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Renters vs owners: the impact of accessibility on residential location choice.

Evidence from Lyon urban area, France (1999-2013)

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Abstract

Urban areas face important challenges linked to contradictory trends of concentration, urban sprawl and segregation. More and more people choose to buy a residence in the suburbs taking advantage of the accessibility increase. At the same time, young households choose to rent in central areas. In this paper, distinguishing between renters and owners, we investigate the evolution of the households' location choice determinants over time with a special focus on accessibility to employment. Our case study is the Lyon urban area. We rely on discrete choice models using the disaggregated census data of the location choices of households from 1999, 2008 and 2013 and we calculate elasticities. The results confirm our initial intuition. Owners become less sensitive to accessibility to employment over time whereas it is the opposite for renters. Our results suggest the importance of incorporating these temporal evolutions into models for a better land-use transport integration and policy.

Keywords: Accessibility, temporal evolution, residential location choices, spatial multinomial logit model

1 Introduction

Urban growth is marked by contradictory trends of concentration, urban sprawl and residential segregation that pose major challenges in terms of sustainability. Integrating the interactions between transport and land use, accessibility is a key concept both for understanding these dynamics and for planning sustainable urban policies (Bertolini et al., 2005; Geurs and van Wee, 2004; Halden, 2002). Accessibility is an essential location attribute explaining the residential location choices (Alonso, 1964; Eliasson, 2010; Lee et al., 2010). It is also central to LUTI modelling (Baraklianos et al., 2020; de Palma et al., 2005). However, its consideration remains limited to observations at a single point in time, regardless of housing tenure status, with a few exceptions (Haque et al., 2018; Inoa et al., 2015; Plaut, 2006; Waddell, 1996). Yet, preferences for accessibility differ between renters and owners and its importance might change and evolve over time and space. Temporal and spatial dynamics can be internal to the land-use and transport system (improvement or deterioration of the transport system, relocations of activities) or external (perception of individuals) and can influence how accessibility is valued by the households for their location choices (Kasraian et al., 2016; Portnov et al., 2011).

In this paper, we aim to contribute to the understanding of the location choices of households and to overcome some limits of previous works. How different is the impact of accessibility on the location choice between renters and owners? From a modelling perspective is it essential to estimate market share models? More importantly, how has the impact between these two groups evolved over time? In case of accessibility increase, do both groups have the same reaction? If not, how do owners and

renters adapt their location choices? To our knowledge, few works have analysed the residential location choices of these two groups together and even less the temporal evolution of their behaviours. Analysing those spatio-temporal dynamics is important not only to understand the residential location behaviour but also to model the interaction with transport and accessibility.

However, such a spatio-temporal analysis is a very demanding task in terms of data. Observations (e.g. household choices), estimations (e.g. generalised times) and socio-demographic data characterising the alternatives need to be available at multiple points in time. This might explain why works studying the temporal evolution of such impacts are rare. Here, building on previous knowledge and taking advantage of the available data through previous works (Aissaoui et al., 2015; Aissaoui, 2016; Baraklianos et al., 2020; Cabrera-delgado, 2013; Homocianu, 2009), we analyse the evolution of the impact of accessibility to employment on the residential location choice of renters and owners over time. For that, we rely on a discrete residential location choice model for the Lyon urban area in France. We use data for residential location choices drawn from the disaggregated census data of 1999, 2008 and 2013 and we estimate elasticities to measure the evolution of the sensitivity to accessibility and other location attributes. During this period, the city of Lyon has strongly increased its public transport supply by introducing new tramway lines and by extending the metro network while there was little investment in heavy car infrastructure (Bouzouina and Nicolas, 2015). In parallel, the urban area faced an important population and employment growth. From 1999 to 2013, the population increased by 22% while the employment progressed by 17%. The economic growth and demographic pressure are reflected in the housing market, increasing housing values especially during 1999-2008. These circumstances provide us with an interesting case study.

The rest of the paper is structured as followed. Section two develops the literature review. Section three presents the study area and the evolution of the population and the transport infrastructure during the analysis period. In section four, we present the applied methodology and in section five the results. In the last sections, we discuss the results and their implications along with the limits and the perspectives of our work.

2 Literature review

Accessibility is an important determinant for a residential location choice, but as it becomes more available, thanks to new transport infrastructures and economic growth, its importance might decrease. This behaviour is explained by the standard urban economics theory, the bid rent theory (Alonso, 1964; Mills, 1967; Muth, 1969). Households will seek larger properties as a result of transport cost reduction. The stability of commuting around one hour – one hour and a half over the last century (Zondag and Pieters, 2005), seems to confirm this hypothesis. Transport improvements were capitalised into longer distance commute trips due to distant residential locations from working locations (Axhausen, 2008). In the USA, the construction of motorways significantly contributed to

the suburbanisation of the population in the period 1950 to 1990 (Baum-Snow, 2007; Wilson et al., 2007). In Switzerland, the increase of accessibility led to a decrease in the importance of accessibility on the evolution of the population in the period 1950 to 2000 (Portnov et al., 2011). In Lyon, the mean distance to work increased in the period 1985 to 2006 (Cabrera Delgado and Bonnel, 2016) mostly due to the transport improvements. Other studies confirm that even investments on public transport infrastructures have contributed to the decentralisation of the population in Europe (Garcia-Lopez, 2012; Levinson, 2008).

Over the last 20 years, despite the constant increase of accessibility of urban areas, we have observed a revival of the city centres across Europe (Buzar et al., 2007; Melia et al., 2018) and the USA (Deka, 2018; Moos, 2013). Arguably, this re-urbanisation is mostly triggered by younger generations, the so-called millennials (roughly the generations born in the 80s and 90s (Deka, 2018)). Young households prefer to live in central locations with good accessibility, where public transport supply is satisfying, at the expense of the spacious but car-dependent suburbs (Deka, 2018; Melia et al., 2018). Although inducing higher housing costs (Palm et al., 2014), this trade-off for transit accessibility is conducive to lower transportation costs. In Lyon, the daily mobility expenditures decreased by 15% for households under 30, who mostly live in the centre, while they increased by 15% for the average population, between 1995 and 2015 (Nicolas and Pelé, 2018). Various explanations have been given to this phenomenon (economic circumstances, anti-car culture, prolonged studies,...) (Deka, 2018; Melia et al., 2018; Myers et al., 2019). Despite the various interpretations of this behaviour, a common denominator seems to be the preference for accessibility for the residential location choices (Thomas et al., 2015).

A characteristic qualifying these two diverging residential choice behaviours is the type of choice (Haque et al., 2018). On the one hand, owners are households that make long-term decisions and sacrifice accessibility over other attributes. They seem to take advantage of the transport improvements to buy a residential unit in locations outside the highly accessible but expensive city centres (Palm et al., 2014). On the other hand, young households are renters and make a short/medium-term choice. They choose to rent a house in locations that offer high accessibility, despite the constant increase of accessibility.

Research analysing the differences between renters and owners converges on the idea that accessibility is more important for renters. This preference is related to the life stage of the household, which explains certain location decisions (Wilson et al., 2007). Specifically, Waddell (1996) analysed the residential location choices of households for Honolulu and confirmed that owners are less sensitive to accessibility to employment than renters. Plaut (2006) analysed the residential choice decisions in the USA of renters and owners to explain the mobility decision of dual-income households. He found that owners commute farther away. Inoa et al. (2015) studied the location choice decisions of households

in Paris and found that renters appreciate better the accessibility of a location than owners. They relate this to the household's life cycle. A young household chooses a location with good accessibility in order to maximise all potential activities and employment. At later stages, when the workplace is more stable and the household has children, a location choice at less accessible areas with other advantages is more likely.

Although the observation that renters are more sensitive to accessibility than owners is not new, recent works have highlighted that this tendency has been reinforced after the 2000s. This trend is identified as a revitalisation process of the city centres due to the massive move of young households (Millsap, 2016). This tendency is highlighted in the works of Florida (2004) and Glaeser et al. (2001), suggesting that the reason behind this re-densification of the city centre is the presence of rich amenities in central - high accessible areas. In the few empirical works, analysing the temporal evolution of the households' location preferences, the results are not conclusive. Rezaei and Patterson (2016), making a temporal analysis of the residential location choices in Montreal, between 1996 and 2006, found that the households are becoming more sensitive to accessibility with time. However, the authors do not distinguish in their analysis between owners and renters for the accessibility variable, but the majority of the sample were renters (69%). We assume that this observation is due to the behaviour of renters. Furthermore, we do not know what the evolution of accessibility was like during that time. Any observed changes could be due to the accessibility improvements or deteriorations. A study for London (Haque et al., 2018) analysed the temporal evolution of the residential choices of renters and owners until 2002 and found a different result. The authors argue that the owners became more sensitive to the distance to the city centre while the renters left the city centre because of the high rents. However, both types of households without cars became more sensitive to the proximity to Public Transport. While these results seem surprising, this study presents some limits. First, the linear distance does not capture any possible differences of the accessibility throughout time. Second, the use of the same data to characterise the alternatives for various observations in time is an issue, as we do not know the level of location attributes at the time the choice was made. Thus, parameters can be biased.

3 Study area

Our study focuses on the Lyon urban area in France. It has a population of 1.87 million and around 0.8 million jobs (INSEE, 2013). The urban area has a surface of about 3.3 thousand square km. It is the second-largest metropolitan area of France after Paris in population and economic terms. Figure 1 presents the perimeter of the urban area of Lyon and the aggregate zoning used for the rest of the analysis.

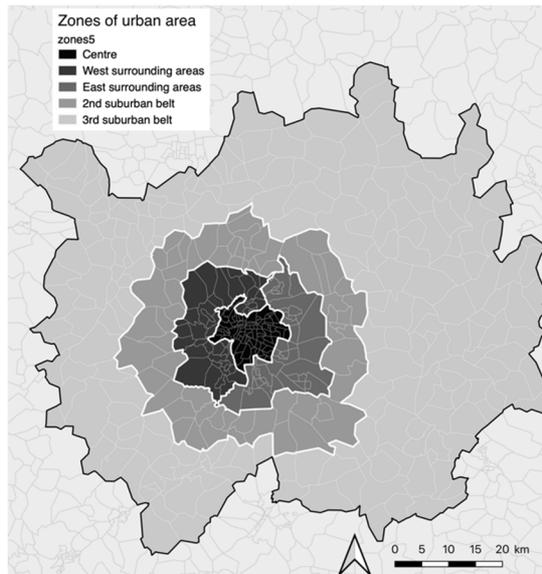


Figure 1. Aggregate urban area zoning of the urban area of Lyon. Source Baraklianos et al., 2020

3.1 Evolution of the population

During the past 50 years, the urban area has increased its population by almost 50%. However, this evolution was not uniform. Like the majority of cities in Europe and the USA, Lyon has experienced the suburbanisation process. During the post-war era and until the 1990s, the population of the city centre decreased dramatically by 18% in the period 1968 to 1990 while the population of the whole area increased by 23% (Figure 2). From 1990 and afterwards, the tendency has changed and the population of the centre started increasing. In the period 1990 to 2013, the population of the centre increased by 22% surpassing the increase rate of the whole area, which was 20% during the same period.

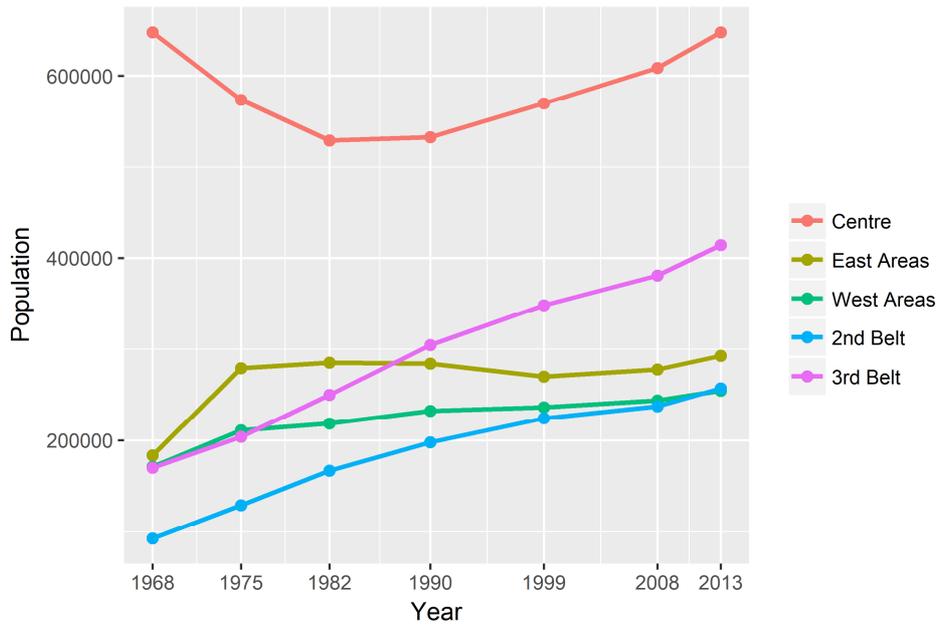


Figure 2. Evolution of population from 1968 to 2013 by analysis zone

From 1999 and onwards, the increase in the population of the centre was principally due to renters (Figure 3). While the number of owners-households increased marginally, the number of renters-households presented an increase of 50%. On the contrary, the owners drove the growth of the other zones (2nd belt and 3rd belt) a little more than the renters in the period 1999 to 2013 (for the aggregate zoning, see Figure 1). This tendency of the return to the city centre is highlighted for Lyon in the literature by Aissaoui et al. (2015) and Rosales-Montano et al. (2015). This observation seems to be related to the attractiveness of central areas by younger generations (Deka, 2018; Melia et al., 2018; Myers et al., 2019). The analysis of the housing construction permits (Table A1 – Appendix) does not reveal any strong relation with the number of moved households.

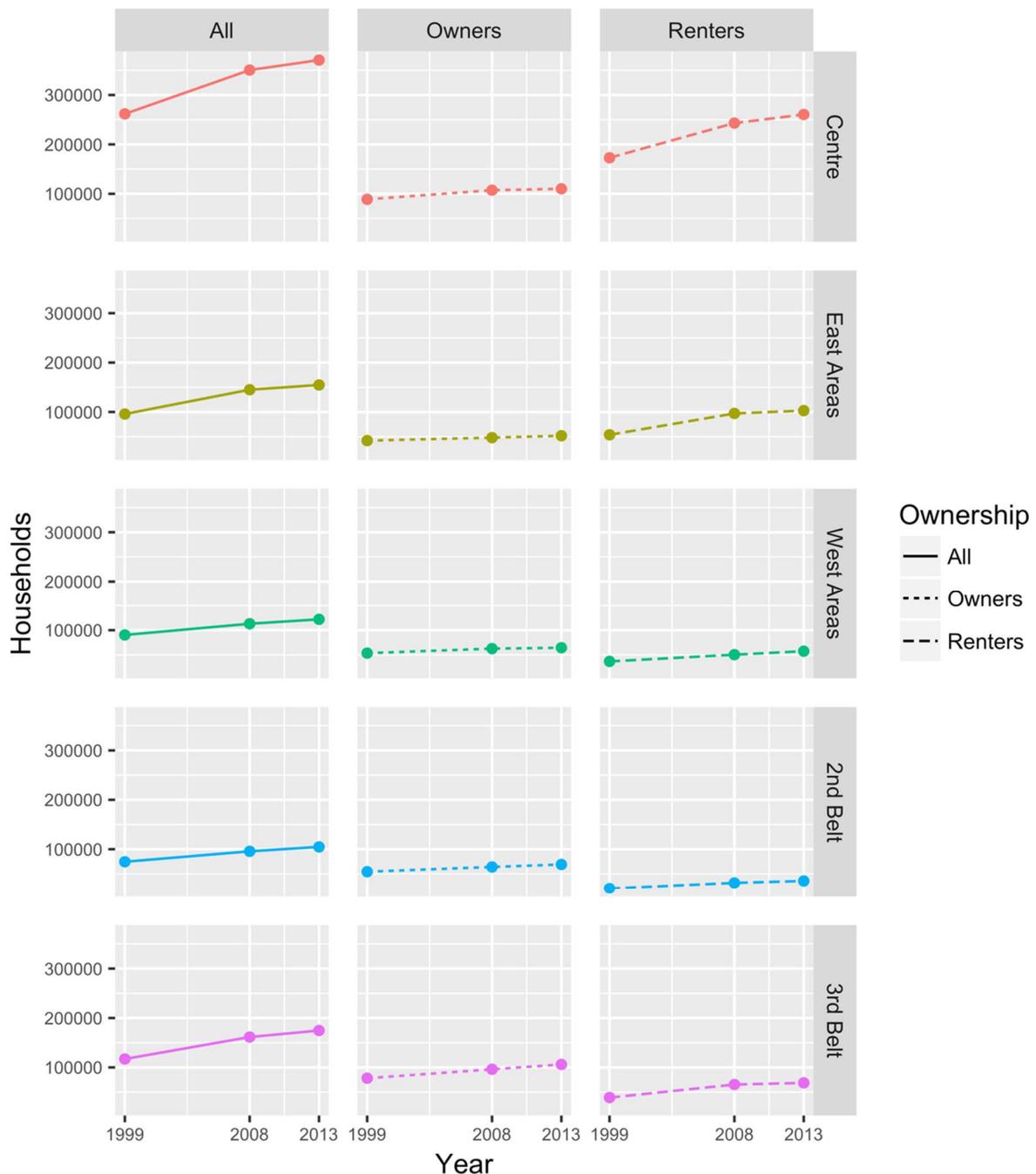


Figure 3. Evolution of the number of households from 1999 to 2013 by aggregated analysis zone (Figure 1) and housing ownership status

3.2 Evolution of public transport supply and accessibility

In the last 15 years, the network of the public transport of Lyon has been significantly improved. While the metro network changed marginally in the period 1999 to 2013 with three new stations, the investments in the tramway network were substantial. The first two tramway lines opened in 2000-2001, and three other new lines were inaugurated in 2006, 2009 and 2012, summing up to 58 kilometres of tramway network (Figure 4). During the same period, there were not any significant car infrastructure investments in the study area. On the contrary, local authorities applied a policy aiming

to decrease the importance of the car in the city of Lyon. Principally, they reallocated the urban space from car to public transport (tramlines, lanes for Buses with High Level of Service, junction priority to buses) or to other softer means of transport (bike lanes, pavement widening).

These investments together with the increase of the employment opportunities of the area (as stated before, the number of jobs has increased by 17% during the analysis period 1999 to 2013) significantly contributed to accessibility increase. Some areas benefited better from this improvement (Table 1). The 3rd and the 2nd belt had the most significant increase in accessibility to employment. Nevertheless, the 3rd belt is still by far the most deprived area in terms of accessibility. This favourable policy for public transport had a significant impact on the evolution of the modal shares in Lyon. Based on data from the Households Travel Surveys, car use decreased significantly for trips to work (from 67% in 1995 to 56% in 2015¹), while the modal share of public transport progressed by 9% (from 12% to 21% respectively¹).

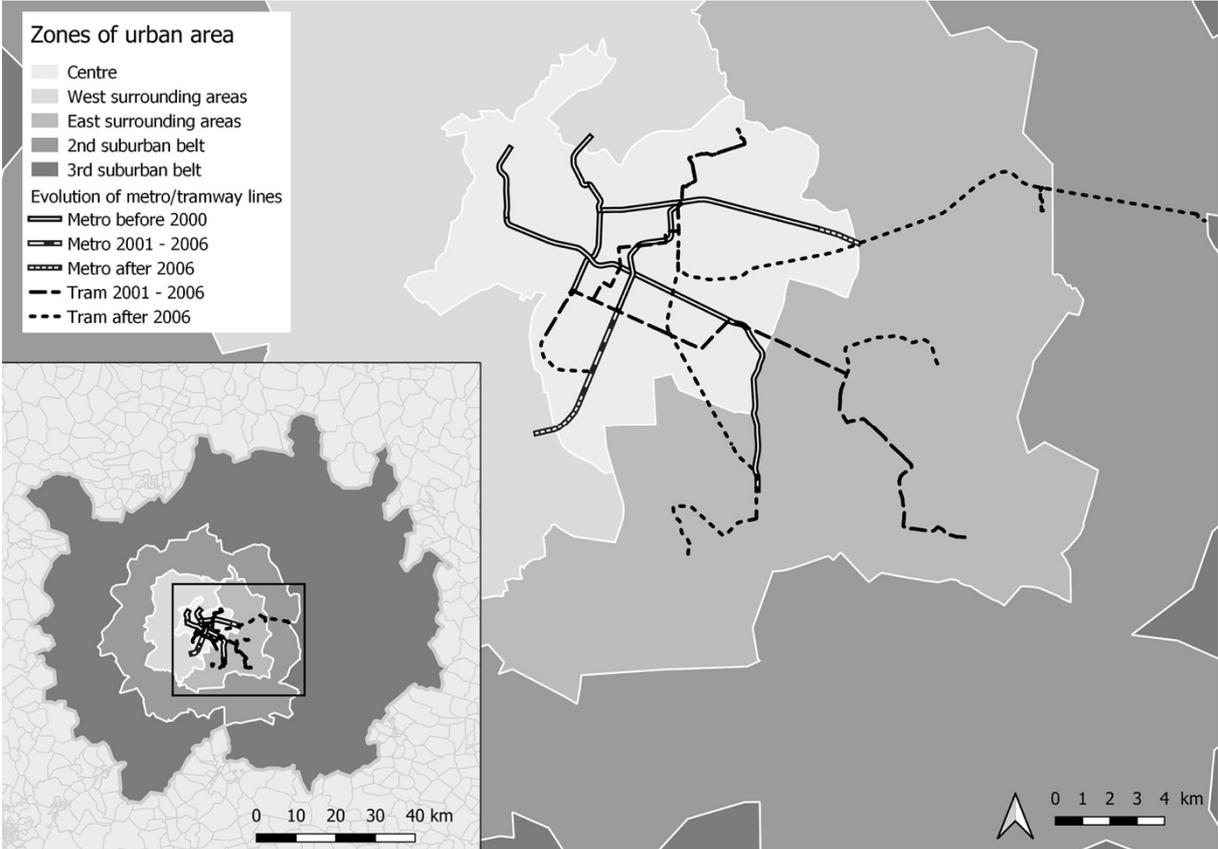


Figure 4. The metro/tramway network evolution

Table 1. Accessibility to employment evolution by aggregate zoning zones

	Centre	East surrounding areas	West surrounding areas	2nd urban belt	3rd urban belt	Total
Mean accessibility to employment (equation 6)						

¹ Own calculations from the household travel surveys data of the years 1995 and 2015.

1999	151,576	86,134	74,333	30,441	7,066	
2008	186,271	119,882	108,081	43,918	11,683	
2013	208,166	139,144	129,055	65,560	21,018	
Accessibility evolution						
1999 - 2008	+23%	+39%	+45%	+44%	+65%	+33%
2008 - 2013	+12%	+16%	+19%	+49%	+80%	+23%

4 Method and data

4.1 Residential location choice model

The methodology used in this case study is based on discrete choice models (McFadden, 1977). In this type of models, the decision-maker selects the alternative from a choice set which maximises his utility (Schirmer et al., 2014). In the residential location choice studies, the decision-maker is the household, and the alternatives are residential units. The individual utility is composed of a deterministic observable part and by a random term (equation 1).

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

where: U_{in} is the utility of household n at location i

V_{in} is the deterministic part of the utility

ε_{in} is the error term

Under the IID assumption about the error terms (McFadden, 1977), the probability of a household n making the choice i from a set of alternatives j , takes the logit form as is given by equation 2.

$$Pn(i) = \frac{e^{V_{in}}}{\sum_{j \in D_n} e^{V_{jn}}} \quad (2)$$

where: V_{in} is the deterministic part of the utility of household n at i

V_{jn} is the deterministic part of the utility of alternatives j in D_n

D_n is the random choice set

In the Multinomial Logit (MNL) model, the deterministic/observable part of the utility depends on the attributes of the alternatives (zonal, dwelling etc.) and the socio-demographic characteristics of the households. The utility function takes the form of equation 3.

$$V_{in} = \alpha X_i + \beta Z_{in} \quad (3)$$

where: X_i is a vector of zonal attributes

Z_{in} are the interaction terms of socio-demographic characteristics of household n with the attributes of alternative i

α, β are parameters to be estimated

The assumption that the error terms are IID is a limit of the spatial logit models (Ibeas et al., 2013). Other nested, cross-nested or mixed logit models relax this hypothesis. However, these modelling structures need an *a priori* assumption on the correlation structure and are difficult from an estimation point of view. Furthermore, they do not seem to improve the modelling results empirically for our case study (Aissaoui, 2016). Another option is to introduce spatially lagged terms into the deterministic part of the utility function (Alamá-Sabater et al., 2011; Rezaei and Patterson, 2016).

The problem of space arises because space is artificially divided into zones for modelling reasons. However, an attribute probably spills over into the contiguous zones. This spillover effect influences the utility of the observed choices. If it is not controlled, the model will estimate biased parameters. To control this effect, we extend the methodology applied to the firm location choice by Alamá-Sabater et al. (2011) into the residential location choice. We introduce spatial lag terms for variables that present important spatial autocorrelation into the deterministic part of the utility function (see Moran's I indices in Table 3 for the spatial autocorrelation). Thus, equation 3 becomes equation 4. For the construction of the contiguity matrix, there are various methods. Alamá-Sabater et al. (2011) used a distance based matrix. In our case, we define the spatial lag terms more simply. We use a binary contiguous zones (queen contiguity) binary matrix and calculate the spatial lag variables as the mean value of the attributes of these zones. A further complication of the spatial weights matrix has not improved the modelling results.

$$V_{in} = \alpha X_i + \beta Z_{in} + \delta(\alpha X'_i + \beta Z'_{in}) \quad (4)$$

Where: X'_i is a vector of spatially lagged variables

Z'_{in} is a vector of spatially lagged variables for the interaction terms

δ is the spatial lag scale capturing the average influence of all the spatially lagged terms

The applied residential location choice model in our study is a Spatial MultiNomial Logit (SMNL) model and the alternatives are neighbourhoods. The study area is divided into 431 zones / neighbourhoods. This zoning is a census breakdown defined by the INSEE (Institut National de la Statistique et des Etudes Economiques - French National Institute for Statistics and Economic Research). These neighbourhoods have the advantage to be more detailed than the communes in the city centre and respecting a certain amount of homogeneity of the socio-demographic composition of the population (INSEE 2016).

The estimation of a model with such a high number of alternatives is computationally difficult. When there is such a large number of alternatives, the parameters can be estimated using a random sample of alternatives D_n of the true choice set C_n and get consistent parameters (equation 2) (McFadden, 1977). There is no theoretical development over the size of the sample. In empirical works, the results are not

conclusive. Authors suggest various sampling strategies (random sampling, stratified) and sizes (Chen et al., 2005; Nerella and Bhat, 2004; Zolfaghari et al., 2012) but the final choice depends on the obtained results of each case study. In the Paris case study, Picard and Antoniou (2014) consider that a sample of 10 alternatives is a reasonable figure for household location choice. In previous work carried out in the Lyon urban area (Aissaoui et al., 2015; Aissaoui 2016), we tested for various sample sizes of the D_n , up to fifty-four choices using random and stratified sampling strategies. We concluded that the best sample for the estimation is a random sample of seven random choices, the observed choice included, for every observed household choice. This small random sample is sufficient and gives robust estimations with stabilized parameters (Aissaoui et al., 2015; Aissaoui 2016; Baraklianos et al., 2020). Bigger samples give the same stable parameters but take a longer time to converge. Smaller samples do not give stabilised parameters.

To capture any potential systematic taste variations, we estimate market share models based on the housing occupancy status, distinguishing between renters and owners. The estimation is made jointly for the two groups. This distinction is important not only from a market point of view (owners are making a long-term choice while the renters are making a shorter-term choice) but also from the point of view of the characteristics of those two groups (Haque et al., 2018). Households that are owners tend to be richer, with more cars and with more household members, while households that are renters tend to be younger with less stable employment status.

The extraction of the observed residential choices was possible using the disaggregated census data provided by the INSEE, for the years 1999, 2008 and 2013. Using this database, we identify the households that moved in a certain neighbourhood during the last two years, the recently moved households. Consequently, we have 112,112 observations in 1998-1999, 102,920 observations during 2006-2008 and 120,623 during 2011-2013. The database contains information about the households like car ownership, number of individuals by household, the age of the household head and the status of the housing occupancy (owner/renter). The distribution by renters/owners and by area is presented in Table 2. We observe that during the period 2006-2008, the share of owners who have recently moved is higher than the other analysed periods. This period coincides with a period of strong economic growth. More and more households are becoming homeowners, a fact that drives prices upwards (Rosales-Montano et al., 2015). However, the inflation of housing values together with the economic crisis made access to home ownership more difficult during the last analysed period.

Table 2. *Distribution of recently moved households by aggregate zoning and housing occupancy status*

	Centre	East surrounding areas	West surrounding areas	2nd urban belt	3rd urban belt	Total
Recently moved households						
1999	55%	12%	12%	8%	14%	112,112
2008	55%	11%	11%	8%	15%	102,920
2013	53%	12%	12%	9%	14%	120,623

Housing occupation status of recently moved households

1999	Renters	85%	80%	69%	57%	66%	78%
	Owners	15%	20%	31%	43%	34%	22%
2008	Renters	78%	65%	62%	52%	59%	69%
	Owners	22%	35%	38%	48%	41%	31%
2013	Renters	84%	74%	69%	58%	63%	75%
	Owners	16%	26%	31%	42%	37%	25%

4.2 Determinants of location choices

Studying the temporal evolution of residential location choice does not only require the disaggregated data of the observed choices but also data on the attributes of the alternatives. This was possible through a combination of various databases. Ideally, data on location attributes must be for the beginning of the analysis period, to guarantee the exogeneity of these attributes. For example, for household choices made in the period 2006 to 2008, we need data characterising the alternatives for 2006. If we use the data of periods long after the observed choices, it is possible that the location attributes have changed, which would bias the parameter estimation. Nevertheless, it is very difficult to have the same historical data for the desired year. Because it was not always possible in our case, we had to make some compromises, while staying methodologically sound, which we describe in detail in this section. After testing for various specifications, the variables included in the model are divided into three categories: the spatial amenities, the social environment and the market trade-off (Aissaoui et al., 2015). Several forms of the different indicators were tested. Table 3 summarises the descriptive statistics of the zonal attributes. For a more detailed discussion of the variables, especially for accessibility, please refer to Baraklianos et al. (2020).

The first category captures self-segregation effects and preferences for social housing. The households have a preference to choose a location that has a high concentration of the same revenue (Bouzouina, 2008). To measure these self-segregation effects, we introduce the percentage of households in a zone per revenue quantile (%REV3, %REV4, %REV5) as interaction terms with the same revenue quantile of the households (rev3, rev4, rev5). Regarding social housing, low revenue households should prefer zones with high social housing but high revenue households might avoid them. We introduce this variable as the percentage share of the social housing residential units of the zone (%HLM) interacted with all the five households' revenue quantiles (rev1, rev2, rev3, rev4, rev5). The data for the construction of the variables come from the databases of the INSEE² for the years 1999, 2006 and 2011. For these variables, we included spatial lag terms because we assume that the attributes of the contiguous zones can influence residential location choices.

² Historical data of the INSEE before 2006 are not free. We used the one from 1999 because it was available at the laboratory.

The second category concerns the amenities that a household would value to have nearby (within the zone), like basic shopping services (bakery, supermarket, convenience store), primary schools and secondary schools in the zone. We expect that these variables would have a positive influence. The data for the estimation of these variables come from the SIRENE³ database of the years 1999, 2006 and 2011. For these variables, we did not include spatial lag terms because they do not suffer from spatial autocorrelation (Table 1). The inclusion of spatial lag terms for these variables did not increase the quality of the model.

The third category is the market trade-off between accessibility to employment and land value. Households make a trade-off between accessibility and land value, as stated by the new urban economics theory (Alonso, 1964). We introduce land value as the zonal mean housing price per square metre. We estimate the housing prices from real estate transactions data from the periods 1998-1999, 2006-2007 and 2012-2013 (notary paid database - Perval). We introduce in all models the mean prices in euros 2013 to account for the impact of inflation. For the accessibility variable at location i , we use the potential accessibility to employment (equation 5) (Geurs and van Wee, 2004). This formulation captures accessibility changes due to transport network modifications (congestion, road network modifications and public transport improvement) or employment increase. We use a composite generalised time, which combines generalised times by car and by public transport (equation 6) (for more details see in Bhat et al. (2002), Bhat et al. (1999) and Baraklianos et al. (2020)). A 4-step transport model estimates the times from zone to zone for each period by car and public transport (Cabrera-delgado, 2013) that permits us afterwards to estimate the composite generalised times. The employment data come from the SIRENE database for the years 1999, 2006 and 2011. Even though these variables show important spatial autocorrelations, we did not include spatial lag terms. Accessibility is by construction spatially autocorrelated, meaning that the value of one zone already includes the effect of the contiguous zones. The housing price includes the spatial correlation effect already so we do not have to control for it. Housing prices are influenced by locational characteristics shared by zones close to each other (Baumont, 2009).

$$A_i = \sum_j D_j e^{-\beta Tc_{ij}} \quad (5)$$

where: D_j is the number of jobs at destination j

Tc_{ij} is the composite generalised time from origin i to destination j

$$Tc_{ij} = \left(\frac{Tcar_{ij}}{1 + \frac{Tpt_{ij}}{Tcar_{ij}}} \right) \quad (6)$$

where: Tc_{ij} is the composite generalised time from i to j

³ SIRENE is a disaggregated database that contains all the companies in France and is provided by the INSEE (French National Institute of Statistics and Economic Studies). This database before 2016 was paid, so we used the most suitable data point for developing the residential location choice models.

$Tcar_{ij}$ is the generalised time for car

Tpt_{ij} is the generalised time for public transport

Table 3. Descriptive statistics and spatial autocorrelation of the zonal attributes

Variable description	Variable	1999			2006			2011			Spatial Lag term
		Mean	SD	Moran's I	Mean	SD	Moran's I	Mean	SD	Moran's I	
Social environment											
Social housing share of households (%)	%HLM	0.11	0.18	0.43	0.12	0.17	0.39	0.12	0.16	0.42	Yes
Share of the 3 rd quantile of revenue (%)	%REV3	0.23	0.04	0.30	0.25	0.07	0.37	0.22	0.04	0.41	Yes
Share of the 4 th quantile of revenue (%)	%REV4	0.20	0.04	0.30	0.19	0.06	0.40	0.21	0.05	0.50	Yes
Share of the 5 th quantile of revenue (%)	%REV5	0.21	0.10	0.51	0.19	0.12	0.54	0.22	0.10	0.52	Yes
Spatial amenities											
Proximity to basic shopping service (number) (0,1)	Prox Basic Serv	0.84	0.34	0.18	0.85	0.35	0.24	0.86	0.35	0.20	No
Primary schools (number)	Prox Pr. Schools	3.79	3.52	0.11	3.79	3.43	0.12	4.1	3.67	0.12	No
Secondary schools (number)	Prox Sec. Schools	0.54	0.97	0.01	0.54	0.92	0.00	0.69	1.35	-0.01	No
Market trade-off											
Mean zonal housing price (€ 2013/m ²)	Housing price	951	268	0.72	2,753	535	0.73	2,503	487	0.63	No
Accessibility to employment	Acc. Emp.	51,333	58,228	0.91	68,482	70,817	0.97	84,018	76,360	0.96	No

5 Results and analysis

We discuss the results of the models before presenting the elasticity analysis. For each analysis period, we estimate all the models with the same independent variables distinguishing between renters and owners. Table 4 summarises the parameters and the significance level after a Bonferroni correction for Family Wise Errors FEW. Five different models were estimated to find the most relevant households characteristics. When one estimates a series of models, adjustments should be made in order to account for FEW. In our case, the number of individuals, the number of children, the employment status and education level of the household head along with the occupation status were tested and the confidence level is set to 99%⁴ after accounting for Bonferroni correction.

The market share approach is highly relevant. The division between renters and owners gave better modelling results than the pooled ones. The estimated parameters are significant and mainly have the expected signs. Accessibility is positive and significant for all periods and for both renters and owners. However, the parameter is higher for renters showing that they are more sensitive to accessibility.

Concerning the other variables, the signs do not vary between the different periods, except for the interaction term %HLM*rev4 (social housing – 4th revenue quantile household) for the owners, which

⁴ Before the correction for FWE, the confidence level was at 95%.

is not significant in 2008 and changes sign in 2013. This change shows a tendency that the presence of social housing decreases its importance for this revenue quantile.

Generally, households are very sensitive to the social environment, depending on their income. All households avoid neighborhoods with a high percentage of social housing, with the exception of renters belonging to the first and second income quantiles and owners belonging to the first income quantile. Whether renters or owners, households in higher income classes have a preference for neighborhoods where the percentage of households in the same income class is high. In addition, the spatial amenities variables have a positive and significant impact on the location choice of renters and owners over the entire period. The spatial scale parameter is significant and has a value under 1. This means that the attributes of the contiguous zones have an effect on the utility of the chosen alternative, but their influence is smaller than the effect of the attribute of the chosen zone (Alamá-Sabater et al., 2011).

Table 4. Estimated parameters and significance of the models

	1999		2008		2013	
	Renters	Owners	Renters	Owners	Renters	Owners
Social environment						
%HLM*rev1	1.21**	0.18**	0.80**	0.35**	1.37**	0.15**
%HLM*rev2	0.49**	-0.62**	0.15**	-0.43**	0.11**	-0.98**
%HLM*rev3	-0.24**	-0.79**	-0.50**	-1.07**	-0.70**	-1.36**
%HLM*rev4	-0.10**	-0.64**	-0.55**	0.13	-0.63**	0.79**
%HLM*rev5	-1.28**	-1.70**	-1.91**	-1.39**	-1.18**	-0.76**
%REV3*rev3	4.66**	3.97**	5.22**	8.38**	5.51**	5.16**
%REV4*rev4	5.04**	5.96**	5.07**	9.83**	6.66**	9.03**
%REV5*rev5	2.77**	2.20**	2.38**	3.67**	1.51**	3.36**
Spatial amenities						
Prox Basic Serv	1.19**	0.74**	1.45**	1.02**	1.42**	1.06**
Prox Pr. Schools	0.10**	0.09**	0.09**	0.10**	0.07**	0.08**
Prox Sec. Schools	0.06**	0.02**	0.07**	0.08**	0.10**	0.09**
Market trade-off						
Housing price	-0.69**	-0.10**	-0.11**	-0.13**	-0.18**	-0.33**
Acc. to Emp.	0.64**	0.43**	0.55**	0.26**	0.53**	0.21**
Spatial lag parameter (δ)	0.64**	0.64**	0.61**	0.27**	0.31**	0.14**
Observations (Total)	112,112		102,920		120,623	
Observations (renters/owners)	77,554	22,376	63,315	28,069	76,792	26,141
Log likelihood zero	-217,086		-199,400		-233,525	
Log likelihood (LL)	-159,666		-147,507		-175,905	
Rho-squared	0.264		0.260		0.247	

** significant at 99% after accounting for FEW.

Due to scale differences between models estimated for different years, we cannot directly compare the parameters. All the variables, except for the proximity to basic services, are continuous, so we can calculate mean point elasticities (equation 7), which are directly comparable. Elasticities are also more

convenient in terms of interpretation. The mean point elasticity shows the mean effect on the choice probability of an increase of 1% of this variable *ceteris paribus* (Washington et al., 2011).

$$E_k = \frac{\sum_{i=1}^I (1-P_{in}) \hat{\beta}_k X_{ink}}{I} \quad (7)$$

where: E_k is the mean elasticity for variable k

I is the number of households

P_{in} is the probability of household i choosing the location n

$\hat{\beta}_k$ is an estimated parameter for k

X_{ink} is the value of k for i at n

In Figure 5a&b, we present the evolution of the mean point elasticities of the market trade-off variables (accessibility to employment and housing price). The evolution of the other variables can be found in the appendix. Analysing the effect of accessibility alone is not consistent. This is why we focus on both market trade-off variables. Accessibility to employment is constantly more important for renters, given that the elasticity values of the renters are systematically higher than the values of the owners. Our results are consistent with previous studies (Inoa et al., 2015; Plaut, 2006; Waddell, 1996).

The evolution of the elasticities of accessibility to employment and housing price are very different between renters (Figure 5a) and owners (Figure 5b). For renters, the elasticity of accessibility to employment increases during the analysis period, meaning that the renters become more sensitive, despite the strong increase of the accessibility levels. The elasticity increases almost linearly, from 1.71% in 1999 to 1.90% in 2008 reaching 2.32% in 2013. The owners' elasticity for accessibility decreases during the analysis period, from 1.02% in 1999 to 0.67% in 2008 and 0.57% in 2013. At the same time, the evolution of the elasticity of the housing price follows the same tendency, as expected. Renters become less sensitive while owners present the opposite tendency. For renters, the evolution is not linear but the elasticity becomes less negative. While the sensitivity of renters to housing price decreased between 1999 and 2008, it increased slightly between 2008 and 2013. Renters chose neighbourhoods where the price is lower in 2013 compared to 2008 (reflected to the value of the elasticity), which is largely due to the economic crisis. For owners, the decrease of elasticity is sharper and almost linear. The evolution of the elasticity for housing price is almost parallel to the elasticity for accessibility to employment, proving the almost perfect trade-off for owners.

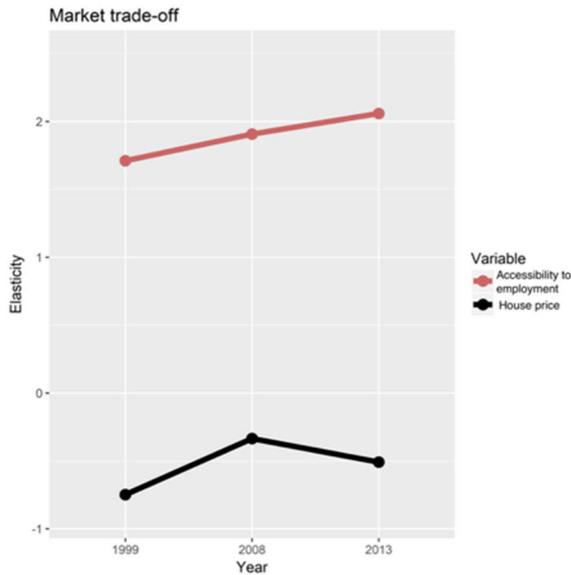


Figure 5a. Evolution of accessibility to employment and housing price elasticities for renters

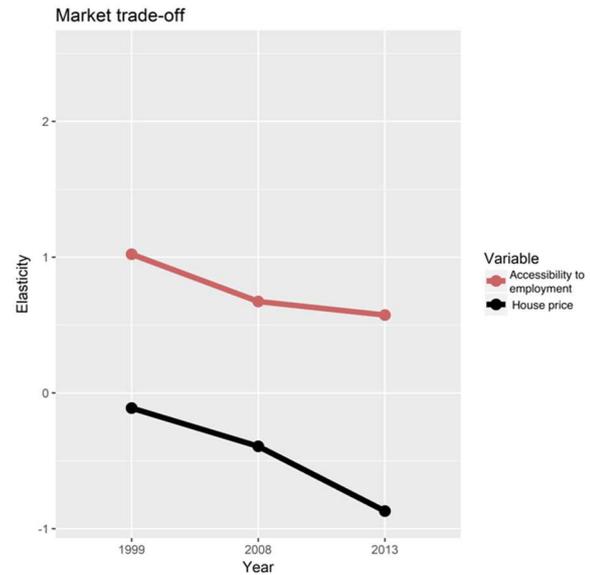


Figure 5b. Evolution of accessibility to employment and housing price elasticities for owners

It seems that the overall increase of accessibility to employment has a different effect on household preferences depending on their housing occupancy status. The improvement of accessibility led the owners to be less sensitive to accessibility, confirming the bid-rent theory on the adjustment of location choices after an accessibility increase. The increasing sensitivity to the housing price (more negative elasticities) is consistent with this behaviour. On the contrary, the renters do not seem to alter their location choice behaviour and they choose areas that increase their accessibility over time. We can see that the improvement of accessibility is capitalised into an increase of the elasticity for renters. The evolution of the elasticity of the housing price shows that the renters are ready to pay more for high accessibility locations.

While the bid-rent theory can explain the behaviour of the owners, the interpretation of the renters' choice behaviour is not straightforward. First, this reaction can be related to the urban amenities theory developed by Glaeser et al. (2001). The city centre offers diverse opportunities for participation and remains attractive throughout time. Possibly for renters, proximity and participation to these activities are highly valued because of their socio-economic characteristics (Melia et al., 2018). Second, there can be an evolution of the lifestyle of these households. Renters are more likely to be young adults forming households of one or two individuals without children. As recent literature points out, millennials create families at an older age than the previous generations (Deka, 2018; Melia et al., 2018; Oakil et al., 2016). This fact has an impact on their lifestyle choices and accessibility is an important location characteristic of their residential choices (Thomas et al., 2015).

We tried to find some relations between the observed location choice behaviour and the characteristics of the households. The socio-demographic characteristics of the moved households are amazingly

stable between the three analysis periods. The distribution of the age and the education level of the household's head, the number of household members and the surface of the residential unit are the same for all periods. Nevertheless, a significant difference is found for car ownership. We observe that the renters own fewer and fewer cars (Table 5). The share of the recently moved renters without a car has risen from 35% in 1999 to 41% in 2013, while at the same time the share of renters with one car fell from 49% in 1999 to 44% in 2013. Various studies have shown that the new generations are less likely to own a car or hold a driver's licence than the previous ones (Klein and Smart, 2017; Melia et al., 2018; Oakil et al., 2016). In Lyon, we observe the same tendency (Bayart et al., 2020; Bouzouina et al., 2020) in line with our findings. Renters without a car may be forced to locate in the centre to benefit from good accessibility. Other renters who prefer to locate in the centre may deliberately abandon the car because this location already allows them to benefit from good accessibility. This behaviour can explain, in both cases, why the elasticity of renters for accessibility increases. Because they do not own a car, deliberately or not.

Table 5. Car ownership based on the housing occupancy status of the recently moved households

Car ownership Housing occupancy status of recently moved households	No car		One Car		Two or more cars	
	Owner	Renter	Owner	Renter	Owner	Renter
1999	7%	35%	48%	49%	45%	16%
2005	6%	37%	46%	48%	48%	15%
2013	8%	41%	48%	44%	45%	15%

6 Discussion

Many studies highlight the importance of accessibility for a residential location choice (Baraklianos et al., 2020; de Palma et al., 2005; Eliasson, 2010; Lee et al., 2010). However, it is not clear in the literature how the sensitivity of different households to accessibility evolves over time. As accessibility levels rise by transport investments and economic growth, households are likely to adapt their preferences for accessibility. Based on the theory of urban economics (Alonso, 1964) and the observed urban sprawl of the post-war era (Baum-Snow, 2007), we can conclude that the increase of accessibility drives households to own residential units in peripheral areas leading to a decreasing sensitivity to accessibility. On the other hand, during the last 20 years, the city centres have regained their lost attractiveness (Buzar et al., 2007; Cheshire, 2006; Deka, 2018; Melia et al., 2018; Moos, 2013; R erat, 2015). This regeneration of the city centres is driven by younger generations, the so-called millennials, who prefer to rent a residential unit in highly accessible areas (Deka, 2018; Melia et al., 2018; Myers et al., 2019). In this changing environment, there are not many empirical works, which could help us understand how the preferences of the households for accessibility evolve over time.

A characteristic that seems to influence the revealed preference for accessibility is the housing occupation status (Haque et al., 2018). The renters are more sensitive to accessibility (Inoa et al., 2015; Plaut, 2006; Waddell, 1996). Nevertheless, the few empirical works on the evolution of households for accessibility do not give us a clear picture. In this article, taking advantage of the available cross-sectional data, we relied on discrete choice models and analysed the evolution of the impact of accessibility to employment on the residential location choice. Distinguishing between renters and owners, we estimated elasticities for accessibility to employment by car and public transport for the urban area of Lyon, for three periods 1999, 2008, and 2013.

The results for the urban area of Lyon confirm the findings of the empirical literature about the sensitivity of the renters. The evolution of the impacts shows that, even though renters already had higher sensitivity to accessibility to employment at the first analysis period (1999), the difference between owners and renters increases over time. Owners show a decreasing sensitivity to accessibility, while renters the exact opposite. For owners, this means that they take advantage of the accessibility changes to select areas that fulfil long-term criteria for a given housing value. The increase of accessibility led to a decreased sensitivity to accessibility and housing value, consistent with the urban economics theory. On the contrary, renters, who make a short-term decision, are not willing to sacrifice the comfort of high accessibility and they present an increasing sensitivity for accessibility over time. This choice behaviour is related to their socio-demographic profile, which explains why accessibility is very important for their residential location choices (Melia et al., 2018). They are more likely to be younger, at the beginning of their career and more importantly without children (Plaut, 2006). It seems that there is a relation between the car ownership levels and the sensitivity to accessibility, without being able to define a clear causality.

7 Conclusion

Distinguishing between renters and owners, this paper investigates the evolution of the households' location choice determinants and enhances the knowledge around the sensitivity to accessibility over time. Accessibility to employment matters, but in different ways. Owners become less sensitive to accessibility when they choose their location, whereas renters become more sensitive. This finding can contribute to the understanding of the complex urban dynamics characterised by contradictory trends of suburbanisation, gentrification and segregation. The temporal centrifugal and centripetal dynamics depend on the characteristics of the decision-makers and urban modellers should be aware of these. Methods combining cross-sectional data from different points in time can capture these temporal variations of the different effects and help in estimating better predictive models (Rezaei and Patterson, 2016). These dynamic modelling technics can help us to model better the spatial effect of increasing accessibility or emerging new mobility solutions, like Mobility as a Service. Our results are in line with Milakis et al. (2018), who suggest that this evolution can cause at the same time more suburbanisation and increased density of the central areas.

While our study gives some interesting insights on the subject, we could not overcome some limits. The analysed period is fourteen years and the time steps are not equal. A longer analysis period and fixed time steps could be more appropriate. However, the use of disaggregated and historical data poses many restrictions. Therefore, the choice of the analysed period and of the time steps is highly dependent on the availability of the data. Furthermore, the temporal analysis of other choices conditioned by residential location choices, like car ownership, can be very interesting. Those choices are interdependent and a more profound understanding can help the construction of better transport and land-use policies.

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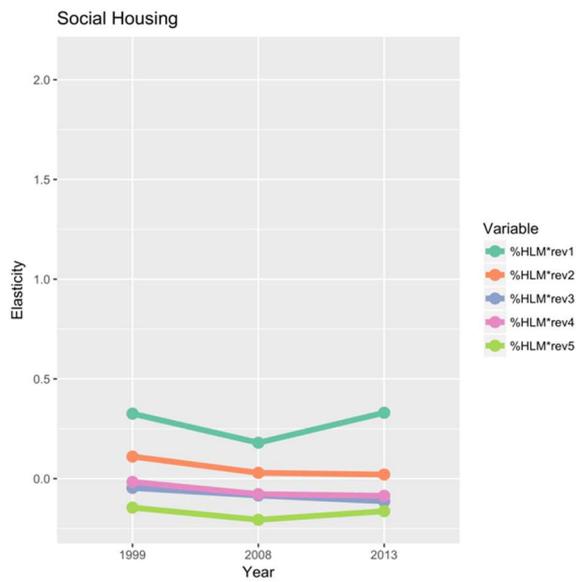
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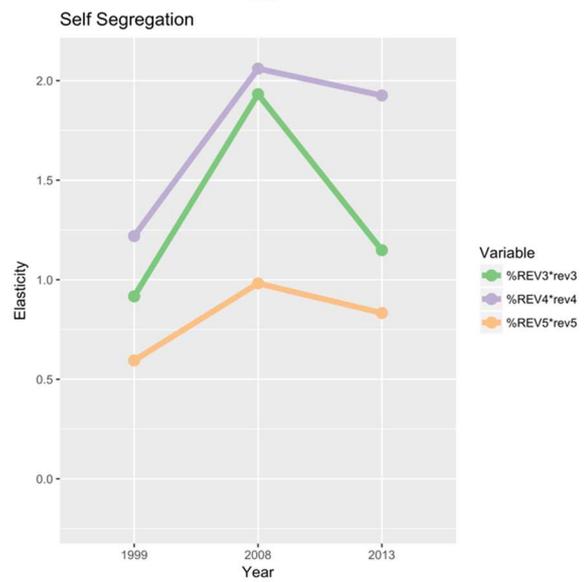
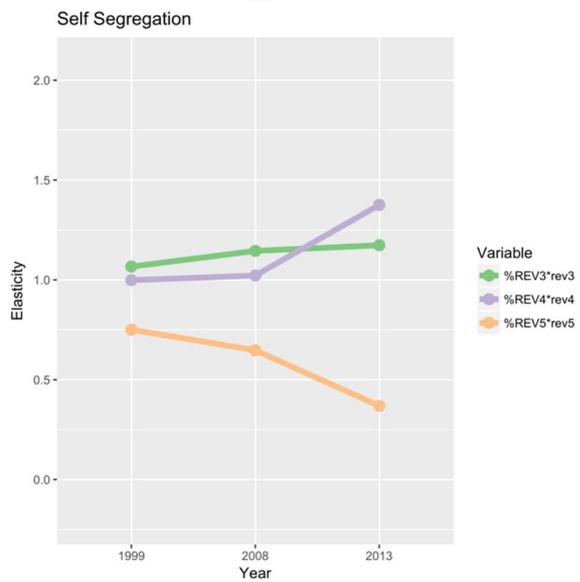
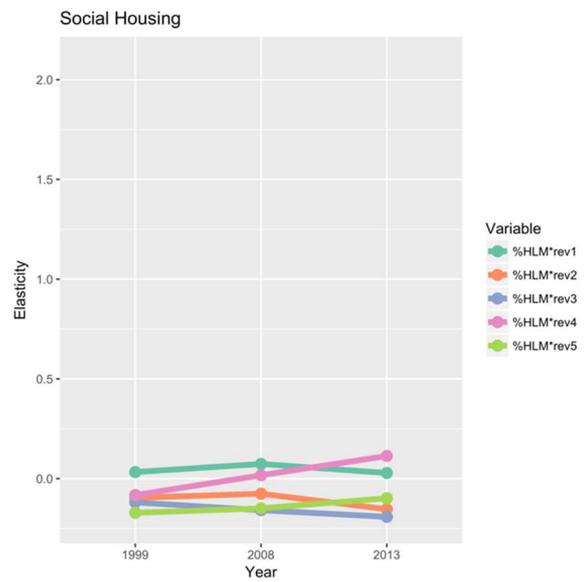
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Appendix

Renters



Owners



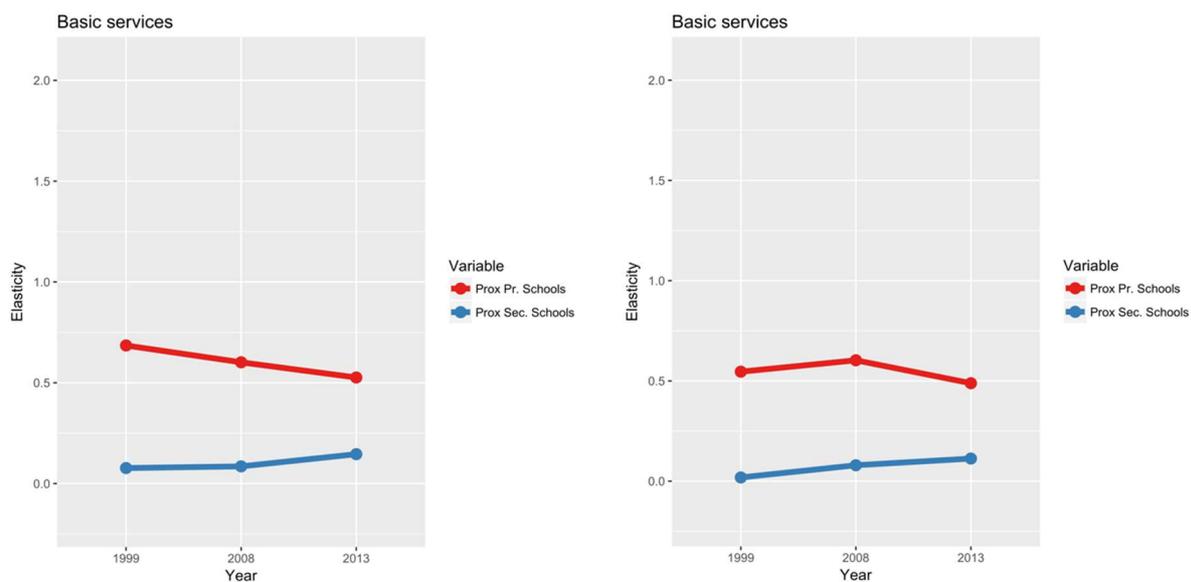


Figure A1. Evolution of elasticities by variable group and by renters/owners

Table A1. Distribution of authorised surface for housing by aggregated zone
Source: Citadel database, Ministry of sustainable development

Zone	Centre	East surrounding areas	West surrounding areas	2nd urban belt	3rd urban belt	Total (m ²)
Housing construction permits 2006-2008	56%	2%	11%	1%	30%	77,352
Housing construction permits 20011-2013	39%	24%	5%	21%	11%	68,753