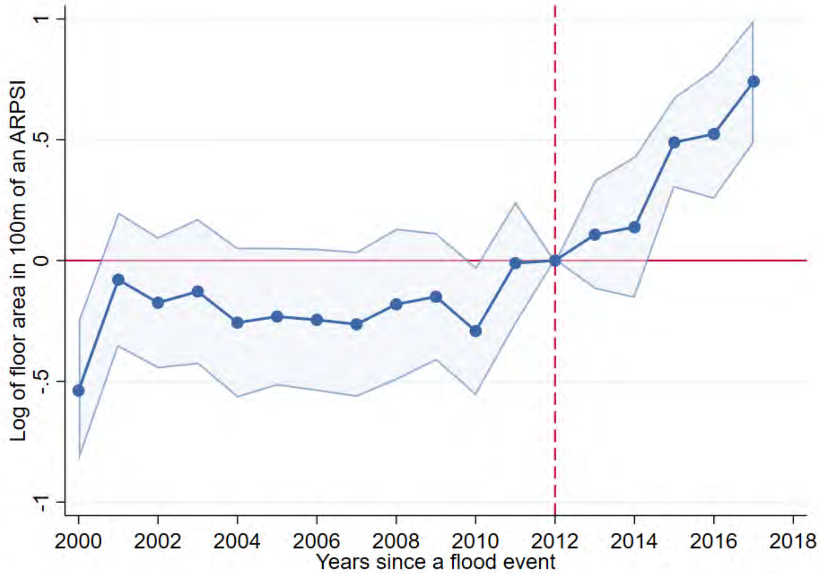
[17]The full report is available at: `https://ec.europa.eu/environment/water/water-framework/impl_reports.htm`.

where y_{ft} is the (log of the) floor space in fringe f at calendar year t. Our variable of interest, $ARPSI_{f2012}$, is an event time indicator that takes value one if the fringe was declared as ARPSI in 2012. Then, α_m and γ_t denote municipality and year fixed effects, respectively. δ_a denote ARPSI fixed effect and ε_{ft} is the error term. The estimated coefficients β_t are relative to the year previous to the public announcement of the areas declared as ARPSI, which is the omitted category in the regressions.

As with our baseline specification, we are not imposing any particular functional form on the effects of the declaration of ARPSI on new development. The dummies δ_a capture the average of the outcome variable across all fringes that were declared as an ARPSI. Also, the specification controls for nationwide shocks and municipalities and fringes time-invariant characteristics.

Results are shown in Figure 4.12, using a 100 meter fringe from the ARPSI or water body. Areas identified as ARPSI were not developing at a different rate than control areas on the ten year period previous to the ARPSI identification, which alleviates potential anticipation concerns.

Figure 4.12: Effect of a flood event on new development within 100m of an ARPSI.



Notes: The vertical axis measures the effect of a flood event on log of the new surface built. Results are based on Equation 4.4. The coefficient for the year before the ARPSI declaration is set to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

Results suggest that identifying an area as an ARPSI increases development near that area in the years following the declaration. Results show a sharp increase in the development levels near the ARPSI areas. The effect is statistically significant after 2015. However, as Figure A16 in the Annex shows, interesting dynamics are happening in those areas. Development was stable until the 2008 crisis, after which it starts to fall significantly both for areas identified as ARPSI as for the control areas. The results can then be interpreted as identifying an area as ARPSI has reduced the fall in the rate of new construction.

A potential explanation for this result is that agents anticipate the government response and, therefore, decide to develop before any restriction is imposed on the area surrounding the ARPSI. This would point to an unexpected effect of the declaration of an area as potentially floodable and an unintended consequence of the government's delayed response on imposing measures from the risk flood management plans.

4.7 Conclusion

Using a rich dataset on historical flood records and the universe of buildings in Spain, we document the patterns of land development in the aftermath of an inundation. First, we show that development tends to historically cluster right outside identified flood zones, except in the absence of a water body nearby. We infer that individuals might want to maximize their access to water – either for economic or amenity reasons while remaining outside the hazardous area.

Using a flexible event study framework, we find that experiencing a flood does not affect new development on average. Development takes place at a pace similar to that before the flood. Interestingly, we find that new development does not take place farther away from flood zones nor on higher ground. When analyzing developments' final uses, we find that residential buildings are being built at the same rate as before the flood. A flood does not significantly affect key economic variables such as unemployment, migration, or housing prices.

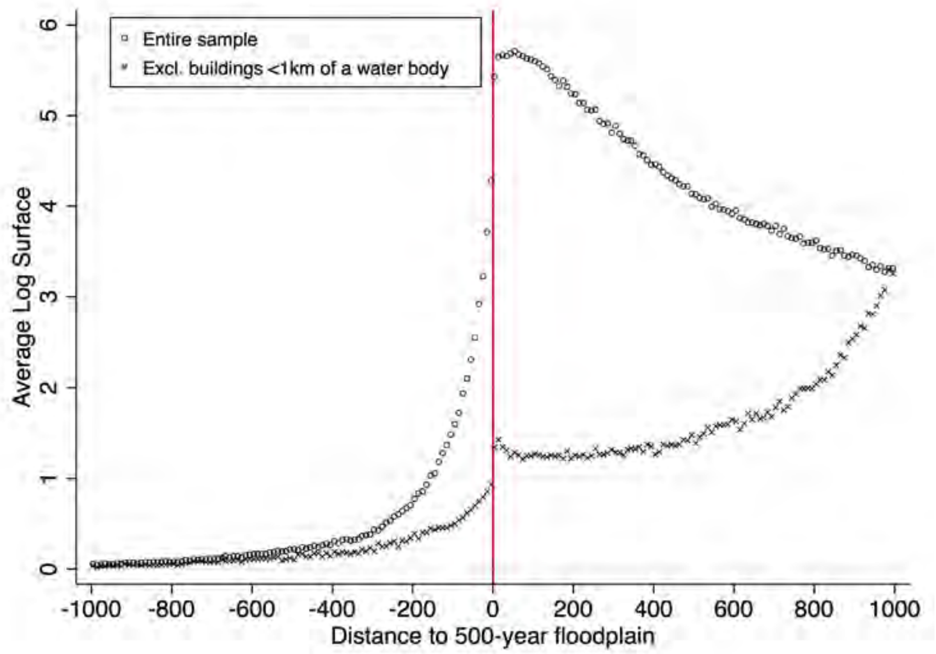
However, when considering the level of development before the flood, there are significant differences. Cities having experienced a development boom before the flood experience a 27% permanent reduction in new construction compared to before the event. Residential development drives this fall in new construction, but transaction prices remain stable. Municipalities having experienced low development levels in the decade before the flood experience a housing boom after the event. For these cities, new development increases permanently by 25% compared to the year previous to the flood. This boom is mainly driven by residential and industrial development and is followed by a fall in transaction prices.

Additionally, we show that signaling an area as potentially dangerous is not enough to deter new development from locating nearby. This is shown with a European-level policy that mandated member states to identify potential flood risk areas. Overall, signaling areas as potentially risky does not deter development from taking place near such areas. Agents do not internalize the risk associated with locating close to a high-risk zone and appear to respond primarily to building restrictions. Moreover, not imposing building restrictions immediately after the areas' designation may have caused an increase in development nearby.

4.8 Appendix

A Descriptive graphs

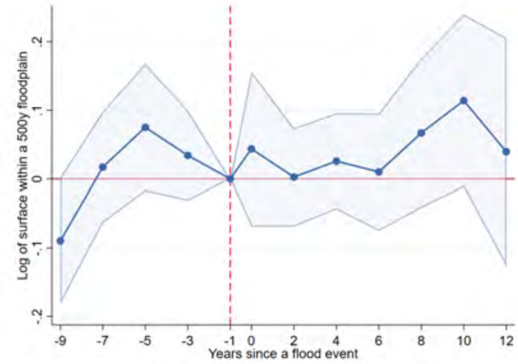
Figure A1: Development and water amenities (1900-2010)



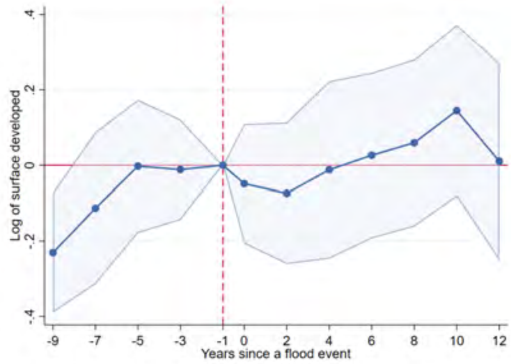
Notes: The outcome is the yearly average log new development (measured in square meters) across municipalities in Spain. On the x-axis is the distance in meters to a floodplain border. Negative values on the x-axis correspond to the interior of a flood zone. The flood zone is defined as a 500-year floodplain, like specified by the Spanish law. Each dot represents the mean outcome within a 10-meter bin.

B Full results

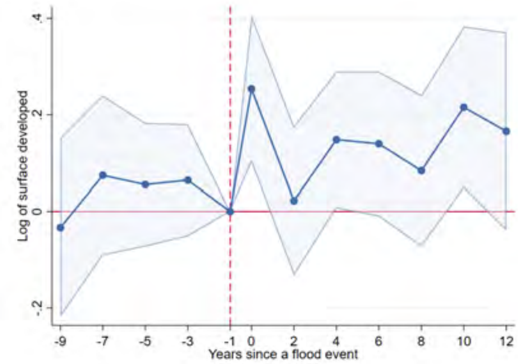
Figure A2: Effect of a flood on the average surface built, according to different fringes from the nearest 500-year floodplain.



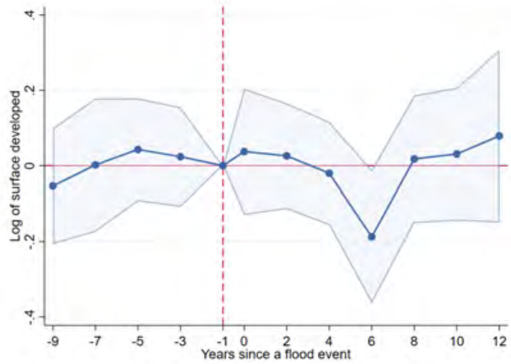
(a) Within a floodplain



(b) Less than 100m of a floodplain



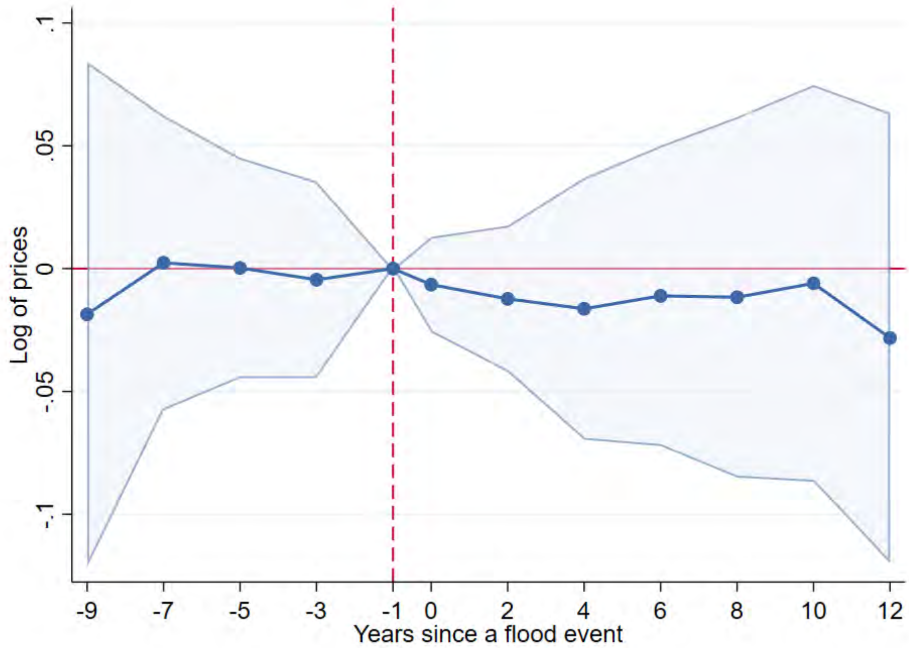
(c) Between 100 and 250m of a floodplain



(d) Between 250 and 500m of a floodplain

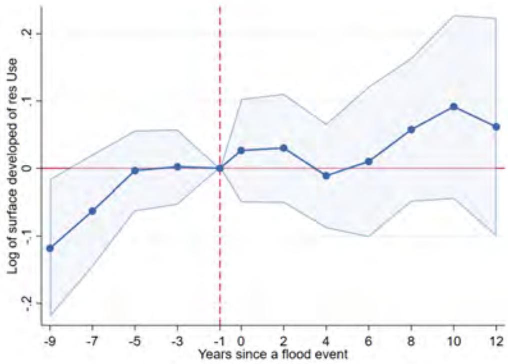
Notes: Effect of a flood on average surface built according to different fringes from the nearest floodzone. Panels show: a) inside the floodplain, (b) less than 100 meters, (c) between 100 and 250 meters, and (d) between 250 and 500 meters from a flood zone border. Results are based on Equation 4.1.

Figure A3: Effect of a flood on prices (per square meter)

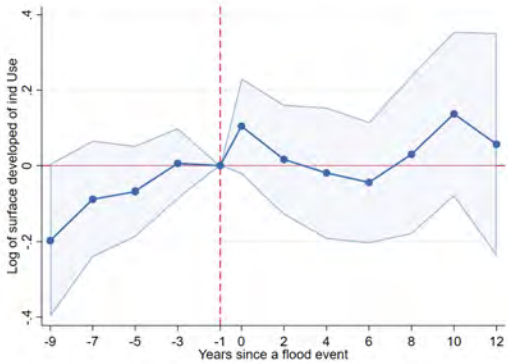


Notes: Effect of a flood on the average price of housing (per square meter). Data is extracted from 358 municipal squared-meter price series from the real estate appraisals 'TINSA' , collected between 1985 and 2010. Results are based on Equation 4.1.

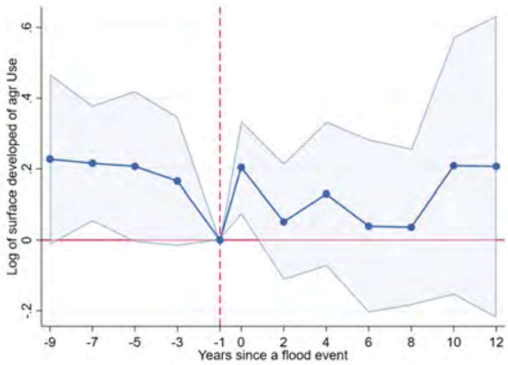
Figure A4: Effect of a flood on the average floor surface built, according to different final uses.



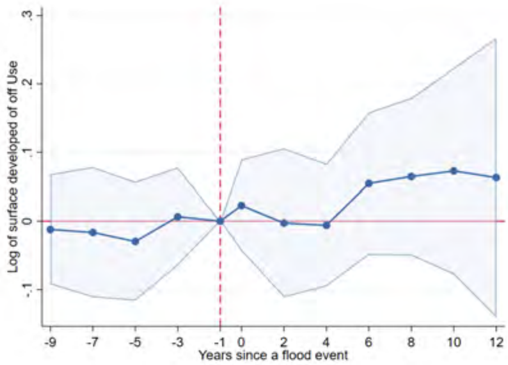
(a) Residential Use



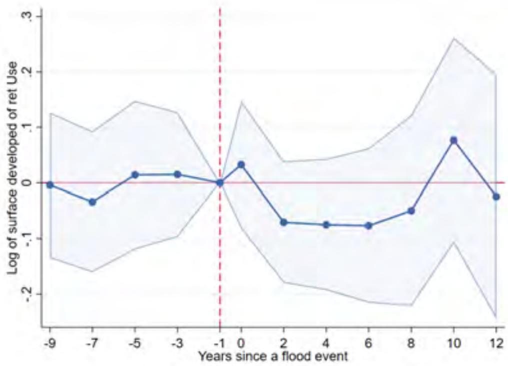
(b) Industrial Use



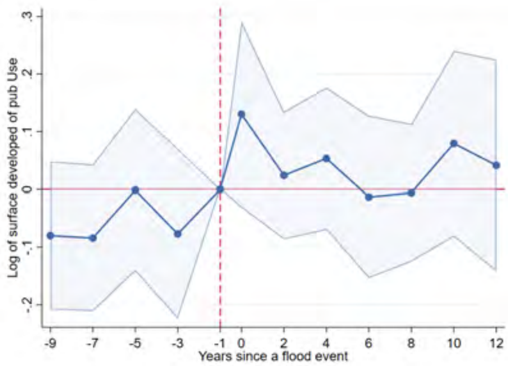
(c) Agricultural Use



(d) Office Use



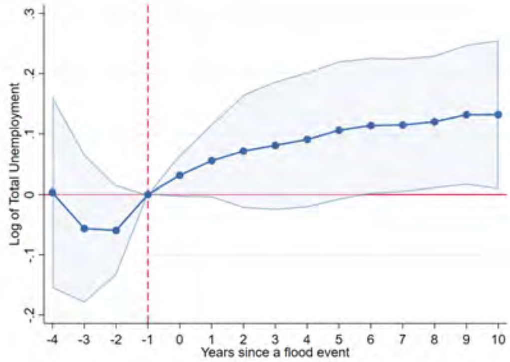
(e) Retail Use



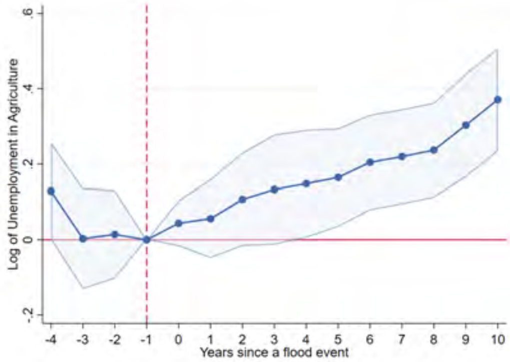
(f) Public Use

Notes: Effect of a flood on average floor surface built according to different final uses. Results are based on Equation 4.1.

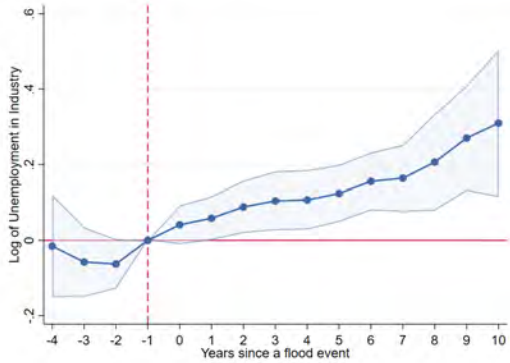
Figure A5: Effect of a flood on unemployment.



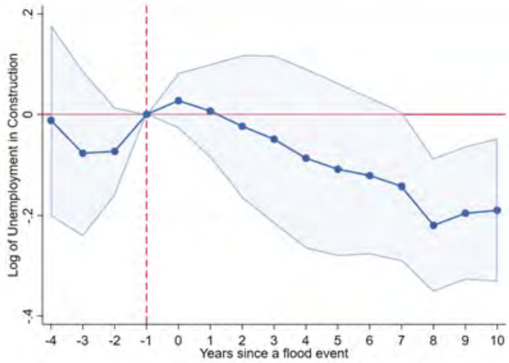
(a) Total unemployment registered



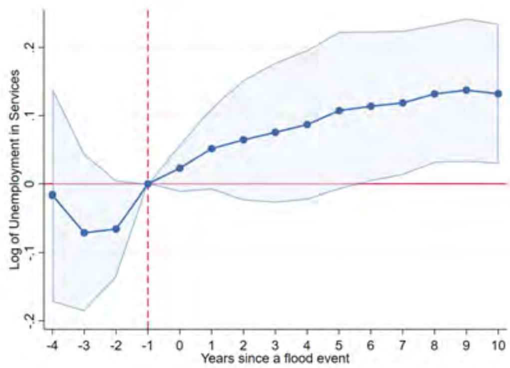
(b) Unemployment in agricultural sector



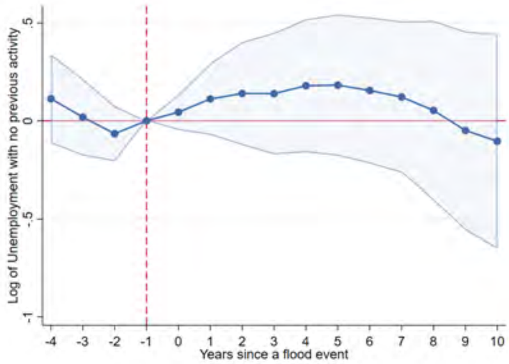
(c) Unemployment in industrial sector



(d) Unemployment in construction sector



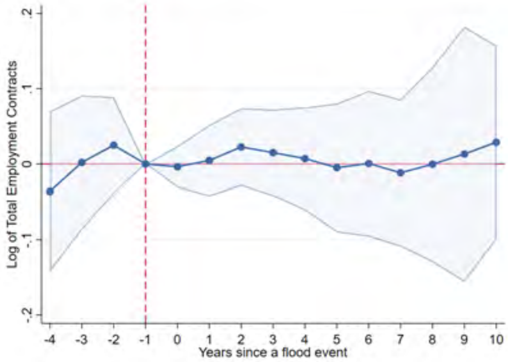
(e) Unemployment in services sector



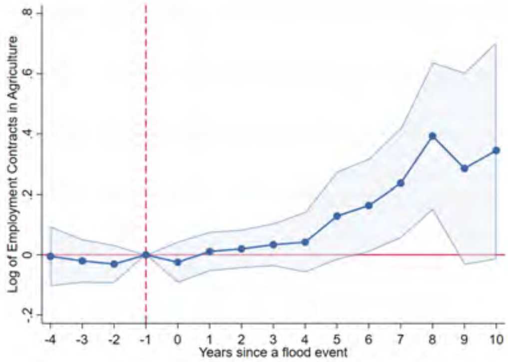
(f) Unemployment with no previous employment

Notes: Effect of a flood event on unemployment according to different sectors of economic activity. Results are based on Equation 4.1.

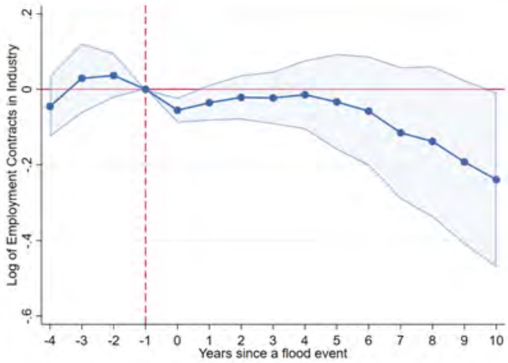
Figure A6: Effect of a flood on employment contracts.



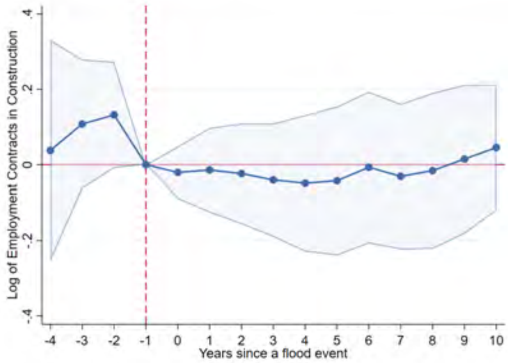
(a) Total contracts



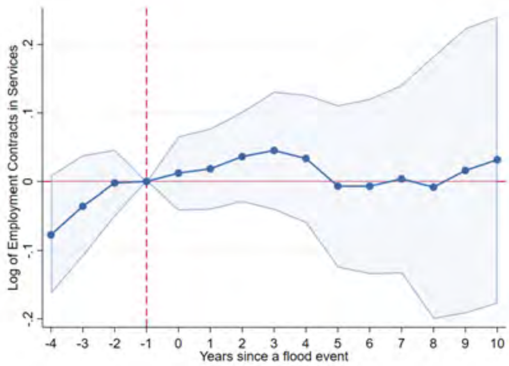
(b) Agricultural contracts



(c) Industry contracts



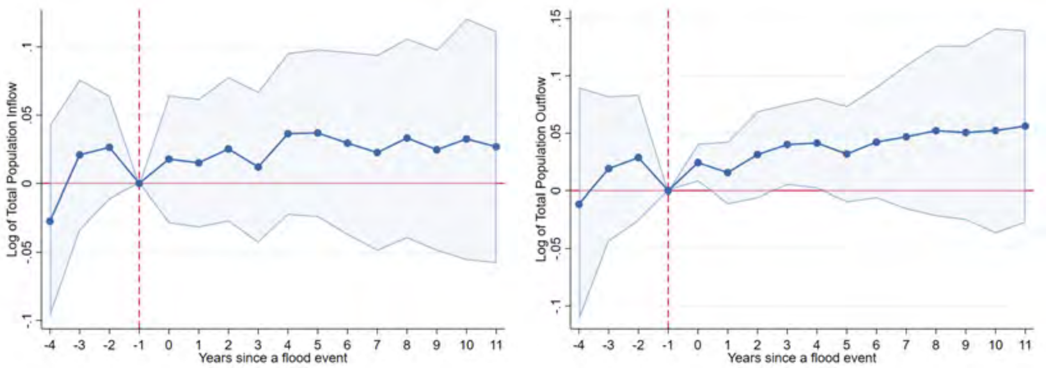
(d) Construction contracts



(e) Services contracts

Notes: Effect of a flood on employment contracts signed according to different sectors of economic activity. Results are based on Equation 4.1.

Figure A7: Effect of a flood on migration.



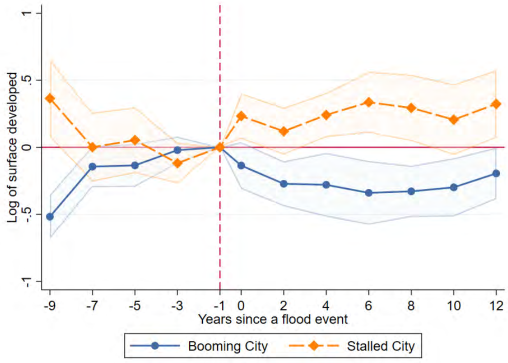
(a) Total inflow

(b) Total Outflow

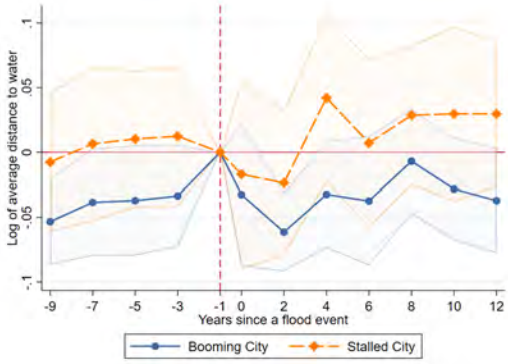
Notes: Effect of a flood on total number of people moving in and out from the flooded municipality. Results are based on Equation 4.1.

Results: Booming versus stalled cities

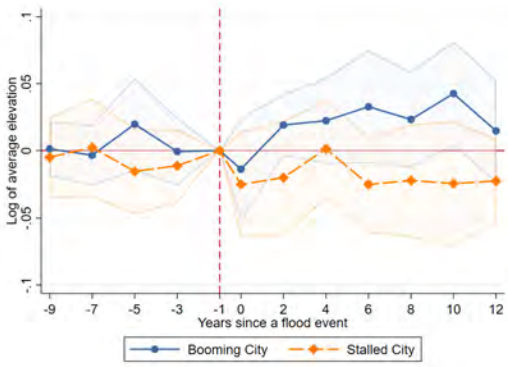
Figure A8: Effect of a flood event on flood surface, distance to nearest water body, and on elevation, for booming and stalled cities.



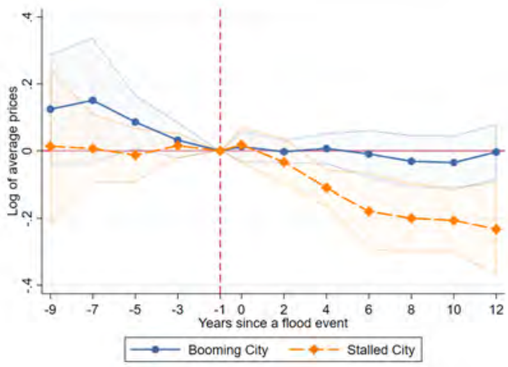
(a) Effect on floor surface



(b) Effect on distance to water body



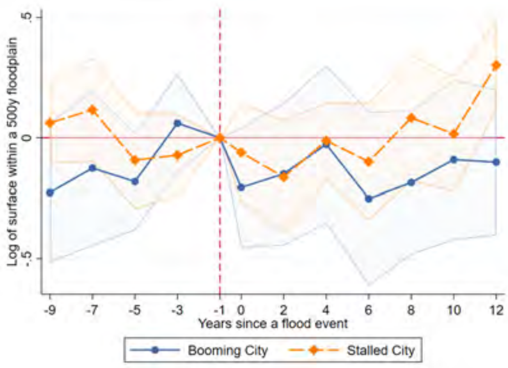
(c) Effect on elevation



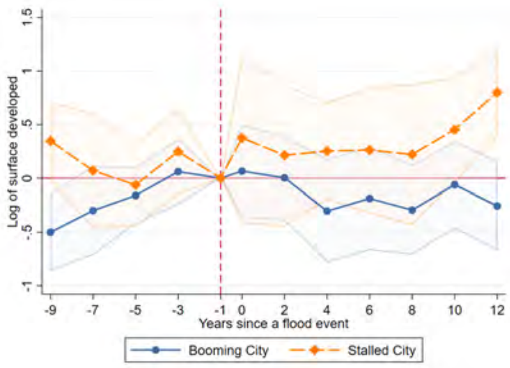
(d) Effect on prices

Notes: These figures plot the impact of a flood on new development's (log of) floor surface built, distance (in meters) to a water body, terrain elevation, and the average housing price per square meter. Data for prices is extracted from 358 municipal square meter price series from the real estate appraisals 'TINSA', collected between 1985 and 2010. A municipality is booming (stalled) if the share of the development on the 10 years previous to the flood is on the top (bottom) 20% of the sample distribution. Results are based on Equation 4.2. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

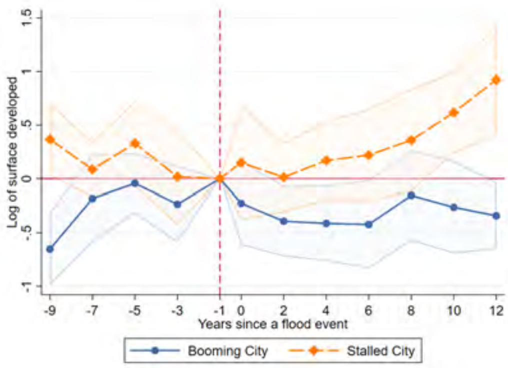
Figure A9: Effect of a flood on the average surface built, according to different fringes from the nearest 500-year floodplain, for booming and stalled cities.



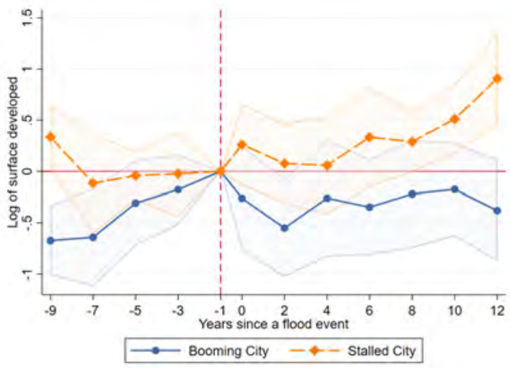
(a) Within a floodplain



(b) Less than 100m of a floodplain



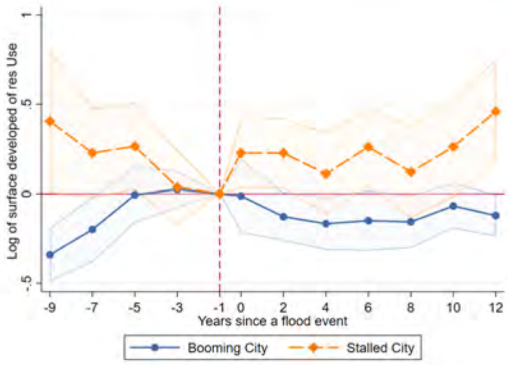
(c) Between 100 and 250m of a floodplain



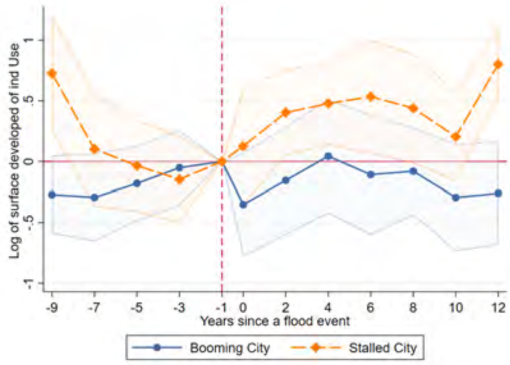
(d) Between 250 and 500m of a floodplain

Notes: Effect of a flood on average floor surface built according to different fringes from the nearest floodzone. A municipality is booming (stalled) if the share of the development on the 10 years previous to the flood is on the top (bottom) 20% of the sample distribution. Results are based on Equation 4.2. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by provicen.

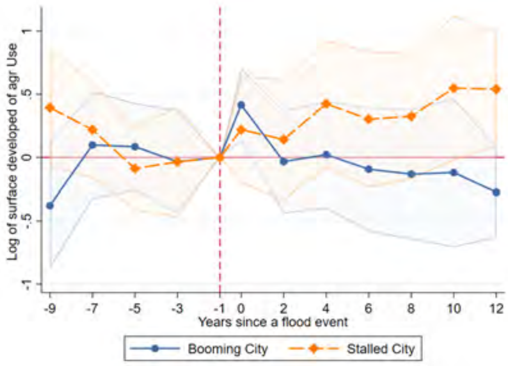
Figure A10: Effect of a flood on the average floor surface built, by different final uses, for booming and stalled cities.



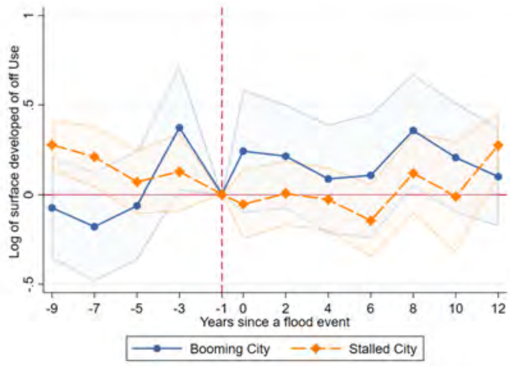
(a) Residential Use



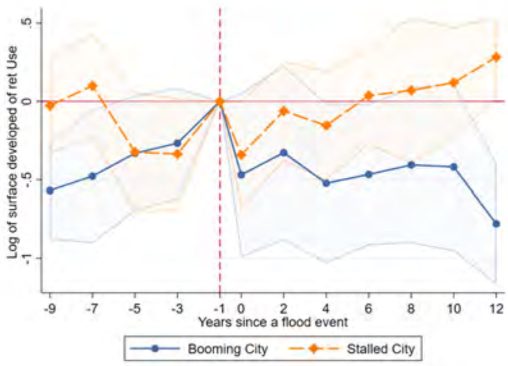
(b) Industrial Use



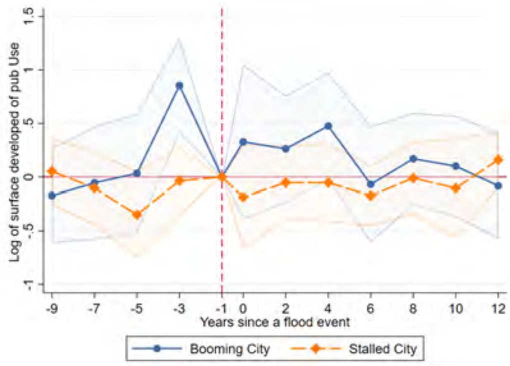
(c) Agricultural Use



(d) Office Use



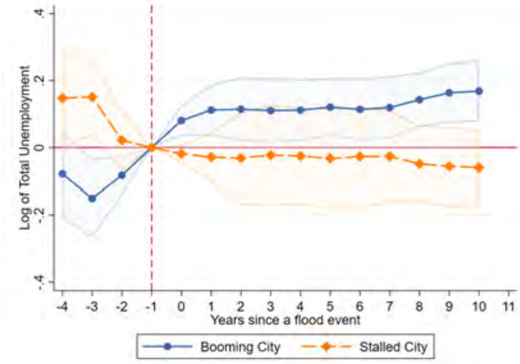
(e) Retail Use



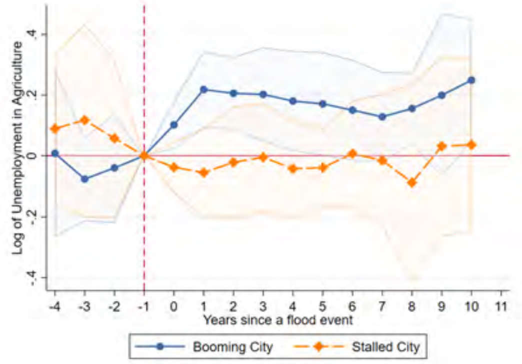
(f) Public Use

Notes: Effect of a flood on average floor surface built according to different final uses. A municipality is booming (stalled) if the share of the development on the 10 years previous to the flood is on the top (bottom) 20% of the sample distribution. Results are based on Equation 4.2. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

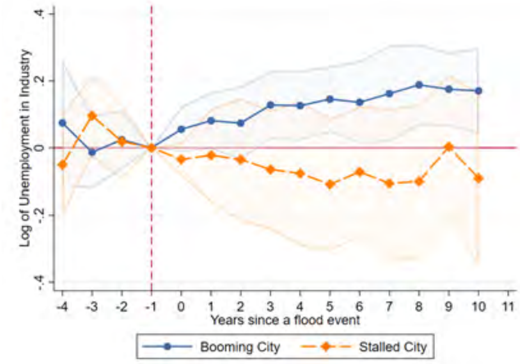
Figure A11: Effect of a flood on unemployment, for booming and stalled cities.



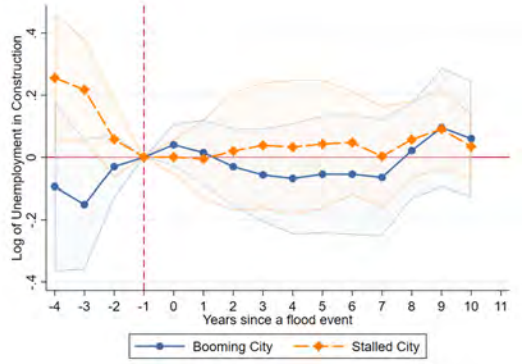
(a) Total unemployment registered



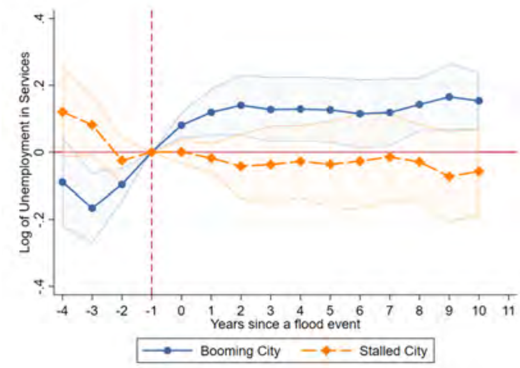
(b) Unemployment in agricultural sector



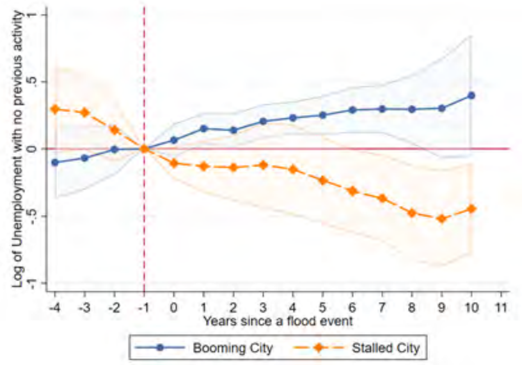
(c) Unemployment in industrial sector



(d) Unemployment in construction sector



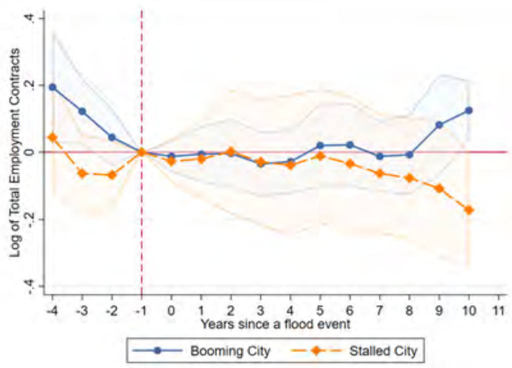
(e) Unemployment in services sector



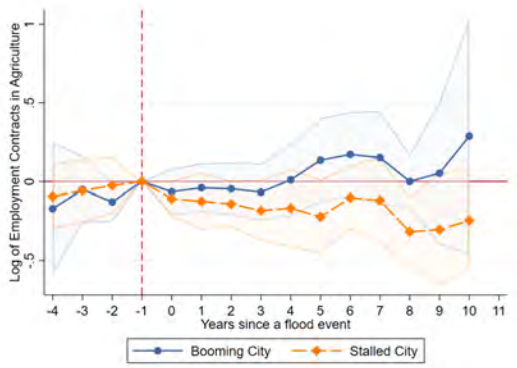
(f) Unemployment with no previous employment

Notes: Effect of a flood event on unemployment according to different sectors of economic activity. A municipality is booming (stalled) if the share of the development on the 10 years previous to the flood is on the top (bottom) 20% of the sample distribution. Results are based on Equation 4.2. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

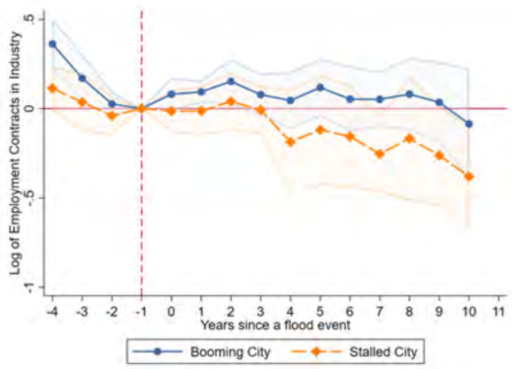
Figure A12: Effect of a flood on contracts, for booming and stalled cities.



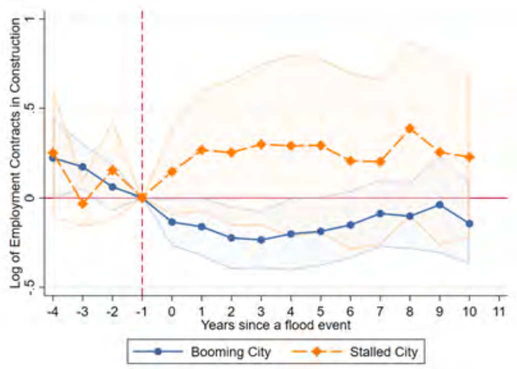
(a) Total contracts



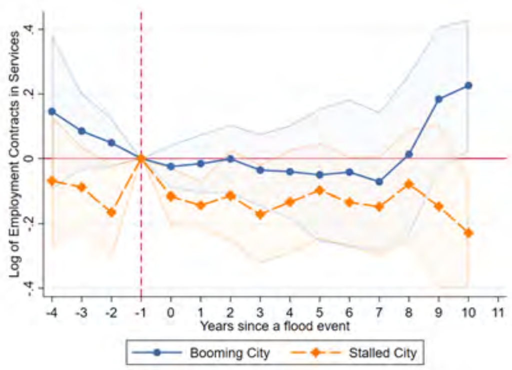
(b) Agricultural contracts



(c) Industry contracts



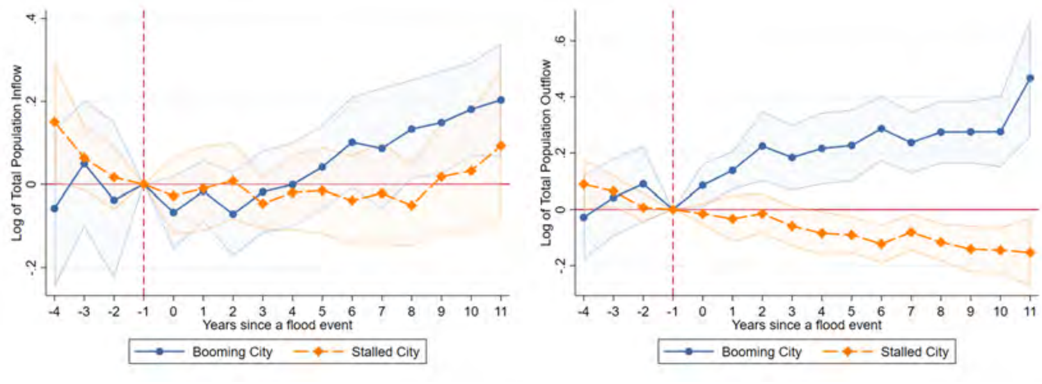
(d) Construction contracts



(e) Services contracts

Notes: Effect of a flood on employment contracts signed according to different sectors of economic activity. A municipality is booming (stalled) if the share of the development on the 10 years previous to the flood is on the top (bottom) 20% of the sample distribution. Results are based on Equation 4.2. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

Figure A13: Effect of a flood on migration, for booming and stalled cities.



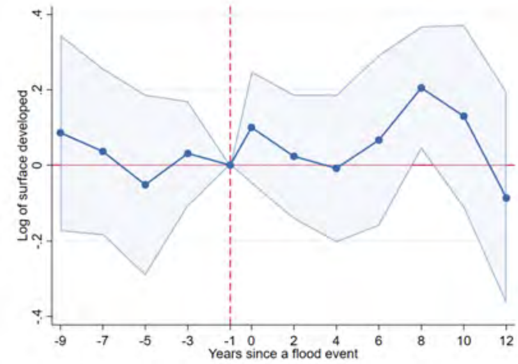
(a) Total inflow

(b) Total Outflow

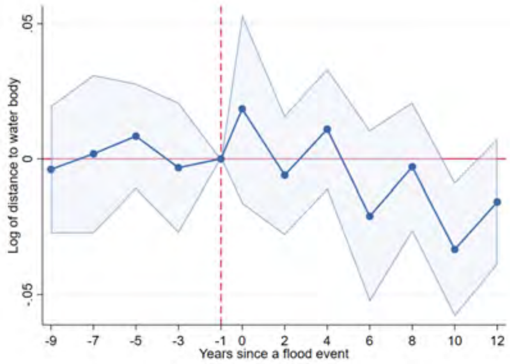
Notes: Effect of a flood on total number of people moving in and out from the flooded municipality. A municipality is booming (stalled) if the share of the development on the 10 years previous to the flood is on the top (bottom) 20% of the sample distribution. Results are based on Equation 4.2. The coefficient for the year before a flood is normalized to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

C Robustness

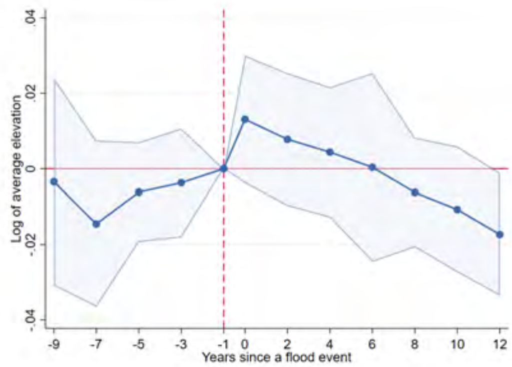
Figure A14: Effect of a flood event on flood surface, distance to nearest water body and on elevation: Destructive floods database.



(a) Effect on floor surface



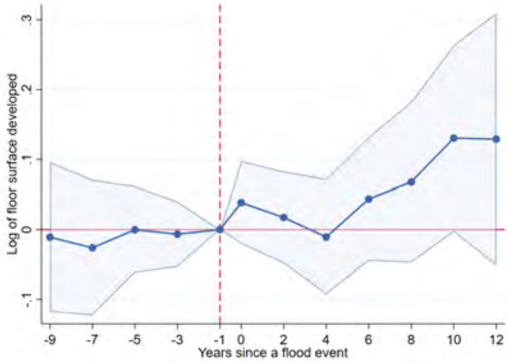
(b) Effect on distance to water body



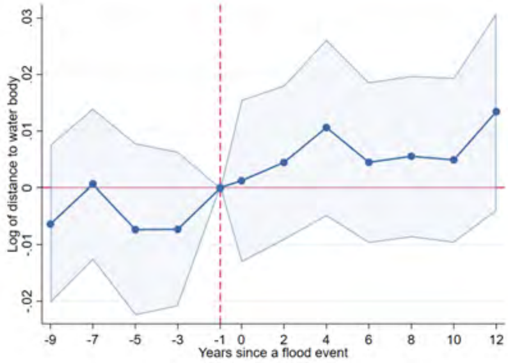
(c) Effect on elevation

Notes: These figures plot the impact of a flood on new development's (log of) floor surface built, distance (in meters) to a water body, and terrain elevation. Results are based on Equation 4.1. See Section 4.6.3 for more details.

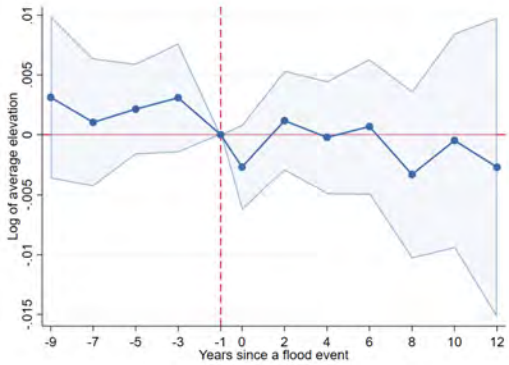
Figure A15: Effect of a flood event on flood surface, distance to nearest water body and on elevation: Rainfall cell-level data.



(a) Effect on floor surface



(b) Effect on distance to water body



(c) Effect on elevation

Notes: These figures plot the impact of a flood on new development's (log of) floor surface built, distance (in meters) to a water body, and terrain elevation. Results are based on Equation 4.3. See Section 4.6.3 for more details.

D ARPSIs

Figure A16: Evolution of new development within 100m of an ARPSI and of control areas.

Notes: The vertical axis measures the effect of a flood event on log of the new surface built within 100 meters of an ARPSI or a water body within the same municipality. Results are based on Equation 4.4. The coefficient for the year before the ARPSI declaration is set to zero. The bars show the 95 percent confidence interval. Standard errors are clustered by province.

5 Concluding Remarks

The urban population is growing at a fast pace: cities add 1.5 million new inhabitants every week and by 2050, there will be an increase of 2.5 billion people living in urban areas (United Nations, 2018). This growth in the urban population implies extensive opportunities for progress, given that no country has been able to develop without urbanization (World Bank, 2016). However, this urban growth also puts enormous pressure on the provision of infrastructure, services, jobs, climate, and the environment (World Bank, 2008). Furthermore, one of the most challenging areas will be the provision of affordable housing. Housing affordability is one of the top concerns for the urban population in developed countries, and cities are becoming increasingly expensive (Causa and Woloszko, 2020). Evidence shows that unaffordable housing imposes high costs for society. This Ph.D. dissertation contributes by shedding new light on three topics that significantly impact housing in urban areas, using fine-grained data.

Chapter 2 studies how Airbnb affects a city's housing market. For that, we apply several regression-based approaches that exploit the timing and geography of the entry of Airbnb in Barcelona to estimate the effects of this platform on housing markets. We use high-quality microdata on both rents and prices and combine these data with information on the location of Airbnb activity within the city.

The results show that Airbnb activity in Barcelona has increased both rents and housing prices, with larger effects for prices than for rents. Results indicate that, for a neighborhood with the average Airbnb activity in the city, rents have increased by 1.9%, while transaction prices have increased by 4.6% and posted prices by 3.7%. However, in the most touristic parts of the city, the effects of Airbnb are substantially higher. In neighborhoods in the top decile of the Airbnb activity distribution, rents are estimated to increase by as much as 7%. In contrast, increases in transaction and posted prices are as high as 17% and 14%, respectively.

Chapter 3 estimates the long-term effects of an increase in the unemployment rate at graduation time on housing tenure and affordability. I exploit the unemployment rate at the time of college graduation as an exogenous income shock to the individual, for a large sample of college graduates since 1960 across Europe. This strategy has been explored extensively for career outcomes, but so far, not for housing tenure and affordability. These two outcomes are essential, as they are key determinants of an individual's welfare.

The results show that a one percentage point rise in the unemployment rate at the time of graduation leads to a 1.5 percentage point increase in the probability of living with parents one year after graduation. Additionally, it decreases the probability of renting by 1.02 percentage points and of ownership by 0.45 percentage points. Worse initial labor market conditions translate into worse affordability ratios for owners and renters due to lower household income and stable rents or prices. Effects are persistent over time and are still present ten years after graduation.

I develop an overlapping generations (OLG) model to link income shocks to younger cohorts to housing tenure and affordability changes. This model provides several predictions. Mainly, that rigidity on the rental market is largely responsible for whether the labor market's welfare shock is absorbed or amplified by the housing market. This rigidity will result from an outside option for landlords, a feature widely documented in the literature. In particular, if rental markets are rigid, an income shock to young agents will create a shift away from renting and ownership in favor of the parental home. Additionally, this shock worsens affordability for both renters and owners, as their incomes drop while housing costs do not. This scenario leads to significant welfare losses for young cohorts, while older agents become relatively wealthier and are better off.

I find that housing aid policies such as the *Aide Personnalisée au Logement* (APL) in France can help mitigate the income shock by enabling young agents to afford to rent. However, these policies only improve young agents' welfare when implemented in rigid rental markets, pointing towards the importance of identifying the correct conditions for applying these policies.

Chapter 4 studies the dynamics of land development in Spanish municipalities having experienced a flood over the last 30 years. For that, we use changes in surface, distance to flood zones and water bodies, and elevation of new development compared to the year before a flood event. Our empirical strategy relies on the assumption that, conditional on municipality and year fixed effects, the timing and the extent of a flood is as good as random. We also study the impact of floods on several other economic indicators, including employment and migration patterns.

Our main results indicate that, on average, experiencing a flood does not affect new development. Development takes place at a pace similar to that of the year previous to the flood. Additionally, we find that new construction does not take place farther away from the flood zones nor on higher ground. When analyzing development's final use, we find that residential buildings are being built at the same rate as before the flood. A flood event does not significantly affect other key economic variables, such as unemployment or migration.

Nonetheless, municipalities with low development levels in the decade before the flood experience a housing boom after the event. New development increases permanently by 25% compared to the year previous to the flood for these cities. In contrast, cities having experienced high levels of development before the flood experience a 27% permanent drop in new construction compared to before the event.

Finally, we study an EU directive mandating EU member states to identify flood-prone areas, named ARPSIs. In the Spanish case, this directive identified areas that were not previously considered dangerous. Still, it was not accompanied by any regulation designed to restrict future development. We compare areas that were newly declared as potentially hazardous to areas close to water bodies but were not affected by the policy. Overall, signaling areas as potentially high-risk does not deter development from taking place near such areas.

To conclude, this dissertation has dealt with topics closely affecting housing, such as new sharing platforms, labor market conditions for young people, and climate change. We can draw three main lessons from this research in terms of policy design. First, home-sharing platforms can increase housing prices in cities like Barcelona, particularly in the most touristic neighborhoods. This points towards the potential effects that regulating these platforms' activities can have on housing affordability. Second, the success of policies directed to improving housing affordability and accessibility for young people can depend heavily on the rental market conditions. In particular, even when policies are targeted towards the young and least well-off population, benefits can still be captured by wealthier and older landlords, leaving the targeted population worse off. Third, signaling certain areas as potentially dangerous is not enough to deter development from taking place near such areas. In particular, if restrictions are not enforced after signaling areas as high-risk, it can lead to overdeveloping close to these zones, exposing more construction to potential flood risks.

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